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Anisakis and anisakidosis: hosts and case reports in South America. Systematic review

Anisákidos y anisakidosis: reportes de caso y hospedadores en América del Sur. Revisión sistemática

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Abstract

Introduction: Anisakidosis is a disease caused by the consumption of raw or undercooked seafood parasitized by nematode larvae of the family Anisakidae. Even though it is a public health issue in Europe and Asia, it is relatively unknown in South America.
Objective: To present case reports on anisakidosis and the intermediate hosts of *Anisakis* reported in South America.
Materials and methods: A systematic review was conducted in Medline, Cochrane, Embase, LILACS and Scopus using a structured search of MeSH and DeCS descriptors. The search strategy included publication period: inception of each database-September 2018; languages: English, Spanish, and Portuguese; and study types: case reports and observational cross-sectional studies. The review was complemented with an unstructured search in SciELO and Google Scholar.
Results: The initial search yielded 172 articles. After removing duplicates and reviewing the inclusion criteria, 69 studies were selected for full analysis: 19 case reports and 50 host records. The most reported form of anisakidosis was gastrointestinal anisakidosis with 45 cases; this infectious disease was caused by a single larva in 41 people (91.1%). Reports of 95 species of fish for human consumption parasitized by larvae of the genera *Anisakis, Contracaecum, Pseudoterranova* and *Hysterothylacium* were identified in Argentina (22 fish species), Brazil (34 species), Chile (15 species), Colombia (17 species), Ecuador (8 species), Peru (7 species), Uruguay and Venezuela (2 species each).
Conclusion: Anisakidosis is a latent risk in South America, so it is necessary to establish effective regulations for efficiently controlling the appearance of this parasitic disease in the region. Furthermore, the general population should receive more information about the precautions regarding saltwater fish consumption.
Keywords: *Anisakis;* Anisakiasis; South America; Zoonoses; Communicable Diseases, Emerging (MeSH).

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Resumen

Introducción. La anisakidosis es una parasitosis ocasionada por el consumo de pescado de mar crudo o semicrudo parasitado por larvas de nematodos de la familia Anisakidae. En Europa y Asia es un problema de salud pública; sin embargo, en América del Sur es poco conocida.
Objetivo. Identificar los reportes de caso de anisakidosis y los hospedadores intermediarios de anisákidos reportados en América del Sur.
Materiales y métodos. Se realizó una revisión sistemática en Medline, Cochrane, Embase, LILACS y Scopus mediante la búsqueda estructurada de términos MeSH y DeCS. Estrategia de búsqueda: periodo de publicación: inicio de cada base de datos-septiembre de 2018; idiomas: inglés, español y portugués; tipos de estudio: reportes de caso y estudios transversales observacionales. La revisión fue complementada con una búsqueda no estructurada en SciELO y Google Scholar.
Resultados. La búsqueda inicial arrojó 172 artículos. Una vez removidos los duplicados y revisados los criterios de inclusión, se seleccionaron 69 estudios para análisis completo: 19 reportes de caso y 50 registros de hospedadores. La forma de anisakidosis más reportada fue la gastrointestinal, con 45 casos, donde la parasitosis fue causada por una larva única en 41 casos (91.1%). Se identificaron reportes de 95 especies de peces para consumo humano parasitadas por los géneros Anisakis, Contracaecum, Pseudoterranova e Hysterothylacium en los siguientes países: Argentina (22 especies), Brasil (34 especies), Chile (15 especies), Colombia (17 especies), Ecuador (8 especies), Perú (7 especies), Venezuela (4 especies) y Uruguay (2 especies).
Conclusión. La anisakidosis es un riesgo latente para América del Sur, por lo que es necesario instaurar normativas efectivas para controlar su aparición en la región y brindar más información a la población general sobre las precauciones necesarias en relación con el consumo de pescado de agua salada.
Palabras clave: Anisakis; Anisakiasis; América del Sur; Zoonosis; Enfermedades Transmisibles Emergentes (DeCS).

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Introduction

Anisakidosis is a parasitic disease that affects humans. Although most patients are asymptomatic, it can cause gastrointestinal symptoms and allergic or gastroallergic reactions.[1] This infection occurs when third-stage larvae (L3) of parasitic nematodes of the family Anisakidae are ingested through raw or undercooked fish or cephalopods.[2]

According to Jofré *et al.*,[3] the term anisakidosis was introduced by Straub in 1960, the same year in which Van Thiel and colleagues reported the first case of this disease in the Netherlands.

The symptoms of anisakidosis are explained by two pathophysiological mechanisms: an immediate hypersensitivity reaction and an inflammatory reaction.[4] Therefore, as mentioned above, symptoms may range from allergic reactions to gastrointestinal manifestations. This infection, which is more frequently observed in adults, is usually caused by a single larva, although there are case reports of more than one larva.[4]

Some of the species associated with anisakidosis are *Anisakis simplex*, *Anisakis physeteris* and *Pseudoterova decipiens*, as well as the genus *Hysterothylacium*.[3,5,6] To diagnose this disease, the symptoms of the patients and their history of consumption of raw or undercooked fish or cephalopods must be reviewed. In the presence of gastrointestinal symptoms, it is necessary to detect and identify the larvae, either in vivo by endoscopy or in situ with a biopsy.[4] Depending on the location of the larva, anisakidosis may be gastric, intestinal, or extraintestinal (lung, liver, and pancreas).[7]

On the other hand, in the presence of allergic symptoms, it is not necessary to directly visualize the larva since the symptoms are mainly attributed to the immune response of the host and the diagnosis is usually made using serological tests.[1] It should be noted that when the result of these tests is positive, a cross-reaction with other ascarids should be ruled out.[8] The allergic and gastroallergic forms are characterized by urticaria, angioedema or anaphylaxis, along with digestive symptoms.[9,10]

In Europe and Asia, more than 2 000 cases of anisakidosis are reported each year; for this reason, as stated by Audícana *et al.*,[11] authorities have extensively studied the disease and have established rules for its control and prevention. On the contrary, in South America, despite having a large fishery industry, anisakidosis is not a common disease and, therefore, its clinical manifestations are little known by the healthcare staff. This creates difficulties with the diagnosis and could lead to underreporting of the disease.[12] Likewise, the information available in the region about this disease is mostly found in some research papers and in a few case reports published in specialized journals,[13-15] but there is no updated review of the subject.

Consequently, the objective of this review was to describe intermediate hosts and identify case reports of anisakidosis published in South America, with a focus on the major marine fish species that could be involved in their transmission, given that this infection is considered a potential emerging disease in the region that needs to be known, studied, and treated.

Materials and methods

A systematic review was conducted to answer two questions: What are the clinical cases of anisakidosis reported in South America? and What are the fish species reported as hosts of anisakid nematodes in South America?

Eligibility criteria

Case reports and cross-sectional observational studies were included in the search. Inclusion criteria for case reports on anisakidosis were that one or more larvae of the family Anisakidae had been identified in the patients that had a history of fish consumption likely to be parasitized by nematode larvae from this family and that came from any South American country.

Also, to identify the hosts, studies reporting cases of fish for human consumption parasitized by nematodes of the family *Anisakidae* and captured in South American waters were included. Studies that did not have the information required to determine their eligibility and whose authors did not respond to the request for such data were excluded.

Search strategy

A structured search using MeSH and DeCS terms was performed in Medline, Cochrane, Embase, LILACS and Scopus databases based on the following search strategy: publication period: from the inception of each database until September 2018; languages: English, Spanish and Portuguese; type of studies: case reports and cross-sectional observational studies; search terms: "Anisakids", "Anisakiasis", "Anisakidosis", "Anisakidae", "Anisakis", "Pseudoterranova" and "Contracecum", which were combined with each of the South American country names (Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Uruguay and Venezuela).

The following is the search equation was used in MEDLINE and Cochrane (tiab means Title/Abstract): ((((anisakis [tiab] OR pseudoterrova [tiab] OR anisakidae [tiab] OR Anisakiosis [tiab] OR ANISAKIASIS [tiab] OR) AND (Argentina [tiab] OR BOLIVIA [tiab] OR BRAZIL [tiab] OR CHILE [tiab] OR COLOMBIA [tiab] OR ECUADOR [tiab] OR FRENCH GUIANA [tiab] OR GUYANA [tiab] OR PARAGUAY [tiab] OR PERU [tiab] OR Suriname [tiab] OR Uruguay [tiab] OR Venezuela [tiab] OR)) OR (("South America"[Mesh]) AND "Anisakis"[Mesh]).

The database search was complemented by an unstructured search in SciELO and Google Scholar and with additional studies recommended by experts in the field. Similarly, the reference lists of the included narrative reviews were assessed to identify publications potentially relevant to the objective of the study, which were also included in the analysis.

The prevalence of infection in articles reporting unspecified hosts was calculated as the ratio between the number of fish parasitized by species of the family *Anisakidae* and the number of fish reviewed, if available.

Results

The initial search yielded 166 results (140 from the databases and 26 from SciELO, Google Scholar and

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expert recommendations), of which 73 were excluded because they were duplicates, 4 because they were incomplete and 26 because they did not meet the inclusion criteria. Subsequently, the reference lists of the 63 publications found were assessed and 6 additional articles were identified, resulting in a total of 69 publications to be included in the review: 16 case reports, 3 seroprevalence studies, and 50 host records (Figure 1). The characteristics of the selected articles are described in Table 1.

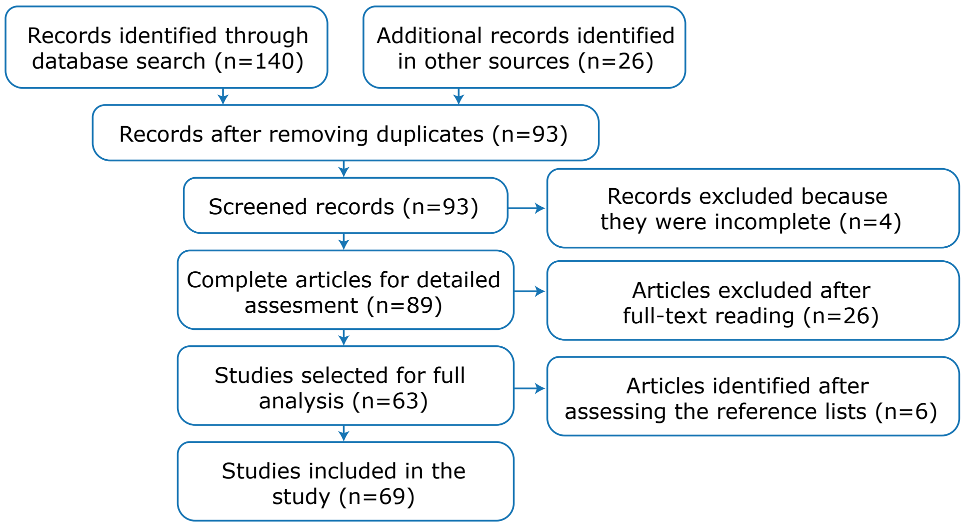

Figure 1. Study search and selection flowchart.
Source: Own elaboration.

Table 1. General characteristics of articles selected for review.

Authors Year	Place of publication	Type of publication	Human/ Host	Sample size (n)	Relevance
Figueiredo *et al.* 2013	Brazil	RA	Humans	67	Positive anti-*Anisakis simplex* immunoglobulin E response
Jofré *et al.*[3] 2008	Chile	CR	Humans	1	Infection with *Pseudoterrova decipiens* after the ingestion of sushi
Castellanos *et al.*[12] 2017	Colombia	RA	Hosts	15	Presence of anisakid nematode larvae parasitizing *Mugil cephalus*
Cabrera & Suárez-Ognio[13] 2002	Peru	C	Hosts	2	Two probable cases of anisakidosis
			Humans	12	Presence of *Anisakis* larvae in *Coryphaena hippurus*
Cabrera & Trillo-Altamirano[14] 2004	Peru	SpC	Humans	1	Probable case of infection by a L4 *P. decipiens* larvae
Mercado *et al.*[15] 2001	Brazil	SC	Humans	7	Identification of seven cases of infection by L4 *P. decipiens* larvae
Torres *et al.*[16] 2007	Chile	RN	Humans	4	Outbreak of pseudoterranovosis in three out of four people who shared the same dish of raw fish (ceviche)
Weitzel *et al.*[17] 2015	Chile	LE	Humans	3	Report of three cases of infection with *Pseudoterranova cattani*
Mercado *et al.*[18] 2006	Chile	CLC	Humans	1	Patient infected with a L4 *Pseudoterranova* sp. larva
Menghi *et al.*[19] 2011	Argentina	CLC	Humans	1	Larva of the *Anisakis-Contraecum* complex in the stool of a girl
Mayo-Iniguez *et al.*[20] 2014	Argentina	SC	Hosts	15	Molecular diagnosis of *Anisakis typica* and *Anisakis physeteris* in larvae of hosts of the Brazilian coast
Timi *et al.*[21] 2014	Argentina	RA	Hosts	34	Molecular diagnosis of *P. cattani* in fish from Argentine waters

Table 1. General characteristics of articles selected for review. (continued)

Authors Year	Place of publication	Type of publication	Human/ Host	Sample size (n)	Relevance
Wadnipar-Cano[22] 2014	Colombia	T	Hosts	360	Parasitic infestation by anisakid nematodes in river fish in the municipality of San Marcos, Colombia.
Dias *et al.*[23] 2010	Brazil	OA	Hosts	100	Parasitation by *Anisakis* spp. and *Contraecum* sp. of *Aluterus monoceros* purchased in markets of the municipalities of Niteroi and Rio de Janeiro, Brazil
Cabrera *et al.*[24] 2003	Peru	PR	Humans	1	Case of human anisakidosis due to L3 *P. decipiens* larva.
Tanteleán & Huiza[25] 1993	Peru	PR	Humans	2	*P. decipiens* larvae obtained from the mouth of two people in Lima, Peru
Barriga *et al.*[26] 1999	Peru	PR	Humans	1	Extraction of larvae by endoscopy, subsequently identified as *Anisakis* spp., in a patient from Lima, Peru
Rosa-da Cruz *et al.*[27] 2010	Brazil	SC	Humans	1	First evidence of larvae similar to *Anisakis* spp. causing gastrointestinal lesions in Brazil
Patiño & Olivera[28] 2019	Colombia	CP	Humans	1	First case of anisakiasis in Colombia
Puccio *et al.*[29] 2008	Venezuela	OA	Humans	144	Report of a high percentage (45%) of children with positive skin tests for *A. simplex* extract
Verhamme & Ramboer[30] 1988	Chile	CR	Humans	6	Case compatible with gastrointestinal anisakidosis after eating salmon in Chile
Torres *et al.*[31] 2000	Chile	CR	Humans	1	Elimination of L2 anisakid larvae in a man from Santiago de Chile who had previously eaten shellfish and raw fish.
Mercado *et al.*[32] 1997	Chile	N	Humans	1	Extraction of L4 *P. decipiens* larva during gastrointestinal biopsy of the stomach in a man from southern Chile
Figueiredo *et al.*[33] 2015	Brazil	OA	Humans	309	Reactivity to anti-*Anisakis* in pregnant mothers in Brazil
Mancini *et al.*[34] 2014	Argentina	OA	Hosts	1402	Identification of *Contraecum* sp. larvae compatible with type 2 L3 larvae in 9 fish species from 19 aquatic environments in Argentina
Ulloa-Ulloa & Carrasco-Mancero[35] 2008	Colombia	T	Hosts	167	Identification of three fish species from Ecuador parasitized by *Contracecum* sp.
Oliverero-Verbel & Baldiris-Avila[36] 2008	Colombia	B	Hosts	Unknown	Identification of multiple species of fish parasitized by nematodes the family Anisakidae in Colombia
Hernández-Orts *et al.*[37] 2013	Argentina	RA	Hosts	542	Identification of *Pseudoterranova* sp. larvae and molecular identification of *P. cattani* in 12 fish species from Patagonia, Argentina.
Castellanos *et al.*[38] 2018	Ecuador. Colombia	OA	Hosts	438	Identification by taxonomic revision of 8 species of host fish of the genera *Anisakis* sp. and *Pseudoterranova* sp. from Ecuador and Colombia
Luque & Alves[39] 2001	Brazil	OA	Hosts	115	Identification of anisakid nematodes in two fish species from Brazil
Knoff *et al.*[40] 2001	Brazil	OA	Hosts	217	Identification of multiple genera of the family Anisakidae parasitizing elasmobranch fish in Brazil.
Rodrigues[41] 2010	Brazil	T	Hosts	52	Presence of anisakids in a fish species marketed in Brazil

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Table 1. General characteristics of articles selected for review. (continued)

Authors Year	Place of publication	Type of publication	Human/ Host	Sample size (n)	Relevance
Timi *et al.*[42] 2000	Argentina Uruguay	OA	Hosts	2086	Identification of four species of anisakid nematode larvae in a fish species from Argentine and Uruguayan waters.
Chavez *et al.*[43] 2007	Chile	CP	Hosts	300	Larvae of *Anisakis* sp. nematodes found in samples of a fish species obtained in two localities in Chile
Bracho-Espinoza *et al.*[44] 2013	Venezuela	OA	Hosts	180	Identification of anisakids in three species of fish from Venezuela
Marigo *et al.*[45] 2015	Brazil	CR	Hosts	1	Identification of Pseudoterranova azarasi in cod sold for human consumption in Brazil
de Paula Toledo Prado & Capuano[46] 2006	Brazil	SC	Hosts	11	Presence of nematodes larvae of the family Anisakidae in cod samples from a Brazilian locality
Torres *et al.*[47] 2014	Chile	OA	Hosts	280	Identification of *Pseudoterranova* sp. in *Thyrsites atun* from Chile, and of other anisakid larvae in two other fish species.
Di Azevedo & Iñiguez[48] 2018	Brazil	RA	Hosts	180	Molecular identification of *Hysterothylacium dearddorffoverstreetorum* (s.l) in three fish species from Brazil.
Pardo *et al.*[49] 2007	Colombia	OA	Hosts	45	Identification of *Salminus affinis* fish from the Sinú and San Jorge rivers parasitized by *Contracecum* sp. anisakids
Knoff *et al.*[50] 2013	Brazil	OA	Hosts	87	Collection of anisakid in larval stages in *Lophius gastrophysus* specimens from Brazil
Torres-Frenzel[51] 2013	Chile	T	Hosts	78	Isolation of L3 anisakid *Pseudoterranova* sp. nematodes in ceviche servings in Chilean restaurants
Torres *et al.*[52] 1993	Chile	RN	Hosts	57	Identification of nematode larvae of the family Anisakidae in five fish species in southern Chile
Vicente *et al.*[53] 1989	Venezuela	OA	Hosts	136	Presence of *Contracecum* sp. (s.l) in *Micropogonias furnieri* from Venezuela
Fernández *et al.*[54] 2016	Chile	BC	Host	1	Identification of larval forms of *Anisakis* sp. (Type I, L3) in the intestinal serosa of ocean sunfish from Chile
Olivero-Verbel *et al.*[55] 2005	Colombia	OA	Hosts	386	Presence of L3 larvae of the family Anisakidae in mugilids from two locations on the Colombian Atlantic Coast
Soares *et al.*[56] 2018	Argentina Brazil	OA	Hosts	186	Identification of anisakid genus in a fish species from Argentine and Uruguayan waters.
Saad & Luque[57] 2009	Brazil	RN	Hosts	36	Collection of *Anisakis* sp. and *Contraecum* sp. larvae in fish from the coastal zone of Rio de Janeiro, Brazil
Soares *et al.*[58] 2014	Brazil	OA	Hosts	100	Presence of *Pseudoterranova* sp. larvae in fish from the coast of Cabo Frio, Brazil
Paraguassú *et al.*[59] 2002	Brazil	OA	Hosts	90	Collection of parasites of the family Anisakidae in fish from the Brazilian coast
Farias-Rabelo *et al.*[60] 2017	Brazil	OA	Hosts	25	Identification of fish infested with L3 larvae of the family Anisakidae in Brazil
Braicovich & Timi[61] 2008	Argentina Uruguay	OA	Hosts	177	Presence of three genera of the family Anisakidae in fish caught in fishing waters located between Argentina and Uruguay

Table 1. General characteristics of articles selected for review. (continued)

Authors Year	Place of publication	Type of publication	Human/ Host	Sample size (n)	Relevance
Pantoja *et al.*[62] 2015	Brazil	OA	Hosts	50	Molecular identification of *A. typica* and *Hysterothylacium* sp. larvae in two fish species from Rio de Janeiro, Brazil
Kuraiem *et al.*[63] 2016	Brazil	OA	Hosts	30	Identification of species marketed in Rio de Janeiro, Brazil, parasitized by *Anisakis* sp. and *Hysterothylacium deardorfoverstreetorum* larvae
Timi & Lanfranchi[64] 2009	Argentina	RA	Hosts	100	Identification of larvae of the family Anisakidae in a species of fish inhabiting the Argentine sea
Ramallo & Torres[65] 1995	Argentina	OA	Hosts	10	Isolation and morphological identification of *Contraecum* sp. in a fish species from the of Rio Hondo pond, Argentina
González *et al.*[66] 2006	Argentina Chile Peru	OA	Hosts	626	Presence of endoparasites of the genus *Anisakis* sp. in a species of fish present on the Pacific Coast of South America
Hamann[67] 1999	Argentina	OA	Hosts	237	Finding of fish from northeastern Argentina parasitized by *Contracecum* sp. larvae
Mattiucci *et al.*[68] 2002	Brazil	OA	Hosts	6	Detection of *A. typica* in multiple fish on the Atlantic Coast of Brazil
Peña-Rehbein *et al.*[69] 2012	Chile	RN	Hosts	20	Description of the frequency and number of *Anisakis* spp. nematodes in the internal organs of *T. atun* fish from Queule, Brazil
Oliva[70] 1999	Chile Peru	OA	Hosts	3034	Identification of anisakid nematodes in a fish species whose specimens were captured in Chile and Peru.
Novo-Borges *et al.*[71] 2012	Brazil	RA	Hosts	64	Morphological and molecular identification of *A. typica* and *Hysterothylacium* sp. larvae in two fish species from Brazil
Braicovich *et al.*[72] 2017	Argentina Brazil	RA	Hosts	488	Identification of larvae of the family Anisakidae in fish from the coastal region of South America between Rio de Janeiro and northern Argentina
Andrade-Porto *et al.*[73] 2015	Brazil	OA	Hosts	100	Identification of *Arapaima gigas* parasitized by L3 larvae of *Hysterothylacium* sp.
Torres *et al.*[74] 1998	Chile	OA	Hosts	80	Identification of *Hysterothylacium geschei* larvae in fish from Brazil
Maniscalchi Badaoui *et al.*[75] 2015	Venezuela	OA	Hosts	913	Identification of fresh fish of popular consumption in Venezuela parasitized by anisakid nematodes
Ruiz & Vallejo[76] 2013	Colombia	OA	Hosts	378	Identification of *Contracecum* sp. and *Pseudoterrova* sp. nematode larvae in *Mugil* cephalus from the Colombian Caribbean
Bicudo *et al.*[77] 2005	Brazil	OA	Hosts	80	Identification of larvae of anisakid nematodes, *Anisakis* sp. and *Hysterothylacium* sp. in fish from the coastal zone of Rio de Janeiro, Brazil
Knoff *et al.*[78] 2012	Brazil	OA	Hosts	60	Characterization of larvae in fish from the state of Rio de Janeiro as H. *deardorffoverstreetorum* sp. nov. larvae

RA: research article; CR: case report; C: communication; SpC: special contribution; SC: short communication; RN: research note; LE: letter to editor; CLC: clinical case; T: thesis; OA: original article; CP: case presentation; N: notes and information; B: book; CA: conference article; BC: brief communication.
Source: Own elaboration.

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Clinical cases of anisakidosis in South America

In Europe and Asia, anisakidosis is considered a public health issue due to the large number of cases reported with gastric, allergic and gastroallergic symptoms; however, in South America, it is still a little-known disease. Table 2 presents a summary of clinical cases associated with anisakid parasites in South America published between 1976 and 2018.

Table 2. Clinical cases associated with anisakid nematodes in South American countries.

No	Year	Country	Patient	Food previously ingested	Symptoms	Identified anisakid	Symptoms	Diagnostic method	Ref
1	1976	Chile	No description	Ceviche	Gastrointestinal	*Pseudoterranova* sp.	Gastrointestinal	Observation of expelled larvae	3
2	1980	Chile	No description	Chilean jack mackerel	Gastrointestinal	*Anisakis* sp.	Gastrointestinal	Gastric endoscopy	3
3	1980	Chile	35-year-old woman	No data	Esophageal pain and productive cough	*Anisakis* sp.	Gastrointestinal	Observation of expelled larvae	32
4	1985	Chile-Belgium	62-year-old man	Raw salmon	Abdominal cramps, small bowel obstruction, slow intestinal transit with area of edematous gastric folds, and transition from a slightly dilated jejunum to a normal ileum	No data	Intestinal	X-ray	30
5	1993	Peru	Men without age report	No data	Oropharyngeal pain	*Pseudoterranova decipiens*	Oropharynx	Observation of the larva in the oral cavity	25
6	1995	Paraguay-Chile	Man without age report	Ceviche	Cough	*Anisakis* sp.	Oropharynx	Identification of expelled larvae	16
7	1997	Chile	45-year-old man	Smoked fish	Acute epigastric pain and empty stomach feeling for three days	*P. decipiens* L4 larva	Gastric	Gastric endoscopy	32
8	1997	Peru	42-year-old woman	No data	No data	*Anisakis simplex*	Oropharynx	Observation of larvae	14
9	1997	Peru	22-year-old man	Mahi-mahi ceviche *(Coryphaena hippurus)*	Abdominal pain that decreased progressively and disappeared spontaneously after two days	*Anisakis physeteris*	Gastrointestinal	Epidemiological history	13
10	1997	Chile	10-year-old child	No data	Cough	*P. decipiens* L4 larva	Oropharynx	Morphological identification of the larva	15
11	1997	Chile	51-year-old woman	No data	Cough	*P. decipiens* L4 larva	Oropharynx	Morphological identification of the larva	15
12	1998	Chile	30-year-old woman	No data	Cough	*P. decipiens* L4 larva	Oropharynx	Morphological identification of the larva	15
13	1998	Chile	22-year-old woman	Chilean common hake slightly fried	Nausea, nasal pruritus, productive cough, and pharyngeal pain that persisted for one week after larva expulsion and was associated with a local allergic reaction	*P. decipiens* L4 larva	Gastroallergic	Morphological identification of the larva	15
14	1998	Peru	36-year-old man	Mahi-mahi ceviche *(C. hippurus)*	Abdominal discomfort eight hours after eating the ceviche that progressed to epigastric pain of increasing intensity within the first 24 hours. Symptoms ceased spontaneously 72 hours later.	*A. physeteris*	Gastric	Epidemiological history	13
15	1998	Peru	38-year-old woman	No data	Retrosternal burning sensation and sporadic colicky pain in right iliac fossa for one week	*Anisakis* spp.	Gastric	Direct observation of the larvae extracted by endoscopy.	26

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Table 2. Clinical cases associated with anisakid nematodes in South American countries. (continued)

No	Year	Country	Patient	Food previously ingested	Symptoms	Identified anisakid	Symptoms	Diagnostic method	Ref
16	1999	Chile	55-year-old woman	Red cusk-eel *(Genypterus chilensis)* sushi	Cough	*P. decipiens* L4 larva	Oropharynx	Morphological identification of the larva	15
17	1999	Chile	37-year-old man	Ceviche	Nausea and pain in the pharynx	*P. decipiens* L4 larva	Oropharynx	Morphological identification of the larva	15
18	1999	Chile	26-year-old woman	No data	Productive cough	*P. decipiens* L4 larva	Oropharynx	Morphological identification of the larva	15
19	2000	Chile	38-year-old man	Mariscal (seafood and raw fish)	Persistent and disabling pain in the epigastrium that evolved into regurgitation of gastric contents (where the larva was found) and decreased in intensity over time until it disappeared after 15 days. Endoscopy of the upper gastrointestinal tract showed mild gastritis without ulcers or presence of other larvae.	*Anisakis* sp.	Gastric	Observation of the larva in the oral cavity	31
20	2001		40-year-old man	Pomfret *(Brama australis* ceviche	Foreign body sensation in the teeth (the patient found a larva when she was washing her teeth)	Anisakid nematode	Oropharynx	Identification of larvae after clarification process with lactophenol.	16
21	2001	Peru	42-year-old woman	No data	No data	*P. decipiens* L4	Oropharynx	Observation of larvae extracted from the oral cavity, initially classified as *Toxocara* sp.	14
22	2002	Peru	17-year-old woman	Chilean jack mackerel *(Trachurus murphyi)*, "bonito" *(Sarda chiliensis)* and tuna (*Thunnus* sp.) ceviche	Nausea and epigastric pain four hours after ingestion and nausea of greater intensity after an hour with sore throat and vomiting of food contents	*P. decipiens*	Gastric	Processing of the larva expelled in vomit	24
23	2002	Chile	54-year-old woman	Ceviche	Coughing and tingling in the pharynx	*Pseudoterranova* sp.	Oropharynx	Morphological identification of the larva	16
24	2002	Chile	19-year-old woman	Hake ceviche	No data	*Pseudoterranova* sp.	Oropharynx	Morphological identification of the larva	16
25	2002	Chile	43-year-old woman	Fried fish	Tingling in the pharynx	*Pseudoterranova* sp.	Oropharynx	Morphological identification of the larva	16
26	2002	Chile	50-year-old man	Hake ceviche	Coughing and tingling in the pharynx	*Pseudoterranova* sp.	Oropharynx	Morphological identification of the larva	16
27	2002	Chile	33-year-old woman	Hake ceviche	No data	*Pseudoterranova* sp.	Oropharynx	Morphological identification of the larva	16
28	2003	Chile	15-year-old child	Chilean jack mackerel ceviche	Severe cough	*Pseudoterranova* sp.	Oropharynx	Morphological identification of the larva	16
29	2003	Chile	26-year-old woman	Chilean common hake slightly fried	Heartburn and vomiting with larva presence	*Pseudoterranova* sp.	Gastric	Morphological identification of the larva	16

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Table 2. Clinical cases associated with anisakid nematodes in South American countries. (continued)

No	Year	Country	Patient	Food previously ingested	Symptoms	Identified anisakid	Symptoms	Diagnostic method	Ref
30	2003	Chile	47-year-old woman	Fried pomfret *(B australis)*	Sensation of asphyxia and increased production of oropharyngeal secretions after larval removal.	*Pseudoterranova* sp.	Gastroallergic	Morphological identification of the larva	16
31	2003	Chile	6-year-old child	Hake ceviche	Tingling in the pharynx with removal of two larvae through the oral cavity	*Pseudoterranova* sp.	Oropharynx	Morphological identification of the larva	16
32	2004	Chile	24-year-old woman	Hake ceviche	Severe cough with subsequent elimination of larvae through the oral cavity.	*Pseudoterranova* sp.	Oropharynx	Morphological identification of the larva	16
33	2004	Chile	Man without age report	Hake ceviche	No data	*Pseudoterranova* sp.	Oropharynx	Morphological identification of the larva	16
34	2004	Chile	Woman without age report	Hake ceviche	No data	*Pseudoterranova* sp.	Oropharynx	Morphological identification of the larva	16
35	2005	Chile	1-year-old girl	No data	Severe diarrhea, loss of appetite, and elimination of larva through the anus	*Pseudoterranova* sp.	Intestinal	Morphological identification of the larva	16
36	2005	Chile	Man without age report	Corvina *(Cilus gilberti)* ceviche	Foreign body sensation in the mouth, tingling in the larynx and severe cough before removing the larva (the patient found the larva when brushing his teeth).	*Pseudoterranova* sp.	Oropharynx	Morphological identification of the larva	16
37	2006	Chile	60-year-old woman	Ceviche	Heartburn, malaise, persistent nausea, abdominal distension, and flatulence for five days	*Pseudoterranova* sp.	Gastrointestinal	Morphological identification of the larva	18
38	2007	Chile	30-year-old woman	Raw salmon sushi	Coughing and sneezing	*P. decipiens*	Oropharynx	Morphological identification of the larva	3
39	2010	Brazil	73-year-old man	Raw seafood	Epigastric pain, sensation of fullness and early satiety. Improvement of symptoms after endoscopic removal of the larva. The patient died at 20 days from unknown causes	Family Anisakidae	Gastrointestinal	Direct observation of the larvae extracted by endoscopy.	27
40	2011	Argentina	9-year-old girl	No data	Nonspecific gastrointestinal symptoms for 9 days	*Anisakis - Contraecum* complex	Gastrointestinal	Morphological identification of the larva through photographs	19
41	2012-2014	Chile	Two women and two men between the ages of 22 and 59	Ceviche	Three patients regurgitated the larva after eating ceviche. One of them had a tingling sensation in the pharynx, nausea and cough before the larva was expelled; two patients had no symptoms, and there is no data on symptoms of the other patient.	*Pseudoterranova cattani*	Oropharynx	Morphological and molecular identification (DNA extraction with DNeasy Blood and Tissue Kit) of the expelled larvae	17
42									17
43									17
44									17
45	2018	Colombia	52-year-old woman	Fish-based raw food	Severe epigastric pain accompanied by nausea, loss of appetite, vomiting, diarrhea and urticaria for two days	*A. simplex*	Gastrointestinal	Morphological identification of larvae after processing with glutaraldehyde	28

Source: Own elaboration.

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Intermediate fish hosts of anisakids reported in South America

Anisakid nematodes are parasites present in marine mammals and fish species for human consumption. For example, in South America, fish parasitized by these species have been identified in Argentina, Brazil, Chile, Colombia, Ecuador, Peru and Venezuela. Table 3 lists the fish species identified as hosts of parasites of the family *Anisakidae* in the region.

Table 3. List of secondary fish hosts of Anisakidae parasites in South American countries.

Host		Country of origin	Genus and/or species	Sampled fish (n)	Prevalence of infection (%)	Ref
Scientific name	Common name					
Acanthisius patachonicus	ND	Argentina	*Pseudoterranova cattani*	16	25	37
				45	57.8	21
			Pseudoterranova sp.	45	42.2	21
Ageneiosus caucanus	"Doncella"	Colombia	*Contracecum* sp.	60	23.3	22
Aluterus monoceros	"Pez puerco"	Brazil	*Anisakis* sp.	100	1	23
			Contracecum sp.	100	16	23
Aphos porosus	ND	Chile	*Anisakis simplex*	8	13	52
			Pseudoterranova decipiens	8	75	52
Arapaima gigas	"Pirarucú"	Brazil	*Hysterothylacium* sp.	100	98	73
Austromenidia laticlavian	ND	Chile	*Contracecum* sp.	30	10	52
Astyanax eigenmanniorum	ND	Argentina	*Contracecum* sp.	ND	100	34
Auxis rochei	Bullet tuna	Ecuador.	*Anisakis physeteris*	6	50	38
Auxis thazard	Frigate tuna	Brazil	*Anisakis physeteris*	ND	ND	20
			Anisakis typica	ND	ND	20
Caquetaia kraussii	"Mojarra amarilla"	Colombia	*Contracecum* sp.	60	95	22
Caranx Hipos	Crevalle jack	Brazil	*Contracecum* sp.	60	3.3	39
	Chilean jack mackerel	Colombia	*Family Anisakidae*	12	8.5	36
	Crevalle jack	Brazil	*Pseudoterranova* sp.	60	6.7	39
Caranx latus	Horse-eye jack	Brazil	*Anisakis* sp.	55	1.8	39
			Contracecum sp.	55	18.2	39
			Hysterothylacium sp.	55	3.6	39
			Pseudoterranova sp.	55	32.7	39
Carcharhinus brachyurus	ND	Brazil	*Contracecum* sp.	7	2.5	40
Carcharhinus signatus	ND	Brazil	*Anisakis* sp.	5	60	40
			Contracecum sp.	5	40	40
Cauque mauleanum	"Cauque del maule"	Chile	*Anisakis simplex*	9	22	52
			Hysterothylacium geschei	14	78.9	74
Centropomus armatus	Armed snook	Colombia	*Anisakis physeteris*	12	42	38
Centropomus undecimalis	ND	Colombia	Family Anisakidae	23	4.3	36
Coryphaena hippurus	Common dolphinfish	Ecuador	*Anisakis physeteris*	69	30	38
	"Dorado"	Peru		12	58.33	14
				12	7	13
			Hysterothylacium sp.	12	4	13
Cottoperca gobio	ND	Argentina	*Pseudoterranova* sp.	8	12.5	37
Cynoscion spp.	ND	Brazil	*Anisakis* sp.	52	30.76	41
			Contracecum sp.	52	67.3	41
			Pseudoterranova sp.	52	3.84	41

Table 3. List of secondary fish hosts of Anisakidae parasites in South American countries. (continued)

Host		Country of origin	Genus and/or species	Sampled fish (n)	Prevalence of infection (%)	Ref
Scientific name	Common name					
Dipturus trachyderma	ND	Brazil	*Anisakis* sp.	8	25	40
			Contracecum sp.	8	62.5	40
Engraulis anchoíta	"Anchoíta"	Argentina Uruguay	*Anisakis simplex*	2 086	5.85	42
		Argentina Uruguay	*Contracecum* sp.	2 086	39.7	42
		Argentina Uruguay	*Pseudoterranova* sp.	2 086	0.34	42
Engraulis ringens	Peruvian anchoveta	Chile	*Anisakis* sp.	598	3	43
Eugerres plumieri	"Mojarra"	Venezuela	*Contracaecum* spp.	90	97	44
			Pseudoterranova spp.	90	3	44
Gadus sp.	Cod	Brazil	*Pseudoterranova azarasi*	ND	ND	45
Gadus macrocephalus	Zarbo cod	Brazil	Family Anisakidae	11	64	46
Galoeorhinus vitaminicus	ND	Brazil	*Anisakis* sp.	37	8.1	40
			Contracecum sp.	37	5.4	40
			Pseudoterranova sp.	37	5.4	40
Genypterus blacodes	Pink cusk-eel	Argentina	*Pseudoterranova* sp.	44	2.3	37
		Chile	*Anisakis* sp. (Type I)	81	7.4	47
			Anisakis sp. (Type II)	81	4.9	47
			Pseudoterranova spp.	81	53.1	47
Genypterus brasiliensis	ND	Brazil	*Anisakis typica*	60	1.7	48
			Hysterothylacium deardorffoverstreetorum (s.l)	60	5	48
Genypterus chilensis	ND	Chile	*Pseudoterranova decipiens*	18	50	47
Heptranchias perlo	ND	Brazil	*Anisakis* sp.	7	14.3	40
			Contracecum sp.	7	28.6	40
Hexanchus griseus	ND	Brazil	*Anisakis* sp.	1	100	40
			Contracecum sp.	1	100	40
Hexanematichthys sp.	"Bagre pintado"	Ecuador	*Contracecum* sp.	64	12.5	35
Hoplias malabaricus	Wolf fish	Argentina	*Contracecum* sp.	10	70	34
		Colombia	*Contracecum* sp.	227	100	36
				60	93.3	22
			Contracaecum spp.	45	100	49
Hoplias microlepis	"Trahira"	Ecuador	*Contracecum* sp.	64	25	35
Katsuwonus pelamis	Skip jack tuna	Ecuador	*Anisakis physeteris*	100	31	38
Larimus argenteus	Silver drum	Colombia	*Anisakis physeteris*	2	100	38
Lophius gastrophysus	Blackfin goosefish	Brazil	*Anisakis simplex*	87	1.14	50
			Hysterothylacium sp.	87	12.6	50
Macruronus magellanicus	ND	Chile	*Anisakis physeteris*	3	33	52
			Anisakis simplex	3	100	52
			Hysterothylacium sp.	4	1	47
				3	33	52
			Pseudoterranova decipiens	4	25	47
				3	33	52

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Table 3. List of secondary fish hosts of Anisakidae parasites in South American countries. (continued)

Host		Country of origin	Genus and/or species	Sampled fish (n)	Prevalence of infection (%)	Ref
Scientific name	Common name					
Merluccius australis	ND	Chile	*Anisakis* sp. *(Type I)*	104	8.7	47
			Pseudoterranova spp.	104	4.8	47
				78	21.8	51
Merluccius gayi	Hake	Ecuador	*Anisakis pegreffi*	62	92	38
			Anisakis physeteris	62	92	38
		Chile	*Anisakis simplex*	17	5.9	47
		Colombia	*Family Anisakidae*	126	26.19	36
		Chile	*Pseudoterranova decipiens*	17	23.5	47
Merluccius hubbsi	Argentine hake	Argentina	*Pseudoterranova* sp.	79	3.8	37
Micropogonias furnieri	"Corvina rubia"	Venezuela	*Contracecum* sp. *(s. l)*	136	0.7	53
		Brazil	*Hysterothylacium deardorffoverstreetorum (s.l)*	60	3.3	48
Mola mola	Ocean sunfish	Chile	*Anisakis* sp.	1	100	54
Mugil cephalus	Flathead gray mullet	Colombia	*Anisakis physeteris*	12	33	38
	"Lisa"	Peru	*Anisakis simplex*	ND	ND	14
		Colombia	*Anisakis* sp.	15	33	12
		Ecuador	*Contracecum* sp.	64	14	35
	"Lebranche"	Colombia	Family Anisakidae	19	100	36
Mugil curema	White mullet	Colombia	*Anisakis physeteris*	16	94	38
	"Lisa"	Venezuela	*Anisakis* spp.	143	47.16	75
			Contracaecum spp.	143	12.74	75
				90	97	44
			Pseudoterranova spp.	143	40.1	75
				90	3	44
	White mullet	Colombia	*Pseudoterranova decipiens*	16	94	38
Mugil incilis	"Lisa"	Colombia	*Contracaecum* spp.	378	100	76
			Pseudoterranova spp.	378	80.5	76
			Family Anisakidae	355	83.9	36
			Family Anisakidae	386	64.51	55
Mugil liza	"Lebranche"	Venezuela	*Anisakis* spp.	65	5.61	75
			Contracaecum spp.	65	84.39	75
			Contracaecum spp.	90	97	44
			Pseudoterranova spp.	65	10	75
				90	3	44
Mugil spp.	Mugil	Colombia	Family Anisakidae	5	100	36
Mullus argentinae	ND	Argentina	*Hysterothylacium dearddorffoverstreetorum (s.l)*	60	48.3	48
			Pseudoterranova sp.	2	100	37
Mustelus canis	ND	Brazil	*Anisakis* sp.	37	5.4	40
			Contracecum sp.	37	2.7	40
			Pseudoterranova sp.	37	10.8	40
Mustelus schmitti	ND	Brazil	*Contracecum* sp.	35	5.7	40
			Pseudoterranova sp.	35	2.9	40

Table 3. List of secondary fish hosts of Anisakidae parasites in South American countries. (continued)

Host		Country of origin	Genus and/or species	Sampled fish (n)	Prevalence of infection (%)	Ref
Scientific name	Common name					
Nemadactylus bergi	ND	Argentina	*Pseudoterranova* sp.	32	3.1	37
Odontesthes bonariensis	ND	Argentina	*Contracecum* sp.	ND	5	34
Oligosarcus jenynsii	ND	Argentina	*Contracecum* sp.	ND	54	34
Oreochromis niloticus	Nile tilapia	Ecuador	*Contracecum* sp.	64	14.06	35
Pagrus pagrus	Red porgy	Argentina	*Anisakis simplex*	38	23.8	56
		Brazil	*Anisakis simplex (s.l)*	148	85.13	56
			Anisakis sp.	36	5.56	57
				100	40	58
				ND	7.7	59
			Contracecum sp.	38	5.3	56
				36	8.33	57
				100	3	58
		Argentina	*Hysterothylacium* sp.	38	100	56
		Brazil		36	13.89	57
				100	90	58
				ND	93.3	59
				148	4.05	56
			Pseudoterranova sp.	100	6.6	58
Paralichthys isosceles	ND	Argentina	*Pseudoterranova cattani*	15	26.7	37
		Brazil	*Hysterothylacium deardorffoverstreetorum* sp. *nov.*	60	ND	78
Paralichthys microps	ND	Chile	*Anisakis simplex*	10	10	47
			Pseudoterranova decipiens	10	70	47
Pellona castelnaeana	ND	Brazil	Family Anisakidae	10	100	60
Percophis brasiliensis	Brazilian flathead	Argentina, Uruguay	*Anisakis simplex*	177	5.08	61
		Brazil	*Anisakis* sp.	178	14.6	72
		Argentina, Uruguay	*Contracecum* sp.	177	5.08	61
		Brazil	*Contracecum* sp.	178	6.74	72
			Hysterothylacium aducum	178	0.56	72
			Hysterothylacium fortalezae	178	2.8	72
		Argentina, Uruguay	*Hysterothylacium* sp.	177	74.01	61
		Brazil	*Hysterothylacium* sp.	178	97.19	72
		Argentina	*Pseudoterranova cattani*	8	25	37
Pimelodus albicans	ND	Argentina	*Contracecum* sp.	ND	100	34
Pinguipes brasilianus	ND	Brazil	*Hysterothylacium* sp.	25	100	62
Plagioscion magdalenae	"Pacora"	Colombia	*Contracecum* sp.	60	46.7	22
Plagioscion squamosissimus	ND	Brazil	Family Anisakidae	5	100	60
Paralonchurus peruanus	"Suco"	Peru	*Anisakis simplex*	ND	ND	14
Priacanthus arenatus	ND	Brazil	*Anisakis* sp.	30	20	63
			Hysterothylacium deardorffoverstreetorum	30	66.7	63

Table 3. List of secondary fish hosts of Anisakidae parasites in South American countries. (continued)

Host		Country of origin	Genus and/or species	Sampled fish (n)	Prevalence of infection (%)	Ref
Scientific name	Common name					
Prionotus nudigula	ND	Argentina	*Pseudoterranova cattani*	32	100	37
Prionotus punctatus	"Cabrinha"	Brazil	*Anisakis* sp.	80	17.5	77
			Hysterothylacium sp.	80	97.5	77
Pseudopercis númida	Namorado sandperch	Brazil	*Anisakis typica*	25	4	62
			Hysterothylacium sp.	25	88	62
Pseudopercis semifasciata	Sea salmon	Argentina	*Anisakis simplex*	100	45	64
			Contracecum sp.	100	26	64
			Hysterothylacium aducum	100	43	64
			Hysterothylacium sp.	100	79	64
			Pseudoterranova sp.	100	35	64
				131	25.8	64
Pseudoplatystoma magdaleniatum	"Bagre pintado"	Colombia	*Contracecum* sp.	60	95	22
Rhamdia quelen	ND	Argentina	*Contracecum* sp.	ND	100	34
Salminus affinis	"Rubio"	Colombia	*Contracecum* sp.	45	95	49
Salminus maxillosus	"Dorado"	Argentina	*Contracecum* sp.	10	80	65
Sarda chiliensis	"Bonito"	Peru	*Anisakis physeteris*	ND	ND	14
Sciades herzbergii	Pemecou sea catfish	Colombia	Family Anisakidae	64	1.6	36
Sciaena deliciosa	"Lorna"	Peru	*Anisakis simplex*	ND	ND	14
Scomber japonicus	Chub mackerel	Peru	*Anisakis physeteris*	ND	ND	14
			Anisakis simplex	ND	ND	14
	"Bonito"		*Pseudoterranova decipiens*	ND	ND	14
	"Estornino"	Argentina	*Pseudoterranova* sp.	13	7.7	37
Scyliorhinus haeckelii	ND	Brazil	*Contracecum* sp.	9	22.2	40
Sebastes capensis	ND	Chile	*Anisakis simplex*	487	36.3	66
			Pseudoterranova decipiens	487	14.6	66
Serrasalmus spilopleura	Dark-banded piranha	Argentina	*Contracecum* sp.	237	91.98	67
Sorubim cuspicaudus	"Blanquillo"	Colombia	*Contracecum* sp.	60	100	22
Sphyrna zygaena	ND	Brazil	*Contracecum* sp.	16	12.5	40
Squalus megalops	ND	Brazil	*Anisakis* sp.	14	7.1	40
			Pseudoterranova sp.	14	14.3	40
Squatina sp.	ND	Brazil	*Anisakis* sp.	20	3.8	40
Thunnus thynnus	ND	Brazil	*Anisakis typica*	ND	ND	68
Thyrsites atun	Sea pike	Chile	*Anisakis* sp.	ND	ND	69
			Anisakis sp. *(Type I)*	95	7.4	47
			Pseudoterranova spp.	95	5.3	47
Trachurus murphyi	Chilean jack mackerel	Peru	*Anisakis physeteris*	ND	ND	14
		Chile	*Anisakis physeteris*	2 200	6.1	70
		Peru	*Anisakis simplex*	ND	ND	14
		Chile	*Anisakis simplex*	16	12.5	47
			Anisakis simplex	2 200	36.9	70
		Peru	*Anisakis simplex*	843	1.8	70
		Chile	*Hysterothylacium* sp.	2 200	7.3	70
		Peru	*Pseudoterranova decipiens*	ND	ND	14
		Chile	*Pseudoterranova decipiens*	16	31.3	47
			Pseudoterranova decipiens	2 200	0.045	70
Trichiurus lepturus	Atlantic cutlassfish	Brazil	*Anisakis typica*	64	57	71
Xystreurys rasile	ND	Argentina	*Pseudoterranova* sp.	29	3.4	37

ND: no data.
Source: Own elaboration.

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The present systematic review also made it possible to establish, for the first time, the geographic distribution of the different species of anisakid nematodes reported in fish marketed in South America (Figure 2).

Figure 2. Geographical distribution of anisakid nematodes reported in fish for human consumption in South America. Source: Own elaboration.

Discussion

The presence of nematodes of the family *Anisakidae* in fish for human consumption in South American countries, both in the Atlantic and Pacific Oceans, is significant. However, cases of anisakidosis reported in humans are few and mostly localized in Chile and Peru, leading to the idea that this infection is present in the region and may be a probable zoonosis that is not being detected due to a lack of awareness among healthcare professionals.

The recent increase in the availability of Mediterranean and Eastern dishes made from raw or undercooked fish and cephalopods in South America has increased the risk of infection and hence the number of cases of anisakidosis. This may also explain why most of the known cases in the region are found in Chile and Peru, countries where the gastronomic culture involves the consumption of marinated or salted seafood, mainly ceviche.

According to the findings of the present study, it is noteworthy that the genera *Anisakis* and *Pseudoterranova*

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were identified in the registry of parasitized fish for consumption since they are the parasites with the greatest impact on human health in countries where anisakidosis is highly prevalent, such as Spain and Japan;[11] however, this is not reflected in the clinical cases described.

Similarly, this registry included fish parasitized by the genera *Contracaecum* and *Hysterothylacium*, of which, at the time of writing this review, no infections had been reported in humans in South America. In contrast, there have been case reports of infection with *Hysterothylacium aduncum* (two in South Korea and two in Japan) and *Contracecum osculatum* (one in Japan) from across the world,[7] indicating either a possible emerging disease or a severe underreporting of this infection in the region.

Reports of anisakidosis in South America are relatively new, except for the first case reported in Chile in 1976, according to Jofré *et al.*,[3] as they were published in the last 25 years. Moreover, in the region, there is evidence of an increase in the registration of cases between 1997 and 2005, followed by a large number of studies, of which the most recent was published in 2018.[28]

As mentioned above, most cases of anisakidosis were found in Chile (n=35)[3,13,18-23] and Peru (n=8),[13,14,24-26] where consumption of raw fish in the form of ceviche is common in coastal areas. However, due to the long periods between cases, healthcare personnel may not issue a disease warning if they are considered rare cases. In addition, in Brazil, Argentina and Colombia, only one report was found in each country.[19,27,28]

It should be noted that the report made public in Colombia was based on studies conducted by Castellanos *et al.*,[38] Castellanos-Garzón[79] and Castellanos *et al.*,[80] all published in 2018, who identified for the first time the presence of *A. physeteris* and *P. decipiens* in fish for human consumption marketed in the country, specifically in the port of Buenaventura. As a result, a warning about the possibility of anisakidosis being an emerging disease was released.

Gastrointestinal anisakidosis was the most frequent in South America, with a total of 45 cases.[3.13-19.24-28.30-32] The oropharyngeal, gastric, intestinal and gastrointestinal presentations were also observed, the oropharyngeal being the most common with 29 cases. In addition, 4 asymptomatic cases with expulsion of larvae through the oral cavity were found, as well as 12 cases with clinical symptoms that varied depending on the section of the gastrointestinal tract affected by the larvae; regarding the latter, cough, pain and tingling in the pharynx, acute epigastric pain (pyrosis), nausea and abdominal cramps were the most frequent symptoms. In general, patients' condition improved in the following 36 hours to 15 days after ingestion.

In 41 (91.1%) cases of gastrointestinal anisakidosis, the infection was caused by a single larva in the late stages (L3 and L4), which was identified taxonomically. At this point it is important to note that diagnosing anisakidosis can be problematic because larval identification only allows for genus identification, and species can only be determined morphologically in adult parasites found in marine mammals. Molecular biology techniques that are costly and not available in the region are required to identify the larval stage of the species.

Despite the above, Weitzel *et al.*,[17] using the DNeasy Blood and Tissue Kit molecular diagnostic technique, identified *Pseudoterranova cattani* as the causal agent of gastrointestinal anisakidosis in the oropharyngeal form in five patients from Chile. Furthermore, Castellanos *et al.*[38] described the species *A. physeteris and P. decipiens* in fish from the Pacific Ocean in Colombia and Ecuador using molecular biology and the multiplex PCR technique.

Similarly, three studies were found in the literature, two from Brazil and one from Venezuela, in which an allergic response to *A. simplex* allergens was reported.[1,29,33] This is evidence that people who have come into contact with *Anisakis* spp. and have formed antibodies against it are present in the region and are more likely to have an allergic reaction, and even an anaphylactic response, in a posterior contact through a type I hypersensitivity reaction.

Based on the information obtained from the clinical case reports, it was established that 95 species of anisakid intermediate fish hosts have been reported in South America, which should be studied in depth as they are the direct source of infection in humans. These species were found in Argentina, Brazil, Chile, Colombia, Ecuador, Peru and Venezuela[11-13.15,19-22,33-77], as described below.

In Argentina, 22 species of fish for human consumption were identified. They were parasitized with species of the genera *Contracaecum*, *Pseudoterranova*, and *Hysterothylacium* and the species *Hysterothylacium aducum*, *A. simplex* and *P. cattani*, with a variable prevalence of up to 100% in several hosts.[34,37,56]

The largest number of host fish species was identified in Brazil, 34 in total, which were parasitized by *A. typica*, *A. physeteris*, *A. simplex*, *P. azarasi*, *Contracaecum* sp., *Anisakis* sp., *Pseudoterranova* sp., *Hysterothylacium* sp., *H. fortalezae* and *H. deardorffoverstreetorum.*[20,23,39-41,45,46,48,50,56-60,62,63,68,71-73,77,78]

In Chile, 15 hosts were identified and there were reports of infection with the genera *Anisakis*, *Pseudoterova* and *Hysterothylacium* and their species *A. simplex*, *A. physeteris, P. decipiens* and *H. geschei*.[43,47,51,52,54,66,69,70,74]

In Colombia, reports were found for 17 host species, including marine and inland water fish, in which the presence of the genera *Anisakis*, *Pseudoterranova* and *Contracaecum* and the species *A. physeteris* and *P. decipiens* was established by taxonomic identification.[12,22,36,38,49,55,76]

In Ecuador, 8 host fish species were identified: Ulloa-Ulloa & Carrasco[38] reported the presence of *Contracaecum* sp. in flathead grey mullet (*Mugil cephalus*), "trahira" (*Hoplias microlepis*), "bagre pintado" (*Hexanematichthy* sp.) and tilapia (*Oreochromis niloticus*), while Castellanos *et al.*,[38] in a study carried out on the country's Pacific coast, identified the species *A. physeteris* and *A. pegreffi* in hake (*Merluccius gayi*); these authors also compiled other reports of infection by *A. physeteris* in bullet tuna (*Auxis rochei*), "bonito" (*Katsuwonus pelamis*) and "dorado" (*Coryphaena hippurus*).

In Peru, which was the country with the second highest number of reports of clinical cases of anisakidosis, 7 species of anisakid fish hosts were identified. *Anisakis* sp, *A. physeteris*, *P. decipiens*, *A. simplex*, *Pseudoterranova* sp., *Contracaecum* sp. and *Hysterothylacium* sp. were isolated.[13,14,70]

In Venezuela, Vicente *et al.*,[53] Bracho-Espinosa *et al.*[44] and Maniscalchi-Badaoui *et al.*[75] reported that two species of fish of the family *Mugilidae* were hosts of the genera *Anisakis*, *Pseudoterranova* and *Contracaecum*. In addition, reports of infestation by *Contracaecum* sp. and *Pseudoterranova* sp. in the fish *Eugerres plumieri* and *Micropogonias furnier* were found in this country.[44,53,75]

Finally, in Uruguay, only two hosts with infection by *A. simplex*, *Contracaecum* sp., *Hysterothylacium* sp. and *Pseudoterranova* sp. were reported.[42,61]

Mullets, especially those of the species *M. cephalus*, rank first among all fish reported to have been infected by nematodes of the family *Anisakidae*, with a prevalence of infection of up to 100%. The high percentage of parasitization in mullets can be attributed to their geographical distribution, as they are found in both Atlantic and Pacific coastal waters, being species of economic and commercial importance.

Among the species with a high number of reports are also Brazilian flathead, which was parasitized by *Hysterothylacium* sp. (74.01%), *A. simplex* (51.41%), *P. cattani* (25%) and *Contracaecum* sp. (6.74%) and *Hoplias malabaricus*, which were all parasitized by *Contraecum* sp. A remarkable finding was that in about 45% (n=43) of the hosts, multiple infection by two or more species of parasites of the family *Anisakidae* was reported.

Based on the above, it is possible to establish that legislation on handling, processing, early evisceration and freezing at standard temperatures (-20°C) of fish is necessary in South America to adequately control the number of infected animals and thus prevent anisakidosis. At the same time, the study of this infectious disease should be promoted in healthcare institutions, with a focus on disease prevention and early management to effectively monitor the emergence of new cases and reduce underreporting.

Conclusions

The present review established the current panorama of the reported intermediate hosts for anisakids and clinical case reports of anisakidosis in South America. It was determined that this infectious disease is a latent risk for the region, so it is necessary to establish effective regulations to control its occurrence and provide more information to the general population on the necessary precautions regarding the consumption of saltwater fish.

Conflicts of interest

None stated by the authors.

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