New record of monogeneans (Platyhelminthes: Monogenea) infecting some marine fishes from the Peruvian coastal zone

Nuevos registros de monogeneos (Platyhelminthes: Monogenea) infectando algunos peces marinos del litoral peruano

Abstract
A parasitological survey searching monogeneans infesting marine fish was carried out during June 2018 and January 2020 from the coastal zone of Puerto Pizarro, Tumbes (northern Peru) and from the coastal zone of Chorrillos, Lima (central Peru). The gills, skin, nasal cavities, or branchial gill-cover of seven species were sampled. Ten monogenean species assigned to six families and nine genera were identified. The monogeneans Callorhynchochotyle callorhynchi (Manter, 1955); Capsula biparaisiticum (Goto, 1894) Price, 1938; Euryhaitrotrema sargamatum Kristys & Boeger, 2002; Listrocotyle kearni Bullard, Payne &Braswell, 2004; Magniexcipula lamatoi特斯 Bravo-Hollis, 1981; Nasicola klawei (Stunkard, 1962) Yamaguti, 1968; and Pseudorhabdosynochus anulus Violante-Gonzalez & Rojas-Herrera, 2011 are registered for the first time in Peru. While Capsula gregalis (Wagner & Carter, 1967) Chisholm & Whittington, 2007; Heterocotyle margarita Chero, Cruces, Sáez, Santos & Luque, 2020; and Monocotyle luquei Chero, Cruces, Iannacone, Sanchez, Minaya, Sáez & Alvariño, 2016 have been previously registered in Peruvian waters, however, the region of Tumbes (northern Peru) represent a new locality record for these species.

Keywords:
Capsalidae; fish parasites; Hexabothriidae; Microcotylidae; Pacific Ocean.

Introduction
Currently, 244 monogenean species have been described or reported infecting marine fish in South America. Of these, 96 species occur in Peru (Luque et al. 2016a, 2016b). Peru has a rich fauna of marine fish with approximately 1070 species, including Chondrichthyans and teleosts, distributed in 549 genera, 194 families and 39 orders (Chi-
richigno & Cornejo 2001). However, approximately 9% of Peruvian marine fish have any parasitological study in monogeneans (Luque et al. 2016b). Thus, the current knowledge of the diversity of these fish parasites in Peru is still underestimated and many monogenean species, especially on poorly studied fish hosts, could be discovered (Cruces et al. 2020).

In this study, we inform about the monogenean records from fishes collected from coastal zone of Puerto Pizarro, norther Peru, and Chorrillos, central Peru, contributing to geographical distribution knowledge of 10 monogenean parasite species infecting marine fishes of the South American Pacific.

Material and methods
Fish were collected between June 2018 and January 2020 from the coastal zone of Puerto Pizarro, Tumbes region (3°29’S, 80°24’W) (northern Peru) and from the coastal zone of Chorrillos, Lima region (12°09’S, 77°01’W) (central Peru), using gillnets and were dissected immediately after capture. Fish were identified according to Chirichigno and Vélez (1998).

Monogeneans were removed from gill filaments, skin, nasal cavities, or internal face of branchial gill-covers and transferred temporarily to dishes containing sea water. The monogeneans were cold fixed in 4% formaldehyde, under light cover glass pressure, stained with Semichon’s carmine or Gomori’s trichrome, dehydrated using a graded ethanol series, cleared with clove oil and mounted on glass slides using Canada balsam. Other specimens were mounted in Gray and Wess ve oil and mounted on glass slides using Canada balsam using a compound Olympus™ BX51 light photomicroscope equipped with Nomarski Differential Interference Contrast (DIC) optics and drawings were made with the aid of a drawing tube. Unless otherwise stated, measurements are in micrometers, representing straight-line distances between extreme points of the structures measured and are expressed as the range followed by the mean and number (n) of specimens measured in parentheses.

The terms prevalence and mean intensity were used according to Bush et al. (1997). Vouchers of all helminth species were deposited in the Helminthological Collection of the Museo de Historia Natural de la Universidad Nacional Mayor de San Marcos (MUSM), Lima, Peru.

Results
We analysed 194 specimens of monogeneans recovered from 92 specimens of seven marine fish species. Detailed of morphological analysis made it possible to identify ten species belonging to nine genera and six families. The family and species of the monogeneans found in the present study, as well as measurements (only for species considered new records for Peru); taxonomic summaries containing the host, locality, site of infection, accession number of deposited specimens, and taxonomic comments for each monogenean species are presented below.

Taxonomy
Class Monogenea Van Beneden, 1858
Subclass Monopisthocotylea Van Beneden, 1858
Family Capsalidae Baird, 1853

Capsala biparasiticum (Goto, 1894) Price, 1938

Figure 1

Measurements: Body 7.65–10.45 (9.05; n = 2) mm long, maximum width 3.90–4.29 (4.09; n = 2) mm. Sucker-like attachment organs 1.11–1.24 (1.17; n = 2) mm long, 0.89–1.01 (0.95; n = 2) mm wide. Pharynx 726–852 (789; n = 2) long, 896–968 (932; n = 2) wide. Haptor 2.68–3.29 (2.98; n = 2) mm long, 2.78–3.39 (3.09; n = 2) mm wide. Testes 150–164 (157; n = 2) long, 87–93 (90; n = 2) wide. Cirrus sac 793–962 (878; n = 2) long, 177–194 (186; n = 2) wide. Ovary 726–849 (788; n = 2) long, 878–915 (897; n = 2) wide.

Host: Thunnus albacares (Bonnaterre, 1788) (Perciformes: Scombridae), yellow-fin tuna.

Site in Host: Nasal cavity.

Locality: Puerto Pizarro, Tumbes Region, Peru (3°29’S 80°24’W).

Voucher specimens deposited: 2 (MUSM 4720a-b).

Remarks: Capsala biparasiticum (Goto, 1894) Price, 1938 was initially described by Goto (1894) as Tristoma biparasitica by having the aforementioned characteristics (see Chisholm & Whitington 2007). Capsala biparasiticum was transferred to genus Capsala Bosc, 1811 by Chisholm and Whitington (2007) based in the presence of a single row of multicuspid sclerites located on the dorsal edge of the body, a common genital pore that opens midway between the midline and the lateral margin of the body and a uterus that joins the MCO at approximately the posterior 1/3 point. Two other species of Caballeroecotyla, C. abidjanii Bussieras & Baudin-Laurencin, 1970 and C. neothunni (Yamaguti, 1968), both from T. albacores, were transferred to genus Capsala and considered synonymous of C. biparasiticum by having the body proper including the haptor.


Figure 2

Host: Sarda chiliensis (Cuvier, 1832) (Perciformes: Scombridae), Eastern Pacific bonito.
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Site in Host: Gill filaments.

Locality: Coastal zone of Puerto Pizarro, Tumbes Region, Peru (3°29'S 80°24'W).

Voucher specimens deposited: 5 (MUSM 4721a-e).

Remarks: Capsala gregalis (Wagner & Carter, 1967) Chisholm & Whittington, 2007 was originally described by Wagner and Carter (1967) as Caballeroctyloa gregalis based on specimens collected from Sarda chiliensis (Girard, 1858) in the North American Pacific Ocean of the United States. This species was characterized mainly by lacking dorsomarginal body sclerites (see Wagner & Carter, 1967). However, Chisholm and Whittington (2007) examined the type specimens of Ca. gregalis and noticed the presence of a single row of small unicuspid dorso-marginal body sclerites. They transferred Ca. gregalis to the genus Capsala. A capsalid species, Ca. australis Oliva, 1986 was described from the gills of S. chilensis in Chile. This species was also reported from the same host in the central coast of Peru. Chisholm and Whittington (2007) synonymized Ca. australis with C. gregalis because both species have a single row of unicuspid sclerites, haptoral accessory sclerites irregularly shaped, a common genital pore that opens close to the body margin and a similar distance from the left anterior attachment organ, and testes ranging in number between 27 and 35. This is the first record of C. gregalis in northern Peru.

Listrocephalus kearni Bullard, Payne & Braswell, 2004

Figure 3

Measurements: Body 2.29–3.25 (2.79; n = 4) mm long, maximum width 0.82–0.99 (0.92; n = 4) mm. Pharynx 186–264 (223; n = 4) long, 166–243 (206; n = 4) wide. Haptor 0.77–1.22 (1.01; n = 4) mm in diameter. Accessory sclerite 34–51 (45; n = 3) long. Anterior anchor 20–31 (25; n = 3) long. Posterior anchor 15–26 (22; n = 3) long. Hook 13–14 (14; n = 3) long. Testes 286–456 (339; n = 4) long. Cirrus sac 700–900 (784; n = 7) long. Testes 29 in number, ovary 120–230 (176; n = 35) long. Gland of Goto 22 in number, 210–550 (316; n = 34) long. Ovary 0.85–1.60 (1.34; n = 9) mm long, with one central and seven peripheral loculi; marginal membrane delicate; accessory sclerites small, 27–43 (37; n = 5) long, with short and bifid shaft. Sucker-like attachment organs 450–725 (608; n = 10) mm long, 375–750 (639; n = 10) wide. Pharynx 1.05–1.63 (1.39; n = 9) mm long; anterior region 1.05–1.50 (1.29; n = 10) mm wide; posterior region 0.85–1.18 (1.09; n = 10) mm wide. Cirrus sac 700–900 (784; n = 7) long. Testes 29 in number, 120–230 (176; n = 35) long. Gland of Goto 22 in number, 210–550 (316; n = 34) long. Ovary 0.85–1.60 (1.34; n = 9) mm long, 0.870–1.65 (1.33; n = 9) mm wide.

Host: Thunnus albacares (Bonnaterre, 1788) (Perciformes: Scombridae), yellow-fin tuna.

Site in Host: Nasal cavity.

Locality: Coastal zone of Puerto Pizarro, Tumbes Region, Peru (3°29'S 80°24'W).

Voucher specimens deposited: 13 (MUSM 4722a-m).

Remarks: This species was initially described as a member of the genus Caballeroctyloa by Stunkard (1962) based in specimens collected from nasal cavity of T. albacares in the Pacific Ocean. Later, Yamaguti (1968) transferred Ca. kearni to genus Nasicola Yamaguti, 1968, as N. klawei (Stunkard, 1962) Yamaguti, 1968. Currently, three valid species of Nasicola are recognized, namely N. brasiliensis Kohn, Baptista-Farias, dos Santos & Gibson, 2004; N. hogansi Wheeler & Beverly-Burton, 1987, and N. klawei, all of them described or reported from tunas in the Atlan-
Euryhaliotrema sagmatum Kritsky & Boeger, 2002


**Host:** Umbrina xanti Gill, 1862 (Perciformes: Sciaenidae), polla drum.

**Site in Host:** Gill filaments.

**Locality:** Coastal zone of Puerto Pizarro, Tumbes Region, Peru (3°29’S 80°24’W).

**Voucher specimens deposited:** 1 (MUSM 4723).

**Remarks:** This is the first record of *Euryhaliotrema sagmatum* in the Peruvian coast.

**Family Monocotylidae**

Heterocotyle margaritae Chero, Cruces, Sáez, Santos & Luque, 2020

**Host:** Hypanus dipterurus (Jordan and Gilbert, 1880) (Myliobatiformes: Dasyatidae), diamond stingray.

**Site in Host:** Gill filaments.

**Locality:** Coastal zone of Puerto Pizarro, Tumbes Region, Peru (3°29’S 80°24’W).

**Voucher specimens deposited:** 3 (MUSM 4725a-c).

**Remarks:** This species was recently described parasitizing *H. dipterurus* from Chorrillos, Lima Region (central Peru) (Chero et al. 2020). *Heterocotyle margaritae* is typified by its male copulatory organ, which is funnel-shaped, spatulate distally with lateral folds and by its club-shaped accessory piece (Chero et al. 2020). In addition, this species is characterized by having a haptor with one central and eight peripheral loculi, 1/2/3 sinuous ridge arrangement and a vagina sclerotized. These findings extend the distribution to a new locality in northern Peru.

Monocotyle luquei Chero, Cruces, Iannacone, Sanchez, Minaya, Sáez & Alvariño, 2016

**Host:** Hypanus dipterurus (Jordan and Gilbert, 1880) (Myliobatiformes: Dasyatidae), diamond stingray.

**Site in Host:** Gill filaments.

**Locality:** Coastal zone of Chorrillos, Lima (central Peru) (Chero et al. 2020). *Heterocotyle margaritae* is typified by its male copulatory organ, which is funnel-shaped, spatulate distally with lateral folds and by its club-shaped accessory piece (Chero et al. 2020). In addition, this species is characterized by having a haptor with one central and eight peripheral loculi, 1/2/3 sinuous ridge arrangement and a vagina sclerotized. These findings extend the distribution to a new locality in northern Peru.

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**Host:** Hypanus dipterurus (Jordan and Gilbert, 1880) (Myliobatiformes: Dasyatidae), diamond stingray.

**Site in Host:** Gill filaments.

**Locality:** Coastal zone of Chorrillos, Lima (central Peru) (Chero et al. 2020). *Heterocotyle margaritae* is typified by its male copulatory organ, which is funnel-shaped, spatulate distally with lateral folds and by its club-shaped accessory piece (Chero et al. 2020). In addition, this species is characterized by having a haptor with one central and eight peripheral loculi, 1/2/3 sinuous ridge arrangement and a vagina sclerotized. These findings extend the distribution to a new locality in northern Peru.

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**Site in Host:** Gill filaments.

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Kritsky & Pereira, 1989; are recognized, namely hynchocotyle C. Christison 2012). To date, five valid species of in Argentina (Atlantic Ocean) (Boeger et al. 1989, Boeger elephantfish, using specimens collected from the gills of the American Suriano and Incorvaia, 1982 geographical distribution of the species from the original mens of M. Christison 2012). The specimens studied here are in accordance with the description given by Vaughan and Christison (2012) and Poddubnaya et al. (2015) for C. Callorhynchocotyle. The taxonomic characters of C. callorhynchi were performed by Manter (1955), Boeger et al. (1989), Beverley-Burton and Chisholm (1990) and Vaughan and Christison (2012), revealing the presence of a papillate surface in the lumen of the haptoral suckers. However, Poddubnaya et al. (2015) show for first time the presence of spines and not papillae on the inner surface of the suckers of C. callorhynchi. In South America, C. callorhynchocotyle has been registered on the gill filaments of C. callorhynchi off the coast of Chile and Falkland-Patagonian Region (Cohen et al. 2013). In Peru, only C. marplatensis has been registered on the gill filaments of C. callorhynchi (Luque et al. 2016). Callorhynchocotyle callorhynchi is a new record to the Peruvian Pacific Ocean. The record of C. callorhynchocotyle in the coast of Peru is not a surprise because the geographical distribution of the fish host includes the Pacific and Atlantic coast of South America.

Family Microcotylidae Price, 1942

Magniexcipula lamothei Bravo-Hollis, 1981

Measurements: Body fusiform, 2.27–5.70 (4.17; n = 10) mm long, 0.29–0.58 (0.46; n = 10) mm in maximum width. Clamp measurements: anterior most clamps 51–59 (55; n = 3) long; medial clamps 48–50 (49; n = 3) long; terminal clamps 38–50 (42; n = 5) long. Buccal suckers septime, 35–77 (57; n = 9) long, 49–90 (65; n = 8) wide. Pharynx 27–39 (34; n = 10) long, 33–36 (35; n = 10) wide. Testes 17–18 in number: Genital atrium unarmed, distant 307–457 (361; n = 9) from anterior end. Cirrus armed with two sclerotized rods and numerous small sigmoid spines; rods 78–88 (856; n = 9) long. Vitelline follicles 307–457 (361; n = 8) from anterior end. Vaginal pore 306–442 (406; n = 4) from anterior end. Egg 157–220 (195; n = 3) long, 62–80 (70; n = 3) wide, with single long filament at abopercular pole.

Host: Calamus brachysomus (Lockington, 1880) (Periformes: Sparidae), Pacific porgy.

Site of infection: Gill filaments.

Locality: Coastal zone of Puerto Pizarro, Tumbes Region, Peru (3°29'S 80°24'W).

Remarks: Magniexcipula is a monotypic genus and was erected by Bravo-Hollis (1981) to accommodate a microcotylid species, Magniexcipula lamothei Bravo-Hollis, 1981, from the gills of the Pacific porgy, Calamus brachysomus (Lockington, 1880) (Periformes: Sparidae) in Mexico. This genus is characterized by having a well-developed vitelline-seminal receptacle and by the great complexity of the copulatory organ and genital atrium.
Morphometrical comparison of the present specimens with the original description of *M. lamothei* provided by Bravo-Hollis (1981) did not reveal any differences. *Magniexcipula lamothei* has also been registered infecting the gill filaments of the spotted head sargo, *Genyatremus dovii* (Günther, 1864) (Perciformes: Haemulidae) in Mexico (Mendoza-Garfias & Pérez-Ponce de León 1998). This is the first record of *M. lamothei* in the Peruvian coast. The presence of *M. lamothei* in the South American Pacific might be a result from the geographical distribution of the host (*C. brachysomus*), who is distributed from the coast of the Southern California (USA) to Peru.


**Discussion**

In the present study, we identified ten monogenean species, assigned to six families (Capsalidae, Dactylogyridae, Diplectanidae, Hexabothriidae, Microcotylidae and Monocotylidae) and nine genera (*Callorhynchocotyle*, *Capsala*, *Euryaliotrema*, *Heterocotyle*, *Listrocephalus*, *Magniexcipula*, *Monocotyle*, *Nasicola* and *Pseudorhabdosynochus*), on marine fish belonging to six families (Callorhinchidae, Dasyatidae, Sciaenidae, Scombridae, Serranidae and Sparidae) from Peru. The monogeneans *C. callorhynchi*, *C. biparasiticum*, *E. sagmatum*, *L. kearni*, *M. lamothei*, *N. klawei* and *P. annulus* are registered for the first time in Peru. While *C. gregalis*, *H. margaritae* and *M. luquei* have been previously registered in Peruvian waters, however, the region of Tumbes (northern Peru) represents a new locality record for these species.

Luque et al. (2016) listed six species representing four genera of monogeneans from three marine chondrichthyans in Peru, a *Callorhynchocotyle* species (Hexabothriidae) from *C. callorhynchos*, two *Rhinobatochocotyle* species (Hexabothriidae) from *Pseudobatos planiceps* Garman, 1880 (Rhinopristiformes: Rhino-
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The Hexabothriidae Price, 1942 (Monogenea) include species that infect the buccal cavity, gill arches or respiratory surfaces of chondrichthyan fishes (sharks, stingrays and chimaeras) (Chero et al. 2018a, 2019). These species are characterized by having a haptor with three pairs of sucker complexes, each of which are armed with a large, hooked sclerites; and by having a haptoral appendix, which bears a pair of small suckers at its distal end (Boeger & Kritsky 1989, Chero et al. 2019). Three hexabothrid species have been described or recorded infecting the gills of marine chondrichthyan in Peru: Ca. marplatensis; Hypanocotyle bullardi Chero, Cruces, Sáez, Camargo, Santos & Luque, 2018 and Rhinobatohexabothriidae pacifica Oliva & Luque, 1995. An additional species, Rhinobatohexabothriidae cyclovaginatus Doran, 1953 was also reported infecting the gills of P. planeus in Peru (Tantaleán et al. 1998). However, according to Chero et al. (2019) this was an identification error. The species of Callorhynchoscotyle registered here increases the number of hexabothrid species to four.

Regard to capsalids, four species have been registered infecting the gills of five marine fish in Peru: C. gregalis from S. chilensis, Encotylabe antofagastensis Sepúlveda, González & Oliva, 2014 from Anisotremus scapularis (Tschudi, 1846) (Haemulidae); E. callaoensis Tantaleán, 1974 from Paralichthys peruanus (Steindachner, 1875) (Sciaenidae) and Sciaena delicosa (Tschudi, 1846) (Sciaenidae); Macrophyllida antarctica (Hughes, 1928) Johnston, 1930 from Cheilodactylus variatus Galicia, 1833 (Cheilodactylidae) (Luque et al. 2016). Listrocephalos kearni is the first capsalid monogenean registered from a marine chondrichthyan in Peru.

At present, eight microcotylid species have been registered in Peru, seven of them infecting the gills of marine perciforms (Luque et al. 2016). This is the first record of a microcotylid species infecting spardin fish from Peru.

Literature cited


Mendoza-Franco EF, Violante-González J, Herrera AAR. 2011. Six new and one previously described species of Pseudorhabdosynochus (Monogeneidea, Diplectanidae) infecting the gills of groupers (Perciformes, Serranidae) from the Pacific Coasts of Mexico and Panama. Journal of Parasitology 97: 20–35. https://doi.org/10.1645/GE-2716.1


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