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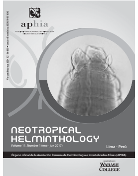

REVIEW ARTICLE/ ARTÍCULO DE REVISIÓN

COMPARISON OF BIODIVERSITY PARASITIC OF *PARALABRAX CLATHRATUS* (GIRARD, 1854) AND *P. HUMERALIS* (VALENCIENNES, 1828) (PISCES: SERRANIDAE) FROM THE EASTERN PACIFIC

COMPARACIÓN DE LA BIODIVERSIDAD PARASITARIA DE *PARALABRAX CLATHRATUS* (GIRARD, 1854) Y *P. HUMERALIS* (VALENCIENNES, 1828) (PISCES: SERRANIDAE) DEL PACÍFICO ORIENTAL

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ABSTRACT

Parasite biodiversity of the groupers *Paralabrax clathratus* (Girard, 1854) and *P. humeralis* (Valenciennes, 1828) (Pisces: Serranidae) from the eastern pacific, host specificity of the parasites and the role groupers play in the life cycle of the parasite is presented. The information is a compilation of records generated by various authors. It was found that the parasite biodiversity of both fish species is grouped into 22 families (helminths and crustaceans), two orders and one class. *Paralabrax humeralis* was infested with a richer diversity of parasites than *P. clathratus* (n=40 vs n=27): monogeneans (n=3 vs n=3), digeneans (n=10 vs n=10), tapeworms (n=6 vs n=1), acanthocephalans (n=2 vs n=1), nematodes (n=9 vs n=4), copepods (n=8 vs n=8), isopods (n=1 vs n=0) and hirudinea (n=1 vs n=0). Of this parasite richness, it was observed that hosts share ten families: Diclidophoridae and Capsalidae (Monogenea), Hemiuridae and Opecoelidae (Digenea), Polymorphidae (Acantocephala), Anisakidae and Cucullanidae (Nematoda), Caligidae, Bomolochidae and Hatschekiidae (Copepoda). Sörensen qualitative index that was used to compare the biodiversity of parasites at the family level and at the species level for *P. clathratus* and *P. humeralis* which showed a value of 57.14% and 11.94%, respectively. Despite this difference, a similar proportion of larvae and adult parasites were observed, as well as in the life cycle types and at the site of infection (ectoparasites and endoparasites) between both species of *Paralabrax*. On the other hand, parasites showing some host specificity towards groupers are copepods of family Hatschekiidae and tapeworms Trypanorhyncha that parasitize elasmobranches fish in adult stage. The remaining parasites are considered generalists. Tapeworms, acanthocephalans and anisakid are registered in the larval stages indicating that *Paralabrax* use paratenic as intermediate hosts in their life cycles. Monogeneans, copepods and digeneans were adult forms suggesting that *P. clathratus* and *P. humeralis* are the definitive hosts. The observed differences in parasite richness of the hosts may be due to specific environmental conditions, the presence of different intermediate hosts, the feeding behavior of the host and host specificity.

Keywords: crustaceans – host specificity – helminths – *Paralabrax clathratus* – *P. humeralis*

RESUMEN

Se presenta la biodiversidad parasitaria de *Paralabrax clathratus* (Girard, 1854) y *P. humeralis* (Valenciennes, 1828) (Pisces: Serranidae) del Pacífico Oriental, su especificidad hospedatoria y el papel que desempeñan en el ciclo de vida de los parásitos. La información es una compilación de los registros de diversos autores durante la revisión de los parásitos de los peces estudiados. Se encontró que la biodiversidad parasitaria de ambas especies de peces está agrupada en 22 familias (entre helmintos y crustáceos), dos órdenes y una clase. *Paralabrax humeralis* presenta mayor riqueza parasitaria que *P. clathratus* (n = 40 vs n = 27): monogeneos (n = 3 vs n = 3), digéneos (n = 10 vs n = 10), céstodos (n = 6 vs n = 1), acantocéfalos (n = 2 vs n = 1), nemátodos (n = 9 vs n = 4), copépodos (n = 8 vs n = 8), isópodos (n = 1 vs n = 0) e hirudineos (n = 1 vs n = 0). De esta riqueza parasitaria, se observó que los hospederos comparten diez familias: Diclidophoridae y Capsalidae (Monogenea), Opecoelidae y Hemiuridae (Digenea), Polymorphidae (Acantocephala), Anisakidae y Cucullanidae (Nematoda), Caligidae, Bomolochidae y Hatschekiidae (Copepoda). El índice de Sörensen cualitativo que sirvió para comparar la biodiversidad parasitaria a nivel de familia y de especie de *P. clathratus* y *P. humeralis* mostró un valor de 57,14% y de 11,94%, respectivamente. A pesar de esta diferencia, se observó una proporción similar de parásitos en los estadios larval y adulto, así como en los tipos de ciclos de vida y en el sitio de infección (ectoparásitos y endoparásitos) entre ambas especies de *Paralabrax*. Por otro lado, los parásitos que muestran cierta especificidad hospedatoria hacia serránidos son los copépodos de la familia Hatschekiidae y los céstodos del orden Trypanorhyncha que parasitan a peces elasmobranquios en estado adulto, el resto se consideran parásitos generalistas. Los céstodos, acantocéfalos y anisákidos registrados son formas larvarias indicando que utilizan a *Paralabrax* como hospederos intermediarios o paraténicos en sus ciclos de vida. Los monogéneos, digéneos y copépodos son formas adultas lo que sugiere que *P. clathratus* y *P. humeralis* son sus hospederos definitivos. Las diferencias observadas en la riqueza parasitaria de los hospederos pueden deberse a condiciones específicas del ambiente, de la presencia de diferentes hospederos intermediarios, del comportamiento alimentario y de su posible especificidad hospedatoria.

Palabras claves: crustáceos – especificidad hospedatoria – helmintos – *Paralabrax clathratus* – *P. humeralis*

INTRODUCTION

The family Serranidae Swainson, 1839 consisting of 537 species is one of the eight most diverse families of teleosteos fish (Nelson, 2006; Froese & Pauly, 2006; Eschmeyer & Fong, 2015). The Serranid has great commercial importance for artisanal, recreational and industrial fishery in the world and several species are highly valued in the market aquaristik (Aburto-Oropeza *et al.*, 2008). These predominantly tropical or subtropical fish of often demersal behavior live on the continental shelves, from the shore to moderate depths (rarely greater than 200 m). Most live associated with coral reefs and rocky bottoms, although some live in seagrass beds, and muddy and sandy bottoms (Fischer *et al.*, 1995; Cisternas & Sielfeld, 2008).

The species of the subfamily Serraninae have sedentary behavior and are predators that feed on fish and benthic invertebrates, mainly crustaceans (Fischer *et al.*, 1995; Pérez-Matus *et al.*, 2012). Some species are hermaphrodites, because individuals function as males and females at the same time. Other species change sex, from females to males during their lifetime, but several have separate sexes (Aburto-Oropeza *et al.*, 2008). Phylogenetically Serraninae is the basal subfamily of the Serranidae family.

Paralabrax Girard, 1856 is one of the 13 genera of the subfamily Serraninae (Nelson, 2006); forms a monophyletic group of American distribution (Pondella *et al.*, 2003). Composed of nine valid species divided into two phylogeographic groups: 1) the group of North America, composed of *P. clathratus* (Girard, 1854), *P. nebulifer* (Girard, 1854), *P. auroguttatus* Walford, 1936, and *P. maculatofasciatus* (Steindachner, 1868), and 2) the group of Central and South America, made up of *P. humeralis* (Valenciennes, 1828), *P. loro* Walford, 1936, *P. albomaculatus* (Jenyns, 1840), *P. callaensis* Starks, 1906 and *P. dewegeri* (Metzelaar, 1919) (Pondella *et al.*, 2003) (Fig. 1). This genus is considered the basal taxon in the subfamily Serraninae (Pondella *et al.*, 2003; Sadovy & Domeier, 2005; Martínez-Brown *et al.*, 2012).

The genus *Paralabrax* includes mesocarnivorous fish, dominant components of the rocky environment and marine reef of the Eastern Pacific and Western Atlantic of the American Continents. Their dominance has made them commercially and ecologically important, and therefore they have been subject to intensive fishing (Pondella *et al.*, 2003). The basal limbs of the *Paralabrax* genus, *P. clathratus* and *P. humeralis*, are the most species representatives of the group (Pondella *et al.*, 2003). *P. clathratus* is distributed from the Columbia River, Washington, USA to Bahía Magdalena, BCS, Mexico and *P. humeralis* from Colombia to southern Chile (Fischer *et al.*, 1995). *P. clathratus* according to its conservation status is considered to be of minor concern and *P. humeralis* as deficient data (IUCN, 2015a, b).

In South America, several comparative studies of eumetazoan parasite communities in congeneric freshwater and marine fish have been carried out in recent years. In the erythrinoids *Hoplias malabaricus* Bloch, 1794 and *H. lacerdae* Miranda Ribeiro, 1908 in Brazil (Rosim *et al.*, 2010). In the labrisomids *Auchenionchus microcirrhis* (Valenciennes, 1836), *A. variolosus* (Valenciennes, 1836) and *A. crinitus* (Jenyns, 1842) in Chile (Muñoz & Castro, 2012). In the blennids *Scartichthys variolatus* (Valenciennes, 1836), *S. viridis* (Valenciennes, 1836) and *S. gigas* (Steindachner, 1876) in Chile (Díaz & Muñoz, 2010), among others. However to date there is no information on the comparative biodiversity of the parasitofauna of *P. clathratus* and *P. humeralis* despite being species of high ecological and economic relevance for each geographic region in which they are distributed. Therefore, this paper presents the comparative analysis of the parasitic biodiversity of *P. clathratus* and *P. humeralis* from the Eastern Pacific.

MATERIAL AND METHODS

The information presented is an exhaustive compilation of the records generated by several authors of the parasitic fauna eumetazoa in the two species of fish studied (*P. clathratus* and *P. humeralis*). Records in scientific articles, unpublished thesis and cybernetic information search portals such as "Google Scholar" were taken into account. The taxonomic classification followed the Cohen *et al.* (2013) nomenclature for the monogeneans, Yamaguti (1971), Gibson *et al.* (2002), Jones *et al.* (2005) and Bray *et al.* (2008) for the digeneans. Heinz & Dailey (1974) and Schmidt (1986) for tapeworms and Moravec (2006) for nematodes was used. Petrochenko (1971) and Amin (2013) were used for acanthocephalans and Luque & Tavares (2007) for crustaceans. At the level of order the classification of parasites of Ruggiero *et al.* (2015) was used.

Comparison of beta parasite biodiversity at family and species level (*P. clathratus* and *P. humeralis*) was measured using the Sörensen (I*s*) qualitative similarity index: Is = (2c*100 /a+b), where a = number of parasite families / species present in *P. clathratus*, b = number of parasite families / species present in *P. humeralis*, and c = number of parasite families / species present in both species of *Paralabrax*. This index varies between 0 when there are no families / species of parasites present in both species of *Paralabrax*, up to 100% when for all species of *Paralabrax* all the families / species of parasites are the same (Iannacone *et al.*, 2010, Calderón- Patrón *et al.*, 2012; Bernués-Bañeres & Jiménez-Peydró, 2013). The Chi-square statistic was used to determine whether the same proportion of larvae and adults of metazoan parasites, direct and indirect biological cycle of parasites, and metazoan ectoparasites and endoparasites exist between *P. clathratus* and *P. humeralis* at a level of significance of 0.05 (Preacher, 2001).

RESULTS

Comparative parasite biodiversity of both species of fish was found to be constituted of helminths and crustaceans grouped into 22 families, two orders and one class. *P. humeralis* presented higher parasite richness at the species level than *P. clathratus* (n = 40 vs n = 27): monogeneans (n = 3 vs n = 3), digeneans (n = 10 vs n = 10), tapeworms (n = 6 vs n = 1), acanthocephalans (n = 2 vs n = 1), nematodes (n = 9 vs n = 4), copepods (n = 8 vs n = 8), isopods (n = 1 vs n = 0) and hirudinean (n = 1 vs n = 0) (Table 1). The 27 species of metazoan parasites of *P. clathratus* were found in the USA (14.81%) and in Mexico (88.88%). In contrast, the 40 species of metazoan parasites of *P. humeralis* were Galapagos-Ecuador (12.5%), Peru (40%) and Chile (67.5%) (Table 1).

From this parasite richness, it was observed that both hosts share ten families: Diclidophoridae and Capsalidae (Monogenea), Opecoelidae and Hemiuridae (Digenea), Polymorphidae (Acanthocephala), Anisakidae and Cucullanidae (Nematoda), Caligidae, Bomolochidae and Hatschekiidae (Copepoda). It was also observed that *P. clathratus* does not share families: Monorchiidae and Zoogonidae (Digenea) and Spiruridae (Nematoda). *P. humeralis* does not share the families: Derogenidae (Digenea), Bothriocephalidea (unidentified family), Lacistorhynchidae, Tentacularidae and Diphyllobothriidae (Cestoda), Philometridae and Cystidicolidae (Nematoda), Lernaeopodidae and Chondracanthidae (Copepoda), Cymothoidae (Isopoda) and an unidentified family of Hirudinea (Table 1). The qualitative Sörensen index was used to compare parasite biodiversity at the family and species levels of *P. clathratus* and *P. humeralis*, and showed a value of 11.94% and 57.14%, respectively. Only four parasitic species: *H. nimia*, *Anisakis* sp., *Corynosoma* sp. and *Hysterothylacium* sp. were present in both species of grouper, *P. clathratus* and *P. humeralis*.

A similar proportion of larvae relative to total parasite load was observed in both fish species (14.81% in *P. clathratus* and 26.83% in *P. humeralis*) (*Chi-square* = 1.75, p = 0.18) and adults (85.19% in *P. clathratus* and 73.17% in *P. humeralis*) (*Chi-square* = 0.46, p = 0.50) for metazoan parasites. The same proportion of metazoan parasites with direct biological cycle (40.74% in *P. clathratus* and 32.5% in *P. humeralis*) (*Chi-square* = 0.43, p = 0.51) and indirect biological cycle (59.26% in *P. clathratus* and 77.5% in *P. humeralis*) (*Chi-square* = 0.32, p = 0.57). The same proportion of metazoan ectoparasites in the fish host (44.44% in *P. clathratus* and 32.5 % in *P. humeralis*) (*Chi-square* = 0.79, p = 0.37) and metazoan endoparasites in the fish host (55.56% in *P. clathratus* and 67.5% in *P. humeralis*) (*Chi-square* = 0.58, p = 0.44).

DISCUSSION

Of the 22 parasite families, two orders and one class present in *P. clathratus* and *P. humeralis*, 10 of them (40%) are probably shared as a result of their phylogenetic kinship as clades of the North American and Central-South American groups respectively (Pondella *et al.*, 2003; Sadovy & Domeier, 2005; Martínez-Brown *et al.*, 2012). However, it turned out that the biodiversity of metazoan parasites at the family level between these two species is not shared in 60% of cases. This maybe due to differences in the composition of marine invertebrates that serve as intermediate hosts and habitats that serve as food, recruitment, larval settlement and reproduction of each species of fish (Cisternas & Sielfeld, 2008). The distribution of *P. humeralis* on the coasts of Peru and Chile is frequently associated with two subsystems of kelps, *Lessonia trabeculata* Villouta & Santelices and *Macrocystis integrifolia* Bory de Saint-Vincent (Cisternas & Sielfeld, 2008; Ortiz, 2010; Henríquez & González, 2012). While *P. clathratus*, although it is a species considered to be close to algae grasslands in southern California and northern Baja California (Quast, 1968; Miller & Lea, 1972; Erisman & Allen, 2005, 2006) has been more frequently associated with rocky-type coral habitats (Stephens *et al.*, 1984; Gómez del Prado-Rosas, 2012). Possibly due to this habitat difference there is a greater parasitic biodiversity in *P. humeralis* with respect to *P. clathratus*.

Monogeneans of the family Diclidophoridae, *Pseudotagia clathratus* and *Mamaevicotyle villalobosi* have not been registered in other species of fish, but *Hemitagia galapagensis* was found in *Paranthias furcifer* (Valenciennes, 1828) and *Tagia* sp. which has been found in a greater variety of fish species (Lamothe-Argumedo, 1984; Gómez del Prado-Rosas, 2012; Cohen *et al.*, 2013). In all cases, both species of groupers act as final hosts of monogeneans.

Table 1. Biodiversity of shared and non-shared metazoan parasite families among Serranids *Paralabrax clathratus* (Pc) and *P. humeralis* (Ph). A = Adult stage. L = larvae stage. D = Direct biological cycle. I = Indirect biological cycle. NI = Not indicated.

Order	Family	Shared families	Genus/Species		Host	Locality (Country)	Reference
Monogenea							
Mazocraeidea	Diclidophoridae	Yes					
			Pseudotagia clathratus Crane, 1972	A, D	Pc	USA	Crane (1972)
			Mamaevicotyle villalobosi Lamothe, 1984	A, D	Pc	Mexico	Gómez del Prado-Rosas (2012)
			Tagia sp.	A, D	Ph	Peru	Armas (1977)
						Chile	Henríquez & González (2012)
			Hemitagia galapagensis (Meserve, 1938) Sproston, 1946	A, D	Ph	Galápagos	Kohn & Cohen (2003)
						Peru	Iannacone & Alvariño (2009)
Capsaloidea	Capsalidae	Yes					
			Bajacaliornia universitaria Gómez del Prado & Lamothe, 2009	A, D	Pc	Mexico	Gómez del Prado-Rosas (2012)
			Neobenedenia sp.	A, D	Ph	Chile	Henríquez & González (2012)
Digenea							
Plagiorchiida	Opecoelidae	Yes					
			Helicometrina nimia Linton, 1910	A, I	Pc	Mexico	Arai (1962)
					Ph	Chile	Oliva & Muñoz (1985); Muñoz & Olmos (2008); Henríquez & González (2012); González *et al.* (2013); Oliva *et al*. (2015)

Order	Family	Shared families	Genus/Species		Host	Locality (Country)	Reference
			Helicometra fasciata (Rudolphi, 1819) Odhner, 1902	A, I	Ph	Chile	Oliva & Muñoz (1985); Kohn *et al*. (2007); Muñoz & Olmos (2008); Henríquez & González (2012); González *et al*. (2013)
						Peru	Iannacone & Alvariño (2009)
			Helicometra pulchella (Rudolphi, 1819) Odhner, 1902	A, I	Ph	Peru	Tantaleán *et al.* (1975)
			Plagioporus isaitschikowi (Layman, 1930) Price, 1934	A, I	Pc	USA	Manter & Van Cleave (1951)
						Mexico	Druk-González (1983)
			Opecoelus mexicanus Manter, 1940	A, I	Pc	Mexico	Gómez del Prado-Rosas (2012)
			Opecoelus lutiani (Bravo Hollis & Manter, 1957) Aken´Ova, 2007	A, I	Pc	Mexico	Gómez del Prado-Rosas (2012)
			Pseudopecoelus sp.	A, I	Ph	Chile	Henríquez & González (2012)
			Macvicaria sp.	A, I	Ph	Chile	Henríquez & González (2012)
			Macvicaria calotomi (Yamaguti, 1934) Gibson & Bray, 1982	A, I	Pc	Mexico	Gómez del Prado-Rosas (2012)
			Macvicaria issaitschikowi (Layman, 1930) Bray, 1985	A, I	Pc	Mexico	Gómez del Prado-Rosas (2012)

Order	Family	Shared families	Genus/Species		Host	Locality (Country)	Reference
			Opecoelidae gen. sp.1	A,I	Ph	Chile	Henríquez & González (2012)
			Opecoelidae gen. sp.2	A,I	Ph	Chile	Henríquez & González (2012)
Plagiorchiida	Hemiuridae	Yes					
			Parahemiurus merus (Linton, 1910) Vaz & Pereira, 1930	A, I	Pc	Mexico	Gómez del Prado-Rosas (2012)
			Ellytrophallus mexicanus Manter, 1940	A, I	Pc	Mexico	Manter & Van Cleave (1951)
			Lecithochirium microstomum Chandler, 1935	A, I	Ph	Galápagos	Manter (1940)
			Lecithiochirium magnaporum Manter, 1940	A, I	Ph	Galápagos	Manter (1940); Kohn *et al.* (2007); Iannacone & Alvariño (2009)
Plagiorchiida	Derogenidae	Yes					
			Derogenes varicus (O.F. Müller, 1784) Looss, 1901	A, I	Ph	Galápagos	Manter (1940); Kohn *et al.* (2007); Iannacone & Alvariño (2009)
Plagiorchiida	Monorchiidae	No					
			Monorcheides alexanderi Arai, 1962	A, I	Pc	Mexico	Arai (1962); Gómez del Prado (2012)
Plagiorchiida	Zoogonidae	No					
			Deretrema (Deretrema) pacificum Yamaguti, 1942	A, I	Pc	Mexico	Gómez del Prado-Rosas (2012)
Cestoda							
Bothriocephalidea	NI	No	Bothriocephalidea gen. sp.	A, I	Ph	Chile	Henríquez & González (2012)
Trypanorhyncha	NI	No	Trypanorhyncha sp.	L, I	Pc	Mexico	Gómez del Prado-Rosas (2012)

Order	Family	Shared families	Genus/Species		Host	Locality (Country)	Reference
Trypanorhyncha	Lacistorhynchidae	No					
			Grillotia sp.	L, I	Ph	Peru	Armas (1977); Tantaleán & Huiza (1994); Iannacone & Alvariño (2009)
			Callitetrarhynchus sp.	L, I	Ph	Peru	Armas (1977)
			Callitetrarhynchus gracilis (Rudolphi, 1819)	L, I	Ph	Peru	Tantaleán & Huiza (1994); Iannacone & Alvariño (2009)
	Tentaculariidae	No					
			Nybelinia sp.	L, I	Ph	Chile	Henríquez & González (2012)
Diphyllobothriidea	Diphyllobothriidae	No					
			Adenocephalus pacificus Nybelin, 1931	L, I	Ph	Peru	Iannacone & Alvariño (2009)
Acanthocephala							
Polymorphida	Polymorphidae						
		Yes	*Corynosoma* sp.	L, I	Pc	Mexico	Gómez del Prado-Rosas (2012)
					Ph	Chile	Muñoz & Olmos (2008); Henríquez & González (2012)
						Peru	Armas (1977); Tantaleán *et al*. (2005)
			Corynosoma obtuscens Lincicome, 1943	L, I	Ph	Chile	Muñoz & Olmos (2008)
						Peru	Tantaleán *et al*. (2005)
Nematoda							
Ascaridida	Anisakidae	Yes					
			Anisakis sp.	L, I	Pc	Mexico	Gómez del Prado-Rosas (2012)
					Ph	Chile	Henríquez & González (2012)

Order	Family	Shared families	Genus/Species		Host	Locality (Country)	Reference
			Anisakis simplex (Rudolphi, 1809)	L, I	Ph	Chile	Jofré *et al*. (2008); Iannacone & Alvariño (2009)
			Hysterothylacium sp.	L, I	Pc	Mexico	Gómez del Prado-Rosas (2012)
				L, A, I	Ph	Chile	Henríquez & González (2012)
Ascaridida	Cucullanidae	Yes					
			Cucullanus sp.	A, I	Pc	Mexico	Gómez del Prado-Rosas (2012)
			Cucullanellus sp.	A, I	Ph	Peru	Armas (1977)
			Dichelyne (Cucullanellus) sp.	A, I	Ph	Peru	Sarmiento *et al*. (1999); Iannacone & Alvariño (2009)
Camallanida	Philometridae	No					
			Philometra sp.	A, I	Ph	Chile	Oliva *et al*. (1992); Henríquez & González (2012)
						Peru	Muñoz & Olmos (2008); Sarmiento *et al.* (1999); Iannacone & Alvariño (2009)
Rhabditia	Cystidicolidae	No					
			Cystidicolidae gen. sp.1	A, I	Ph	Chile	Henríquez & González (2012)
			Ascarophis sp.	A, I	Ph	Chile	Henríquez & González (2012)
			Pseudoascarophis sp. ?	A, I	Ph	Chile	Henríquez & González (2012)
Spiruroidea	Spiruridae	No					
			Dollfusnema piscícola Caballero-Rodríguez, 1974	A, I	Pc	Mexico	Caballero-Rodríguez (1974)

Order	Family	Shared families	Genus/Species		Host	Locality (Country)	Reference
Copepoda							
Siphonostomatoida	Caligidae	Yes					
			Caligus mutabilis Wilson, 1905	A, D	Pc	Mexico	Causey (1960); Gómez del Prado-Rosas (2012)
			Caligus productus Dana, 1853	A, D	Pc	Mexico	Causey (1960)
			Caligus elongatus von Nordmann, 1832	A, D	Pc	Mexico	Gómez del Prado-Rosas (2012)
			Caligus quadratus (Shiino, 1954)	A, D	Ph	Chile	Muñoz & Olmos (2007); Henríquez & González (2012);
						Peru	Iannacone & Alvariño (2009)
			Lepeophtheirus dissimulatus Wilson, 1905	A, D	Ph	Galápagos	Wilson (1937)
			Lepeophtheirus longipes Wilson, 1905	A, D	Pc	USA	Wilson (1921)
			Lepeophtheirus frecuens Castro-Romero & Baeza-Kuroki, 1984	A, D	Ph	Chile	Henríquez & González (2012)
Siphonostomatoida	Lernaeopodidae	No					
			Clavella sp.	A, D	Ph	Chile	Henríquez & González (2012)
Cyclopoidea	Bomolochidae	Yes					
			Bomolochidae gen. sp.	A, D	Ph	Chile	Henríquez & González (2012)
			Acantholochus paralabracis Luque & Bruno, 1990	A, D	Ph	Peru	Luque & Bruno (1990); Iannacone & Alvariño (2009)

Order	Family	Shared families	Genus/Species		Host	Locality (Country)	Reference
			Bomolochus longicaudus Cressey, 1969	A, D	Pc	USA	Cressey (1969)
			Bomolochus soleae Claus, 1864	A, D	Pc	Mexico	Causey (1960)
Siphonostomatoida	Hatschekiidae	Yes					
			Hatschekia albirubra Wilson, 1913	A, D	Pc	Mexico	Causey (1960)
			Hatschekia amphiprocessa Castro & Baeza, 1986	A, D	Ph	Chile	Castro & Baeza-Kuroki (1986); Muñoz & Olmos (2007); Henríquez & González (2012)
						Peru	Luque *et al*. (1991); Iannacone & Alvariño (2009)
			Hatschekia pacifica Cressey, 1970	A, D	Pc	Mexico	Gómez del Prado-Rosas (2012)
Poecilostomatoida	Chondracanthidae	No					
			Juanettia cornifera Wilson, 1921	A, D	Ph	Chile	Stuardo & Fagetti (1961); Muñoz & Olmos (2007)
Isopoda							
Cymothoida	Cymothoidae	No					
			Meinertia sp.	L, D	Ph	Chile	Henríquez & González (2012)
Hirudinea							
	NI	No	Hirudinea gen. sp.	A, D	Ph	Chile	Henríquez & González (2012)

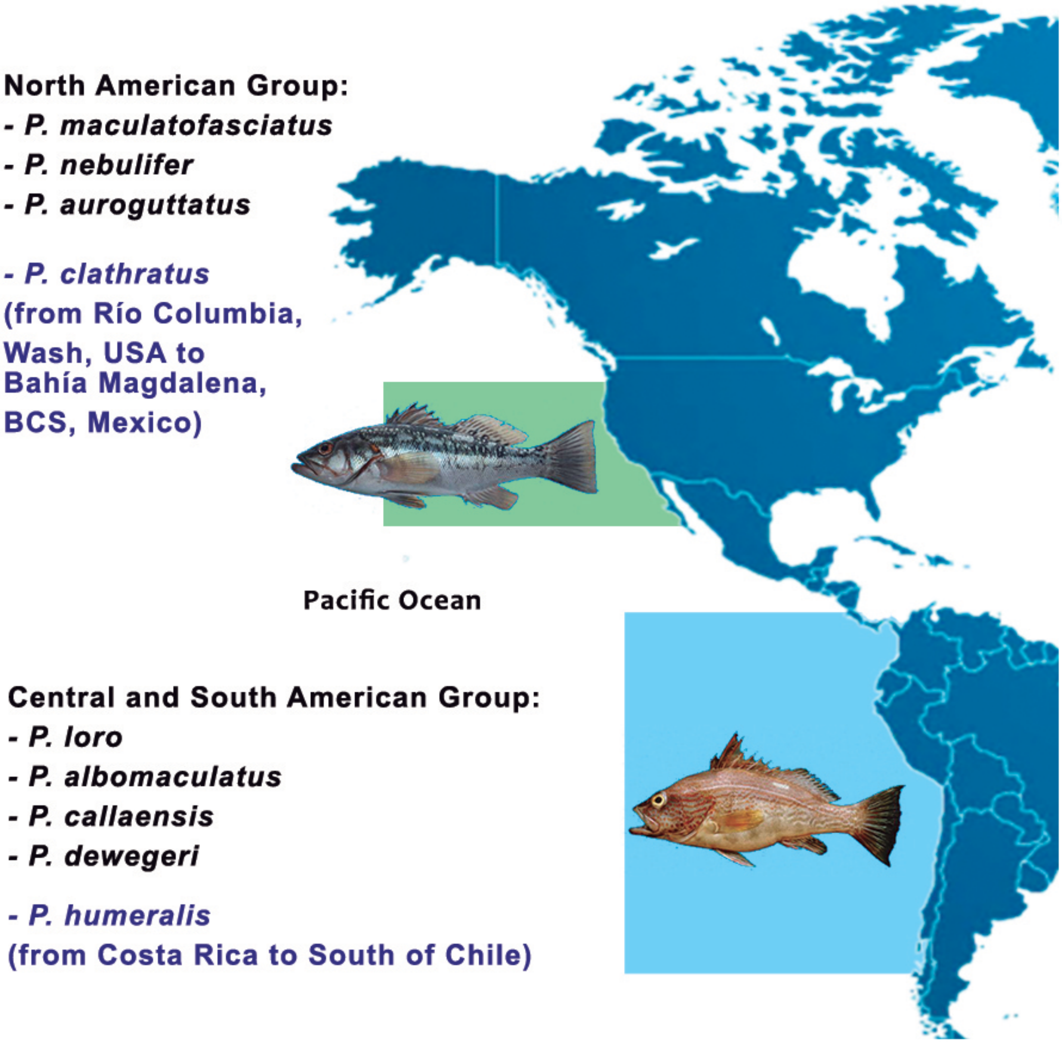

Figure 1. Geographical distribution of *Paralabrax* spp. of the phylogeographic group of North America (*P. clathratus*, *P. auroguttatus*, *P. nebulifer* and *P. maculatofasciatus*) and of the phylogeographic group of Central and South America (*P. humeralis*, *P. loro*, *P. albomaculatus*, *P. callaensis* and *P. dewegeri*).

Regarding the digeneans, although they are generalists, only the families Opecoelidae and Hemiuridae were found in both fish species probably reflecting the fact that groupers are their definitive hosts when these helminths are found in adult stage (Gibson & Bray, 1982; Bray, 1985; Aken'Ova, 2007; Iannacone *et al.*, 2011). Opecoelidae was the family that presented the greatest diversity of species (n = 12) in the genus *Paralabrax*. Bray *et al.* (2016) notes that this is the largest family of digenea with 90 genera and about 900 species. Derbel *et al.* (2012) notes that Opecoelidae is a family well represented in marine fish, with species that can be used to assess the health of the aquatic ecosystem.

Helicometrina nimia is a digenean trematode with wide distribution in the world (Roumbedakis *et al.*, 2014) that is located in the intestine and stomach of fish. It has been registered to date in more than 60 fish species, mainly of the families Serranidae, Haemulidae Gill, 1885 (Syn = Pomadasyidae), Scorpaenidae Risso, 1827 and Clinidae Swainson, 1839 in 13 countries: United States of America, Bahamas, Jamaica, Puerto Rico, Mexico, Panama, Colombia, Peru, Brazil, Chile, the Arabian Gulf, Pakistan and India (Vélez, 1987; Pérez-Ponce de León *et al.*, 2007; Iannacone & Alvariño, 2011; Roumbedakis *et al.*, 2014; Oliva *et al.*, 2015; Ramos-Ascherl *et al.,* 2015; Sowjanya *et al.*, 2015; Merlo-Serna & García-Prieto, 2016). *H. nimia* has been recorded in both species of grouper studied here, *P. clathratus* and *P. humeralis* (Table 1).

On the other hand, the acanthocephalans registered in both species of groupers belong to the genus *Corynosoma* in larval stage. Aznar *et al.* (2006) point out that in the marine ecosystem the cystacanths of *Corynosoma* species are most frequently in fishes, which act as paratenic hosts and serve as a link between intermediate hosts (mainly crustacean-amphipods) and definitive hosts (marine mammals) (Yamaguti, 1963a; Aznar *et al.*, 2006). Although recently Lozano-Cobo *et al.* (2017) propose the chaetognaths as a new intermediate host in the life cycle of the *Corynosoma* species due to the presence of 12 cystacanths in three species of chaetognaths in a monthly zooplankton time series of three years (1996 to 1998). Tantaleán *et al.* (2005) and Chero *et al.* (2014) mentioned that *Paralabrax* spp. are only an intermediate or paratenic host in the life cycle of these acanthocephalans and we consider the same.

Regarding nematodes, the species recorded in the family Anisakidae (*Anisakis* sp., *A. simplex* and *Hysterothylacium* sp.) are cosmopolitan (Gómez del Prado-Rosas, 2012; Luque *et al.*, 2016). All correspond to larval forms and indicate the role of *Paralabrax* spp. in the Anisakidae life cycle as intermediate or paratenic hosts, because of *Anisakis* spp. have marine mammal as definitive hosts and *Hysterothylacium* spp. have fish as definitive hosts (Anderson, 2000). Nematodes of the family Cucullanidae [*Cucullanus* sp. and *Dichelyne* (*Cuculanellus*) sp.] are generalists (Yamaguti, 1961) and in the *Paralabrax* spp. were found in the adult stage, so that the groupers are definitive hosts for these nematodes (Luque *et al.*, 2016).

The coincidence of copepods corresponding to the families Hatschekiidae, Caligidae and Bomolochidae is an indicator of the preference that shown the first family by serranid fish (Jones, 1985; Castro & Baeza-Kuroki, 1986). While the parasites of the second family are generalist (Cressey, 1969). The copepods Caligidae are among the ectoparasites with the most species richness in *Paralabrax*. Regarding to *Juanettia cornifera* there are only one record of this species in *P. humeralis* (Stuardo & Fagetti, 1961; Yamaguti, 1963b). In all cases, the groupers are their definitive hosts (Muñoz & Olmos, 2007).

The monogenean *Bajacalifornia universitaria* is a capsalid that was found in adult stage in *P. clathratus* and could be occurs in other two species of *Paralabrax* (*P. nebulifer* and *P. auroguttatus*) in the Pacific ocean of the Peninsula of Baja California and Gulf of California, Mexico respectively. For this monogenean the *Paralabrax* groupers are the definitive hosts (Gómez del Prado-Rosas, 2012)..

The digenean *Monorcheides alexanderi* of the family Monorchiidae, seems so far, preference for fish of the genus *Paralabrax*. Because it had previously been recorded in *P. clathratus* from Isla Guadalupe, Mexico (Arai, 1962), in *P. nebulifer* from Ensenada, Baja California, Mexico (Druk-González, 1983) and in *P. maculatofasciatus* from El Pardito, Bahía de La Paz, Baja California Sur, Mexico (Gómez del Prado-Rosas, 2012). While *Deretrema* (*Deretrema*) *pacificum* of the family Zoogonidae is considered as generalist (although part of a genus with nine species) because it has been found in fish of the families Labridae, Monocentridae, Pempheridae, Triglidae and the order Scorpaeniformes. However, *D.* (*D.*) *pacificum* has been described in fish belonging to the following orders: Scorpaeniformes, Perciformes and Beryciformes (Linton, 1910; Gómez del Prado-Rosas, 2012). *Derogenes varicus* of the family Derogenidae is a parasite of little host specificity because it has been found in a great variety of fishes (Yamaguti, 1971), so due to its attributed a wide geographical distribution.

The records of tapeworms belong to the orders Trypanorhyncha and Diphyllobothriidea were in larval stage (plerocercoid), while the order Bothriocephalidea was in adult stage. Khalil *et al.* (1994) mentioned that adult of these parasites are in elasmobranch fish and marine mammals. The presence in larval stage indicating that the *Paralabrax* spp. are only an intermediate or paratenic host in the cycle of these parasites

(Iannacone & Alvariño, 2009; Gómez del Prado-Rosas, 2012; Luque *et al.*, 2016). *Adenocephalus pacificus* in plerocercoid larvae was found only in *P. humeralis*. Kutcha *et al.* (2015) mentioned that marine fish such *P. humeralis* act as a second intermediate host and these fish would be part of the marine mammal diet (Iannacone & Alvariño, 2009; Chero *et al.*, 2014).

The nematode *Dollfusnema piscicola* of the family Spiruridae, apparently, has not been registered in another host in Mexico. *P. clathratus* is the type host (Gibbons, 2010). While the nematode *Philometra* sp. of the family Philometridae, generally parasitizes a great diversity of fishes (Yamaguti, 1961).

Respect to copepods, the members of the family Chondracanthidae are recorded parasitizing a wide variety of marine fish, but in particular the copepod *Juanettia cornifera* has been found only in *P. humeralis* of Isla Juan Fernández, Chile (Stuardo & Fagetti, 1961; Yamaguti, 1963b; Muñoz & Olmos, 2007).

As regards the presence of families of parasites non-shared between the two species of groupers (*P. clathratus* and *P. humeralis*) could be indicate: 1) particular conditions of the environment in the geographical distribution; 2) presence of different intermediary hosts; 3) more specific food behavior and 4) a certain degree of host specificity of each parasite (Manter, 1967; Díaz & Muñoz, 2010). It is also considered that the absence of overlap in the distribution of host fish could reduce the similarity of species and families of parasites among congeneric hosts (Díaz & Muñoz, 2010). *P. clathratus* is a subtropical species that is distributed from Columbia River, Washington, USA to Bahía Magdalena, BCS, Mexico and *P. humeralis* is a tropical species from Colombia to southern Chile (Fischer *et al.*, 1995). There are families of parasites that do not coincide between both species of *Paralabrax* despite being congeneric species.

Henríquez & González (2012) and Muñoz & Castro (2012) indicated that the variation in the community of parasites among species of fish of the same family would be to the sizes of the hosts, observing a greater diversity in the larger fish. However, this condition was not observed in this study. *P. clathratus* may have a maximum length of 72 cm while *P. humeralis* can measure a maximum length of 55 cm. In this sense we would be expected to have higher parasite richness in *P. clathratus* than *P. humeralis*. Contrary to this, the diversity was higher in *P. humeralis* (n = 40) than in *P. clathratus* (n = 27), so that differences in size between the two hosts were not a factor in determining their parasitic biodiversity.

Although both species are carnivorous, *P. clathratus* has a greater spectrum of prey (benthic and planktonic invertebrates, cephalopods and fish) (Roberts *et al.*, 1984; Henríquez & González, 2012). In contrast, the diet of *P. humeralis* is dominated mainly by decapod crustaceans and to a lesser extent by invertebrates and fish (Love *et al.*, 1996; Pérez-Matus *et al.*, 2012). Although, *P. clathratus* has a greater spectrum of prey, this host did not have a greater richness of parasites that could be transmitted trophically (digeneans, tapeworms and nematodes) in comparison to *P. humeralis*. Lowe *et al.* (2003) and Pérez-Matus *et al.* (2012) indicated that *P. clathratus* and *P. humeralis* have greater residence to their geographic distribution and have little variation in diet. Lira-Guerrero *et al.* (2008) indicate that differences in the diet of host carnivorous fish species could cause differences in the interactions with their prey that are their possible intermediate hosts. It is likely that the differences in the parasitic richness of endoparasites in *P. clathratus* and *P. humeralis* can be attributed to the general behavior of hosts that can modulate the loss and acquisition of new parasites (Henríquez & González, 2012).

Luque & Oliva (1999) and Rosim *et al.* (2010) indicate that the unstable environmental conditions in the aquatic environment would cause a disturbance in the population dynamics of the endoparasites transmitted trophically in *Paralabrax*. As can be seen with the outcrop systems in the Peruvian cold current and in the California current where both species of grouper in this study (*P. humeralis* and *P. clathratus*) are distributed respectively. Also being periodically affected by the El Niño event which may represent a direct influence on the distribution of parasites (Marcogliese, 2008). Henríquez & González (2012) point out that the differences in the composition of ectoparasites (monogeneans, copepods, isopods and hirudineans) in *P. humeralis* of four localities from Chile could be attributed to different circulation models of water bodies. that would affect the dispersal ability of the infective larval stages of these ectoparasites. The richness of ectoparasites in *P. humeralis* and *P. clathratus* can be explained by this factor.

The results of this comparative study of helminth and crustacean parasites between *P. clathratus* and *P. humeralis* reflect possible differences in the parasite richness of two congeneric hosts. Even though they are species that come from the same monophyletic group, the evidence of the phylogeographic importance of these two hosts is clear and reflected in the families of parasites that were not shared. Probably the parasitic fauna in the species of the genus *Paralabrax* has greater similarity between those species of the same phylogeographic group than between species of different distribution. This would mean that the parasitic biodiversity of *P. clathratus* would be similar to that of *P. maculatofasciatus*, *P. nebulifer* and *P. auroguttatus* because they belong to the North American group (Fig. 1). While *P. humeralis* would be more similar to the parasites of *P. loro*, *P. albomaculatus*, *P. callaensis* and *P. dewegeri* belonging to the Central and South American group (Pondella *et al*., 2003) (Fig. 1). However it would be necessary to analyze if there are differences in the parasitic biodiversity among the species of each phylogeographic group. This review represents one of the first comparative studies of parasitic richness among congenital basal species of a monophyletic group of marine environment in any Teleosteos fish family. Therefore it is advisable to continue efforts to better understand the factors that determine the differences in parasitic biodiversity of host species of monophyletic origin.

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