

2  
3 Is ectoparasite **burden** related to host **density**? **Evidence from** nearshore fish larvae off  
4 central Chile

5  
6 Pamela Palacios-Fuentes<sup>1,\*</sup>, Mauricio F. Landaeta<sup>1</sup>, María T. González<sup>2</sup>, Guido Plaza<sup>3</sup>, F.  
7 Patricio Ojeda<sup>4</sup> & Gabriela Muñoz<sup>5</sup>

8  
9 1 Laboratorio de Ictioplancton (LABITI), Facultad de Ciencias del Mar y de Recursos  
10 Naturales, Universidad de Valparaíso, Avenida Borgoño 16344, Reñaca, Viña del Mar,  
11 Chile.

12 2 Instituto de Ciencias Naturales “Alexander von Humboldt”, Facultad de Ciencias del Mar  
13 y Recursos Biológicos, Universidad de Antofagasta, Antofagasta, Chile.

14 3 Escuela de Ciencias del Mar, Facultad de Recursos Naturales, Pontificia Universidad  
15 Católica de Valparaíso, Valparaíso, Chile.

16 4 Departamento de Ecología, Pontificia Universidad Católica de Chile, Santiago de Chile,  
17 Chile.

18 5 Laboratorio de Parasitología Marina, Facultad de Ciencias del Mar y de Recursos  
19 Naturales, Universidad de Valparaíso, Viña del Mar, Chile.

20  
21 \* To whom correspondence should be addressed.

22 Email: [palaciosf.pamela@cienciasdelmar.cl](mailto:palaciosf.pamela@cienciasdelmar.cl), Phone: +56-322507828, Fax: +56-322507859.

23  
24 Running head: **Ectoparasites burden versus host density**

25 **Abstract**

26 Variation in parasite populations may be temporal and/or spatial, related to  
27 environmental factors, but it may also be due to differences in host-population density,  
28 which is one of the main factors affecting the abundance of directly transmitted parasites.  
29 Fish larvae and their ectoparasites were collected by ichthyoplankton samplings in a three-  
30 year survey near the coast of central Chile. To estimate the variation of ectoparasite  
31 abundance with fluctuations of host density, the prevalence and intensity of ectoparasites  
32 (copepods and isopods) were calculated and compared with the density (larval fish  
33 abundance standardized to 1000 m<sup>-3</sup>) of six species of nearshore fish larvae, belonging to  
34 the families Gobiesocidae, Labrisomidae and Tripterygiidae. Copepods (Pennellidae and  
35 Caligidae) and isopods (Cryptoniscidae) were found to be parasitizing the fish larvae. The  
36 pennellid copepods were the most prevalent ectoparasite, and clingfish *Gobiesox*  
37 *marmoratus* (Gobiesocidae) was the most parasitized fish species (12.81%). The  
38 ectoparasite burden of pennellids, caligids or isopods, separately, did not show any  
39 correlation with larval densities of four fish species, *Auchenionchus crinitus*,  
40 *Auchenionchus microcirrhis*, *Sicyases sanguineus* or *Helcogrammoides chilensis*.  
41 Nonetheless, the prevalence and intensity of the pennellid copepods showed a significant  
42 and positive correlation with the density of a gobiesocid species (*G. marmoratus*), whereas  
43 the prevalence of pennellid copepods (5.10%) showed a significant but negative correlation  
44 with the density of larval tripterygid fish (*Helcogrammoides cunninghami*). Ectoparasite  
45 abundance is a result of a species-specific relationship with their hosts, but the evidence  
46 found suggests no correlation between ectoparasite burden and host density in larval fishes  
47 from coastal environments.

48 Key words: Host density, Prevalence, Tripterygiidae, Gobiesocidae, Pennellidae, Caligidae

## 49 **Introduction**

50 Variation in parasite populations and communities may be temporal or spatial  
51 (Kennedy 1975); and **it** can be of high magnitude and without any stable pattern, varying  
52 both among and within fish species (Grutter 1994). Another cause of variability is **the**  
53 **environment of the parasites, which differs from that of free-living organisms, because it**  
54 **has two components: (1) the macro-environment, which is the environment of the host, and**  
55 **(2) the micro-environment, which is the host body itself (Rohde 1984). Therefore, both**  
56 **environments have an important role in the ecology of parasite communities, by controlling**  
57 **the interactions, abundances and diversity of parasites.**

58 **Macro-environment variations can be associated with natural changes in climate,**  
59 **seasonal variations and other environmental conditions that can influence parasites through**  
60 **direct and indirect pathways (Violante-González et al. 2008; Altman and Byers 2014). For**  
61 **example, the prevalence of metazoan ectoparasites of marine fishes is positively and**  
62 **strongly related to water temperature (Rohde et al. 1995).**

63 **On the other hand, micro-environment variations,** which include reproductive  
64 periods, food availability, mortality rates (Negovetich and Esch 2007) and density (Fellis  
65 and Esch 2004) of the host, as well as any biological change in the host, would also affect  
66 the abundance of parasite populations (Anderson and May 1978; May and Anderson 1978;  
67 Muñoz and Randhawa 2011) leading temporal variations in the dynamics of parasite  
68 populations and communities (Muñoz and Randhawa 2011). **The characteristic of the hosts,**  
69 **such as host size (Guégan 2005) and host density (Simková et al. 2001), can be important**  
70 **for the acquisition and retention of parasites.**

71 Host density usually has a central role on directly transmitted parasites, explaining  
72 **species richness,** distribution and abundance (Arneberg et al. 1998; Morand and Poulin

73 1998). Moreover, the probability of the transmission stage (e.g. eggs, larvae) contacting a  
74 host (Arneberg et al. 1998) increases with increasing host density, for example, the larval  
75 stages of *Caligus rogercresseyi* have a direct relationship with salmon density (Molinet et  
76 al. 2011), demonstrating that host density can be more important than oceanographic  
77 variables in certain circumstances. Consequently, those species of hosts occurring at high  
78 densities should harbor more parasitic species than species occurring at low abundances  
79 (Morand and Poulin 1998; Morand et al. 2000).

80 Most research concerning the ecology of marine fish ectoparasites has been carried  
81 out on the adult and/or juvenile stages of fishes, but there is scarce information related to  
82 ectoparasites on fish larvae. These developmental stages are more vulnerable to the effects  
83 of parasites than adult fish (Fogelman and Grutter 2008) due to their fragile nature (Herrera  
84 1984; 1990) and considering they are in early stages of immunological and physiological  
85 development (Uribe et al. 2011).

86 By using a three-year time series (2010-2012) of plankton sampling in nearshore  
87 waters (<500 m offshore) from central Chile, we hypothesize that the variability of the host  
88 density (i.e., fish larvae) will influence the ectoparasite burden, considered as prevalence  
89 and intensity, in different host species. This will be addressed in the larval stages from three  
90 fish families (Gobiesocidae, Labrisomidae and Tripterygiidae) which serve as hosts of the  
91 ectoparasites' developmental stages.

92

## 93 **Material and Methods**

### 94 *Fieldwork*

95 During the late winter and spring of 2010 (three cruises on 9/2, 9/9 and 10/4), 2011  
96 (five cruises on 9/8, 9/15, 10/18, 11/18 and 11/23) and 2012 (five cruises on 11/8, 11/13,

97 11/27, 12/5 and 12/11), nearshore (<500 m offshore) night surveys (1900 to 2300 h) were  
98 conducted at El Quisco Bay (33°24'S, 71°43'W), central Chile, on board an artisan vessel.  
99 Oblique hauls of a Bongo net (60 cm diameter, 300 µm mesh size) with one TSK flow  
100 meter (The Tsurumi-Seiki Co., Ltd.; Tsurumi-ku, Yokohama, Japan) mounted in the frame  
101 of the net, were performed for 10-15 min each from a depth of 20 m. Seawater filtered by  
102 the net ranged from 13.1 to 437.4 m<sup>3</sup> (mean ± one standard deviation: 141.8 ± 102.5 m<sup>3</sup>).  
103 All zooplankton samples ( $n = 192$ ) were initially fixed with 5% formalin buffered with  
104 sodium borate and preserved in 96% ethanol after 12 h.

105 Unfortunately, macro-environmental factors, such as sea water temperature, salinity,  
106 density and wind strength, could not be incorporated into the study, because the  
107 oceanographic and meteorological data were not available in every sampling period.

108

#### 109 *Laboratory work*

110 All fish larvae were separated from the general plankton samples, counted and  
111 identified into the lowest possible taxon following the descriptions of Pérez (1979, 1981)  
112 and Neira et al. (1998). After this, all fish larvae were observed under a stereomicroscope  
113 (Olympus ZS-61; Olympus Corporation, Shinjuku-ku, Tokyo, Japan) to separate and  
114 preserve each parasitized larva into individual containers for further analysis. Each  
115 ectoparasite was identified to the lowest possible taxon according to their mouth parts and  
116 appendages (Castro and Baeza 1986; 1989; Muñoz et al. unpublished).

117

#### 118 *Data analysis*

119 Fish larval abundances were standardised as individuals 1000 m<sup>-3</sup> for each taxon.  
120 From the whole taxocenosis, only three families were selected due to higher prevalence in

121 the samples: Labrisomidae, Gobiesocidae and Tripterygiidae, each represented by two  
122 selected species: *Auchenionchus crinitus* (Jenyns, 1841), *Auchenionchus microcirrhis*  
123 (Valenciennes, 1836), *Gobiesox marmoratus* Jenyns, 1842, *Sicyases sanguineus* Müller &  
124 Troschel, 1843, *Helcogrammoides chilensis* (Cancino, 1960) and *Helcogrammoides*  
125 *cunninghami* (Smitt, 1898), respectively (Online Resource 1). These species were grouped  
126 into two categories, i.e. non-parasitized larvae (NPL) and parasitized larvae (PL), for  
127 calculation of the ectoparasite burden; and the prevalence and intensity were determined  
128 according to Bush et al. (1997).

129 Host density, prevalence and intensity for each parasite taxon were tested for  
130 normality distribution according to Shapiro-Wilks test. As none of these variables presented  
131 a normal distribution (Shapiro-Wilks Test  $W > 0.8$ ;  $P < 0.05$ ) Spearman correlations were  
132 carried out to evaluate the existence of a significant relationship between each larval fish  
133 host abundance (ind. \* 1000 m<sup>-3</sup>) and the ectoparasite burden. All the statistical analyses  
134 were run using the STATISTICA 7 package (Statsoft Inc, U. S. A.).

135

## 136 Results

137 During the study period (2010-2012), a total of 22,671 fish larvae were analysed,  
138 consisting of a total of 46 fish larval species. The most parasitized larval fish families were  
139 kelpfish labrisomids (*Aucheniunchus crinitus* 3.43%, *A. microcirrhis* 5.51%), clingfish  
140 (*Gobiesox marmoratus* 12.81%, *Sicyases sanguineus* 0.52%) and triplefins  
141 (*Helcogrammoides chilensis* 5.46%, *H. cunninghami* 5.10%) (Figure 1).

142 Three ectoparasitic taxa belonging to two taxonomic groups (Copepoda, from  
143 different chalimus stages, and Isopoda at the larval stage) were recognized in the samples:  
144 *Caligus* sp. (Copepoda: Caligidae), *Trifur* spp. (Copepoda: Pennellidae) and Cryptoniscidae

145 (Isopoda) (Figure 2). Prevalence and intensity of the parasite species presented  
146 considerably differences in the recorded samples (Table 1). The most prevalent  
147 ectoparasites were pennellid copepods, showing the variable intensity range, 1-8 for  
148 pennellid copepods, 1- 2 for caligid copepods, and one isopod per parasitized fish. .

149 The prevalence and intensity of ectoparasites were not correlated with the density of  
150 most fish larvae ( $r_s < 0.7$ ;  $P > 0.05$ ). However, significant correlations were found in two  
151 fish species: pennellid copepods' prevalence (Spearman correlation,  $r_s = 0.72$ ;  $P = 0.005$ )  
152 and intensity (Spearman correlation,  $r_s = 0.83$ ;  $P < 0.001$ ) showed a significant and positive  
153 correlation with *Gobiesox marmoratus* density (Figure 3), whereas pennellid prevalence  
154 showed a significant but negative correlation with larval *Helcogrammoides cunninghami*  
155 density (Spearman correlation,  $r_s = -0.76$ ;  $P = 0.021$ ) (Figure 3).

156

## 157 Discussion

158 All the species studied showed low and variable ectoparasite prevalence, between  
159 0.52% and 12.81%, which is not uncommon for fish larvae. Other studies performed on  
160 larval fish of different families have described low prevalence in gobiids (4.4%), *Anchoa*  
161 sp. (Engraulidae) (3.6%), *Brevoortia* sp. (Clupeidae) (0.22%) (Felley et al. 1987),  
162 *Engraulis ringens* (Engraulidae) (prevalence ranged between 0.9% and 4.7%),  
163 *Pomacentrus moluccensis* (Pomacentridae) (4%) (Grutter et al. 2010), and Chilean triplefin  
164 *H. chilensis* (Tripterygiidae) (2.7-20.8%) (Palacios-Fuentes et al. 2012).

165 Ectoparasite intensities were also low and variable, mostly between 1-3 parasites  
166 per host (the median value was 1 ectoparasite per fish larva), and higher values were rarely  
167 found (e.g. up to eight pennellid copepods in one specimen of clingfish *G. marmoratus*).  
168 These results concur with the descriptions given by Felley et al. (1987), in which the

169 majority of parasitized fish larvae in an estuary had a single copepod attached and just four  
170 fish larvae (Gobies 0.028%, *Anchoa* sp 0.011%, *Brevoortia* sp. 0.0077%) had two or three  
171 parasites.

172 This study is a first attempt to find a relationship between ectoparasite burden and  
173 larval fish density. The difficulty of estimating host densities in coastal areas limits the  
174 probability of determining significant correlations for the parasite-host relationship in  
175 marine fishes. Despite that we were unable to find significant correlations between  
176 ectoparasite burdens and host densities for most of the fish species considered in this study.  
177 The lack of correlation may be caused by random environmental processes near the coast,  
178 such as tides, coastal water advection, lunar cycles, wind-driven turbulence and/or seasonal  
179 variability (Narváez et al. 2004). Therefore, macro-environmental factors would affect, in  
180 different ways, the parasite transmission to the hosts, which should be taken into account in  
181 future analyses.

182 *G. marmoratus* was the only host species that showed positive correlations with  
183 pennellid copepod burdens (i.e., prevalence and intensity). This fish species was not the  
184 most abundant, but it had the highest prevalence and intensity of pennellids, which suggests  
185 that these parasitic taxa might prefer this host species. This relationship may be explained  
186 by the life cycle of this host, which has planktonic larval stages that spend about one month  
187 in the water column (Contreras et al. 2013); thereafter they locate near the sea floor where  
188 the probability of infection by pennellidae may increase, because many parasites develop  
189 their life cycles near the benthos where they are invertebrates that are intermediate hosts for them  
190 (Chambers and Dick 2005; Klimpel et al. 2006).

191 Most parasites are host-specific as a strategy to improve their fitness, because each  
192 host species provides different micro-environments for the parasites, i.e., some host species

193 are more suitable for a successful life for a parasite than other hosts (Muñoz and Cortés  
194 2009). In fact, a similar result was found in the copepod *Caligus rogercresseyi*, which has  
195 shown a positive correlation between their larval abundance and density of salmon hosts  
196 (Molinet et al. 2011). This link was generated by host densities positively affecting parasite  
197 transmission rates, but also because *C. rogercresseyi* prefers salmon hosts to the native  
198 hosts.

199 On the other hand, the prevalence of pennellid copepods showed a negative  
200 correlation with the larval density of triplefin *H. cunninghami*. The pelagic larval duration  
201 of triplefin lasts approximately four months (Plaza et al. 2013; Mansur et al. 2014;  
202 Palacios-Fuentes et al. 2014); during these months they aggregate as dense schools near  
203 surface waters (Palacios-Fuentes, pers. obs.). Fishes with schooling behaviour may show a  
204 lower rate of parasitism depending on their position in the group (Krause 1994), and exhibit  
205 significantly greater distances from their neighbours than uninfected shoal members  
206 (Barber and Huntingford 1996). This might be a reason why only a few specimens of larval  
207 *H. cunninghami* were infected, in spite of the large densities found in the study.

208 Those characteristics of the host biology that increase self-recruitment may benefit  
209 the closure of the life cycle of ectoparasite copepods by increasing the probability of their  
210 finding a definite host, and thus favour the dispersal of pennellid ectoparasites (Cribb et al.  
211 2000). Therefore, pennellid and caligid copepods could be utilizing meroplanktonic fish  
212 larvae as intermediate hosts (Palacios-Fuentes et al. 2012; Muñoz et al. accepted), and they  
213 would detached before the fish move to the intertidal zone. This means that the definitive  
214 host for penellids and caligids found in the larval fish considered in this study would be  
215 adult fish from the demersal and subtidal zones, e.g. *Bovichtys chilensis*, *Merluccius gayi*,

216 and *Sebastes oculatus* (Muñoz et al. 2002; George-Nascimento 1996; Oliva and González  
217 2004).

218 This is a first approach to gain an understanding how developmental stages of  
219 ectoparasites relate to the early life stages of coastal fishes. Consequently there are several  
220 questions that still need to be addressed, and it is important for studies of larval fish  
221 ecology to comprehend the effects of ectoparasites on feeding habits, growth, condition and  
222 survival rates of fish larvae.

223

#### 224 **Acknowledgments**

225 This research was funded by project Fondecyt 1100424 adjudicated to FPO, GP and  
226 MFL, and Fondecyt 1120868 adjudicated to GM, MFL and MTG. We thank Randy Finke,  
227 Eduardo González, Jorge Contreras, David Ortiz, Camilo Rodríguez, Carlos González and  
228 Cristian Acevedo for their assistance with the sampling surveys and the collection of the  
229 material, and Nicole Jahnsen-Guzmán and Camila Ardiles for their help with the revision of  
230 the fish larvae and larval ectoparasites. Thanks are also due to two anonymous reviewers  
231 who helped improve the first drafts of this manuscript.

232

#### 233 **References**

234 Altman I, Byers JE (2014) Large-scale spatial variation in parasite communities influenced  
235 by anthropogenic factors. *Ecology* 95(7):1876-1887. doi: 10.1890/13-0509.1

236 Anderson RM, May RM (1978) Regulation and stability of host-parasite population  
237 interactions. I. Regulatory Processes. *J Anim Ecol* 47:219-247.

238 Arneberg P, Skorping A, Grenfell B, Read AF (1998) Host densities as determinants of  
239 abundance in parasite communities. Proc R Soc Lond B 265:1283-1289. doi:  
240 10.1098/rspb.1998.0431

241 Barber I, Huntingford FA (1996) Parasite infection alters schooling behaviour: deviant  
242 positioning of helminth-infected minnows in conspecific groups. Proc R Soc Lond B Biol  
243 Sci 263:1095-1102. doi: 10.1098/rspb.1996.0161

244 Bush AO, Lafferty KD, Lotz JM, Shostaka AW (1997) Parasitology meets ecology on its  
245 own terms: Margolis et al. revisited. J Parasitol 83:575-583.

246 Castro R, Baeza H (1986) Premetamorphosis stages of two Pennellids (Copepoda,  
247 Siphonostomatoida) from their definitive hosts. Crustaceana 50:166-175.

248 Castro R, Baeza H (1989) Characters for the pennellid taxonomy based on *Peniculus*,  
249 *Metapeniculus*, *Lernaeenicus* and *Lernaeocera* specimens revision with SEM. Estud  
250 Oceanol 8:21-45.

251 Castro R, Santos MJ (2013) Metazoan ectoparasites of Atlantic mackerel, *Scomber*  
252 *scombrus* (Teleostei: Scombridae): macro- and microhabitat distribution. Parasitol Res 112:  
253 3579-3586. doi: 10.1007/s00436-013-3543-8

254 Chambers CA, Dick TA (2005) Trophic structure of one deep-sea benthic fish community  
255 in the eastern Canadian Arctic: application of food, parasites and multivariate analysis.  
256 Environ Biol Fish 74:365-378. doi: 10.1007/s10641-005-2922-0

257 Contreras JE, Landaeta MF, Plaza G, Ojeda FP, Bustos CA (2013) The contrasting  
258 hatching patterns and larval growth of two sympatric clingfishes inferred by otolith  
259 microstructure analysis. Mar Freshw Res 64:157-167. doi: 10.1071/MF12232

260 Cribb TH, Pichelin S, Dufour V, Bray RA, Chauvet C, Faliex E, Galzin R, Lo CM, Lo-Yat  
261 A, Morand S, Rigny MC, Sasal P (2000) Parasites of recruiting coral reef fish larvae in  
262 New Caledonia. *Int J for Parasitol* 30:1445-1451. doi:10.1016/S0020-7519(00)00121-1  
263 Felley SM, Vecchione M, Hare SGF (1987) Incidence of ectoparasitic copepods on  
264 ichthyoplankton. *Copeia* 1987:778-782.

265 Fellis KJ, Esch GW (2004) Community structure and seasonal dynamics of helminth  
266 parasites in *Lepomis cyanellus* and *L. macrochirus* from Charlie's Pond, North Carolina:  
267 Host size and species as determinants of community structure. *J Parasitol* 90(1):41-49. doi:  
268 10.1645/GE-3037

269 Fogelman RM, Grutter AS (2008) Mancae of the parasitic cymothoid isopod, *Anilorca*  
270 *apogonae*: early life history, host-specificity, and effect on growth and survival of preferred  
271 young cardinal fishes. *Coral Reefs* 27:685-693. doi: 10.1007/s00338-008-0379-2

272 George-Nascimento M (1996) Populations and assemblages of parasites in hake,  
273 *Merluccius gayi*, from the southeastern Pacific Ocean: stock implications. *J Fish Biol*  
274 48:557-568. doi: 10.1111/j.1095-8649.1996.tb01452.x

275 Grutter AS (1994) Spatial and temporal variations of the ectoparasites of seven reef fish  
276 species from Lizard Island and Heron Island, Australia. *Mar Ecol Progr Ser* 115:21-30.

277 Grutter AS, Cribb TH, McCallum H, Pickering JL, McCormick MI (2010) Effects of  
278 parasites on larval and juvenile stages of the coral reef fish *Pomacentrus moluccensis*.  
279 *Coral Reefs* 29:31-40. doi: 10.1007/s00338-009-0561-1

280 Guegan JF, Morand S, Poulin R (2005) Are there general laws in parasite community  
281 ecology? The emergence of spatial parasitology and epidemiology. In Thomas F, Guégan  
282 JF, Renaud F (eds), *Parasitism and Ecosystems* (pp. 22-42). Oxford: Oxford University  
283 Press.

284 Herrera G (1984) Parasitismo de juveniles de copépodos caligoideos sobre larvas de peces  
285 de la Bahía Coliumo (36 32'S; 75 57'W), Chile. Biol Pesq 13:31-38.

286 Herrera G (1990) Incidence of larval anchovy, *Engraulis ringens*, parasitized by caligid  
287 developmental stages. Bull Mar Sci 47:571-575.

288 Kennedy CR (1975) Ecological animal parasitology. Blackwell Scientific Publications,  
289 Oxford.

290 Krause J (1994) Differential fitness returns in relation to spatial position in groups. Biol  
291 Rev Camb Philos Soc 69:187-206

292 Klimpel S, Palm HW, Busch MW, Kellermanns E, Rückert S (2006) Fish parasites in the  
293 Arctic deep-sea: Poor diversity in pelagic fish species vs. heavy parasite load in a demersal  
294 fish. Deep-Sea Research Part I 53:1167-1181. doi:10.1016/j.dsr.2006.05.009

295 Mansur L, Plaza G, Landaeta MF, Ojeda FP (2014) Planktonic duration in fourteen species  
296 of intertidal rocky fishes from the south.eastern Pacific Ocean. Mar Freshw Res 65:901-  
297 909. doi: 10.1071/MF13064

298 May RM, Anderson RM (1978) Regulation and stability of host-parasite population  
299 interactions. II. Destabilizing Processes. J Anim Ecol 47:249-267.

300 Morand S, Poulin R (1998) Density, body mass and parasite species richness of terrestrial  
301 mammals. Evol Ecol 12:717-727. doi: 10.1023/A:1006537600093

302 Morand S, Cribb TH, Kulbicki M, Rigby MC, Chauvet C, Dufour V, Faliex E, Galzin R,  
303 Lo C, Lo-Yat A, Pichelin SP, Sasal P (2000) Endoparasite species richness of New  
304 Caledonian butterfly fishes: host density and diet matter. Parasitology 121:65-73.

305 Muñoz G, Valdebenito V, George-Nascimento M (2002) La dieta y la fauna de parásitos  
306 metazoos del torito *Bovichthys chilensis* Reagan, 1914 (Pisces: Bovichthyidae) en la costa

307 de Chile centro-sur: variaciones geográficas y ontogenéticas. Rev Chil Hist Nat 75:661-  
308 671.

309 Muñoz G, Cortés Y (2009) Parasite communities of a fish assemblage from the intertidal  
310 rocky zone of central Chile: Similarity and host specificity between temporal and resident  
311 fish. Parasitology 136:1291-1303. doi: 10.1017/S0031182009990758

312 Muñoz G, Randhawa HS (2011) Monthly variation in the parasitic communities of the  
313 intertidal fish *Scartichthys viridis* (Blenniidae) from central Chile: are there seasonal  
314 patterns? Parasitol Res 109:53-62. doi: 10.1007/s00436-010-2220-4

315 Muñoz G, Landaeta MF, Palacios-Fuentes P, López Z, González MT (2015) Identification  
316 of parasites in fish larvae from the coast of Chile: morphological and molecular analyses.  
317 Folia Parasitol (accepted)

318 Narváez DA, Poulin E, Leiva G, Hernández E, Castilla JC, Navarrete SA (2004) Seasonal  
319 and spatial variation of nearshore hydrographic conditions in central Chile. Cont Shelf Res  
320 24:279-292. doi:10.1016/j.csr.2003.09.008

321 Negovetich NJ, Esch GW (2007) Long-term analysis of Charlie's pond: fecundity and  
322 trematode communities of *Helisoma anceps*. J Parasitol 93:1311-1318. doi: 10.1645/GE-  
323 1184.1

324 Neira FJ, Miskiewicz AG, Trnski T (1998) Larvae of temperate Australian fishes:  
325 Laboratory guide for larval fish identification. University of Western Australia Press,  
326 Western Australia.

327 Oliva ME, González MT (2004) Metazoan parasites of *Sebastes capensis* from two  
328 localities in northern Chile as tools for stock identification. J Fish Biol 64(1):170-175. doi:  
329 10.1111/j.1095-8649.2004.00295.x

330 Palacios-Fuentes P, Landaeta MF, Jahnsen-Guzmán N, Plaza G, Ojeda FP (2014) Hatching  
331 patterns and larval growth of a triplefin from central Chile inferred by otolith  
332 microstructure analysis. *Aquat Ecol* 48:259-266. doi: 10.1007/s10452-014-9481-4

333 Palacios-Fuentes P, Landaeta MF, Muñoz G, Plaza G, Ojeda FP (2012) The effects of  
334 parasitic copepod on the recent larval growth of a fish inhabiting rocky coasts. *Parasitol*  
335 *Res* 111:1661-1671. doi: 10.1007/s00436-012-3005-8

336 Pérez R (1979) Postembryonic development of *Tripterygion chilensis* Cancino, 1955, in  
337 Valparaíso Bay (Tripterygiidae: Perciformes). *Rev Biol Mar* 16:319-329.

338 Pérez R (1981) Desarrollo embrionario y larval de los pejesapos *Sicyases sanguineus* y  
339 *Gobiesox marmoratus* en la Bahía de Valparaíso, Chile, con notas sobre su reproducción  
340 (Gobiesocidae: Pisces). *Invest Mar* 9:1-24.

341 Plaza G, Landaeta MF, Espinoza CV, Ojeda FP (2013) Daily growth patterns of six species  
342 of young-of-the-year of Chilean intertidal fishes. *J Mar Biol Assoc U. K.* 93(2):389-395.  
343 doi: 10.1017/S0025315412000859

344 Rohde K (1984) Ecology of marine parasites. *Helgol Meeresunters* 37:5-33.

345 Rohde K, Hayward C, Heap M (1995) Aspects of the ecology of metazoan ectoparasites of  
346 marine fishes. *Int J Parasitol* 25(8):945-970.

347 Simková A, Morand S, Matejusová I, Jurajda P, Gelnar M (2001) Local and regional  
348 influences on patterns of parasite species richness of central European fishes. *Biodivers*  
349 *Conserv* 10:511-525. doi: 10.1023/A:1016658427730

350 Uribe C, Folch H, Enríquez R, Morán G (2011) Innate and adaptive immunity in teleost  
351 fish: a review. *Vet Med* 56:486-503.

352

Tables

353

354 Table I. Prevalence and intensity range of the three parasites families found on six different larval fish species from nearshore waters

355 of central Chile.

356

357

Taxa	Sample size (n)	Total density (ind*1000 m <sup>-3</sup> )	Pennellidae		Caligidae		Cryptoniscidae		Total	
			Prevalence	Intensity	Prevalence	Intensity	Prevalence	Intensity	Prevalence	Intensity
<i>Auchenionchus microcirrhis</i>	936	7877.698	4.515	[1-2]	0.948	[1-2]	0.043	[1]	5.506	[1-2]
<i>Auchenionchus crinitus</i>	770	5930.722	1.197	[2]	1.642	[1]	0.592	[1]	3.43	[1-2]
<i>Gobiesox marmoratus</i>	1349	13785.591	12.161	[1-8]	0.648	[2]			12.81	[1-8]
<i>Sicyases sanguineus</i>	619	6867.016	0.435	[1]	0.081	[1]			0.52	[1]
<i>Helcogrammoides chilensis</i>	1846	15071.746	5.269	[1-5]	0.126	[1]	0.067	[1]	5.46	[1-5]
<i>Helcogrammoides cunninghami</i>	1124	11927.750	4.109	[1-2]	0.993	[1]			5.10	[1-2]

358

Figure captions

359

360 Figure 1. Three mayor parasitized fish families. Labrisomidae: A. *Auchenionchus*  
361 *microcirrhis*, B. *Auchenionchus crinitus*; Gobiesocidae: C. *Gobiesox marmoratus*, D.  
362 *Sicyases sanguineus* and Trypterigiidae: E. *Helcogrammoides chilensis*, F.  
363 *Helcogrammoides cunninghami*. Scale bars = 1 mm length.

364 Figure 2. Ectoparasites present during the study period. A. Cryptoniscidae B. Pennellidae  
365 C-D. Caligidae.

366 Figure 3. Correlations between: A. *G. marmoratus* abundance and prevalence, B. *G.*  
367 *marmoratus* abundance and intensity, and C. *H. cunninghami* abundance and prevalence.

368

Supplementary material

369 Online Resource 1

370 Number of specimens for each species through the study period (2010-2012). The value in parenthesis corresponds to the species

371 partial density (ind\*1000 m<sup>-3</sup>) on each sampling date.

Sampling date	Taxa					
	<i>A. microcirrhis</i>	<i>A. crinitus</i>	<i>G. marmoratus</i>	<i>S. sanguineus</i>	<i>H. chilensis</i>	<i>H. cunninghami</i>
2010-09-02	111 (695.81)	57 (367.49)	61 (347.87)	17 (81.40)	96 (547.91)	0
2010-09-09	312 (3588.17)	254 (2572.7)	137 (1907.27)	48 (631.45)	539 (5421.66)	25 (84.58)
2010-10-04	52 (330.57)	77 (412.22)	71 (429.24)	27 (180.10)	259 (1330.84)	4 (30.42)
2011-09-08	325 (2094.67)	50 (344.59)	151 (1011.38)	55 (307.38)	373 (3200.94)	148 (733.40)
2011-09-15	60 (168.52)	176 (502.88)	132 (383.97)	42 (121.41)	324 (916.96)	3 (8.06)
2011-10-18	10 (119.25)	7 (107.31)	8 (138.96)	2 (13.91)	34 (678.57)	22 (269.72)
2011-11-18	5 (93.39)	7 (100.43)	2 (36.48)	1 (20.42)	5 (139.34)	12 (229.34)
2011-11-23	10 (99.59)	1 (10.80)	5 (49.92)	2 (20.56)	27 (259.71)	229 (2037.41)
2012-11-08	32 (281.97)	66 (506.55)	305 (2584.68)	132 (2057.68)	62 (417.90)	226 (1869.05)
2012-11-13	6 (90.34)	18 (258.11)	135 (1976.41)	49 (740.41)	36 (641.80)	241 (3636.06)
2012-11-27	3 (35.26)	41 (490.41)	113 (1378.13)	124 (1529.33)	48 (766.35)	174 (2183.11)
2012-12-05	4 (105.27)	14 (215.39)	30 (545.91)	26 (529.91)	21 (376.38)	4 (118.95)
2012-12-11	6 (118.91)	2 (33.22)	199 (2973.82)	94 (1588.40)	22 (373.39)	36 (706.12)

372