DOI: 10.2478/s11686-012-0003-z
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Acta Parasitologica, 2012, 57(1), 83–89; ISSN 1230-2821

New records of parasitic copepods (Crustacea, Copepoda) from marine fishes in the Argentinean Sea

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Abstract

Increasing knowledge of the biodiversity of parasitic copepods in the Argentinean Sea will provide a baseline against which changes in the distribution of marine biota can be detected. We provide new information on the distribution of 13 known species of parasitic copepods gathered from 11 species of marine fishes from Argentinean Sea, including 7 new host records and 9 new locality records. These species are: *Bomolochus globiceps* (Vervoort et Ramírez, 1968) and *Nothobomolochus cresseyi* Timi et Sardella, 1997 (Bomolochidae Sumpf, 1871); *Brasilochondria riograndensis* Thatcher et Pereira, 2004 (Chondracanthidae Milne Edwards, 1840); *Taeniacanthus lagocephali* Pearse, 1952 (Taeniacanthidae Wilson, 1911); *Caligus rogercresseyi* Boxshall et Bravo, 2000 and *Metacaligus uruguayensis* (Thomsen, 1949) (Caligidae Burmeister, 1835); *Hatschekia conifera* Yamaguti, 1939 (Hatschekiidae Kabata, 1979); *Clavellotis pagri* (Krøyer, 1863), *Clavella adunca* (Strøm, 1762), *Clavella bowmani* Kabata, 1963 and *Parabrachiella amphipacifica* Ho, 1982 (Lernaeopodidae Milne Edwards, 1840), and *Lernanthropus leidyi* Wilson, 1922 and *Lernanthropus caudatus* Wilson, 1922 (Lernanthropidae Kabata, 1979). A list of host species lacking parasitic copepods, for which large samples were investigated by the authors, is also provided in order to compare in future surveys.

Keywords

Parasitic copepods, fishes, Argentinean Sea

Introduction

During the last few decades the exploration of the ocean have revealed an incredible diversity of life, including ecosystems and communities with a wealth of endemic species; however, much of the oceans biology and ecology remains poorly explored and understood. This is particularly the case of marine parasites that, despite being recognized as an important component of global biodiversity and research efforts directed at documenting parasite species have increased (Poulin and Morand 2000), they are probably the least known group of organisms (Rohde 1993).

The copepods are a common component of the ectoparasite assemblages of all kind of fishes, from all environments and ecosystems (Boxshall and Halsey 2004), however, only about 16% of extant fish species have been reported as hosts for these parasites (Ho 2001). This is probably because, among ichthyoparasitologists, the number of copepodologists is surprisingly small (Ho 2001), possible as a result of the complex anatomy of copepods and the scattered and largely archaic nature of systematic literature (Benz 2005).

Today, human impacts on the world's oceans have been substantial, leading marine taxa to become extinct or disappear at top speed (Dulvy *et al*. 2003) as a result of habitat loss and destruction, the introduction of exotic species, human-generated pollution, over-fishing and global climate change. The latter is impacting the ecology and biogeography of marine fish populations and will continue to do so in the future (Arvedlund 2009); some species and populations could be lost if they are unable to adapt to the new climate conditions or relocate to adequate habitats, while others may flourish and expand their ranges.

It has been argued that the records of fish in unusual habitats may aid as an indicator of climate changes (Arvedlund 2009). Due to the dependence of parasites to their hosts and the strong effect of climatic conditions on parasite transmis-

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Table I. Parasitic copepod species infecting marine fishes in the Argentinean Sea, with information about host identity, number of examined hosts (n), site of infection, locality and date of host capture, prevalence (P), mean intensity (MI) and material deposited (VS = voucher specimens, CN = collection number)

Parasite species	Host (n)	Site	Date locality	P (%)	MI (range)	VS-CN
CYCLOPOIDA						
Bomolochidae						
Bomolochus globiceps (Vervoort et Ramírez, 1968)	*Odontesthes incisa* (Jenyns) (Atherinopsidae) (60)	gills	October, 2000 Mar del Plata (38°08´S, 57°32´W)	8.3	1.2 (1–2)	4 females 6434
Nothobomolochus cresseyi Timi et Sardella, 1997	*Thyrsitops lepidopoides* (Cuvier) (Gemplydae) (1)	gills	April, 2010 Mar del Plata (38°08´S, 57°32´W)	–	2	1 female 6435
Chondracanthidae						
Brasilochondria riograndensis Thatcher et Pereira, 2004	*Paralichthys patagonicus* Jordan (Paralichthydae) (51)	inner side of operculum	September, 2010 Necochea (38°52´S, 58°10´W)	5.9	1	2 females 2 males 6436
Taeniacanthidae						
Taeniacanthus lagocephali Pearse, 1952	*Lagocephalus laevigatus* (Linnaeus) (Tetraodontidae) (1)	pectoral fins, gills	December, 2008 Mar del Plata (38°08´S, 57°32´W)	–	6	3 females 6437
SIPHONOSTOMATOIDA						
Caligidae						
Caligus rogercresseyi Boxshall et Bravo, 2000	*Odontesthes argentinensis* (Valenciennes) (Atherinopsidae) (27)	body surface	July, 2000 Mar del Plata (38°08´S, 57°32´W)	59.3	1.9 (1–5)	5 females, 5 males, 1 chalimus 6438
Metacaligus uruguayensis (Thomsen, 1949)	*Trichiurus lepturus* Linnaeus (Trichiuridae) (4)	oral and gill cavities	June, 2010 Mar del Plata (38°08´S, 57°32´W)	100	47.5 (5–84)	5 females, 5 males, 5 chalimus 6439
Hatschekiidae						
Hatschekia conifera Yamaguti, 1939	*Brama brama* (Bonnaterre) (Bramidae) (4)	gills	November, 2007; April, 2004 Mar del Plata (38°08´S, 57°32´W) San Matías gulf (41°10´–42°10´S, 63°50´–65°00´W)	50.0	1.5 (1–2)	1 female 6440
Lernaeopodidae						
Clavellotis pagri (Krøyer, 1863)	*Pagrus pagrus* (Linnaeus) (Sparidae) (124)	gills	December, 2004 to October, 2005 Mar del Plata (38°08´S; 57°32´W)	35.5	2.5 (1–11)	10 females 6441
Clavella adunca (Strøm, 1762)	*Patagonotothen ramsayi* (Regan) (Nototheniidae) (8)	gills	September, 2007 Patagonian waters (45°S, 61°W)	50.0	1.5 (1–3)	3 females 6442
Clavella bowmani Kabata, 1963	*Patagonotothen ramsayi* (Regan) (Nototheniidae) (8)	pectoral fins	September, 2007 Patagonian waters (45°S, 65°W)	12.5	2	1 female 6443
Parabrachiella amphipacifica (Ho, 1982)	*Cottunculus granulosus* Karrer (Psychrolutidae) (2)	gills	February, 2009 Patagonian waters (49°13´S, 63°14´W)	50.0	5	2 females 6444
Lernanthropidae						
Lernanthropus leidyi Wilson, 1922	*Umbrina canosai* Berg (Sciaenidae) (6)	gills	April, 2004 Mar del Plata (38°08´S, 57°32´W)	16.7	2	1 female 6445
Lernanthropus caudatus Wilson, 1922	*Pagrus pagrus* (Linnaeus) (Sparidae) (124)	gills	December 2004 to October 2005 Mar del Plata (38°08´S, 57°32´W)	34.7	1.8 (1–7)	10 females, 10 males 6446

sion and distribution (Marcogliese 2001, Mouritsen and Poulin 2002), geographical shifts in copepod distribution can reinforce the utility of the detection of changes in ecosystem structure and function.

Recent discoveries of several fish species in southern regions of the Argentinean Sea, where they were never recorded previously (Góngora *et al*. 2009), are a clear indication of the effect of global warming in this region. It is necessary to increase our knowledge of the biodiversity of parasitic copepods to provide a baseline to detect future changes in the distribution of the marine biota.

Here we report the discovery of known species of parasitic copepods we gathered over recent years, which remained unpublished because only few fish hosts of each species were sampled plus other species found in ongoing studies that have not yet been published. A list of host species lacking parasitic copepods, for which large samples were investigated by the authors, is also provided in order to compare in future surveys in a scenario where the outbreak of parasitic diseases could occur (see Lafferty *et al*. 2004).

Materials and methods

Copepods were collected from fish examined during parasitological research carried out between 2000 and 2010. Fishes were caught in different regions of the Argentinean Sea. The parasites were removed from the fishes, fixed in formaldehyde solution 4%, and then transferred to 70% ethanol for storage until being studied; the copepods were cleared in lactic acid and examined under a light microscope, appendages were dissected when necessary. The terms prevalence and mean intensity of infestation are used according to Bush *et al*. (1997).

Voucher specimens were deposited in the Carcinological Collection of the Museo de La Plata (CCMLP), La Plata, Argentina.

Higher-level classification of copepods follows Boxshall and Halsey (2004). The taxonomy and scientific names of fishes have been updated using FishBase (Froese and Pauly 2010).

A list of 4 fish species found free of parasitic copepods in the Argentinean Sea, is given, together with their taxonomic position, number of examined fish and date and locality of capture.

Results

A total of 13 host-parasite associations were found in 15 marine fish species from Argentinean Sea. Copepods belonged to 2 orders and 7 families while fishes were representatives of 5 orders and 10 families. Table I includes information on the distribution of the parasitic copepods species found and Table II provides information on fish species free of parasitic copepods in the Argentinean Sea.

Discussion

The present work provides new information on the distribution of 13 known species of parasitic copepods found in 11 species of marine fishes from Argentina, including 7 new host records and 9 new locality records and a list of host species lacking parasitic copepods, for which large samples were investigated, including first reports from the Southwestern Atlantic of *H. conifera*, *C. adunca* and *P. amphipacifica*, broadening considerably the geographical range of each.

Bomolochus globiceps was originally described as *Parabomolochus globiceps* from specimens collected from the gills of *Odonthestes smitii* (Lahille) (as *Austroatherina smitti*) caught in Mar del Plata Port (Argentina) (Vervoort and Ramírez 1968). Later the genus *Parabomolochus* was discarded for being established based on false criteria (Vervoort 1969) and all species considered as *Parabomolochus* by Vervoort (1962) were transferred to the genus *Bomolochus* von Nordmann, 1832. This species was later redescribed by Timi and Etchegoin (1998) based on specimens collected from the type host, as well as from *Odontesthes argentinensis* (Valenciennes), both from the same locality. The presence of *B. globiceps* in the congeneric silverside, *O. incisa* (Jenyns), from Mar del Plata, constitutes a new host record.

Nothobomolochus cresseyi was described by Timi and Sardella (1997) from *Engraulis anchoita* Hubbs et Marini (Engraulidae) in coastal areas of Argentina and Uruguay. Over a

Table II. Fish species free of parasitic copepods in the Argentinean Sea, including the number of examined hosts (n), date and locality of capture

Order	Family	Species	n	Date-locality
Anguilliformes	Congridae	*Conger orbignianus* Valenciennes	100	April-May, 2004, June, 2010, Mar del Plata (38°08´S, 57°32´W)
Clupeiformes	Engraulidae	*Anchoa marinii* Hildebrand	136	May, 1996, Mar del Plata (38°08´S, 57°32´W)
Pleuronectiformes	Paralichthydae	*Paralichthys isosceles* Jordan	51	May, 2009, Necochea (39°00´S, 58°55`W)
Scorpaeniformes	Congiopodidae	*Congiopodus peruvianus* (Cuvier)	265	May, 2007, January-March, 2009, Patagonian waters (41°10´-47°30´S, 58°26-66°26´W)

total of 1,490 specimens of *E. anchoita* examined, only 8 specimens of *N. cresseyi* were found with prevalence 0.6% and mean intensity 1 (Timi and Sardella 1997). Later, Luque and Tavares (2007) found this species in *Anchoa marinii* Hildebrand (Engraulidae) from Rio de Janeiro, Brazil. The fact that in the present study 2 specimens were found in a single fish could indicate that *Thyrsitops lepidopoides* (Cuvier) represents the most common host in this area. The presence of *N. cresseyi* in *T. lepidopoides* represents a new host record.

Brasilochondria riograndensis was described as a parasite of *Paralichthys orbignyanus* (Valenciennes) from Rio Grande, Brazil (Thatcher and Pereira 2004). This species was later redescribed based on material collected from the branchial cavity of the same host from the coast off Buenos Aires Province, Argentina (Braicovich and Alarcos 2007). The presence of this species in the Patagonian flounder, *P. patagonicus* Jordan from coastal waters off Mar del Plata, represents a new host record.

Taeniacanthus lagocephali was described by Pearse (1952) from specimens obtained from the gills of *Lagocephalus laevigatus* (Linnaeus) collected off Padre Island, Texas, and then redescribed by Ho (1969). It was reported from the same host from Brazil and USA (Mississippi, Alabama and Texas) by Dojiri and Cressey (1987). Its presence has been also recorded in other species of *Lagocephalus*, namely *L. spadiceus* (Richardson) from Japan (as *T. sabafugu*) by Yamaguti and Yamasu (1959), and *L. lunaris* (Bloch et Schneider) and *L. inermis* (Temminck et Schlegel) from India (Pillai 1963, Uma Devi and Shyamasundari 1980). Pillai (1963) transferred *T. lagocephali* to *Irodes*, being transferred back to *Taeniacanthus* by Ho (1969). This is the first record of this species in Argentinean waters, and is the southernmost report for this species.

Caligus rogercresseyi is the most important parasite impacting the salmon industry in Chile since it was recorded for the first time in 1997 (Bravo 2003, 2010; Johnson *et al*. 2004). It was described from the Atlantic salmon, *Salmo salar* Linnaeus, from Chile (Boxshall and Bravo 2000). It is a non-specific parasite of several wild marine fish, which are frequently found in the vicinity of salmon cages attracted by the waste feed (Carvajal *et al*. 1998, Bravo 2003). This species has also been reported as a parasite of the introduced anadromous brown trout, *Salmo trutta* Linnaeus, in the Rio Gallegos estuary, Patagonia, southern Argentina, since 1998 (Bravo *et al*. 2006). The record of *C. rogercresseyi* in *O. argentinensis* from waters off Mar del Plata constitutes therefore a new host and locality record, representing the northernmost locality reported for this species in the Atlantic.

Thomsen (1949) proposed the subgenus *Metacaligus* to accommodate a new species of *Caligus* found parasitizing the cutlassfish, *Trichiurus lepturus* Linnaeus from the Uruguayan coast. Subsequently, Ho and Bashirullah (1977) elevated *Metacaligus* to generic status, including three species: *M. uruguayensis* (Thomsen, 1949), *M. rufus* (Wilson, 1908) and *M. hilsae* (Shen, 1957). Later, Ho and Lin (2002) based on cladistic analysis of morphological characters of Caligidae confirmed *Metacaligus* as a valid genus. Another species, *Metacaligus latus* Ho et Lin, 2002 was found together with *M. uruguayensis* parasitic on *T. lepturus* from Taiwan (Ho and Lin 2002). The authors also reported chalimus larvae at various stages of development as being attached randomly to the cephalothorax, genital complex or abdomen of the adults of both sexes. According to Ho and Lin (2002) it is an unusual event, because chalimus stages are usually found attached directly to the fish host. However, Thomsen (1949) described three stages of development (chalimus I to chalimus III) found attached to three females. In the present study, of the 59 chalimus found, 42 were found attached to females (1 to 6 per female), 1 to a male and 16 to the hosts. Recently, *M. uruguayensis* was found in *T. lepturus* from Brazil (Luque and Tavares 2007). The present finding constitutes a new locality record.

Hatschekia conifera originally described from *Stromateoides argenteus* (Euphrasen) [valid name *Pampus argenteus*] (Stromateidae) from Japan (Yamaguti 1939), is a widely distributed species. Since its description it has been redescribed by Cressey (1968) from *Cubiceps caeruleus* Regan, a stromateid fish taken off the coast of Chile. It has been also reported from South Africa, Chile, Pacific coast of Canada, New Zealand and Japan (Yamaguti 1939; Barnard 1955; Cressey 1968; Kabata 1981; Oldewage 1993; Villalba 1986; Jones 1985; Ho and Kim 1996, 2001). Barnard (1948) described *H. acuta* Barnard, 1948 from False Bay, South Africa, parasitizing *B. brama* Bonnaterre (as *B. raii*). Kabata (1981), after finding *H. conifera* on *Brama japonicus* Schenider, in the eastern North Pacific Ocean, relegated *H. acuta* to a junior synonym of *H. conifera*. The presence of this copepod species in Argentinean waters represents a new locality record and the first one in the southwestern Atlantic.

The genus *Clavellotis* was established by Castro-Romero and Baeza-Kuroki (1984) to accommodate *C. dilatata* (Krøyer, 1863), which become its type species. Later, Kabata (1990) in a revision of the genus *Clavellopsis* Wilson transferred seven nominal species and one unnamed species to *Clavellotis*; including *C. pagri*. *Clavellotis pagri* has been recorded on the red porgy, *Pagrus pagrus* (Linnaeus), the salema, *Sarpa salpa* (Linnaeus) and the common pandora, *Pagellus erythrinus* (Linnaeus), all of them being sparids from the Mediterranean Sea. In Brazilian waters another species, *C. dilatata* has been reported as a parasite of *P. pagrus* (Luque and Tavares 2007). The present finding represents the southernmost locality record for this species and the first one in the western Atlantic.

Clavella adunca (Strøm, 1762) is a highly polymorphous species, with a great range of morphological variability and a wide range of fish hosts (Kabata 1979); this is reflected in its long list of synonyms and complex taxonomic history. This species has been recorded from as many as 30 fish species, mostly belonging to the family Gadidae, but also to other families (Kabata and Gusev 1966, Kabata 1979). Among the unusual host records for *C. adunca* is the scaly rockcod, *Trematomus loennbergi* Regan (Nototheniidae) from the Antarctic (Kabata and Gusev 1966). The present study presents the second report of *C. adunca* parasitizing a nototheniid fish and is a new host record. *Clavella adunca* is considered a cosmopolitan species (Kabata and Gusev 1966), which inhabits predominantly the waters of the northern hemisphere; its records south of the Equator being comparatively few. The presence of this species in Patagonian waters, Argentina constitutes the first record of this ubiquitous species from the South Atlantic Ocean.

Kabata (1963) described *Clavella bowmani* from the fins of the nototheniid fish *Notothenia sima* (Richardson) (Nototheniidae) [valid name *Patagonotothen sima*], caught in the Strait of Magellan, Argentina. This species was also reported from the skin of *P. sima* from Malvinas Islands (Longshaw 1997). The present finding extends northwards its known geographical distributions in Patagonian waters, Argentina and represents a new host record. The male of *C. bowmani* is recorded for the first time; its description depends on increasing the number of specimens recovered.

Parabrachiella amphipacifica was originally described as *Neobrachiella amphipacifica* from two psychrolutid fish in the Pacific, *Psychrolutes phrictus* Stein et Bond from northern California and *P. sio* Nelson from northern Chile (Ho 1982). Recently, the species assigned to this genus by Kabata (1979) were transferred to *Parabrachiella* Wilson (Boxshall and Halsey 2004, Piasecki *et al*. 2010). Species of *Parabrachiella* seem to be highly host specific infecting a single fish species or a few closely related hosts (Piasecki *et al*. 2010). The finding of *P. amphipacifica* in the psychrolutid *C. granulosus* represents a new host record and the first record of this species in Atlantic waters. The male of *P. amphipacifica* is recorded for the first time; its description depends on increasing the number of specimens recovered.

Lernanthropus leidyi was firstly described from the gills of the white perch, *Morone americana* (Gmelin) (Moronidae) and from the gills of the yellowtail, *Bairdiella chrysura* (Lacepède) (Sciaenidae) from North Carolina, USA (Wilson 1922). This species was also reported parasitizing *B. chrysura* from Florida, USA (Pearse 1952, Causey 1955). Subsequently, Luque and Paraguassú (2003) redescribed it from specimens found in the Argentine croaker, *Umbrina canosai* Berg (Sciaenidae) from Rio de Janeiro, Brazil. The present finding of *L. leidyi* is the first record of this species from Argentinean waters.

Lernanthropus caudatus was originally described by Wilson (1922) from the gills of the sheepshead, *Archosargus probatocephalus* (Walbaum) (Sparidae) at North Carolina, USA. Other records of this species on *A. probatocephalus* were made from Florida and Texas, USA (Bere 1936, Pearse 1952). Subsequently the female was redescribed and the male was described for the first time by Luque and Paraguassú (2003) from *Pagrus pagrus* from the coastal zone of the State of Rio de Janeiro, Brazil. This is the first record of *L. caudatus* from Argentinean waters.

We acknowledge that identification of parasitic copepods based on morphology alone cannot prevent confusion between very similar or cryptic species. Future studies based on genetic analyses will be necessary to confirm the identity and accurately assess the distribution of these species. We are also aware that the effect of global climate change on distribution of marine biota is an ongoing process and therefore, the present findings of some parasitic copepods could be a consequence of recent shifts in relation to their original geographic ranges.

It is interesting to note that some fish species found to be devoid of parasitic copepods in the Argentinean Sea are commonly parasitized by copepods in Brazil, for example *A. marinii* harbour *Caligus itacurussensis*, *C. haemulonis*, and *Nothobomolochus cresseyi*, and *P. isosceles* is parasitized by *Chondracanthus* sp. The same occurs for *P. pagrus*; which was found harbouring two copepod species in Argentina and six species in Brazil (Luque and Tavares 2007). Therefore an increase in copepod diversity should be expected in these hosts in case global warming increases considerably the mean water temperatures at higher latitudes in the Southwestern Atlantic.

Acknowledgements. We thank Lic. N. Scarlatto (Instituto Nacional de Investigación y Desarrollo Pesquero) for gently providing fish samples from southern Patagonian waters; to Dr. Ju-Shey Ho (Department of Biological Sciences, California State University, USA) by his valuable help with the identification of *C. rogercresseyi*, and Dr. Danny Tang (Laboratory of Aquaculture, Department of Bioresource Science, Hiroshima University, Japan) by his assistance with part of the bibliography. At the time this manuscript was written, D.M.P.C. and D.G.V were supported by a PhD Fellowship from National Research Council of Argentina (CONICET). Financial support provided by grants from CONICET (PIP # 112-200801-00024); ANPCYT (PICT # 02199) and UNMdP (EXA 531/10).

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(Accepted December 7, 2011)