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UPDATE OF THE CHECKLIST OF METAZOAN PARASITES OF FISHES FROM PERU: 2016 – 2021

(Atualização da lista de verificação de parasitas metazoanos de peixes do Peru: 2016 a 2021)

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ABSTRACT

An updated checklist of marine and freshwater fish parasitic metazoans of Peru: 2016-2021 is provided. The present review was carried out through a bibliographic search of scientific articles published in academic journals between 2016 - 2021, using databases such as Google Scholar, Scielo, ResearchGate, Elsevier, and Scopus. Data compilation was restricted to studies reporting metazoan parasites of fish in Peruvian waters. A total of 202 species of metazoan parasites were recorded in 103 fish species in Peru. The marine fish species with the highest parasitic record were Sarda chiliensis Cuvier, 1832 (n=23) and Paralabrax humeralis Valenciennes, 1828 (n=19). The freshwater fishes with the highest parasitic record were Colossoma macropomun Cuvier, 1818 (n=9), Sorubim lima Bloch & Schneider 1801, Brochis multiradiatus Orcés V., 1960, Brycon amazonicus Spix & Agassiz, 1829 and Osteoglossum bicirrhosum Cuvier 1829, each with five species reported. The metazoan parasite with the highest number of records was the larva of the cestode Adenocephalus pacificus Nybelin, 1931 (n=28). The diversity of metazoan parasites in Peruvian fish increased by 25,18% from 2016 to 2021.

Keywords*: Biodiversity, fish parasites, helminth, metazoan, Peru.*

RESUMO

É fornecida uma lista de verificação atualizada dos metazoários parasitas de peixes marinhos e de água doce do Peru: 2016-2021. O presente trabalho de revisão foi realizado através de uma pesquisa bibliográfica de artigos científicos publicados em periódicos acadêmicos entre 2016 - 2021, utilizando bancos de dados como Google Scholar, Scielo, ResearchGate, Elsevier e Scopus. A coleta de dados foi restringida a estudos que relatam parasitas metazoários de peixes em águas peruanas. Um total de 202 espécies de parasitas metazoários foram registradas em 103 espécies de peixes no Peru. As espécies de peixes marinhos com maior registro parasitário foram *Sarda chiliensis* Cuvier, 1832 (n=23) e *Paralabrax humeralis* Valenciennes, 1828 (n=19). Os peixes de água doce com o maior registro parasitário foram *Colossoma macropomun* Cuvier, 1818 (n=9), *Sorubim lima* Bloch & Schneider 1801, *Brochis multiradiatus* Orcés V., 1960, *Brycon amazonicus* Spix & Agassiz, 1829 e *Osteoglossum bicirrhosum* Cuvier 1829, cada um com 5 espécies reportadas. O parasita metazoário com o maior número de registros foi a larva da cestode *Adenocephalus pacificus* Nybelin, 1931 (n=28). A diversidade de parasitas metazoários nos peixes peruanos aumentou em 25,18% até 2021, em comparação com a lista de 2016.

Palavras-chave: Biodiversidade, parasitas de peixes, helminto, metazoários, Peru.

INTRODUCTION

Peru is currently home to a high diversity of marine and freshwater fish species, ranking first globally (CORNEJO *et al*., 2015; MEZA-VARGAS *et al*., 2021). The fishery is an important source of protien for human consumption. The fishing activity includes the activities of extraction and transformation of hydrobiological resources such as fish, mollusks, crustaceans and other species for direct human consumption (canned, fresh or frozen) and indirect (fishmeal and fish oil) (COAYLA, 2020; LONDOÑE-BAILÓN *et al*.,

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2020). However, the presence of parasites affects various species of commercial interest, presenting abnormalities in their morphology, thus affecting their growth and survival. On the other hand, massive infestations in the muscles of the fish can cause an unpleasant appearance or the deterioration of the fish, being less attractive to the consumer, affecting its commercial value, in addition to posing a risk to human health (EIRAS *et al*., 2016).

To date, there are 1,646 species of known fish in Peru (FROESE AND PAULY, 2022), of which only 207 have been reported as hosts of metazoan parasites until may 2016, including unidentified parasites representing 30% of all species (LUQUE *et al*., 2016). Within this group, the fish species that harbored the highest number of parasites were *Merluccius gayi peruanus* Ginsburg, 1954 (n=32), followed by *Paralonchurus peruanus* (Steindachner, 1875) (n=31), *Scomber japonicus* Houttuyn, 1782 (n=31), *Sciaena deliciosa* (Tschudi, 1846) (n=31), and *Stellifer minor* (Tschudi, 1846) (n=28), in records published up to May 2016 (LUQUE *et al*., 2016). In contrast, to mid-2016 to 2021, in which there are 1,423 fish species that have not yet been identified by studying their parasitic composition (MINAYA *et al*., 2021b). Despite this, the number of investigations related to parasitic fauna in fish species of commercial interest has been increasing, reporting new geographic records and host-parasite interactions. On the other hand, as some researchers point out, South America is undoubtedly a region where parasitic biodiversity is underestimated, due to its great ichthyological richness, as well as the helminth fauna present in the hosts that inhabit it (GARCÍA-DÁVILA *et al*., 2021).

In this update of the mid-2016 to 2021 metazoan parasite checklist, we highlight the parasitic species associated with freshwater and marine fishes from Peru, including detailed information on their locality, habitat, site of infection and life cycle stage. The information is presented in the form of parasite-host and host-parasite lists and the distribution of fish with the highest parasite load is detailed.

MATERIAL AND METHODS

Taxonomic Literature Search

The database was compiled from an extensive bibliographic review of scientific articles and review articles on metazoan parasites reported from fishes in Peruvian waters according to their taxonomic group, using two approaches. First, different databases were searched such as: Google Scholar, Scielo, ScienceDirect, ResearchGate, Elsevier, Scopus, using a combination of several key words: biodiversity; fish parasites; helminth; metazoan parasites; Peru. Second, original articles, review articles and research notes published in Spanish, Portuguese and English between mid-2016 to 2021 were selected.

Classification and systematic arrangement of metazoan parasites

The following parasite taxa were included: Acanthocephala, Crustacea (Copepoda, Malacostraca and Maxillopoda), Myxozoa, Nematoda and Platyhelminthes (Monogenea, Trematoda and Cestoda). The checklist follows the classification and systematic arrangement proposed by Ahyong *et al*. (2011) for Branchiura and Isopoda; Amin (2013) for Acanthocephala; Anderson *et al*. (2009) and Gibbons (2010) for Nematoda; Boxshall and Halsey (2004) for Copepoda; Cohen *et al*. (2013) for Monogenea; Davies (1991) for

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Hirudinea; Gibson *et al*. (2002), Jones *et al*. (2005) and Bray *et al*. (2008) for Trematoda; Khalil *et al*. (1994) for Cestoda; and Lom & Dyková (2006) for Myxozoa.

Parasite species are arranged by Phylum, Class, Order and Family and are presented in alphabetical order, followed by information on host / locality records, sites of infection/infestation, stage of development, habitat (freshwater/marine) and references (between parentheses, in chronological order) (Supplements 1 and 2).

Classification of fish and their parasites

The name of the fish species in the list of host parasites are ordered according to the classification of Froese & Pauly (2022). Parasite names were updated in agreement with the recent literature, but inclusion in the parasite or host lists does not necessarily imply that authors agree with their validity.

Statistical Analysis

The parasites were ordered by taxonomic groups and catalogued and numbered according to freshwater or marine environment. The results were compared with what was obtained in 2016 (LUQUE *et al*., 2016).

RESULTS AND DISCUSSIONS

A total of 202 metazoan parasites were found in the period mid-2016 to 2021, belonging to the following taxa: Monogenea (n=91), Trematoda (n=32), Copepoda (n=29), Nematoda (n=15), Cestoda (n=14), Acanthocephala (n=9), Myxozoa (n=8), Isopoda (n=3), Maxillopoda (n=1) (Tab. 01).

Table 01: Nominal and undetermined fish parasite species registered in Peru according to their taxonomic group.

Taxonomic group	Nominal sp.	Undetermined sp.	Total	Nominal sp. 2016*	Undetermined sp. 2016*	Total 2016*	Total recorded
Monogenea	85	6	91	135	40	175	266
Trematoda	25	7	32	53	57	110	142
Copepoda	21	8	29	76	12	88	117
Nematoda	6	9	15	31	18	49	64
Cestoda	10	4	14	106	34	140	154
Acanthocephala	6	3	9	10	6	16	25
Myxozoa	5	3	8	7	9	16	24
Isopoda	2	1	3	5	4	9	12
Maxillopoda	1	0	1	0	0	0	1
Aspidogastrea	0	0	0	4	1	5	5
Annelida	0	0	0	1	1	2	2
Branchiura	0	0	0	2	0	2	2
			202			**612**	**814**

*The 2016 data were taken from the Luque *et al*. (2016).

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One hundred and twenty-three species were marine parasites, seventy-six species were freshwater and two species were recorded in the both habitats (Tab. 02; supplement 1 and 2). Of them, 98 are teleosts and five are elasmobranchs.

Table 02: Environmental distribution of parasites in fish species registered in Peru according to their taxonomic group.

Taxonomic group	Marine	Fresh water	Both environ -ment	Total	Marine 2016*	Fresh water 2016*	Both environ-ments 2016*	Total 2016*	Total recorded
Monogenea	52	39	0	91	90	85	0	175	266
Trematoda	15	17	0	32	82	27	1	110	142
Copepoda	22	7	0	29	86	2	0	88	117
Nematoda	11	2	2	15	28	19	2	49	64
Cestoda	13	1	0	14	68	71	1	140	154
Acanthocephala	7	2	0	9	10	6	0	16	25
Myxozoa	1	7	0	8	11	5	0	16	24
Isopoda	3	0	0	3	8	1	0	9	12
Maxillopoda	0	1	0	1	0	0	0	0	1
Aspidogastrea	0	0	0	0	5	0	0	5	5
Annelida	0	0	0	0	2	0	0	2	2
Branchiura	0	0	0	0	1	1	0	2	2
	124	**76**	**2**	**202**	**391**	**217**	**4**	**612**	**814**

*The 2016 data were taken from the Luque *et al*. (2016).

Parasites from marine fishes were most commonly reported with *Sarda chiliensis* Cuvier, 1832 (n=23) and *Paralabrax humeralis* Valenciennes, 1828 (n=19) being reported most frequently. The freshwater fishes with the most parasite records were *Colossoma macropomum*, Cuvier, 1818 (n=9), *Sorubim lima* Bloch & Schneider 1801, *Brochis multiradiatus* Orcés, 1960*, Brycon amazonicus* Spix & Agassiz, 1829 and *Osteoglossum bicirrhosum* Cuvier, 1829 (each with 5 reports).

Parasites with the most reports were the larval stage of the diphyllobothriidean *Adenocephalus pacificus* Nybelin, 1931 (n=28), larvae of *Anisakis* sp. (n=8) and larvae of *Contracaecum* sp. (n=3), all of which are parasitic in marine fishes, except for *Contracaecum* sp., which is parasitic in marine and freshwater fish. The localities with the highest number of records were Lima (n=113), Loreto (n=76), Tumbes (n=32) and Piura (n=21) (Fig. 01).

Peru is a megadiverse country, and this is reflected in its fishes also. Fishing is considered a strategic activity to boost the country's economy (INEI, 2022), and is an important source of protein for the economically vunerable.

Based on studies carried out in the last years, an update of the checklist of parasitic metazoans in fish from the coastal, highlands regions and the Amazon basin of Peru is presented. The present updated records include the following taxonomic groups: Acanthocephala, Crustacea (Copepoda, Malacostraca and Maxillopoda), Myxozoa, Nematoda and Platyhelminthes (Monogenea, Trematoda and Cestoda).

In the present study, the highest parasite prevalence was recorded in four departments: Lima, Loreto, Piura, and Tumbes, with the department of Lima showing the highest number of records of parasitized hosts (n=11). The fact that a higher record of parasitic hosts is probably attributable to a high ichthyodiversity of species in the marine environment than in freshwater environments. The Peruvian

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coastal waters have around 1081 species of fish (MINAM, 2021). While in freshwater environments, approximately 873 species have been recorded (MEZA-VARGAS *et al.*, 2021).

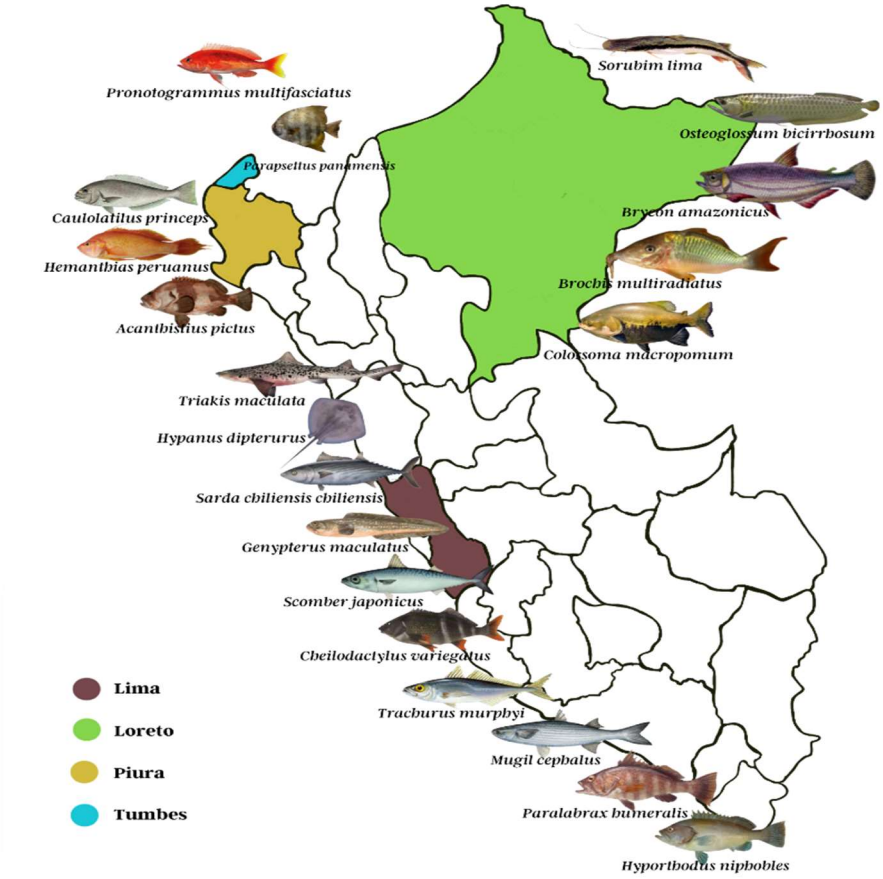

Figure 01: Environmental distribution of the fish with the highest parasitic prevalence recorded in 4 provinces: Lima, Loreto, Piura and Tumbes.

The highest richness of parasites was observed in monogeneans (n=91), followed by trematodes (n=32) and copepods (n=29), considering monogeneans as the dominant group of parasites. In the 2016 checklist it was also evidenced that monogeneans were the group with the highest parasitic record with 175 species recorded. In studies realized in Brazil and Argentina, monogeneans have also been recorded as the dominant group with a richness of 50 and 14 species recorded, respectively (RAUQUE *et al*., 2018; LEHUN *et al*., 2020). In relation to the data collected, this taxonomic group has a high affinity with both freshwater and marine fish, so it is suggested that environmental factors of both environments favor parasitosis, as mentioned by Violante-González *et al.* (2020), that the high or low association of these ectoparasites with their hosts is usually influenced by factors such as habitat, behavior and host density, as well as environmental characteristics.

Nematodes (n=15) and cestodes (n=14) were also important parasites. Two genera of public health interest were recorded: *Anisakis* (Nematoda) and *Adenocephalus* (Cestoda), in adult and larval stages, mainly infecting the digestive tract in freshwater and marine fishes. These taxonomic groups are relevant because they have zoonotic importance. The infective stages of these endoparasites are plerocercoids in cestodes and third instar larvae in nematodes, these are localized at the viscera or muscle tissue in fish (FERRE, 2001). The genera *Anisakis* and *Adenochepahlus* recorded in this review

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are responsible for two zoonotic diseases known as Anisakiasis and Diphyllobothriasis. These infections can be transmitted to humans through the consumption of raw or undercooked fish (VICENTE, 2016). Although the records obtained show a low zoonotic potential for transmission to humans. Nevertheless it is necessary to carry out sanitary controls to control parasitic species with zoonotic potential.

Other groups of parasites, such as Acanthocephala, Isopoda, Maxillopoda, were represented by few species.

The species of bony fish that presented a greater parasitosis were *Sarda chiliensis* (n=23), *Paralabrax humeralis* (n=19), *Mugil cephalus* (n=13), *Trachurus murphyi* (n=11), *Scomber japonicus* (n=10), *Cheilodactylus variegatus* (n=10), *Coryphaena hippurus* (n=09), *Hemanthias peruanus* (n=09), *Parapsettus panamensis* (n=09), *Pronotogrammus multifasciatus* (n=08), *Genypterus maculatus* (n=08), *Caulolatilus princeps* (n=08). *Sarda chiliensis* presented the highest parasite load among the twelve species mentioned. Of the total number of parasite species recorded, these do not directly represent a risk to human health. Nevertheless, better management of quality control is required in establishments that distribute fish for direct human consumption, since the presence of parasites in fish accelerates the decomposition process, thus devaluing its commercial value. And within the cartilaginous fish group, the species with the highest parasitic prevalence was *Triakis maculata* with seven species of parasites: four species of ectoparasites (monogeneans and copepods) and three species of endoparasites (nematodes and cestodes), with the copepod group registering the highest number of parasites.

Caira *et al*. (2012) mention that copepods are one of the most diverse groups of ectoparasites that parasitize elasmobranchs followed by monogeneans. One other group of relevance are the cestodes. They are the most diverse group of metazoan parasites of elasmobranchs and represent more than half of the species described for this group (MÉNDEZ and DORANTES–GONZÁLEZ, 2017). The presence of parasitic helminths in elasmobranchs is due to various factors, especially the ingestion of prey that act as intermediate hosts of larval stages and by ingestion of definitive hosts constituting an accidental transmission (WEAVER and SMALES 2014). Another factor to highlight is that the parasite load in elasmobranchs will depend on the depths at which they live.

CONCLUSIONS

In the present study, a higher parasites register was observed in the coastal zone of Peru and the diversity of metazoan parasites in Peruvian fish increased by 814 (25,18%) from 2016 to 2021. This would suggest that more studies need to be done in relation to the identification of parasitic species in fishes, to determine the prevalence of parasitosis and to identify species that may pose a health risk, like the *Anisakis* and *Adenocephalus* genera registered in the study.

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