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# Community structure of metazoan parasites of the Panama spadefish *Parapsettus panamensis* (Perciformes: Ephippidae) from the coastal zone of Tumbes, Peru

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**Abstract** Fifty-seven specimens of *Parapsettus panamensis* (Ephippidae) were collected from the coastal zone of Puerto Pizarro, Tumbes, Peru (45°54'S, 81°05'W) between December 2014 and January 2015. The specimens were necropsied to study their metazoan parasites. All specimens of *P. panamensis* were parasitized by at least one parasite species. Eleven species of parasites were collected: 2 monogeneans, 3 digeneans, 2 nematodes, and 4 arthropods. The endoparasites represented 87.29%, of the total number of parasite specimens collected. *Parapsettus panamensis* is a new host record for nine parasites collected. The digenean *Aponurus laguncula* was the highest prevalent and abundant parasite of *P. panamensis*. Only the digeneans *A. laguncula* and *Multitestis* sp1. showed a positive correlation between the hosts' total length and abundance of infection. The relative condition factor (Kn) of the host correlated with the abundance of *A. lagungula* and *Caligus haemulonis*. *Parapsettus panamensis* had two pairs of parasite species with significant positive association, 1 pair of ectoparasites and 1 pair of endoparasites. Non-metric multidimensional scaling (NMDS) and the relationship between infra-community composition and explanatory variables (host length and sex) were examined by permutational analysis of variance (PERMANOVA) applied to species abundances which shows high homogeneity among metazoan parasites infra-communities of *P. panamensis*.

**Keywords:** *Aponurus,* helminth parasites, *Multitestis,* Parasite ecology, Pacific Ocean

**Resumen. Estructura de la comunidad de parásitos metazoos del Curaca *Parapsettus panamensis* (Perciformes: Ephippidae) de la zona costera de Tumbes, Perú** Cincuenta y siete especímenes de *Parapsettus panamensis* (Ephippidae), colectados de la zona costera de Puerto Pizarro, Tumbes, Perú (45 ° 54'S, 81 ° 05'W), entre diciembre de 2014 y el enero de 2015, fueron sometidos a autopsia para estudiar sus parásitos metazoos. Todos los especímenes de *P. panamensis* fueron parasitados por al menos una especie parásita. Se colectaron once especies de parásitos: 2, Monogeneos, 3 digeneos, 2 nematodos y 4 artrópodos. Los endoparásitos representaron el 87,29%, del número total de especímenes de parásitos colectados. *Parapsettus panamensis* es un nuevo registro de hospedero para nueve parásitos colectados. El digeneo *Aponurus laguncula* fue la especie más abundante y prevalente en la comunidad de parásitos de *P. panamensis*. Sólo los digeneos *A. laguncula* y *Multitestis* sp1. mostraron una correlación positiva entre la longitud total del hospedero y la abundancia de la infección. El factor de condición relativo (Kn) sólo mostró correlación con la abundancia de *A. lagungula* y *Caligus haemulonis. Parapsettus panamensis* presentó dos pares de especies de parásitos con asociación positiva significativa, 1 par de ectoparásitos y 1 par de endoparásitos.

El escalamiento multidimensional no métrico (NMDS) y la relación entre la composición de la infracomunidad y variables explicativas (longitud y sexo del hospedero) fueron examinadas por el análisis de varianza de permutación (PERMANOVA) aplicadas a la abundancia de especies y muestran una alta homogeneidad entre los parásitos metazoos de las infracomunidades de *P. panamensis*.

**Palabras clave**: *Aponurus*, helmintos parásitos, *Multitestis*, ecología parasitaria, Océano Pacífico

## Introduction

Ephippidae are fish species known from the Atlantic, Indian and Pacific Oceans (Bilecenoglu & Kaya 2006, Nelson 2006). The Panama spadefish, *Parapsettus panamensis* (Steindachner, 1876) (Ephippidae) is a demersal species, endemic to the Eastern Pacific that inhabits coastal waters from Sihuatanejo (México) to Chimbote (Perú) (Smith-Vaniz *et al.* 2010, Nuñez-Orosco *et al*. 2013, Amezcua & Amezcua-Linares 2014). This species is listed as presenting least concern by International Union for Conservation of Nature and Natural Resources (IUCN Red List) (Smith-Vaniz *et al.* 2010). Papers on parasites of *P*. *panamensis* are restricted to two records: the isopod *Cymothoa exigua* Schioedte & Meinert, 1884 from the Colombian Pacific (Ramos *et al.* 1994, Salgado *et al.* 2015) and the monogenean *Parancylodiscoides chaetodipteri* Caballero & Bravo-Hollis, 1961 from the Peruvian Pacific (Chero *et al.* 2015, Luque *et al.* 2016).

In the present study, we report on the metazoan parasites of Panama spadefish, *P. panamensis* from Tumbes, Peru.

## Material and Methods

Between December 2014 and January 2015, 57 specimens of *P. panamensis* from the coast of Puerto Pizarro, Tumbes, Peru (45°54'S, 81°05'W) were necropsied, to study their community of metazoan parasites. Fishes were identified according to Chirichigno & Cornejo (2001). The average total length of the fish was 12 – 16 (13.61 ± 0.77) cm, and the weight was 53 – 100 (69.59 ± 11.89) g. The average total length of male (13.77± 0.75 cm, n = 37) and female (13.31 ± 0.74 cm, n = 20) fishes in the study sample were not significantly different by the t-Student test ($t$ = 1.20; p = 0.23).

To search and collect the parasitic fauna of *P. panamensis*; the skin, fins, nostrils, gills, oral cavity, stomach, intestine, kidney, heart, and mesentery coelomic cavity were examined under a 10x stereoscope. Metazoan parasites were fixed, preserved, stained and mounted following the recommendations of Cribb & Bray (2010).

The ecological approximation of the metazoan parasite community was made to component and infracommunity levels (Esch *et al.* 1990). The analysis included only parasite species with prevalence higher than 10% (Bautista-Hernández *et al.* 2015).

The variance-to-mean ratio of parasite abundance (index of dispersion), was computed using the program Quantitative Parasitology 3.0 (Rózsa *et al.* 2000), to examine the distribution patterns of the infrapopulations (Poulin 1993, Amarante *et al*. 2015). The dominance frequency and the relative dominance (number of specimens of one species/total number of specimens of all species in the infracommunity) of each parasite species were calculated according to Rohde *et al.* (1995). The parasite species diversity and dominance was calculated using the Brillouin index ($H$) because each fish analyzed corresponded to a fully censused community; also the Berger-Parker dominance index (d) (Zar 2014) was calculated. The Pearson's correlation coefficient $rp$ was used to assess the relationship between the host's total length and parasite abundance. Spearman's rank correlation coefficient $rs$ was calculated to determine possible correlations between the total length of hosts and parasite prevalence, with previous arcsine transformation of the prevalence data (Zar 2014). The possible influence of host sex on abundance and prevalence of parasites was tested using the t-Student test and the chi-square test, respectively. The probable variation of diversity in relation to host sex was tested with the $Z_c$ test and parasite diversity vs. total length was tested with Spearman's rank correlation coefficient (Zar 2014).

Possible interspecific association between concurrent parasite species was determined using the chi-square test. Possible covariation among the abundance of concurrent parasite species was analyzed using the Spearman's rank correlation coefficient.

Fish weight (g) and total length (cm) data were used to calculate the relative condition factor (Kn) of the hosts, which was compared with the standard value (Kn = 1.00) using the *t* test. Body weight (g) and total length (cm) were also used to calculate the length-weight relationship (Body weight = a*total length$^b$) after logarithmic transformation of length (L) and weight (W) (Minaya *et al.* 2016). Subsequently, two linear regressions were fitted to the data, thus obtaining lnBody weight = lna + Bln*total length. The Spearman correlation coefficient (*rs*) was used to determine possible correlations between parasite abundance of each species with the Kn of the hosts. The t-Student test was used to compare Kn values of male and female hosts (Zar 2014).

The non-metric multi-dimensional scaling (NMDS), an ordination technique, was used to study pattern in the parasite community structure based on abundance of parasite species. A similarity matrix was constructed based on the Bray–Curtis measure. The abundance of infection of each parasite species in each host and its relation to length and sex of the host were analyzed through a one-way analysis of variance with anon-parametric permutational ANOVA (PERMANOVA) test (Anderson, 2001, Míguez-Lozano *et al*. 2012).

The ecological terminology used follows Bush *et al.* (1997) and Bautista-Hernández *et al.* (2015). Statistical significance was evaluated at $p \leq 0.05$. Voucher specimens of metazoan parasites are deposited in the Helminthological Collection and Related Invertebrates of the Museum of Natural History at San Marcos University (MUSM), Lima, Peru.

## Results

*Component community:* Eleven species of metazoan parasites were collected (Table 1). *Parapsettus panamensis* is a new host record for nine of these species. The digenetic trematode *Aponurus laguncula* Looss, 1907 was the most abundant, prevalent, and dominant species, with 1290 specimens collected (41% of all metazoan parasites) with highest values of mean relative dominance and frequency of dominance (Table 2). Adult endoparasites represented 86.53% of all parasites collected, larval endoparasites amounted to only 0.76%, and ectoparasites made up 12.71%. All parasites of *P*. *panamensis* had the typical aggregated pattern of distribution observed in many parasite systems (Table 3). Only the digeneans *A. laguncula* (*rp* = 0.35, p = 0.007) and *Multitestis* sp1. (*rp* = 0.27, *p* = 0.03) showed a positive correlation between parasite abundance and the host's length. The host's length was not correlated with the prevalence of any parasite species. The sex of the hosts influenced the prevalence of *A. laguncula* ($X^2$ = 3.83; p = 0.05) and the abundance of an unidentified larval parasite ($X^2$ = 4.62; p = 0.03). The abundance of *Multitestis* sp1. (t = 2.41; p = 0.02) was heavily influenced by the sex of the host.

*Infracommunities:* All specimens of *P*. *panamensis* were parasitized by at least one parasite species. A total of 3148 individual parasites were collected, with mean of 55.22 ± 48.49 parasites/fish. No relationship between total parasite abundance and total body length (*rs* = 0.06; p = 0.61) or sex ($Z_c$ = 370; p = 1.00) of fish was observed. The mean parasite species richness was 4.44 ± 1.50 (1-7) and not correlated with total body length (*rs* = 0.06; p = 0.63) or sex ($Z_c$ = 351; p = 0.75) of fish. One host (1.75%) showed infection with one parasite species and 4 (7.02%), 11 (19.30%), 14 (24.56%), 13 (22.81%), 9 (15.79%), 4 (7.02%) and 1 (1.75%) had multiple infections with 2, 3, 4, 5, 6, 7 and 8 species, respectively. The mean value of the Brillouin index of diversity (*H*) was 1.34 ± 0.19 and individual values were not significantly correlated with host's length (*rs* = 0.003; p = 0.98) and no significant differences in parasite diversity were observed between male (*H* = 1.35 ± 0.19) and female (*H* = 1.32 ± 0.21) fishes ($Z_c$ = –0.53, p = 0.59). The Berger-Parker index of dominance for the infracommunities was 0.47 ± 0.13.

For *P. panamensis*, the equation that described the length-weight relationship was $y = 1.224x^{0.474}$ ($r^2$ = 0.47), thus showing that growth was allometrically negative, i.e. that there were greater increases in body mass than in length. The Kn values did not differ between male (0.99 ± 0.02) and female (1.00 ± 0.03) fishes (t=0.71, p=0.48). The Kn (1.00 ± 0.03) of the hosts did not differ (t = 0.08; p = 0.93) from the standard (kn = 1.00). The abundance of *A. lagungula* (r= 0.35, p= 0.006) was positively correlated with Kn values, and *Caligus haemulonis* Krøyer, 1863 abundance was negatively correlated with Kn values (r=-0.26, p=0.04). The other metazoan parasites did not show correlation with Kn values (r = 0.04 – 0.20; p = 0.13- 0.77).

To detect possible inter species relationships, parasitic infracommunities were separated in two groups: ectoparasites (monogeneans, copepods and isopods) and endoparasites (digeneans). Only one pair of ectoparasites, *Sprostoniella* sp. – *P. chaetodipteri* were associated. The abundance of the

**Table I.** Prevalence, intensity range, mean intensity, mean abundance, and site of infection of metazoan parasites found in 57 specimens of *Parapsettus panamensis* from Puerto Pizarro, Tumbes, Peru. †New geographical record. *New host record

| Parasite | Prevalence (%) | Intensity range | Mean intensity ± SD | Mean abundance ± SD | Site of infection |
|---|---|---|---|---|---|
| **Monogenea** | | | | | |
| *Parancylodiscoides chaetodipteri* MUSM 3247 | 38.60 | 1–3 | 1.47±0.80 | 0.39±0.79 | Gills |
| *Sprostoniella* sp.†* MUSM 3310 | 26.32 | 1–4 | 1.32±0.76 | 0.51±0.75 | Gills |
| **Digenea** | | | | | |
| *Aponurus laguncula*†* MUSM 3311 | 96.49 | 7–96 | 23.45±16.16 | 22.63±16.16 | Stomach |
| *Multitestis* sp1.†* MUSM 3312 | 43.86 | 2–6 | 21.48±14.59 | 9.42±14.50 | Intestine |
| *Multitestis* sp2.†* MUSM 3313 | 49.12 | 1–153 | 32.04±30.71 | 15.74±30.64 | Intestine |
| **Nematoda** | | | | | |
| *Anisakis* sp.* (larvae) MUSM 3314 | 5.26 | 4–6 | 5±1.29 | 0.26±1.13 | Mesenteries |
| Unidentified larvae†* MUSM 3315 | 12.28 | 1–3 | 1.29±0.51 | 0.16±0.49 | Intestine |
| **Copepoda** | | | | | |
| *Bomolochus* sp.* MUSM 3316 | 7.02 | 1–2 | 1.25±0.37 | 0.09±0.34 | Operculum |
| *Caligus haemulonis** MUSM 3317 | 21.05 | 1–8 | 2.08±1.26 | 0.44±1.24 | Operculum |
| *Lernanthropus pupa*†* MUSM 3318 | 73.68 | 1–25 | 4.98±4.87 | 3.67±4.86 | Gills |
| **Isopoda** | | | | | |
| *Cymothoa exigua* MUSM 3319 | 70.18 | 1–7 | 2.75±1.76 | 1.93±1.76 | Oral cavity |

**Table II.** Frequency of dominance and mean relative dominance of metazoan parasites of *Parapsettus panamensis* from Puerto Pizarro, Tumbes, Peru.

| Parasites | Frequency of dominance | Frequency of dominance shared with one or more species | Mean relative dominance |
|---|---|---|---|
| *Parancylodiscoides chaetodipteri* | 0 | 1 | 0.007 ± 0.27 |
| *Sprostoniella* sp. | 0 | 2 | 0.009± 0.35 |
| *Aponurus laguncula* | 39 | 52 | 0.41 ± 15.71 |
| *Multitestis* sp1. | 9 | 17 | 0.171± 6.54 |
| *Multitestis* sp2. | 11 | 24 | 0.285 ± 10.93 |
| Unidentified larvae | 0 | 1 | 0.003± 0.11 |
| *Caligus haemulonis* | 0 | 3 | 0.008± 0.30 |
| *Lernanthropus pupa* | 2 | 15 | 0.066± 2.59 |
| *Cymothoa exigua* | 0 | 14 | 0.035± 1.34 |

rest of the ectoparasites was not correlated with the abundance of the other parasites (Table IV). Among the endoparasites one pair of species, *Multitestis* sp1. and *Multitestis* sp2, showed positive covariation in relation to prevalence and abundance (Table IV).

Figure 1 and 2 display the NMDS ordination plot of the 57 metazoan parasites infracommunities from *P. panamensis*. The NMDS ordination suggests a high degree of homogeneity across infracommunities. The PERMANOVA analysis confirmed the low heterogeneity among metazoan parasites infracommunities of *P. panamensis*.

**Table III.** Values of variance to mean ratio of parasite abundance (ID) of metazoan parasites of *Parapsettus panamensis* from Puerto Pizarro, Tumbes, Peru.

| Parasites | ID | Type of distribution |
|---|---|---|
| *Parancylodiscoides chaetodipteri* | 1.63 | aggregated |
| *Sprostoniella* sp. | 1.13 | aggregated |
| *Aponurus laguncula* | 11.74 | aggregated |
| *Multitestis* sp1. | 22.73 | aggregated |
| *Multitestis* sp2. | 60.71 | aggregated |
| Unidentified larvae | 1.52 | aggregated |
| *Caligus haemulonis* | 3.57 | aggregated |
| *Lernanthropus pupa* | 6.56 | aggregated |
| *Cymothoa exigua* | 1.63 | aggregated |

## Discussion

We detected some patterns in the structure and composition of the community of metazoan parasites of *P. panamensis* from Peru: (1) endoparasites dominance; (2) absence of correlation for the majority of parasites with regards to parasite species abundance at the infracommunity level, and no relationship between parasite abundance and the size or sex of the host; (3) low number of parasite interspecific relationships.

With the exception of the monogenean *P. chaetodipteri* (Chero *et al.* 2015, Luque *et al.* 2016) and the isopod *C. exigua* (Ramos *et al.* 1994, Salgado *et al.* 2015), the rest of the parasites are new records for Peru. The parasite community of *P. panamensis* showed endoparasite dominance, and this was in disagreement with results previously report by Cezar & Luque (1999) in a quantitative study of ephippid fishes from the coastal Atlantic zone of the state of Rio de Janeiro, where ectoparasites where the dominant parasites. In this study the digenean *A. laguncula* was the most prevalent and abundant species. The dominance of endoparasites has been described for several parasite communities of marine fishes from the coastal zone of Peru (Iannacone *et al*. 2011, Cruces *et al*. 2014, 2015, Ñacari & Sanchez 2014, Iannacone *et al.* 2015, Tarmeño *et al.* 2015, Chero *et al.* 2016). *Aponurus laguncula* is a “complex of cryptic species” and is a cosmopolitan and euryxenic helminth parasitizing at least 60 Osteichthyes species of 27 families across eight taxonomic orders (Bray & Mackenzie 1990, Braicovich *et al.* 2009, Carreras-Aubets *et al.* 2011, Carballo *et al.* 2011).

**Table IV.** Concurrent species pairs of ectoparasites and endoparasites in *Parapsettus panamensis* from Puerto Pizarro, Tumbes, Peru. $\chi^2$ = Chi-square test. $r_s$ = Values of Spearman’s rank correlation coefficient. *p* = Significant level. *significant values.

| Parasite | $\chi^2$ | *P* | $r_s$ | *p* |
|---|---|---|---|---|
| **Ectoparasites** | | | | |
| *Sprostoniella* sp. – *Parancylodiscoides chaetodipteri* | 3.93 | 0.04* | 0.25 | 0.06 |
| *Sprostoniella* sp. – *Cymothoa exigua* | 0.06 | 0.79 | 0.05 | 0.70 |
| *Sprostoniella* sp. – *Lernanthropus pupa* | 0.89 | 0.34 | 0.10 | 0.45 |
| *Sprostoniella* sp. – *Caligus haemulonis* | 0.06 | 0.80 | 0.02 | 0.87 |
| *P. chaetodipteri* – C. *exigua* | 0.09 | 0.75 | -0.05 | 0.71 |
| *P. chaetodipteri* – *L. pupa* | 0.27 | 0.60 | 0.12 | 0.36 |
| *P. chaetodipteri* – *C. haemulonis* | 2.53 | 0.11 | -0.22 | 0.09 |
| *C. exigua* – *L. pupa* | 0.70 | 0.40 | -0.18 | 0.18 |
| *C. exigua* – *C. haemulonis* | 0.08 | 0.76 | 0.06 | 0.65 |
| *L. pupa* – *C. haemulonis* | 0.56 | 0.45 | -0.11 | 0.40 |
| **Endoparasites** | | | | |
| *Aponurus lagungula* – *Multitestis* sp1. | 1.61 | 0.20 | 0.24 | 0.07 |
| *A. lagungula* – *Multitestis* sp2. | 0.001 | 0.98 | 0.21 | 0.10 |
| *Multitestis* sp1. – *Multitestis* sp2. | 16.98 | 0.00* | 0.53 | 0.00* |

Recently *A. laguncula* has been registered in fishes from Africa (Châari *et al.* 2015), America (Fernandes *et al.* 2009, Cárdenas *et al.* 2011, Gonçalves & Alves 2012) and Asia (Al-Zubaidy & Mhaisen 2014), but with less prevalence of infection than found in this research.

**Table 5.** Summary of main results of the non-parametrical permutational ANOVA (PERMANOVA) relating abundances of parasite species of *Parapsettus panamensis* and length and sex.

| Source | SS | MS | Pseudo F | P (perm) |
|---|---|---|---|---|
| Length | 9.74 | 9.19 | 1.61 | 0.10 |
| Groups | | | t | |
| 12-13 cm x 13-14cm | | | 0.74 | 1 |
| 12-13 cm x 14-15.5cm | | | 1.54 | 0.17 |
| 13-14 cm x 14-15.5cm | | | 1.53 | 0.15 |
| Sex | 9.78 | 9.63 | 0.82 | 0.53 |
| Groups | | | t | |
| Males x females | | | 0.91 | 0.52 |

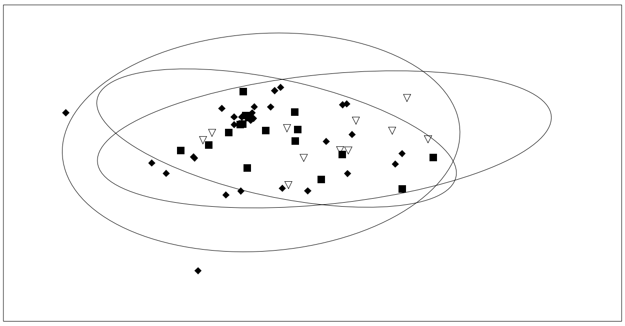

**Figure 1**. Non-metric multidimensional scaling (NMDS) plots results of all lengths (1, 12.0 cm -13.0 cm. 2, 13.0 cm – 14.0 cm. 3, 14.0 cm -15.5 cm) in terms of their parasitic abundance. Bray Curtis similarity. 2D Stress = 0.17. 1 =■. 2 =♦. 3 = Δ.

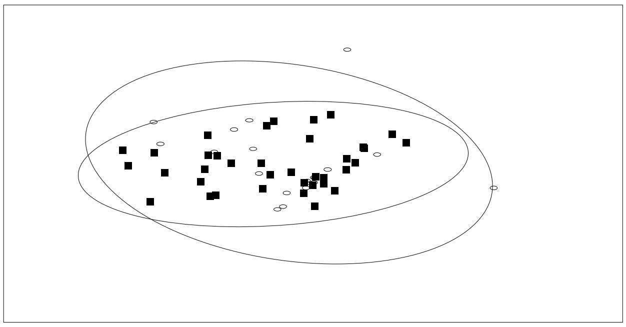

**Figure 2**. Non-metric multidimensional scaling (NMDS) plots results of sex (1, males. 2, females) in terms of their parasitic abundance. Bray Curtis similarity. 2D Stress = 0.17. 1= ■. 2= ○.

According to Alves & Luque (2001) feeding habits and broad diet spectrum of demersal fishes might increase the presence of endoparasites in these fishes. Studies regarding *P. panamensis* feeding habits showed that this fish has a varied diet, which is predominantly composed of some species of sponge, arthropods and mollusks (Smith-Vaniz *et al.* 2010). The varied diet of *P. panamensis* may give this species a huge potential to act as intermediate or definitive host in trophically transmitted parasitic systems. A large part of their diet (mainly arthropods and mollusks) can act as intermediate host in the life cycle of some sea fish's helminth endoparasites.

Helminth larval stages infecting *P. panamensis* may possibly be an intermediate life stage of this parasite as this fish may be part of the diet of marine mammals, which are the definitive hosts of anisakids. This characteristic was also observed in other parasite communities of demersal marine fishes from Peru (Iannacone *et al.* 2011, Chero *et al.* 2014a, Cruces *et al.* 2015; Tarmeño *et al.* 2015). The larvae of *Anisakis* sp. were found only on the mesenteries of *P. panamensis*, which apparently reduces the zoonotic potential (Cordeiro & Luque 2004).

A study made by Cezar & Luque (1999) recorded parasites from a sample of 110 specimens of *C. faber* from Brazil, and gave information on the prevalence of 11 metazoan parasites. The parasite fauna described by Cezar & Luque (1999) showed similarity with monogenean species but differences in some copepod and digenean species. Nematodes and isopods were not recorded by Cezar & Luque (1999). Another important change was the presence of larval stages of helminths that were absent in the study performed by Cezar & Luque (1999). Also, prevalence values detected in the present work were higher than those determined by Cezar & Luque (1999), which may have been influenced by fish host ecology, metazoan parasite specificity, biogeographic, hydrological conditions (mainly water temperature and salinity) or environmental and ecological conditions of the marine region (Moreira *et al.* 2015).

The parasite community of *P. panamensis* had a typically aggregated pattern of distribution. According to Von Zuben (1997) there are three factors that can lead to an aggregated pattern of distribution: (1) heterogeneity in host susceptibility to infection; (2) direct reproduction of the parasite within the host and (3) heterogeneity in the ability of the host to eliminate the parasites with immune or other response. This aggregated distribution pattern is typical for parasitic fauna of marine fish from the Peruvian coast (Iannacone *et al*. 2011, Chero *et al*. 2014a,b, Amarante *et al*. 2015).

Only the digeneans *A. laguncula* and *Multitestis* sp1 showed a positive correlation between the host'ss total length and abundance. The host's total length was not correlated with the prevalence of any other species. There are different factors such as breadth of diet, body mass and school formation that may be responsible for the number of parasite species harbored by a fish host, but generalizations should be avoided (Moreira *et al.* 2015).

Bilecenoglu & Kaya (2006) indicated that Lepocreadiidae (Digenea) is the most commonly reported family in Ephippidae, and *Multitestis* sp1. and *Multitestis* sp2. are members of this family. Species of this genus *Multitestis magnacetabulum* Mamaev, 1970 and *M. pyriformis* Manter, 1963 have been described from *Platax teira* (Forsskål, 1775) (Ephippidae) (Bray *et al*. 2010, Bray & Justine 2012).

Kn had a negative correlation with the abundance of *A. lagungula* and positive correlation with *C. haemulonis*. This fact suggested that only one species of parasite; *C. haemulonis* might alter fish welfare and may have had an impact on their host, because an increase of abundance of *C. haemulonis* correlated with low in Kn values (Kn <1.0). The level of infection by this copepod parasite (*C. haemulonis*) was moderate. Kn also depends on food availability, feeding ratio, gonadal development and stress (Tancredo *et al.* 2015). Further studies should be undertaken on *A. laguncula* because the positive correlation between the abundance of this digenean species and Kn values was surprising. The rest of parasite species appeared to be uncorrelated to fish host health, represented by Kn, and therefore probably these parasites have a low pathogenicity for the host (Minaya *et al.* 2016).

Two pairs of positively associated species were detected and this is in agreement with the data obtained from other marine fishes, where a low number of associated parasite species is a common pattern (Rohde *et al.* 1995). The monogeneans pair, *Sprostoniella* sp. – *P. chaetodipteri*, showed positive association, which may be an indication of occurrence of the infective stages of both species in the same habitat (Rohde *et al.* 1995). On the other hand, the positive association between the digeneans, *Multitestis* sp1. and *Multitestis* sp2., showed that possibly the intermediate host is the same for both species (Cesar & Luque 1999). However, these data on quantitative associations between parasite species should be used with caution to explain the parasite community structure. According to Poulin (2001), interspecific relationships can only be considered valid when tested under experimental conditions.

High homogeneity among metazoan parasites infracommunities of *P. panamensis* was observed. The parasites communities generally did not exhibit clear differences in abundance in relation to length and sex of *P. panamensis*. Lack of differences in local environmental characteristics during the period of evaluation, a limited spatial dispersal of their intermediate hosts and the free living stages of the parasites in the area, and also the narrow length ranges of the host between 12.0 and 15.5 cm could explain the low heterogeneity in parasites communities of the hosts (Míguez-Lozano *et al.* 2012). Of 11 parasites registered only the abundance of one species, *Multitestis* sp1. was influenced by the sex of the host.

The parasite community of *P. panamensis* from Peru can be defined as a complex of species with high prevalence and abundance with few interspecific associations. This situation is in concordance with that observed by Cesar & Luque (1999) in relation to marine spadefish fish species.

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