UNIVERSIDAD AUTÓNOMA DEL ESTADO DE MÉXICO

MAESTRÍA EN CIENCIAS AGROPECUARIAS Y RECURSOS NATURALES

Parámetro de infección de las Helmintiasis en aves acuáticas de las Ciénegas del Lerma, Estado de México.

TESIS

QUE PARA OBTENER EL GRADO DE:

MAESTRO EN CIENCIAS AGROPECUARIAS Y RECURSOS NATURALES

PRESENTA

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RESUMEN

Los parásitos a través del tiempo han sido considerados solo causantes de enfermedades que deben ser erradicados. Inclusive han sido ignorados en estudios de manejo y conservación de ecosistemas a pesar de que su presencia puede reflejar las interacciones tróficas de diferentes organismos que participan en su ciclo de vida aportando información valiosa sobre el estatus de conservación del ambiente. El objetivo del presente estudio fue conocer los parámetros de infección de las helmintiasis en aves acuáticas y la posible relación de la abundancia con el sexo del hospedero. En total se examinaron 47 ejemplares de aves acuáticas de las Ciénegas del Lerma, Estado de México, identificando 15 especies de helmintos, siendo el tremátodo *Notocotylus seineti* y el céstodo *Sobolevicanthus krabbeella* quienes registraron los mayores parámetros de infección. Resalta la presencia de un helminto no registrado previamente en México, *Patagifer bilobus* además de 11 nuevos registros de hospederos. No hubo diferencias estadísticamente significativas en la abundancia de los helmintos dominantes *N. seineti* y *S. krabbeella* entre machos y hembras de *Anas clypeata* (U= 22.0, n=11, p= 0.151642; U= 9.0, n= 11, p= 0.390748), y no hay relación estadísticamente significativa entre la longitud del intestino y la abundancia de *N. seineti* y *S. krabbeella* en *A. clypeata* (n:11; r -0.274021; p≥ 0.05 y n:11; r -0.00142569; p≥ 0.05). Ni el sexo ni la longitud del intestino explican las diferencias en los parámetros de infección. Sin embargo, la dominancia de solo unas pocas especies de helmintos hallados en este estudio, bien podrían ser causadas por la capacidad del parásito de infectar al hospedero y/o la susceptibilidad de este a las infecciones.

ABSTRACT

Parasites over time have been considered only causing diseases and should be eradicated. They have even been ignored in ecosystem management and conservation studies, although their presence may reflect the trophic interactions of different organisms that participate in their life cycle, providing valuable information on the conservation status of the environment. The objective of the present study was to know the infection parameters of the helminthiasis in waterfowl and the possible relationship of the abundance with the sex of the host. In total, 47 specimens of waterfowl from the Ciénegas del Lerma, State of Mexico, were examined, identifying 15 species of helminths, being the trematode *Notocotylus seineti* and the *Sobolevicanthus krabbeella* tapeworm that recorded the highest infection parameters. It highlights the presence of a helminth not previously registered in Mexico, *Patagifer bilobus*, in addition to 11 new host records. There were no statistically significant differences in the abundance of the dominant helminths *N. seineti* and *S. krabbeella* between males and females of *Anas clypeata* ($U = 22.0$, $n = 11$, $p = 0.151642$; $U = 9.0$, $n = 11$, $p = 0.390748$), and there is no statistically significant relationship between intestine length and abundance of *N. seineti* and *S. krabbeella* in *A. clypeata* (n: 11; r -0.274021; $p \geq 0.05$ and n: 11; r -0.00142569; $p \geq 0.05$).

Neither the sex nor the length of the intestine explain the differences in the infection parameters. However, the dominance of only a few species of helminths found in this study could well be caused by the parasite's ability to infect the host and/or its susceptibility to infections.

Helminths in Aquatic Birds (Anatidae, Rallidae, Threskiornithidae) of the Lerma Wetlands, in the Highlands of Central Mexico.

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ABSTRACT: Little is known about helminth parasites of migratory and resident aquatic birds of Mexican latitudes. We investigate the helminth parasites of 45 aquatic bird species: Anatidae: *Anas acuta* Linnaeus, 1758 (2 specimens), *Anas clypeata* Linnaeus, 1758 (11), *Anas crecca* Linnaeus, 1758 (5), *Anas cyanoptera* Vieillot, 1816 (6), *Anas discors* Linneo, 1766 (5), Rallidae: *Fulica americana* Gmelin, 1789 (11), *Gallinula galeata* Lichtenstein, 1818 (3), and Treskiornitidae: *Plegadis chihi* Vieillot, 1817 (2), from the Lerma wetlands at the highlands of central Mexico during two hunting seasons from November 2015 to March 2016 and from November 2016 to March 2017. We identified 15 helminth taxa including Digenea, Echinostomatidae *Echinoparyphium recurvatum* Linstown, 1873, *Patagifer bilobus* (Rudolphi, 1819), Notocotylidae *Notocotylus seineti* Fuhrmann, 1919, *N. pacifer* (Noble, 1933), Paramphistomidae *Zygocotyle lunata* (Diesing, 1836), Leucochloriidae *Leucochloridium insigne* (Looss, 1899), and Strigeidae *Cotylurus brevis* Dubois and Rausch, 1950; Cestoda Gryporhynchidae *Cyclustera ralli* (Underwood and Dronen, 1986), Hymenolepididae *Hymenolepis megalops* (Nitzsch in Creplin, 1829), *Diorchis americana* Ransom, 1909, *Diorchis* sp., and *Sobolevicanthus krabbeella* Hughes, 1940; Acanthocephala Polymorphidae *Polymorphus trochus* Van Cleave, 1945, *Pseudocorynosoma constrictum* (Van Cleave, 1918) and *Polymorphus* sp. Most birds sampled were infected with at least one helminth taxa. The results shown the presence of one helminth taxa not previously recorded from Mexico, *P. bilobus*. Moreover, 11 new host parasite records were documented.

Aquatic birds harbour numerous parasites (Lapage, 1961; Alemán-Canales *et al*. 2014). Due to migratory movements of many species of aquatic birds, these birds may facilitate parasite movement across broad geographic areas (Violante-González *et al*. 2011). Many northern aquatic birds especially waterfowl winter in or migrate through Mexico in large numbers. Such that Mexican habitats are shared in winter by populations of nonmigratory and migratory birds (Saunders and Saunders, 1981). Knowledge about helminth parasites and their distributions would help elucidate the dynamics of parasite infections of resident non-migratory, as well as wintering migratory birds. A sound knowledge of bird biology and ecology would be obtained continentally to serve as basis for any management programs and protection of migratory birds (Saunders and Saunders, 1981). However, little is known about helminth parasites of aquatic birds of southern latitudes (Violante-González *et al*. 2011). Aquatic birds are widely hunted species in central Mexico highlands. While some is known about their general biology and distribution (Berlanga *et al*. 2015) little is known about its parasite fauna. The research of helminth parasites of aquatic wild birds of Mexico has been conducted sporadically, rather few published papers are available (Larios, 1943; León-Règagnón, 1992; Martínez-Haro *et al*. 2012). The results of the available researches in central Mexico suggested the necessity of additional faunistic research, particularly in Lerma wetlands, since that area is geographically special and remarkably for its rich avifauna (Ceballos, 2003).

Martínez-Haro *et al.* (2012) published a list of helminths from aquatic birds of the Lerma wetlands at central area of Mexico. Recently, new dissection and routine work in the same localities and hosts gave more additional data, and it seems desirable to publish a supplementary list of records. Examination of several birds sympatric from a given locality could provide information about the presence of helminths, their relative abundance and importance. The purpose of this paper is to report on the prevalence and intensities of helminths harboured by 45 aquatic birds examined post-mortem and collected from Lerma wetlands in central Mexico.

The Lerma river wetlands are situated in the Upper Lerma Valley, are the headwaters of the main river of the highlands of Mexico, the Lerma River. However, this upper valley near Toluca has been vastly changed with the drainage of the marshes, canalization of the river, water consumption for irrigation, and in general losing water supply and volume of flow down the valley (Saunders and Saunders, 1981). Despite having been so strongly impacted by anthropogenic activities, the Lerma wetlands remains an ecologically important wetland ecosystem in central Mexico highlands. The remaining habitat for aquatic birds is in the groups of small reservoirs and marshes scattered down the valley. Hunters and sportsmen shoot ducks and other aquatic birds at these lakes.

Forty-five individuals of wild water birds belonging to Anatidae: *Anas acuta* Linnaeus, 1758 (2 specimens), *Anas clypeata* Linnaeus, 1758 (11), *Anas crecca* Linnaeus, 1758 (5), *Anas cyanoptera* Vieillot, 1816 (6), *Anas discors* Linneo, 1766 (5); Rallidae: *Fulica americana* Gmelin, 1789 (11), *Gallinula galeata* Lichtenstein, 1818 (3), and Treskiornitidae: *Plegadis chihi* Vieillot, 1817 (2) were examined for helminths (taxonomy of birds follows Berlanga *et al*. 2015). The birds were hunted and donated by local hunters in the Lerma wetlands (19°14’31’’N, 99°29’50.8’’W), Estado de México, in central Mexican highlands, during two hunting seasons: November 2015 to March 2016 and

November 2016 to March 2017. Parasitological examination of each bird included, body cavity, trachea, lungs, liver, kidneys, intestine and cloaca. All found helminths were isolated and then fixed in hot 4% formalin. Posteriorly all helminths were stained with Mayer's paracarmine and mounted in Canada balsam. Infections are recorded as prevalence (percent of birds infected), and intensity (mean number of helminths per infected bird). Voucher specimens will be deposited in the Colección Nacional de Helmintos (CNHE), Instituto de Biología, Universidad Nacional Autónoma de México.

Fifteen helminths taxa representing 12 genera from eight families, were found including Digenea, Echinostomatidae *Echinoparyphium recurvatum* Linstown, 1873, *Patagifer bilobus* (Rudolphi, 1819), Notocotylidae *Notocotylus seineti* Fuhrmann, 1919, *N. pacifer* (Noble, 1933), Paramphistomidae *Zygocotyle lunata* (Diesing, 1836), Leucochloridiidae *Leucochloridium insigne* (Looss, 1899), and Strigeidae *Cotylurus brevis* Dubois and Rausch, 1950; Cestoda, Gryporhynchidae *Cyclustera ralli* (Underwood and Dronen, 1986), Hymenolepididae *Hymenolepis megalops* (Nitzsch in Creplin, 1829), *Diorchis americana* Ransom, 1909, *Diorchis* sp., and *Sobolevicanthus krabbeella* Hughes, 1940; Acanthocephala Polymorphidae *Polymorphus trochus* Van Cleave, 1945, *Pseudocorynosoma constrictum* (Van Cleave, 1918) and *Polymorphus* sp. Table 1 list the sites, prevalences and intensities of infection for the helminth collected. These results shown the presence of one helminth taxa not previously recorded from Mexico, *P. bilobus.* Moreover, 11 new host parasite records were documented (Table 1).

All birds were infected with specimens of at least one taxa of helminth (range 1 – x helminth taxa). The five species of Anatidae were infected with 11 helminths taxa including five trematodes, two of which *N. seineti* and *E. recurvatum* infected five and three species of anatids respectively, while the four taxa of cestodes and the two of acanthocephalans found were shared also between several of the anatid hosts (Table 1). The rallid *Fulica americana* was infected with five helminth taxa, three of them shared with *G. galeata* the other rallid examined and that resulted infected with only these three species. All helminth taxa found in the rallid hosts were shared with the anatids, except the trematode *L. insigne* and acanthocephalan *P. trochus* that was recovered only from *F. americana* and *G. galeata*, while the treskionrnitid *P. chihi* was infected with two helminth taxa not shared neither with anatids nor with rallids.

Two trematode species, *N. seineti* and *E. recurvatum* and one cestode specie *H. megalops* were the more widely found among the species of birds examined; *N. seineti* and *H. megalops* infecting only anatids, while *E. recurvatum* was found infecting three anatids and one rallid species. These same three species mentioned above, were also those that reached the highest prevalences (generally >20%) in the samples, nevertheless the cestode *S. krabbeella* reached the maximum mean intensities in *A. clypeata* and in *A. discors*. Mean intensities of the infection by *N. seineti* were also high, however, not as higher as those by *S. krabbeella* (Table 1).

Most taxa of helminths found (11/15) were species that are common in waterfowl and other aquatic birds, and previously recorded from northern host populations north of Mexico. These are parasites of wide geographical distribution and a large host records, they have been recorded from numerous species of birds from several families, mostly from Charadriiformes, Anseriformes, Passeriformes and Galliformes (Yamaguti, 1963, 1971; Schmidt, 1986). The carried out study showed however, the existence of one, not previously recorded in Mexican fauna, helminth taxa, *Patagifer bilobus*.

Only two species of *Patagifer* has been described in North America: *P. viscoai* was described from white ibis *Eudocimus albus* in Louisiana (Lumsden, 1962) like *P. lamothei* but in Texas and Mexico (Dronen and Blend, 2008; Ortega-Olivares *et al.* 2011). *P. bilobus* has only been reported in South America was described from *Plegadis chihi* (Digiani, 2000). The present record increases its host range. Most species (9/12) in the genus *Patagifer* have a rather restricted geographical distribution and host range, generally linked to birds of the family Threskiornitidae, which may suggest a relatively high degree of host specificity between parasites of this genus *Patagifer* and the hosts of the family Threskiornitidae (Onda *et al*. 1983).

All other species listed in this work have been previously recorded from central Mexico aquatic birds (Larios, 1943; León-Règagnón, 1992; Martínez-Haro *et al*. 2012). Moreover, 11 not previously recorded parasite – host systems were documented; this last fact underlies the lack of studies of the Mexican fauna of parasites of aquatic birds, because all these are well known helminths in Nearctic surveys.

It has been well documented that Anatidae and Rallidae share helminth fauna when habiting together. The presence of a parasite species in different hosts may be due to a similar dynamic of infection or parasitic species may be found in the same host if the modes of transmission are comparable and even common (Saad-Fares and Combes, 1992), as a result of changes in the host diet that affect the parasite populations according to the availability of alternative prey (Poulin, 2006) or may be similar during the time that the hosts occupy the same geographic region (Canaris *et al*. 1981). However, helminth taxa of the Threskiornithidae *Plegadis chihi* did not show any similarity to those reported from the other hosts. Which is remarkably in due fact that most of the documented helminth taxa are generalist widely distributed geographically, suggesting a most particular helminth fauna for this host species. However, sample-sizes neither for the number of host species examined from each bird family (Anatidae, 5 spp; Rallidae, 2 spp; Threskiornithidae, 1 sp.), nor for the number of bird specimens examined (Anatidae, 29 specimens; Rallidae, 14; Threskiornithidae, 2) allow for sound comparisons.

Amongst the recorded helminths, at least the cercariae of *E. recurvatum* that has been recorded from snails *Physa* sp. and adults recovered experimentally from chickens (Unpublished data); and metacestodes of several gryporhynchid species, including *C. ralli* from the mesenteries and coelom of several freshwater fishes including Cyprinidae and Goodeinae (Salgado-Maldonado, 2006 and literature recorded there). As well as cystacanths of *Polymorphus* sp., from the mesenteries and coelom of several freshwater fishes, including Atherinopsidae, Cyprinidae and Goodeinae (Unpublished data), have been documented from central México wetlands and other bodies of water, such that these species presumably complete its life cycle in freshwater there, although this has yet to be demonstrated, because migratory birds could have acquired their parasites elsewhere.

The need for an understanding of the parasite fauna of wild aquatic birds is essential in light of increases efforts to bird conservation and management of species. Studies such as the foregoing are important in determining the "normal" parasite burden of a given species, and thus allowing us to assess the impact of these organisms on the host, should their numbers increase significantly (Mahoney and Threlfall, 1978).

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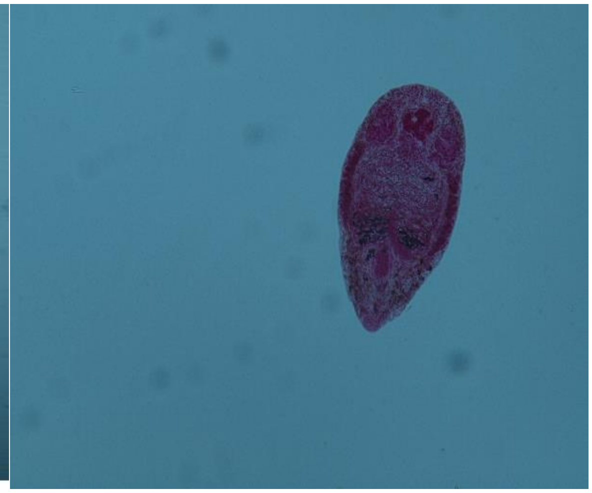
Table 1. Infection parameters of gastrointestinal helminths in aquatic birds

	Anas clypeata (11)			*Anas discors* (5)			*Anas crecca* (5)			*Anas acuta* (2)			*Anas cyanoptera* (6)			*Fulica americana* (11)			*Gallinula galeata* (3)			*Plegadis chihi* (2)		
TREMATODA (7)	P	IM	**SI**	P	IM	**SI**	P	IM	**SI**	P	IM	**SI**	P	IM	**SI**	P	IM	**SI**	P	IM	**SI**	P	IM	**SI**
Cotylurus brevis Dubois y Rausch, 1950	-	-	-	-	-	-	-	-	-	-	-	-	16.7	14	I	-	-	-	-	-	-	-	-	-
Notocotylus seineti Fuhrman, 1919	72.7	40.3	Ce	60	28	Ce	40	1	I	50	123	I	66.7	36.3	Ce, I	-	-	-	-	-	-	-	-	-
Notocotylus pacifier (Noble, 1933) Harwood, 1939	27.3	49.7	Ce	-	-	-	-	-	-	-	-	-	-	-	-	27.3	15	Ce, I	33.3	3	Ce	-	-	-
Zigocotyle lunata Stunkard, 1916.	-	-	-	-	-	-	-	-	-	50	1	Ce	-	-	-	-	-	-	-	-	-	-	-	-
Echinoparyphium recurvatum Linstow, 1873	-	-	-	40	5	Ce	-	-	-	50	4	Ce	33.3	15.5	Ce, I	27.3	6	Ce, Cl,I	-	-	-	-	-	-
Leucochlorydium insigne Loss, 1899	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	18.2	13	I	33.3	1	Ce	-	-	-
Patagifer bilobus (Rudolphi, 1819) Dietz, 1909	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	2	I
CESTODA (5)																								
Himenolepis megalops (Nitzsch in Creplin, 1829) Ransom, 1902	27.3	17.7	Ce,Cl,I	80	8.5	Ce, Cl,I	20	1	I	50	3	Ce	33.3	7	Cl	-	-	-	-	-	-	-	-	-
Diorchis sp.	18.2	96.5	I	-	-	-	20	115	I	-	-	-	16.7	32	Ce, I	-	-	-	-	-	-	-	-	-
Sobolevicanthus krabbeella Hughes, 1940	72.7	184.8	Ce,Cl,I	60	1228.7	I	-	-	-	-	-	-	50	78	I	-	-	-	-	-	-	-	-	-
Diorchis americana Ransom, 1909	-	-	-	-	-	-	20	58	I	50	19	I	-	-	-	45.5	4	I	-	-	-	-	-	-
Cyclustera ralli (Underwood and Dronen 1986) Bona, 1994	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50	1	I
ACANTOCEPHALA (3)																								
Polymorphus trochus Van Cleave, 1945	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	36.4	8	Ce, I	33.3	12	I	-	-	-
Polymorphus sp.	27.3	4.3	I	40	22	I, Ce	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pseudocorynosoma constrictum Van cleave, 1918	9.1	8	I	40	9	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abreviatte: SI: Infection site; I: Intestine; Ce: Cecum; Cl: Cloaca

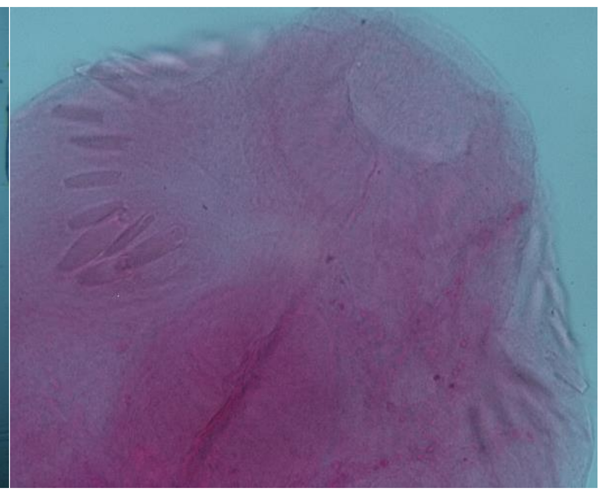
ANEXO 2

Notocotylus seineti (10X)

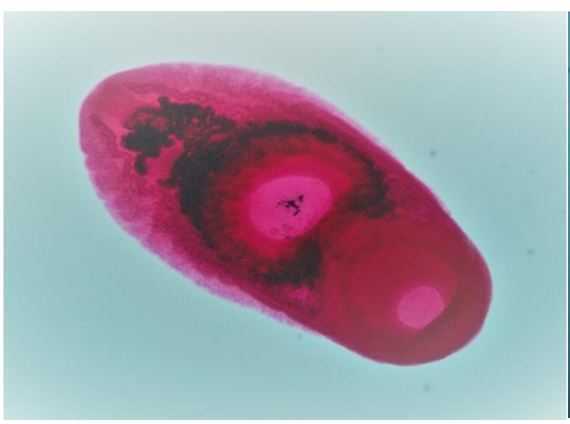


Notocotylus pacifer (10X)

E. recurvatum (10X)



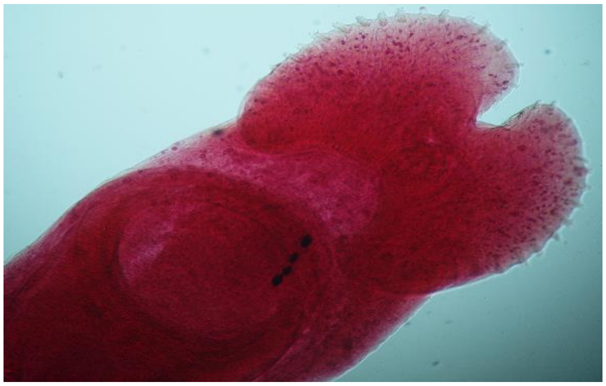
E. recurvatum. Collar de espinas (40X)



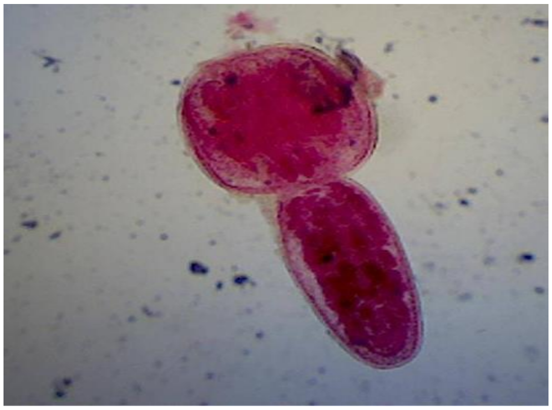
L. insigne (10X)

Z. lunata (10X)

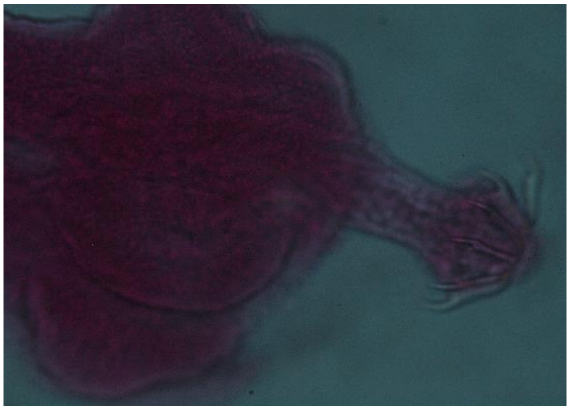
P. bilobus (10X)



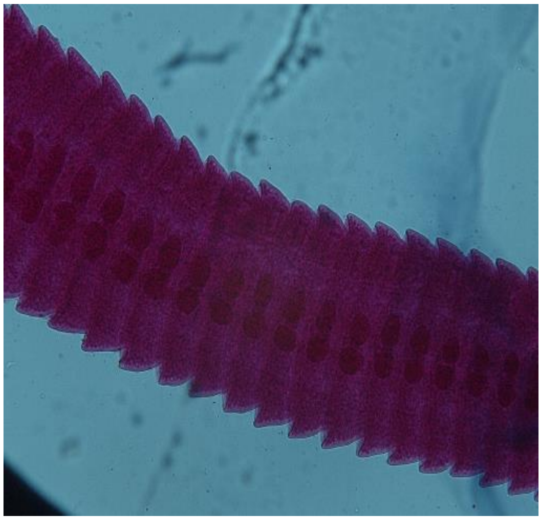
P. bilobus. Corona de ganchos(40X)



Cotylurus brevis (4X)

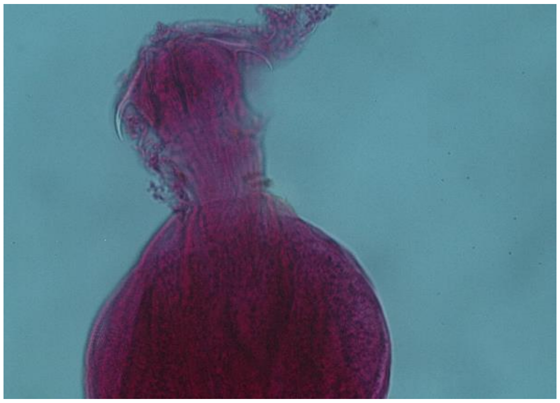


D. americana. Escolex (10X)

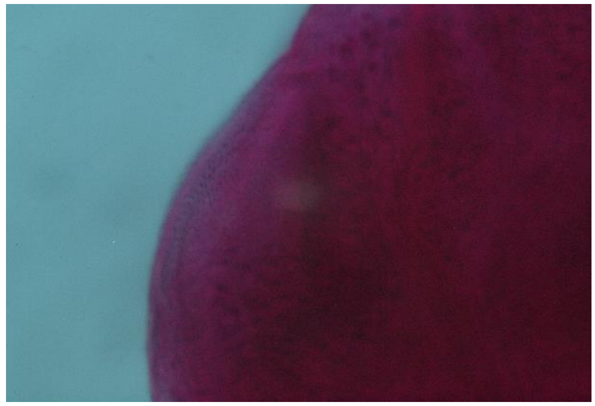


D. americana. Proglótido maduro (10X)

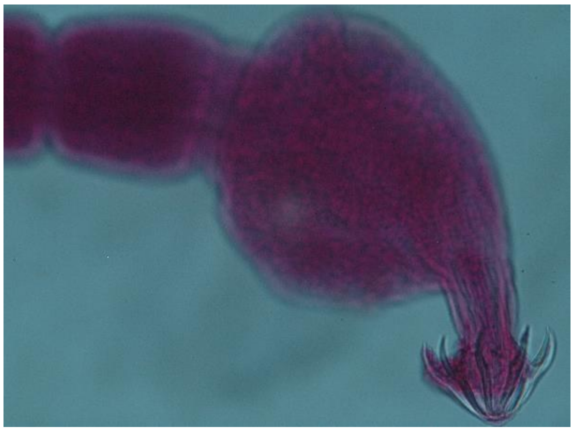
C. ralli. Escolex (10X)



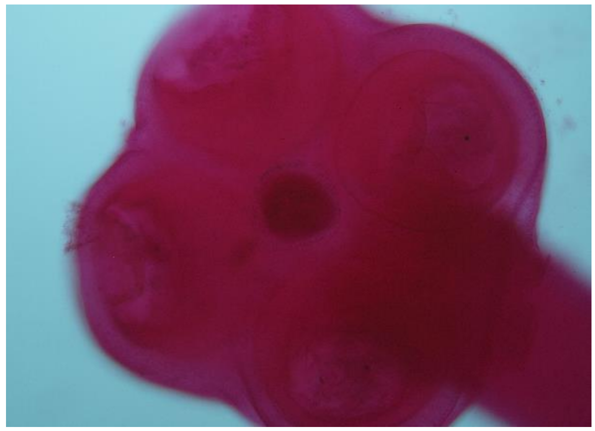
Diorchis sp. Excolex (10X)



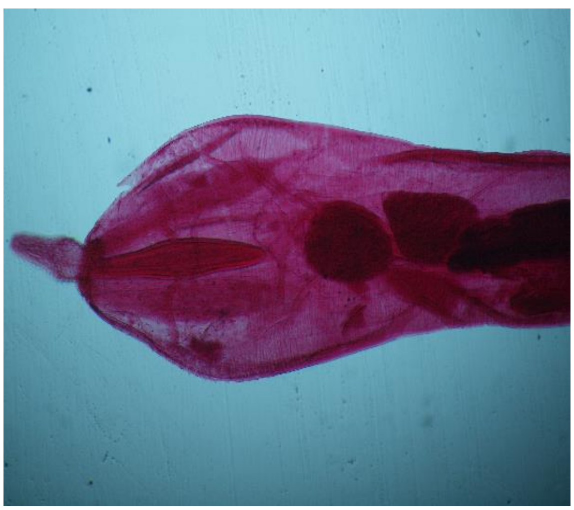
Diorchis sp. Ventosas con espinas (40X)



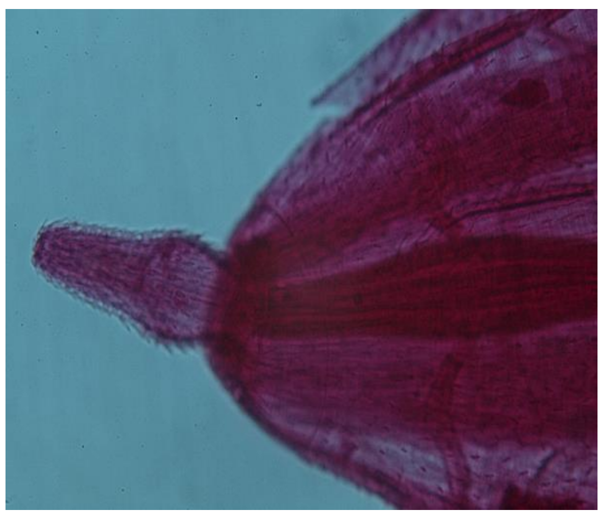
S. krabbeella. Corona de ganchos(10X)



H. megalops. Escolex (10X)



P. trochus (4X)



P. trochus. Proboscide (10X)

Polymorphus sp. (4X)

P. constrictum (4X)

P. constrictum. Bursa y espinas genitales (10X)