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Community of metazoan parasites of the cockfish *Callorhinchus callorynchus* (Linnaeus, 1758) (Chimaeriformes: Callorhinchidae) from artisanal fishing in Pisco, Ica, Peru

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Abstract: There is an extensive lack of information on the parasitic fauna accompanying cartilaginous fish in Peru. The objective of this work was to identify the community of parasite metazoans of the cockfish *Callorhinchus callorynchus* (Linnaeus, 1758) (Chimaeriformes: Callorhinchidae) from artisanal fishing in San Andrés, Pisco, Ica, Peru. Thirty-one specimens of *C. callorynchus* were collected between June 2018 and October 2019. Following necropsy, six species of parasites were obtained: *Gyrocotyle rugosa* Diesing, 1850 (Cestoda), *Callorhynchocotyle callorhynchi* (Manter, 1955) (Monogenea), *Callorhynchicola branchialis* Brinkmann, 1952 (Monogenea), *Branchellion lobata* Moore, 1952 (Hirudinea), *Prokroyeria meridionalis* (Ramírez, 1975) (Copepoda) and an unidentified species of the Anisakidae family (Nematoda). The *G. rugosa* tapeworm was the most prevalent parasite (77.42%), followed by the monogenean *Cle. callorhynchi* (54.84%) and finally the copepod *P. meridionalis* (16.13%). The total body length and sex of *Ca. callorynchus* showed no association with respect to the parasitological indices of prevalence, intensity, and mean abundance. *Cle. callorhynchi* and *Cla. branchialis* were registered for the second time in the same host, but for the first time in the department of Ica. However, the present study constitutes the first geographic record of *G. rugosa*, *B. lobata*, and *P. meridionalis*, and a new host for an unidentified species of the Anisakidae family in cockfish in Peru.

Key words: elephant fish, Holocephalans, ichthyoparasitology, parasitic fauna

Resumen: Comunidad de metazoos parásitos del pejegallo *Callorhinchus callorynchus* (Linnaeus, 1758) (Chimaeriformes: Callorhinchidae) procedentes de la pesca artesanal en Pisco, Ica, Perú. En el Perú, en los peces cartilaginosos aún hay un extenso vacío de información sobre su fauna parasitaria acompañante. El objetivo de este trabajo fue determinar la comunidad de metazoos parásitos del pejegallo *Callorhinchus callorynchus* (Linnaeus, 1758) (Chimaeriformes: Callorhinchidae) procedentes de la pesca artesanal en San Andrés, Pisco, Ica, Perú. Se colectaron 31 especímenes de *C. callorynchus* entre junio del 2018 y octubre del 2019. Tras realizar la necropsia se obtuvieron seis especies de parásitos: *Gyrocotyle rugosa* Diesing, 1850 (Cestoda), *Callorhynchocotyle callorhynchi* (Manter, 1955) (Monogenea), *Callorhynchicola branchialis* Brinkmann, 1952 (Monogenea), *Branchellion lobata* Moore, 1952 (Hirudinea), *Prokroyeria meridionalis* (Ramírez, 1975) (Copepoda) y una especie no identificada de la familia Anisakidae (Nematoda). El céstodo *G. rugosa,* fue el parásito de mayor prevalencia (77,42%), seguido por el monogeneo *Cle. callorhynchi* (54,84%) y finalmente el copépodo *P. meridionalis* (16,13%). La longitud total corporal y el sexo de *Ca. callorynchus* no mostraron ninguna asociación con respecto a los índices parasitológicos de prevalencia, intensidad y abundancia media. Se registra por segunda vez a *Cle. callorhynchi* y *Cla. branchialis* en el mismo hospedero, pero por primera vez en el departamento de Ica. El presente estudio constituye el primer registro geográfico para el Perú de *G. rugosa*, *B. lobata*, *P. meridionalis* y un nuevo registro de hospedero para una especie no identificada de la familia Anisakidae en el pejegallo.

Palabras claves: fauna parasitaria, Holocefalo, ictioparasitología, pez elefante

INTRODUCTION

The number of studies on parasitic metazoan communities and estimation of the relative biodiversity of parasites to the search relationships parasite-host in marine bony fishes in Peru have increased in recent years (Céspedes-Chombo *et al*., 2017; Chero *et al*., 2019; Ferré-Alcántara *et al*., 2019; Londoñe-Bailón *et al*., 2020; Minaya *et al*., 2020a,b). Currently, there is a remarkable relevance in studies on the biodiversity of the parasitic fauna because they are important for maintaining the balance in the ecosystem by regulating the density and abundance of their hosts, structuring food chains (Poulin *et al*., 2016). Unfortunately, the same cannot be said for parasitological studies in elasmobranch fish, being one of the least studied lines of research within ichthyoparasitology in Peru, despite being a country with a wide diversity of cartilaginous fish (Cornejo *et al*., 2015).

Among the 1,188 species of cartilaginous fish worldwide, holocephali or chimera fish constitute 49 species (Carrier *et al*., 2004; Weigmann, 2016). In the last five years, multiple aspects of parasitology in holocephalan fishes have been studied worldwide, including studies on the structure of the parasite community as a tool to predict the population structure of its host, the discovery of new parasite species by molecular and morphological analysis, parasite-host phylogenetic relationships and the lack of geographic patterns in the distribution of their species, and their utility as bioindicators of heavy metal contamination, among others (Morris *et al*., 2016; Derouiche *et al*., 2019; Morris *et al*., 2019; Bray *et al*., 2020; Barčák *et al*., 2021).

The cockfish *Callorhinchus callorynchus* (Linnaeus, 1758) (Chimaeriformes: Callorhinchidae) belongs to the group of cartilaginous fish and is representative of the holocephalans associated with the marine coasts. It is distributed only in the southern hemisphere, being found on the Southeast Pacific side, from northern Peru including the coast of Ecuador, to the Strait of Magellan. On the Atlantic side, it is distributed along the coast of Brazil, Uruguay, and Argentina, up to the Beagle Channel. *Ca. callorynchus* is a demersal marine fish, with a depth range of 10 to 116 m. It is usually found in sandy and muddy substrates; it is oviparous and according to the International Union for Conservation of Nature its conservation status is vulnerable. It is caught as bycatch and is consumed by the local population on the marine coasts of South America (Chirichigno & Cornejo, 2001; Cousseau & Perrotta, 2000; López *et al*., 2000; Swing & Beárez, 2006; Bernasconi *et al*., 2015; Weigmann, 2016; Finucci & Cuevas, 2020; Froese & Pauly, 2021).

This species is economically important in the artisanal fishery of the town of San Andrés, Pisco, Ica, because its commercialization and human consumption is almost constant, despite being caught as bycatch. It is consumed in the form of ceviche, fish stew, and fried. Considering the commercialization of this species, there is a need to investigate the parasitology of cockfish from an ecological aspect, seeing the diversity of species of parasites described in this host in studies carried out in Peru compared to other countries such as Chile and Argentina (Luque & Iannacone, 1991; Di Giácomo & Perier, 1994; Tantaleán & Huiza, 1994; Di Giácomo & Perier, 1996; Aedo *et al*., 2010; Luque *et al*., 2016; Martínez *et al*., 2016; Carvalho-Azevedo *et al*., 2021).

Therefore, the present study aimed to determine the characteristics of the community of parasite metazoans of the cockfish *Ca. callorynchus* from the artisanal fishing landing of San Andrés, Pisco, Ica, Peru, and evaluate the ecological aspects of the host-parasite and observe possible interactions among these characteristics.

MATERIALS AND METHODS

Collection and execution place. Thirty-one specimens of *Ca. callorynchus* were obtained from Lagunillas (Paracas Bay) and Laguna Grande (Independencia Bay) through the artisanal fishing landing of San Andrés, Province of Pisco, Department of Ica (13°44’01” S; 76°13’30” W), Peru from June 2018 to October 2019. The fish were frozen and transported to the laboratory in Lima, Peru.

Collection of parasites. The skin, oral cavity, gills, stomach, heart, spiral valve, liver, gonads, and spleen of the collected fish were thoroughly examined. The parasitic metazoans collected were fixed in 4% formaldehyde and conserved in 70% ethanol alcohol. For identification, the parasitic metazoans were stained with Semichon acetic carmine, dehydrated in a consecutive battery of ascending concentrations of ethanol (70%, 80%, 90% and 100%), diaphanized in eugenol and finally mounted on permanent preparations with Canada balsam (Almeida & Almeida, 2014). The copepods were preserved with alcohol-formaldehyde-acetic acid for later observation of the structures of taxonomic importance (Eiras *et al*., 2006). The hirudineans were fixed in 70% ethyl alcohol. Nematodes and copepods were rinsed with Amann's lactophenol and preserved in 70% ethyl alcohol. A Euromex®-SB.1903 trinocular stereoscope was used for the observations.

Classification and determination of parasites. The identification of cestodes, monogeneans, copepods, and hirudineans parasites was based on specialized publications (Szidat, 1972; Castro & Baeza, 1984; Fernández *et al*., 1986; Deets, 1987; Boeger & Kritsky, 1989; Beverly-Burton *et al*., 1993; Oceguera-Figueroa & Pacheco-Chaves, 2012; Vaughan & Christison, 2012; Poddubnaya *et al*., 2015; Luque *et al*., 2016; Caira & Jensen, 2017; Ruiz-Escobar & Oceguera-Figueroa, 2019).

Data processing and statistical analysis. The ecological parasitological indices of prevalence (P), mean abundance (MA), and mean intensity (MI) were estimated (Bush *et al*., 1997; Bautista-Hernández *et al*., 2015). The specific importance index (I) calculated as the importance of each parasitic species in the ecological assembly was used. I = Prevalence + (mean abundance [numerical or volumetric] x 100) in order to obtain an integrated infection index for both ecological descriptors (Iannacone *et al*., 2012). The type of strategy of each parasitic species was evaluated according to the percentage of P%. Species with a prevalence higher than 45% were classified as "core" species, while those with a prevalence between 10% - 45% were defined as "secondary" species, and species with a prevalence lower than 10% were classified as "satellite" species (Bush & Holmes, 1986).

The following indices were used: dispersion index (dI), Poulin discrepancy index (PDI) and K of the negative binomial equation with its respective Chi square value (X^2) to determine the type of distribution and degree of aggregation (Bego & Von Zuben, 2010). The Pearson correlation coefficient (r) was used to determine the relationship of the total body length (TBL) of the host fish with the MA and MI of each parasitic species. The Spearman correlation coefficient (r_s) was applied to evaluate the association between TBL versus the prevalence of infestation, previously transforming the P% values to square root of arcsine. In all cases, the normality of the data was verified using the Kolmogorov-Smirnov test with the modification of Lillierfors and the homoscedasticity of variances based on the Levene test (Zar, 2014). The Student's t test was used to compare the MA and MI of each parasite and the sex of the host. The analysis of parasites in relation to TBL and host sex was performed only for species with a prevalence greater than 10% (Esch *et al*., 1990). 2 x 2 contingency tables were used to calculate the degree of association between the sex of the host and P% of each parasite by means of X^2. Yates' correction was used to correct for possible X^2 errors with respect to the P% of parasites. For the determination of the descriptive and inferential statistics, a p value of 0.05 was considered significant.

The following alpha dI were calculated: richness: species richness and Margalef, and the richness estimator: Chao-1; equity: Shannon-Wiener and Equitability; and dominance: Berger-Parker (Bego & Von Zuben, 2010) for the total parasitic community component, and for males and females. A dendrogram with the Ward method and Euclidean index was constructed to compare the similarity between the parasites of the 31 specimens of *Ca. callorynchus* studied. For the determination of the dI, the statistical package PAST-Palaeontological Statistics ver.4.09 was used, and for the descriptive and inferential statistics the statistical package Quantitative Parasitology 3.0 was used (Reiczigel *et al*., 2019).

Finally, the representative specimens of the metazoan parasite species collected were deposited in the collection of parasitic helminths and related invertebrates belonging to the Zoological Collection of the Natural History Museum of the Universidad Nacional Federico Villarreal (UNFV) under the codes: MUFV: ZOO-HPIA: 177 - 182.

RESULTS

The *Callorhinchus callorynchus* population consisted of 31 specimens distributed in 13 females (TBL = 64.12 ± 12.85 cm) and 18 males (TBL = 55.70 ± 9.30 cm). The female population had a larger TBL than the males ($t = 2.02$, $p < 0.05$). At least one parasite specimen was found in 90.32% (n = 28) of the fish. A total of 263 specimens belonging to 6 parasites species were found and identified (Table 1).

The three parasites with the highest prevalence of infestation and which had a P%> 10% were *Gyrocotyle rugosa* Diesing, 1850 (Cestoda), followed by *Callorhynchocotyle callorhynchi* (Manter, 1955) (Monogenea) and *Prokroyeria meridionalis* (Ramírez, 1975) (Copepoda). Similarly, the parasites with the highest MA and MI of in-

Table 1. Ecological parameters of the parasite metazoans of the cockfish *Callorhinchus callorynchus* from the artisanal fisheries of San Andrés, Pisco, Peru.

Parasites	Voucher code	Site of infection	P %	MA ± SE	MI ± SE	PDI	K	Strategy type
CESTODA								
Gyrocotyle rugosa	HPIA 177	spiral valve	77.42	1.26 ± 0.15	1.63 ± 0.17	0.32	NA*	Core
MONOGENEA								
Callorhynchocotyle callorhynchi	HPIA 178	Gills	54.84	6.68 ± 0.32	12.18 ± 3.68	0.78	0.22	Core
Callorhynchicola branchialis	HPIA 179	back muscles	6.45	0.06 ± 0.44	1 ± 0.17	-	-	satellite
COPEPODA								
Prokroyeria meridionalis	HPIA 182	Gills	16.13	0.39 ± 0.18	2.4 ± 0.46	0.85	0.13	Secondary
HIRUDINEAN								
Branchellion lobata	HPIA 180	Anus	3.23	0.03 ± 0.18	1 ± 0.18	-	-	satellite
NEMATODA								
Anisakidae unidentified	HPIA 181	spiral valve	3.23	0.06 ± 0.06	2 ± 0.36	-	-	satellite

MA = mean abundance, PDI = Poulin's discrepancy index, MI = mean intensity, K = negative binomial, P% = Prevalence, SE = standard error. * Procedure did not converge.

festation were *Cle. callorhynchi*, followed by *G. rugosa* and *P. meridionalis*. Regarding the type of strategy, only *G. rugosa* and *Cle. callorhynchi* were considered as core species in the cockfish parasite community (Table 1). The PDI for *Cle. callorhynchi* and *P. meridionalis* showed values close to 1, and thus, the type of distribution was considered aggregate or contagious (Table 1).

The correlation coefficients of the most prevalent parasites (*G. rugosa*, *Cle. callorhynchi*, and *P. meridionalis*) showed no degree of association between the ecological variables of the parasites and the morphological aspects of the host (TBL and sex). There was also no significant association between the sex of *Ca. callorynchus* and the ecological variables. The Student's t test showed no differences between males and females of *Ca. callorynchus* (Table 2). Likewise, for *Cle. callorhynchi* the homogeneity of variances was not fulfilled, and therefore, the Mann Whitney U test was used.

According to the alpha dIs, higher values were observed in richness, number of individuals, and dominance (Berger-Parker) in the population of females compared to males. On the other hand, equitability and diversity (Shannon-Wiener) was biased in favor of the male population of *Ca. callorynchus*. The sampling effort was optimal, which was corroborated with the Chao-1 richness estimator (Table 3).

A dendrogram was constructed based on Ward method and the Euclidean index to determine the similarity of the *Ca. callorynchus* parasites. The most similar were Anisakidae gen. et sp. indet, *Callorhynchicola branchialis* Brinkmann, 1952 and *Branchellion lobata* Moore, 1952 based on the shortest distance presented. The monogeneous *Cle. callorhynchi*, the most abundant of all the parasites collected, presented a greater distance in the dendrogram in relation to the rest of the parasitic metazoans, followed by the cestode *G. rugosa* and the copepod *P. meridionalis* (Fig. 1).

Finally, in the bibliographic search for reports of parasites in *Ca. callorynchus*, it was found that 13 species of metazoan parasites and three indeterminate species had been described in this host from 1927 to the present study. All reports are restricted to the southeast of the Pacific (Peru and Chile) and southwest of the Atlantic of the South American continent (Brazil, Uruguay, and Argentina). The finding of the parasites *G. rugosa*, *B. lobata*, and *P. meridionalis* constitutes new geographical records in Peru. Likewise, the unidentified nematode appears as a new record in the host of the cockfish (Table 4).

DISCUSSION

In the present study, the community of metazoan parasites of *Callorhinchus callorynchus* was determined, thereby increasing the geo-

Table 2. Correlation of total body length and sex of *Callorhinchus callorynchus vs.* prevalence, mean abundance, and mean intensity of the most prevalent metazoan parasites.

		G. rugosa	*Cle. callorhynchi*	*P. meridionalis*
TBL *vs.* P%	r_s	0.52	0.67	0.46
	p	0.28	0.14	0.35
TBL *vs.* MA	*r*	-0.37	0.02	-0.27
	p	0.46	0.95	0.60
TBL *vs.* MI	*r*	0.37	0.58	0.15
	p	0.46	0.22	0.77
Sex *vs.* P%	X^2	3.23	0.41	0.01
	p	0.07	0.52	0.92
	Y	1.85	0.07	0.16
	p	0.17	0.78	0.68
Sex *vs.* MA	*F*	1.29	19.37	2.71
	p	0.26	0.00	0.11
	t	1.53	88.5*	0.69
	p	0.13	0.23	0.49
Sex *vs.* MI	*F*	0.00	12.16	1.83
	p	1.00	0.00	0.26
	t	0.00	21.0*	1.95
	p	1.00	0.15	0.14

F = Levene's test, *p* = significance, r = Pearson, r_s = Spearman, *t* = Student's test, X^2 = Chi square, *Y* = Yates's test. TBL = total body length, P = prevalence, MA = mean abundance, MI = mean intensity

Table 3. Parasitic alpha diversity indices according to community component and sex of *Callorhinchus callorynchus* from artisanal fishing in San Andrés, Pisco, Ica, Peru.

Indices	Total	Males	Females
Richness	6	4	5
Individuals	263	62	201
Shannon-Wiener	0.70	1.03	0.47
Equitability	0.40	0.74	0.29
Berger-Parker	0.78	0.46	0.88
Margalef	0.89	0.72	0.75
Chao-1	6	4	5

graphic distribution of some parasites and range of hosts for others. It is known that the vast majority of these parasites are primitive organisms in their lineages, they infest almost exclusively chimeras and have established a co-evolutionary dependence with their hosts (Caira *et al.*, 2012).

Previous records have shown that chimeras are usually parasitized by cestodes of the Gyrocotylidae family in the spiral valve, a site that is specific for this helminth (Alves *et al.*, 2017). The genus *Gyrocotyle* Diesing, 1850 is indicated as a parasitic cestodaria restricted only to holocephalan fishes of the genus *Callorhinchus* (Bray *et al.*, 2020; Barčák *et al.*, 2021). *Gyrocotyle* is a group reduced to 10 valid species (Barčák *et al.*, 2021; WoRMS, 2021). In Peru, only *Gyrocotyle maxima* MacDonagh, 1927 was registered parasitizing *Ca. callorynchus* from Lima and La Libertad (Luque *et al.*, 2016). The present study constitutes the first record of *G. rugosa* from Peru. This species has been previously recorded on the marine coasts of Argentina, Chile, South Africa, and New Zealand (Reed, 2015; Barčák *et al.*, 2021).

According to parasitological parameters, the parasite with the highest prevalence was *Gyrocotyle rugosa* (P% = 77.4%), making it an important and core species in the communi-

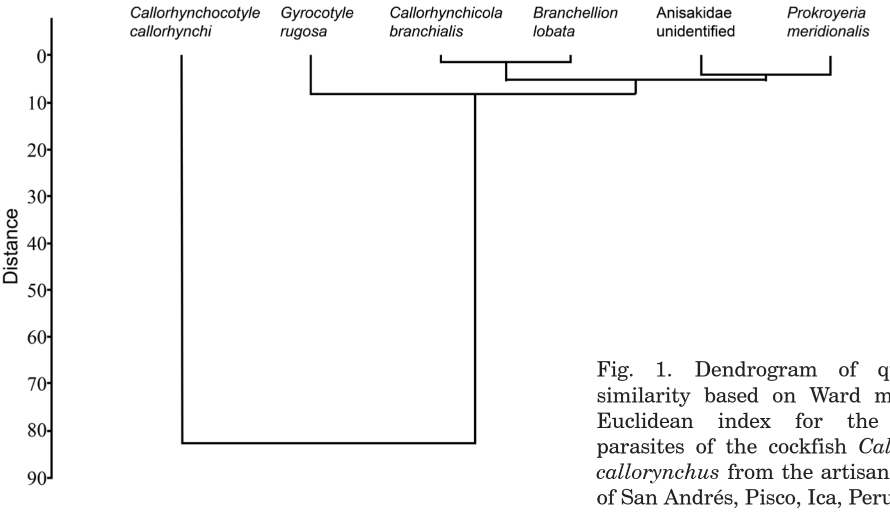

Fig. 1. Dendrogram of quantitative similarity based on Ward method and Euclidean index for the metazoan parasites of the cockfish *Callorhinchus callorynchus* from the artisanal fisheries of San Andrés, Pisco, Ica, Peru.

ty of parasites in *Ca. callorynchus*. A P% value of 71.43% has been reported for *G. rugosa* (Synonym of *G. plana*) in *C. capensis* from South Africa (Morris *et al*., 2019). In the present study, no more than one *Gyrocotyle* species was found in the studied host. It has been argued that most of the cockfish studied are parasitized by one or two specimens per fish and by a single (rarely two) *Gyrocotyle* species, which is why they are considered oioxenic parasites (Barčák *et al*., 2021).

It is suggested that *Ca. callorynchus* is infected with the *G. rugosa* cestode because of its benthic diet mainly based on bivalves, brachyurans, gastropods, isopods, and anomurans (Roman *et al*., 2020), which are invertebrates that have previously been reported as intermediate hosts of several species of helminths. *Gyrocotyle* seems to remain within the digestive tract of its hosts for a long time and possibly throughout the life of the holocephalans, which could explain why the *Gyrocotyle* species were the most prevalent in south american *Ca. callorynchus* as well as those studied in South Africa (Halvorsen & Williams, 1968; Williams *et al*., 1987).

Although *G. rugosa* is a species with a high P%, the degree of aggregation was the lowest among the most prevalent parasites, probably due to the low number of parasitic individuals per fish. Nonetheless, the distribution of this parasite encompassed the majority of holocephalans evaluated.

On the other hand, the monogenean *Callorhynchocotyle callorhynchi* presented the highest value of MA and MI in fish from Peru (MA = 6.68; MI = 12.18) which was also similar in *C. capensis* from South Africa (MA = 1.55; MI = 4.79) (Morris *et al.,* 2019). This is due to the greater number of specimens per host, which varied from 1 to 61 individuals of *Cle. callorhynchi* for each cockfish. It is known that the MI index is higher when a population of parasites is high in a small group of hosts, which is why it is argued that the species *Cle. callorhynchi* is characterized by presenting this high value in the host populations.

Many studies on cockfish carried out in Peru have registered the monogeneans *Callorhynchocotyle marplatensis* Suriano & Incorvaia, 1982 (Luque & Iannacone, 1991; Tantaleán & Huiza, 1994), *Cla. branchialis* (Martínez *et al*., 2016), and *Cle. callorhynchi* (Carvalho-Azevedo *et al*., 2021) in the gills of cockfish, all from the town of Chorrillos, Lima. In this study, *Cle. callorhynchi* and *Cla. branchialis* were registered for the second time in the same host but were registered for the first time in the department of Ica. In the mentioned surveys, both species of monogenean were evaluated qualitatively and descriptively, and therefore, this is the first determination of the quantitative nature of this population of parasites in Peru.

The third species considered important in this community of parasites was the population of *Prokroyeria meridionalis*, which had a secondary category due to the prevalence presented (P% = 16.13%). This host-parasite association has been previously described in Argentina and Chile and now for the first time in Peru (Ramírez, 1975; Castro & Baeza, 1984; Fernández *et al*., 1986; Deets, 1987; Castro-Romero *et al*., 2016). The

Table 4. Summary of historical reports of parasites in *Callorhinchus callorynchus* in South America.

Parasites	**Localization**	**Country**	**Bibliographic references**
HIRUDINEA			
Branchellion callorhynchus	Body surface	Chile	Ringuelet (1985), Fernández *et al.* (1986)
Branchellion lobata	Anus	Chile	Ringuelet (1985)
		Perú*	Present study (2022)
Branchellion sp.	Body surface	Chile	Szidat (1972)
MONOGENEA			
Callorhynchicola branchialis	Bills	Chile	Fernández *et al.* (1986)
	Facial muscles	Uruguay	Beverley-Burton *et al.* (1993)
	Gills	Perú	Martínez *et al.* (2016)
	Back muscles	Perú	Present study (2022)
Callorhynchocotyle callorhynchi	Gills	Chile	Fernández *et al.* (1986)
		Argentina	Kuznetsova (1975)
		Perú	Carvalho-Azevedo *et al.* (2021)
		Perú	Present study (2022)
Callorhynchocotyle marplatensis	Gills	Argentina	Boeger & Kritsky (1989)
		Perú	Luque & Iannacone (1991)
		Perú	Tantaleán & Huiza (1994)
		Uruguay	Boeger & Kritsky (1989)
Callorhynchicola multitesticulatus	Gills	Argentina	Kuznetsova (1975)
CESTODA			
Gyrocotyle rugosa	Spiral valve	Argentina	MacDonagh (1927), Alves *et al.* (2017)
		Chile	Fernández *et al.* (1986)
		Perú*	Present study (2022)
Gyrocotyle maxima	Spiral valve	Brasil	Rego *et al.* (1974), Alves *et al.* (2017)
		Chile	Fernández *et al.* (1986), Alves *et al.* (2017)
		Perú	Tantaleán (1991), Tantaleán & Huiza (1994), Alves *et al.* (2017)
		Uruguay	Szidat (1968)
ASPIDOGASTREA			
Multicalyx elegans	----	Chile	Fernández *et al.* (1986)
Rugogaster callorhinchi	Rectal gland	Brasil	Amato & Pereira (1995)
Rugogaster hydrolagi	Rectal gland	Brasil	Amato & Pereira (1995)
COPEPODA			
Prokroyeria meridionalis	Gills	Chile	Castro & Baeza (1984)
		Chile	Fernández *et al.* (1986)
		Perú*	Present study (2022)
Caligus teres	Body surface	Chile	Fagetti & Stuardo (1961)
		Chile	Fernández *et al.* (1986)
ISOPODA			
Ceratothoa sp.	Oral cavity or body surface	Chile	Fernández *et al.* (1986)
NEMATODA			
Anisakidae unidentified	Spiral valve	Perú	Present study (2022) **

* New geographic records for Peru. ** New host record *Callorhinchus callorynchus*.

MI of infestation of this species was the second highest (MI = 2.4 ± 0.46) recorded in this study, similar to that observed in *G. rugosa*. Likewise, it was the species with the highest degree of aggregation (DOA = 0.85).

Branchellion Savigny, 1822 is a genus that includes blood-sucking leeches of strictly marine hosts, with a preference for batoid fish to which they adhere to the surface and / or body orifices (Rohde, 2005; Caira *et al*., 2012). In the Eastern Pacific, the species *B. lobata* and *B. callorhynchus* Szidat, 1972, both in Chile, are qualitatively reported (Szidat, 1972; Ringuelet, 1985; Fernández *et al*., 1986). In the present study, only one individual of *B. lobata* was found in the anal orifice of a cockfish, making it difficult to determine the behavior of this species in *Ca. callorynchus*.

In our study, no correlation was observed between the TBL of the fish and the P%, MA, and MI of the parasites *Gyrocotyle rugosa*, *Cle. callorhynchi*, and *Prokroyeria meridionalis*. In contrast, Morris *et al*. (2019) found a correlation between the abundance of *Cle. callorhynchi* and the TBL and weight of *C. capensis*. Additionally, these same authors found a significant positive relationship between the weight of *C. capensis* and the abundance of *G. rugosa*. The findings of Morris *et al*. (2019) suggest that smaller fish contain a lower abundance of parasites compared to larger fish. This idea is reinforced by Poulin (2011) who indicated that the largest hosts can provide a greater supply of nutrients to the parasites and, consequently, they would be the most susceptible to a greater parasite diversity and load. In our case, the lack of association between the parameters evaluated indicates that other factors may influence the population dynamics of the parasites, such as host infection at an early age. Halvorsen & Williams (1968) speculated that *Gyrocotyle* infections begin when young hosts begin to feed, which was also observed in this study as fish with a shorter total length (33.1 cm) presented a moderately elevated parasitic infection indicating that the infection begins in the early stages of life.

According to the alpha dIs, the Berger Parker dominance index showed low values of parasites found in male fish and high values in females (0.46 and 0.88, respectively) and consequently, a greater diversity in the population of males. Iannacone *et al*. (2012) argue that the selection of parasites by either sex of the host fish could be attributed to differences in the ecological relationships (habitat, behavior, and feeding) of males and females (Minaya *et al*., 2020c). Regarding the Chao-1 richness estimator, the number of parasitic species present in the sampled *Ca. callorhynchus*, in both males and females and the total population (males + females) showed a richness similar to that estimated by this index. Therefore, the sampling effort was optimal for the 31 specimens collected.

Addressing the historical aspects in the parasitological studies in *Ca. callorynchus*, Fernández *et al*. (1986) found the largest number of species in a single population of cockfish from central-southern Chile to date, describing nine species of parasites (Table 4). Of these, six corresponded to phylogenetic type parasites conditioned by historical and zoogeographic factors: *Cla. branchialis*, *Cle. callorhynchi*, *Multicalyx elegans* (Olsson, 1869), *G. rugosa*, *G. maxima*, and *P. meridionalis*. The other three species corresponded to ecologically-acquired parasites: *Branchellion callorhynchus*, *Caligus teres* Wilson, 1905 and *Ceratothoa* sp.

CONCLUSION

The three parasites with the highest prevalence of infestation were *Gyrocotyle rugosa* (Cestoda), followed by *Callorhynchocotyle callorhynchi* (Monogenea) and *Prokroyeria meridionalis* (Copepoda). Similarly, the parasites with the highest MA and MI of infestation were *Cle. callorhynchi*, followed by *G. rugosa* and *P. meridionalis*. Regarding the type of strategy, only *G. rugosa* and *Cle. callorhynchi* were considered as core species in the cockfish parasite community. The sampling effort was optimal, which was corroborated with the Chao-1 richness estimator. This work provides the first extensive quantitative analysis of the parasitic community in the cockfish *Ca. callorynchus* in Peru, as well as three new geographic records for *G. rugosa*, *P. meridionalis*, and *B. lobata* in Peru and a new record for a host of a nematode infesting *Ca. callorynchus*.

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