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Pacific Broad Tapeworm *Adenocephalus pacificus* as a Causative Agent of Globally Re-emerging Diphyllobothriosis

Technical Appendix

Technical Appendix Table 1. Historical survey of global records of adult *Adenocephalus pacificus* tapeworm*

Year	Name	Host	Location	Reference
1899	*Bothriocephalus* sp.	*Callorhinus ursinus*	St. George Island, Alaska, USA	(*1*)
1931	*Adenocephalus pacificus* n. sp.†	*Arctocephalus australis*	Juan Fernandez Island, Chile	(*2*)
	Adenocephalus septentrionalis n. sp.‡	*Callorhinus ursinus*	St. George Island, Alaska	
1937	*Diphyllobothrium arctocephali* n. sp.	*Arctocephalus pusillus*	Lady Julia Percy Island, Australia	(*3*)
	D. arctocephalinum	*Arctocephalus forsteri*	Pearson Island, Australia	(*4*)
1941	*A. septentrionalis*	*Callorhinus ursinus*	Commander Islands, Russia	(*5*)
1947	*Cordicephalus arctocephalinus*	*Callorhinus ursinus*	St. Pauls Island, Alaska, USA	(*6*)
1948	Species No. 2	*Callorhinus ursinus*	St. Pauls Island, Alaska, USA	(*7*)
1951	*A. pacificus*	*Callorhinus ursinus*	Onahama, Japan	(*8*)
1952	*D. hians*	*Callorhinus ursinus*	Sakhalin, Russia	(*9*)
	D. glaciale	*Callorhinus ursinus*	Pribilof Island, Alaska, USA	(*10*)
	D. scoticum	*Otaria flavescens*	Falkland Island, UK	(*10*)
1954	*D. glaciale*	*Callorhinus ursinus*	Pribilof Island, Alaska, USA	(*11*)
1955	*Diphyllobothrium krotovi* n. sp.	*Callorhinus ursinus*	Tyuleniy Island, Russia	(*12*)
1956	*D. pacificum*	*Eumetopias jubatus*	Triangle Island, Canada	(*13*)
1957	***D. latum***	**Human (2 cases)**	**Lima, Peru**	(*94*)
1961	***D. latum***	**Human (1 case)**	**Trujillo, Peru**	(*14*)
1962	***D. latum***	**Human (1 case)**	**Chiclayo, Peru**	(*15*)
1963	***D. latum***	**Human (1 case)**	**La Oroya, Peru**	(*67*)
1964	***D. latum***	**Human (1 case)**	**Lima, Peru**	(*67*)
	D. latum	**Human (1 case)**	**Lima, Peru**	(*67*)
1965	***D. latum***	**Human (5 cases)**	**Lima, Peru**	(*67*)
	D. latum	**Human (1 case)**	**Trujillo, Peru**	(*67*)
	D. latum	**Human (1 case)**	**Chiclayo, Peru**	(*67*)
	D. latum	**Human (2 cases)**	**Lima, Peru**	(*67*)
	D. pacificum	*Callorhinus ursinus*	Pribilof Island, Alaska, USA	(*16*)
1967	***D. pacificum***	**Human (7 cases)**	**Trujillo, Peru**	(*17*)
	D. latum	**Human (15 cases)**	**Lima, Peru**	(*67*)
	D. latum	**Human (3 cases)**	**Trujillo, Peru**	(*18*)
	***Luehella* sp.**	**Human (1 case)**	**Peruvian student in Argentina**	(*19*)
1968	*Diphyllobothrium atlanticum* n. sp.	*Arctocephalus pusillus*	off South Africa	(*20*)
1969	*D. pacificum*	*Otaria byronica*	Guañape Islands, Peru	(*21*)
	D. pacificum	*Callorhinus ursinus*	Off northern Japan coast	(*22*)
1970	*D. glaciale*	*Eumetopias jubatus*	Off California coast, USA	(*23*)
1971	*D. krotovi*	*Callorhinus ursinus*	Tyuleniy Island, Russia	(*24*)
1975	*D. krotovi*	*Callorhinus ursinus*	Kuril Islands	(*25*)
	D. pacificum	**Human (2 cases)**	**Salaverry, Peru**	(*67*)
	D. pacificum	**Human (11 cases)**	**Arequipa, Peru**	(*67*)
	D. pacificum	**Human (total 115 cases)**	**Peru**	(*67*)
1976	***D. pacificum***	**Human (1 case)**	**Los Vilos, Chile**	(*26*)
	D. latum	**Human (1 case)**	**Valdivia, Chile**	(*27*)
	D. pacificum	**Human (2 cases)**	**Mejillones & Antofagasta, Chile**	(*28*)
1977	*D. pacificum*	*Otaria flavescens*	Los Vilos, Chile	(*29*)
	D. pacificum	**Human (25 cases)**	**Lima, Peru**	(*30*)
	D. pacificum	**Human (7 cases)**	**Lambayeque, Peru**	(*31*)
1978	*D. pacificum*	*Eumetopias jubatus*	off Oregon, USA	(*32*)
1979	***D. pacificum***	**Human (11 cases)**	**North Chile**	(*33*)
1980	*D. pacificum*	*Arctocephalus philippii*	Alejandro Selkirk Island, Chile	(*34*)
1981	*D. pacificum*	*Otaria flavescens*	Isla Santa Maria, Chile	(*35*)
	D. pacificum	*Callorhinus ursinus*	Northern Honshu, Japan	(*36*)
1982	***D. pacificum***	**Human (1 case)**§	**Okinawa, Japan**	(*37*)
	D. pacificum	**Human (32 cases)**	**Lima, Peru**	(*38*)
1983	***D. pacificum***	**Human¶**	**Los Gavilanes, Peru**	(*39*)
	D. pacificum#	Dog (*Canis familiaris*)	Valdivia, Chile	(*40*)
1984	***D. pacificum***	**Human¶**	**Tiliviche, Chile**	(*41*)
1986	*D. pacificum*	*Eumetopias jubatus*	Gulf of Alaska, USA	(*42*)

Year	Name	Host	Location	Reference
	D. pacificum	*Callorhinus ursinus*	Medny Island in the Bering Sea	(*43*)
1987¶	***D. pacificum***	**Human (1 case)**	**Japan (seaman)**	(*44*)
1988	***D. pacificum***	**Human (1 case)**	**Santiago de Chile, Chile**	(*45*)
1989	*Diphyllobothrium* sp.	*Arctocephalus tropicalis*	Gough Island, South Africa	(*46*)
1990	***D. pacificum***	**Human (1 case)**	**Huancayo, Juníh, Peru**	(*47*)
	D. pacificum	**Human (1 case)**	**seaman in Kyushu, Japan**	(*48*)
	D. atlanticum	*Arctocephalus pusillus*	Namibia	(*49*)
1991	***D. pacificum***	**Human (13 cases)**	**Jambeli archipelago, Ecuador**	(*50*)
1993¶	*Diphyllobothrium* sp.	*Callorhinus ursinus*	N California, USA	(*51*)
	D. pacificum	*Otaria flavescens*	Juan de Marcona, Peru	(*52*)
	D. pacificum	**Human (1 case)**	**Matsuyama City, Japan**	(*53*)
	D. pacificum	**Human (18 cases)**	**Arequipa, Peru**	(*67*)
1994	***D. pacificum***	**Human (13 cases)**	**Lima, Peru**	(*54*)
	D. pacificum	**Human (5 cases)**	**San Juan de Miraflores, Peru**	(*55*)
1995¶	***D. pacificum***	**Human (14 cases)**	**Paiján, La Libertad, Peru**	(*56*)
1996	***D. pacificum***	**Human (2 cases)**	**Lima, Peru**	(*57*)
1997	***D. pacificum***	**Human (597 cases)**	**Lima, Peru**	(*67*)
1998¶	*D. pacificum*	*Arctocephalus pusillus*	Off Cape coast of South Africa	(*58*)
	D. pacificum	*Callorhinus ursinus*	Medny Island in the Bering Sea	(*59*)
1999	***D. pacificum***	**Human (1 case)**	**Chile**	(*60*)
2000	***D. pacificum***	**Human (21 cases)**	**Peru**	(*61*)
	D. pacificum	**Human (1 case)**	**Antofagasta, Chile**	(*62*)
2001	*D. pacificum*	Dog (*Canis familiaris*)	Chincha Alta, Peru	(*63*)
	D. pacificum	**Human (3 cases)**	**Antofagasta, Chile**	(*64*)
	D. pacificum	**Human (790 cases)****	**Peru (several localities)**	(*65*)
	D. pacificum	**Human (1 case)**	**Trujillo, Peru**	(*82*)
2002	***D. latum***	**Human (1 case)**	**Spain**	(*66*)
	D. pacificum	**Human (21 cases)**	**Lima, Peru**	(*67*)
2003	***Diphyllobothrium* sp.**	**Human ¶**	**Ilo, southern Peru**	(*68*)
	D. pacificum	**Human ¶**	**Osmore drainage, Peru**	(*69*)
	***D. pacificum*#**	**Human ¶**	**northern Chile**	(*70*)
	***D. pacificum*#**	**Human ¶**	**Lluta Valley, Chile**	(*71*)
2006	***D. pacificum***	**Human (2 cases)**	**Lima, Peru**	(*72*)
	D. pacificum	*A. australis*, *O. flavescens*	Montevideo, Uruguay	(*73*)
2010¶	***D. pacificum***	**Human (2 cases)**	**Antofagasta, Santiago, Chile**	(*74*)
	D. pacificum & *A. arctocephalinum*	*C. ursinus*, *O. flavescens*	Japan & Juan Fernandez Island	(*75*)
2011	***D. pacificum***	**Human (1 case)**	**Arequipa, Peru**	(*76*)
2012	***D. pacificum***	**Human (20 cases)**	**Tumbles, Piura, Lima, Peru**	(*77*)
	Diphyllobothrium sp.	Dog§	Osmore river in southern Peru	(*78*)
2013	*Diphyllobothrium* sp.	*A. australis*, *O. flavescens*	northern Patagonia, Argentina	(*79*)
	D. pacificum	**Human¶**	**Peru and Chile**	(*80*)
	D. pacificum	**Human¶**	**Peru**	(*81*)
2014	***D. pacificum***	**Human (3 cases)**	**Spain**	(*83*)
	D. pacificum	**Human (1 case)**	**Spain**	(*84*)
2015	*A. pacificus*	Several hosts	Several localities	(*85*)

*Bold text indicates cases among human patients.
†New genus Adenocephalus established.
‡Described from material collected by Stiles and Hassall (1899).
§Re-examination of material published by Sunagawa (1965).
¶Archeological finding (coprolites or mummy).
#ENSO reported in 1983, 1987, 1992, 1995, 1998, 2003, and 2010.
**Report of all cases from 1981–2001 by Ministry of Health, Peru.

Technical Appendix Table 2. Marine fish reported in the South Pacific Ocean as second intermediate hosts of *Adenocephalus pacificus*,*

Host species and family	Site	Location	Prevalence	Reference
Anisotremus scapularis HA	v,p	Peruvian coast	ND	(*86*); (*87*)†; (*89*)† 1417
***Ariopsis seemanni* AR**	**p**	**Trujillo coast**	**4/32**	**(*87*)**
Cilus gilberti SC	ND	Peru coast	ND	(*18*)‡
Coryphaena hippurus CO	v,p	Peru coast	ND	(*77*‡, *88*)
Cynoscion analis SC	v	Trujillo coast	2/43	(*89*)
***Galeichthys peruvianus* AR**	**v,p**	**Peru coast**	**16/30**	**(*90*), PS**
Genypterus maculates OP	v	Trujillo coast	1/6	(*89*)
Menticirrhus ophicephalus SC	ND	Peru coast	ND	(*86*)
Merluccius gayi peruanus ME	p	Trujillo coast	2/32	(47) ‡ (*86*,*89*),
Mugil cephalus MU	ND	Peru coast	ND	(*17*,*18*,*77*)‡ (*91*); † 50 (*89*); † 46 (*87*); † 23; PS† 10
Mustelus lunulatus TR	ND	Trujillo, Peru	ND	(*18*)‡
***Paralichthys adspersus* PA**	**s**	**Trujillo coast**	**2/27**	**(*87*)**
Paralonchurus peruanus SC	i	Chimbote, Peru	1/180	(*91*); (*17, 18, 67, 77*)‡; (*21*) † 27; (*89*)† 24
***Sarda chiliensis* SO**	**b**	**Peru coast**	**17/30**	**PS; (*17, 18, 67, 77*)‡; (*21*)**§
***Sciaena deliciosa* SC**	**p**	**Chimbote, Peru**	**25/318**	**(*91– 93*), PS; (*87*)‡**
***Sciaena deliciosa* SC**	**p**	**Trujillo coast**	**16/112**	**(*17, 18, 60, 62*)**§

Host species and family	Site	Location	Prevalence	Reference
***Sciaena deliciosa* SC**	**p**	**Ventanilla-Callao area**	**6/35**	**(*24*)† 26**
Sciaena callaensis SC	s, p	Trujillo coast	4/17	(*91*)
Scomber japonicus SO	v, p	Peru coast	ND	(*86*); (*21*)† 4; (*87*)† 48; (*89*)† 36
Scomberomorus maculatus SO	b	Peru coast	3/16	(*21*)§; (*87, 89*)†16
***Seriolella violacea* CE**	**p**	**Trujillo coast**	**3/56**	**(*87*); (*21*)† 4; (*91*)† 250**
***Trachinotus paitensis* CA**	**p**	**Trujillo coast**	**2/16**	**(*87*); (*21*)† 4; PS† 9**
***Trachurus murphyi*[4] CA**	**b**	**Chorrillos, Lima**	**8/20**	**PS; (*26, 33, 45, 47, 67, 77, 90*)‡; (*21*)† 37; (*87*)† 59; (*89*)† 34; (*91*)† 222**

*Bold text indicates fish hosts confirmed by DNA sequencing or experimental infections (*89*); AR, Ariidae; CA, Carangidae; CE, Centrolophidae; CO, Coryphaenidae; HA, Haemulidae; ME, Merlucciidae; MU, Mugilidae; ND, no data available; OP, Ophidiidae; PA, Paralichthyidae; SC, Sciaenidae; SO, Scombridae; TR, Triakidae; Site, site of infection; b, body cavity; I, intestinal surface; p, peritoneum; s, stomach surface; v, viscera; PS, present study.
†Plerocercoids were not found, followed with several dissected fish.
‡Anamnesis (case-patient–provided) data.
§Experimental infections of dogs and man failed (Baer et al. 1969).
¶Also reported as *Trachurus symmetricus murphyi* (see Froese & Pauly, 2015).

Technical Appendix Table 3. Historical survey of clinical cases of diphyllobothriosis caused by *Adenocephalus pacificusI*, 1961–2015*

Country	Age, sex	Symptoms	Treatment	Dietary habits	Reference
Peru	23, M	Grow fat†	Spontaneously	Fish	(*14*)
	47, F	A, D, V	Clorhidrat (acranyl)	ND	(*15*)
	4, M	None	Chloromycetin	P. peruanus	(*17*)
	14, F	A,F,N	After taking “weaver oil”	Cebiche	(*17*)
	21, M	None	Spontaneously	Cebiche	(*17*)
	7, F	None	Spontaneously	S. chilensis	(*17*)
	23, M	None	Spontaneously	Cebiche	(*17*)
	26, M	A,I, N,W	Spontaneously	ND	(*17*)
	30, F	H,N,W	Spontaneously	Marine fish	(*17*)
	23, M	A	Metroquin	Cebiche	(*18*)
	38, F	A,D	Metroquin	Several fish species	(*18*)
	24, F	A,W	Metroquin	Several fish species	(*18*)
	M	ND	Spontaneously	ND	(*19*)
	ND	25 cases, no details	Praziquantel	Cebiche	(*30*)
	ND	7 cases, no details	ND	Cebiche	(*31*)
	4–75	A, D, N, W	Praziquantel	ND	(*38*)
		None	ND	ND	(*38*)
	5, F	ND	ND	M. gayi	(*47*)
	2–18	A, D, V	Niclosamide	marine fish	(67)
	ND	None	Spontaneously	marine fish	(*67*)
	3–66	A, D, M, W	Niclosamide	Cebiche	(77)
		None	Spontaneously	Cebiche	(*77*)
	42, F	A, D, N, V	Praziquantel	Cebiche	(82)
Chile	6	A,N,V	Niclosamide	Cebiche	(*26*)
	29	A,N,M	Yomesan		(*27*)
	45, F	ND	ND	Raw sea fish	(*28*)
	23,M	ND	ND	Raw sea fish	(*28*)
	55, F	A,D,N	Niclosamide	*T. murphyi*	(*33*)
	35, M	A,D,N	Niclosamide	*T. murphyi*	(*33*)
	7, M	A,D,N	Niclosamide	*T. murphyi*	(*33*)
	43, F	A,D,N	Niclosamide	*T. murphyi*	(*33*)
	32, M	A,D,N	Niclosamide	*T. murphyi*	(*33*)
	53, M	A,D,N	Spontaneously	*T. murphyi*	(*33*)
	48, M	A,D,N	Spontaneously	*T. murphyi*	(*33*)
	45, F	A,N	Niclosamide	*T. murphyi*	(*33*)
	23, M	None	Niclosamide	*T. murphyi*	(*33*)
	40, M	None	Niclosamide	*T. murphyi*	(*33*)
	7, M	None	Niclosamide	*T. murphyi*	(*33*)
	3, M	None	Spontaneously	Smoked *T. murphyi*	(*45*)
	26, F	ND	Spontaneously	*Sciaena deliciosa*	(*60*)
	3, M	None	Spontaneously	Cebiche	(*62*)
	36, F	A	ND	Cebiche	(*74*)
Japan	54, M	ND	Spontaneously	Seaman	(*44*)
	59, M	None	Spontaneously	Sashimi	(*53*)
Spain	3	None	Spontaneously	ND	(*66*)
	50, M	None	Spontaneously	Raw fish	(*83*)
	52, F	None	Praziquantel	Raw fish	(*83*)
	27, M	None	Spontaneously	ND	(*84*)

* A, abdominal pain; D, diarrhea; F, female; H, male; ; I, intensive salivation in the morning;*M. gayi*, *Merluccius gayi peruanus*; M, megablastic anemia; N, nausea; ND, no data available; *P. peruanus*, *Paralonchurus peruanus*; *S. chilensis*, *Sarda chilensis*; Spontanously, spontaneous elimination of tapeworms from the patient; *T. murphyi*, *Trachurus murphyi;* V, vomiting; W, weight loss.
†The only change in the patient’s condition was described as “grow fat.” This term was not defined.

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