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RESEARCH PAPER

# Gill monogenean communities on three commercially important sparid fish in Omani waters

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# تجمعات المونوجينا في خياشيم أهم ثلاثة أسماك السباريدية التجارية في المياه العمانية

جيلها يون[1*] وهشام العدوي[2] واندرو شين[3]

ABSTRACT. The prevalence and intensity of polyopisthocotylean monogeneans on the gills of three commercially important species of sparid caught in Omani coastal waters close to the city port of Muscat were determined and compared. Throughout May 2012 to April 2013, infections on bi-weekly samples of the soldier seabream, *Argyrops filamentosus* (Valenciennes, 1830), the king soldier seabream, *Argyrops spinifer* (Forsskål, 1775), and, the silver seabream, Rhabdosargus sabra were evaluated. From a total of 200 specimens (standard length of 26–52 cm), caught by line angling or by traps, at least three species of gill monogenean, namely *Omanicotyle [Bivagina] heterospina*, *Heteromicrocotyla* sp. and *Microcotyle* sp., were commonly encountered. Silver bream, which was infected by all three monogeneans, bore the highest infections (100% prevalence; mean intensity of 20.14 ± 0.92 parasites fish-1), whilst the soldier bream, which was infected only by *O. heterospina* had the lowest levels of infection (of the three sparids with 63.8% prevalence; mean intensity 5.8 ± 0.17 parasites fish-1). Comments on the distribution of monogeneans on each host are provided but to what extent this is influenced by water current speeds passing through the buccal and opercular cavities, gill morphology, parasite size, and / or the morphology and efficiency of the parasite's attachment apparatus requires establishing and forms the basis of ongoing investigations.

***Keywords:*** gill monogenea; Oman, seabreams; disease; aquaculture.

**المستخلص**: تم تحديد ومقارنة انتشار وكثافة الطفيليات وحيدة العائل (polyopisthocotylean) في خياشيم ثلاثة أنواع من الأسماك المهمة إقتصاديا من فصيلة الاسباريد التي تم صيدها في المياه الساحلية بالقرب من ميناء مسقط. خلال الفترة من مايو ٢٠١٢ إلى ابريل ٢٠١٣ ولمرتين كل أسبوع تم تقييم الإصابات في الثلاث أنواع من أسماك الكوفر وهي: (*Argyrops filamentosus*)، (*Argyrops spinifer*)، (*Rhabdosargus sabra*). من مجموع ٢٠٠ عينة من الأسماك (ذات طول قياسي تراوح بين ٢٦ إلى ٥٢ سم) تم صيدها بواسطة خيوط الصيد أو الأقفاص تم العثور على ثلاث أنواع من طفيليات الخياشيم وحيدة العائل على الأقل بصفة عامة وهي Omanicotyle (*Bivagina*) *heterospina* ، *Heteromicrocotyla* *Microcotyle sp* ,.*sp*. كانت أعلى نسبة إصابة في أسماك (*Rhabdosargus sabra*) حيث أصيبت بجميع الثلاثة أنواع من الطفيليات وحيدة العائل بنسبة تفش بلغت ١٠٠٪ ومتوسط كثافة ٢٠,١٤ ± ٠,٩٢ نسبة طفيل الى السمكة الواحدة. بينما كانت أقل نسبة إصابة في أسماك (*Argyrops filamentosus*) حيث أصيبت بنوع واحد من الطفيليات وحيدة العائل وهو (*O. heterospina*) بنسبة تفش ٦٣,٨٪ ومتوسط كثافة ٥,٨ ± ٠,١٧ نسبة طفيل الى السمكة الواحدة. تم أيضا توثيق ملاحظات حول إنتشار الطفيليات في العائل، ولكن إلى أي مدى يتأثر ذلك بسرعة تيارات المياه المارة بتجويف الفم والخياشيم أو شكل الخياشيم أو حجم الطفيلي أو فعالية و شكل أجزاء التمسك بحاجة إلى بحث استقصائي مستمر مستقبلا.

**الكلمات المفتاحية**: طفيليات الخياشيم وحيدة العائل، سلطنة عمان، سمك الكوفر، الأمراض، الاستزراع السمكي.

## Introduction

The Sultanate of Oman has an extensive coast line that exceeds 3000 km in length providing a wealth of natural fishery resources, renewable sources of revenue and opportunities for the development of sustainable aquaculture enterprises. Like Bahrain, Kuwait, Qatar, Saudi Arabia, UAE and Yemen, the Sultanate of Oman has no extensive regions of freshwater and so much of the country's population is distributed along its coast, with easier access to marine resources. Oman's affinity for the sea is reflected in its rich traditions and cuisine and Oman's average *per capita* consumption of marine fish remains among the highest in the world and surpasses that of many South-East Asia countries.

Fishbase (Froese & Pauly, 2014) cites 1,018 fish species for the Sultanate of Oman. Of these nine species belong to freshwater (four endemic, two native and three introduced species) whilst the remaining species belong to brackish and marine waters of which five species are misidentifications, 12 species are of questionable identity and three species are thought to be species that have strayed into Omani waters. FAO FishStatJ (2013) indi-

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cates that Oman wild fishery catches in 2012 were in the order of 191,563 tonnes (t) (see Table 1), with over 40 species being commonly landed. Collectively, this marine harvest is worth an estimated US$ 180 million. Fish and fishing, therefore, remains an important part of source of income and livelihood options and is at the very heart of Oman's culture and love of eating fish. Domestic fish purchases represent ~6% of the household budget and, on a national scale, fisheries represents 0.6% GDP and 34% of the agriculture sector.

By comparison, aquaculture is still very much in its infancy but there is an impetus to invest in and to develop a range of aquaculture industries. The government scripted legislation regarding aquaculture in 2004 and in collaboration with FAO has developed a national strategy for aquaculture development in 2007 (FAO, 2011). With a national strategy for the development of aquaculture, there is also a parallel need to be aware of factors that may impact on production and to put in place management practices to either prevent or minimize their effect. The prevention and treatment of disease, for example, throughout the aquaculture industry is essential. Deterioration in water quality combined with heavy losses from a variety of fish diseases has proven a major obstacle to the further development of fish aquaculture industries.

The impacts that parasites can have on marine aquaculture, for example, has been recently reviewed by Shinn *et al.* (2014). In particular, diseases caused by monogenean parasites have resulted in considerable economic damage to the aquaculture industry (Buchmann *et al.*, 1995; Bondad-Reantaso *et al.*, 2005; Bakke *et al.*, 2007). In marine aquaculture, infections of *Heteraxine heterocerca* (Goto, 1894) Yamaguti, 1938 and *Benedenia seriolae* (Yamaguti, 1934) Meserve, 1938 on Japanese amberjack, *Seriola quinqueradiata* Temminck et Schlegel, 1845 as reported by Kubota & Takakuwa (1963) were calculated by Shinn *et al.* (2014) to have cost the Japanese industry approx. US$ 1 M at the time of the event whilst more recent figures for the collective impact of *B. seriolae* on *S. quinqueradiata*, on greater amberjack, *Seriola dumerili* (Risso, 1810), and on kingfish, *Seriola lalandi* Valenciennes, 1833, has been estimated at US$ 214 M (Whittington *et al.*, 2001; Ernst *et al.*, 2002). Variable losses due to the gill polyopisthocotylean *Zeuxapta seriolae* (Meserve, 1938) on these seriolid hosts also contribute to losses throughout the industry (see Shinn *et al.*, 2014). Other notable monogenean induced losses of marine aquaculture species include infections of *Diplectanum aequans* (Wagener, 1857) Diesing, 1958 on European seabass, *Dicentrarchus labrax* (L.). Infections on juvenile Italian stock as reported by Dezfuli *et al.* (2007) was later estimated by Shinn *et al.* (2014) to have caused losses worth US$ 0.925 - 1.85 M. Yoon *et al.* (1997) reported that high prevalences of infection (i.e. 77.8-100%) of *Microcotyle sebastis* Goto, 1894 on Korean rockfish, *Sebastes schlegelii* Hilgendorf, 1880 can lead to high parasite burdens of up to 2120 fish$^{-1}$ and the mass mortality of stock. Estimates of loss at the time of the report are put at US$ 7,910 t-1 (Shinn *et al.*, 2014). There are also numerous reports in the literature relating to the impact of the capsalid *Neobenedenia* [syn. *Girellae*] *melleni* (MacCallum, 1927) Yamaguti, 1963 on a range of host fish. Notable recorded losses of aquaculture stock include infections on cobia, *Rachycentron canadum* (L., 1766) reared in Taiwanese waters (Lopez *et al.*, 2002; Ogawa *et al.*, 2006) worth an estimated US$ 0.9-1.8 M (Shinn *et al.*, 2014). Infections of Sciaenocotyle panceri (Sonsino, 1891) on meagre, *Argyrosomus regius* Asso, 1801 (see Merella *et al.*, 2009; Shinn *et al.*, 2014) and *Heterobothrium okamotoi* Ogawa, 1991 on tiger pufferfish, *Takifugu rubripes* (Temminck et Schlegel, 1850) (see Ogawa & Inouye, 1997; Ogawa *et al.*, 2005; Shinn *et al.*, 2014) are also recorded to result in the mass mortality of stock and heavy economic loss.

Of the 989 valid fish species found in Omani coastal waters, FishBase suggests that 45 of these may be of potential use in aquaculture (see Table 2). In this study, we take the first steps to assessing the potential of some of these species as candidates for aquaculture by looking at their parasite profiles with a view to being better informed of the potential risks that some of these may pose under intensive aquaculture conditions. Here we look at the communities of platyhelminth monogeneans on the gills of three commonly caught and traded species of sparid (Sparidae, Perciformes) in Omani waters, namely the soldier seabream, *Argyrops filamentosus* (Valenciennes, 1830), the king soldier seabream, Argyrops spinifer (Forsskål, 1775), and the silver seabream or "tarwhine", *Rhabdosargus sabra* (Forsskål, 1775).

# Materials and methods

## Sampling location and parasites collection

The three species of seabream, *A. filamentosus, A. spinifer* and *R. sabra*, caught within the Sea of Oman off the coastal city of Muscat and landed at the port of Muttrah (23° 37' 08.65" N; 58° 35' 33.76 E) were sampled throughout the period May 2012 to April 2013. A total of 200 specimens, that were either alive or fresh dead at the time of acquisition, were screened from biweekly samples. Following collection, the specimens were immediately transported to the parasitology laboratory at Sultan Qaboos University where the fish were measured (total length to the nearest 1 cm) and weighed (to the nearest 1 g). Thereafter, the gills were excised and screened for monogenetic trematodes under an Carl Zeiss Stemi 2000 dissecting microscope.

## Identification of monogeneans

The isolated monogeneans from individual fish were fixed and stored in 80% ethanol. The internal morphology was discerned by staining representative samples in

**Table 1.** Landings from commercial fisheries in the marine waters of the Sultanate of Oman in 2012 ranked by tonnage. Figures have been extracted from FAO FishStatJ (2013).

| Common name | Species details | tonnes | % |
|---|---|---|---|
| Indian oil sardine | *Sardinella longiceps* Valenciennes, 1847 | 43499 | 22.73 |
| Longtail tuna | *Thunnus tonggol* (Bleeker, 1851) | 14287 | 7.46 |
| Hairtails, scabbardfishes nei | *Trichiurus lepturus* L., 1758, | 10878 | 5.68 |
| Lepidopus caudatus (Euphrasen, 1788) | | | |
| Carangids nei | 21 genera, 48 species | 9328 | 4.87 |
| Emperors nei | Genus *Lethrinus*, 8 spp. | 8962 | 4.68 |
| Indian mackerel | *Rastrelliger kanagurta* (Cuvier, 1816) | 8596 | 4.49 |
| Jacks, crevalles nei | Confused potentially 2 families, 4 genera, 10 spp. | 7645 | 3.99 |
| Croakers, drums nei | Sciaenidae, 6 genera, 13 spp. | 6863 | 3.58 |
| Pharaoh cuttlefish | *Sepia pharaonis* Ehrenberg, 1831 | 6530 | 3.41 |
| Narrow-barred Spanish mackerel | *Scomberomorus commerson* (Lacepède, 1800) | 5620 | 2.93 |
| Yellowfin tuna | *Thunnus albacares* (Bonnaterre, 1788) | 5582 | 2.91 |
| Sharks, rays, skates nei [1] | 20 families, 27 genera, 75 spp. | 5482 | 2.86 |
| Sea catfishes nei | 2 families, 4 genera, 6 spp. | 5153 | 2.69 |
| Pelagic percomorphs nei [2] | Perciformes 66 families, 273 genera, 628 valid spp. | 4814 | 2.51 |
| Kawakawa | *Euthynnus affinis* (Cantor, 1849) | 4609 | 2.41 |
| Queenfishes | Genus *Scomberoides*, 3 spp. | 4244 | 2.22 |
| Barracudas nei | Genus *Sphyraena*, 8 spp. | 4002 | 2.09 |
| Groupers nei | 4 genera, 27 spp. | 3947 | 2.06 |
| Demersal percomorphs nei [2] | Perciformes 66 families, 273 genera, 628 valid spp. | 3714 | 1.94 |
| Anchovies, nei | Genera *Encrasicholina, Stolephorus & Thryssa*, 11 spp. | 3590 | 1.87 |
| Indo-Pacific sailfish | Istiophorus platypterus (Shaw, 1792) | 3392 | 1.77 |
| Porgies, seabreams nei | Sparidae, 10 genera, 17 spp. | 3352 | 1.75 |
| Mullets nei | Mugilidae, 6 genera, 10 spp. | 3151 | 1.64 |
| Grunts and sweetlips | Gen. *Diagramma*, *Plectorhinchus* & *Pomadasys*, 17 spp. | 2677 | 1.40 |
| Threadfin and dwarf breams nei | Genus *Nemipterus*, 4 spp., Genus *Parascolpsis*, 3 spp. | 2337 | 1.22 |
| Marine fishes nei [4] | | 1844 | 0.96 |
| Tuna-like fishes nei [3] | Scombridae, 5 genera, 5 spp. | 1225 | 0.64 |
| Rays, stingrays, mantas nei [1] | 7 families, 16 genera, 28 spp. | 1127 | 0.59 |
| Snappers, jobfishes nei | Lutjanidae, 8 genera, 34 spp. | 1071 | 0.56 |
| Bullet and frigate tunas | *Auxis rochei* rochei (Risso, 1810), | 943 | 0.49 |
| | *Auxis thazard* thazard (Lacepède, 1800) | | |
| Spinefeet (= rabbitfishes) nei | Genus *Siganus*, 4 spp. | 757 | 0.40 |
| Penaeid shrimp nei | *Fenneropenaeus indicus* (H. Milne-Edwards, 1837) | 742 | 0.39 |
| | *Penaeus semisulcatus* (De Haan, 1844) | | |
| Striped bonito | *Sarda orientalis* (Temminck et Schlegel, 1844) | 501 | 0.26 |
| Needlefishes nei | Belonidae, 4 genera, 7 spp. | 396 | 0.21 |
| Tropical spiny lobsters nei | *Panulirus homarus* (L., 1758) | 243 | 0.13 |
| Black marlin | *Istiompax indica* (Cuvier, 1832) | 128 | 0.07 |
| Cobia | *Rachycentron canadum* (L., 1766) | 128 | 0.07 |
| Skipjack tuna | *Katsuwonus pelamis* (L., 1758) | 100 | 0.05 |
| Abalones nei | *Haliotis mariae* Wood, 1828 | 54 | 0.03 |
| Total | | *191563* | |

*Footnotes: [1] The species details listed for sharks, rays and skates include the general species details provided for rays, stingrays and mantas. Providing precise details for each requires further detailed assessment. [2] The perciforms are large and diverse order of fish, in the absence of detailed capture fisheries data, the species found in Omani waters have been grouped and not separated into pelagic and demersal species as classified by FAO FishStatJ. [3] Does not include the other nine scombrid species listed in Table 1. [4] FAO FishStatJ does not provide sufficient details to determine the composition of this group of fish. Abbreviations: nei = not included elsewhere.*

**Table 2.** Forty five species of marine and brackish fish found within Omani waters that have the potential use for aquaculture as listed by Fishbase (Froese & Pauly, 2014).

| Scientific binomial | Common name | Local name |
|---|---|---|
| *Acanthopagrus latus* (Houttuyn, 1782) | Yellowfin seabream | Shaam |
| *Argyrosomus japonicus* (Temminck et Schlegel, 1843) | Japanese meagre | Yanam |
| Carangoides equula (Temminck et Schlegel, 1844) | Whitefin trevally | Sall |
| *Caranx ignobilis* (Forsskål, 1775) | Giant trevally | Dibsy |
| *Caranx lugubris* Poey, 1860 | Black jack | |
| *Caranx melampygus* Cuvier, 1833 | Bluefin trevally | Dibsy |
| *Chanos chanos* (Forsskål, 1775) | Milkfish | |
| *Chelon macrolepis* (Smith, 1846) | Largescale mullet | Anubah |
| *Chelon subviridis* (Valenciennes, 1836) | Greenback mullet | Gutarana |
| *Coryphaena hippurus* L., 1758 | Common dolphinfish | |
| *Crenimugil crenilabis* (Forsskål, 1775) | Fringelip mullet | |
| *Eleutheronema tetradactylum* (Shaw, 1804) | Fourfinger threadfin | |
| *Ellochelon vaigiensis* (Quoy et Gaimard, 1825) | Squaretail mullet | Gutarana |
| *Epinephelus areolatus* (Forsskål, 1775) | Areolate grouper | Hamour |
| *Epinephelus bleekeri* (Vaillant, 1878) | Duskytail grouper | Hamour |
| *Epinephelus coioides* (Hamilton, 1822) | Orange-spotted grouper | |
| *Epinephelus lanceolatus* (Bloch, 1790) | Giant grouper | Hamour |
| *Epinephelus malabaricus* (Bloch et Schneider, 1801) | Malabar grouper | Hamour |
| *Gnathanodon speciosus* (Forsskål, 1775) | Golden trevally | Bakes |
| *Hippocampus kuda* Bleeker, 1852 | Spotted seahorse | Buzizi |
| *Leiognathus equulus* (Forsskål, 1775) | Common ponyfish | |
| *Lethrinus nebulosus* (Forsskål, 1775) | Spangled emperor | Khutam |
| *Lutjanus argentimaculatus* (Forsskål, 1775) | Mangrove red snapper | Hamra |
| *Lutjanus erythropterus* Bloch, 1790 | Crimson snapper | |
| *Lutjanus johnii* (Bloch, 1792) | John's snapper | Khadharcha |
| *Lutjanus monostigma* (Cuvier, 1828) | One-spot snapper | Hamra |
| *Lutjanus rivulatus* (Cuvier, 1828) | Blubberlip snapper | Sbetti |
| *Lutjanus russellii* (Bleeker, 1849) | Russell's snapper | Aglaa |
| *Lutjanus sebae* (Cuvier, 1816) | Emperor red snapper | Hamra |
| *Megalops cyprinoides* (Broussonet, 1782) | Indo-Pacific tarpon | |
| *Muraenesox cinereus* (Forsskål, 1775) | Daggertooth pike conger | Asfan |
| *Platax orbicularis* (Forsskål, 1775) | Orbicular batfish | Emad |
| *Platycephalus indicus* (L., 1758) | Bartail flathead | Wahar |
| *Polydactylus plebeius* (Broussonet, 1782) | Striped threadfin | |
| *Pomadasys kaakan* (Cuvier, 1830) | Javelin grunter | Nagrur |
| *Pomatomus saltatrix* (L., 1766) | Bluefish | Tekwa |
| *Protonibea diacanthus* (Lacepède, 1802) | Blackspotted croaker | |
| *Rachycentron canadum* (L., 1766) | Cobia | Goada |
| *Rhabdosargus sarba* (Forsskål, 1775) | Goldlined seabream | Gorgofan |
| *Scatophagus argus* (L., 1766) | Spotted scat | Bushami |
| *Seriola dumerili* (Risso, 1810) | Greater amberjack | Gazala |
| *Siganus canaliculatus* (Park, 1797) | White-spotted spinefoot | Safi |
| *Sillago sihama* (Forsskål, 1775) | Silver sillago | Swam |
| *Terapon jarbua* (Forsskål, 1775) | Jarbua terapon | Yanam |
| *Trachinotus blochii* (Lacepède, 1801) | Snubnose pompano | Suban |

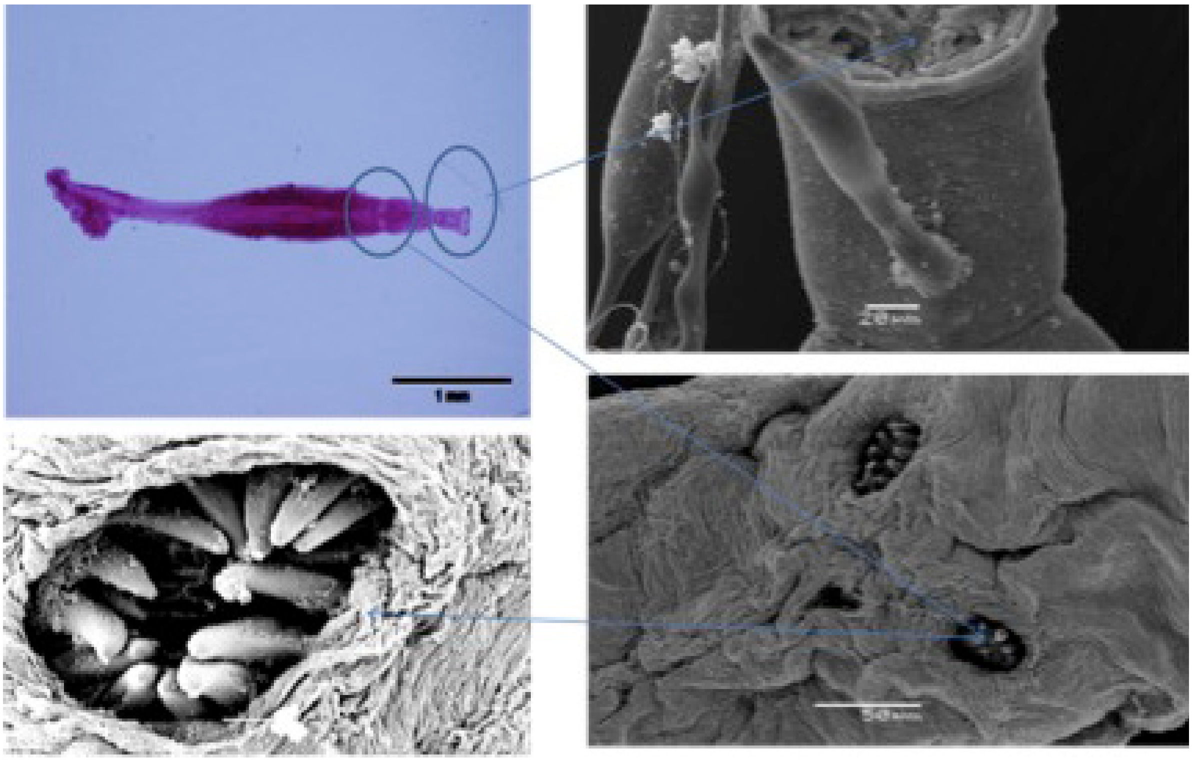


**Figure 1.** The microcotylid monogenean *Omanicotyle [Bivagina] heterospina* was found on the gills of all three sparids: soldier bream, *Argyrops filamentosus*, king soldier bream, *Argyrops spinifer*, and, on silver bream, *Rhabdosargus sabra*.

1% acetic carmine. Identification of the monogeneans was based using a series of key morphological features, including those relating to the eggs (when present), clamp (including sclerite morphology) shape, number and configuration, shape and relative armature of the genital / vaginal atria etc. using the key of Yamaguti (1963) and a recent description provided in Yoon *et al.* (2013).

### Data analysis

From the parasitological examinations a number of basic metrics are provided and these follow those detailed in Bush *et al.* (1997), i.e. parasite prevalence is the number of fish infected with one or more individuals of a particular parasite species divided by the number of hosts examined expressed as a percentage; and, the mean intensity is given by the total number of parasites encountered divided by the number of infected hosts.

## Results and discussion

Three species of monogenean were encountered on the gills of the three sparids in the current study and the prevalence, mean intensity and distribution of these are summarized in Table 3 and Figure 4a-c. The microcotylid *Omanicotyle [Bivagina] heterospina* (Mamaev et Parukhin, 1974) Yoon, Al-Jufaili, Freeman, Bron, Paladini et Shinn, 2013 (Family Microcotylidae Taschenberg, 1879; subfamily Microcotylinae Monticelli, 1892) was encountered on the gills of all three sparids, whilst the unidentified species of *Microcotyle* van Beneden et Hesse, 1863, was found on only a single species, the silver seabream, R. sabra. The species of *Heteromicrocotyla yamaguti*, 1953 (Family Heteromicrocotylidae Unnithan, 1961), which as yet remains to be formally identified, was found on the species of two *Argyrops* i.e., the soldier seabream *A. filamentosus*, and the king soldier seabream, *A. spinifer*. This pattern of host infection is interesting and leads to the question of whether *O. heterospina* demonstrates a broad host specificity that includes other sparids found in Omani waters. Currently 17 species of sparid (Sparidae, Perciformes) classified into ten genera (*Acanthopagrus* - 5 species; *Argyrops* - 1 species; Boops - 1 species; *Cheimerius* - 1 species; *Crenidens* - 1 species; *Diplodus* - 3 species; *Lithognathus* - 1 species; *Pagellus* - 1 species; *Rhabdosargus* - 2 species; and, *Sparidentex* - 1 species) are documented in Fishbase as occurring in Omani waters (Froese & Pauly, 2014). Interestingly though, this list does not include the soldier seabream, *A. filamentosus*, and suggest a need for update. Although this study documents the occurrence of *O. heterospina* on hosts from two different genera, future studies could determine whether they occur on other sparid genera. Monogeneans are generally regarded as being host-specific or having a narrow host range and different degrees of this was demonstrated by the study of Rohde (1979) who from a survey of marine mono-

**Table 3.** Summary of the monogeneans encountered on three commercially important species of sparid fish caught in Omani coastal waters and brought in through the port of Muttrah. The mean intensity is given for each followed by the prevalence in parentheses.

| | *Argyrops filamentous* **(n= 240)** | *Argyrops spinifer* **(n =183)** | *Rhabdosargus sabra* **(n=237)** |
|---|---|---|---|
| *Heteromicrocotyla sp.* | 2.7 ± 0.45 (23.5%) | 0 (0) | 7.5 ± 0.72 (48.1%) |
| *Microcotyle sp.* | 0 (0) | 0 (0) | 3.5 ± 0.39 (21.9%) |
| *Omanicotyle heterospina* | 3.2 ± 0.72 (63.8%) | 5.1 ± 0.15 (70.5%) | 9.1 ± 0.21 (100%) |
| Overall prevalence | 5.8 ± 0.17 (63.8%) | 5.1 ± 0.15 (70.5%) | 20.1 ± 0.92 (100%) |

geneans found that 340 species (78%) were restricted to single host species, 388 species (89%) to one genus, 420 species (96%) to one family and 429 species (98%) to one order. Similar ideas on the host-specificity of monogeneans were discussed by Llewellyn *et al.* (1984).

One observation worthy of note is that during the post-mortem dissection, the gill filaments of the silver seabream were noticeably more delicate than those of the other two hosts and this may be factor in the colonization success of polyopisthocotylean monogeneans. The distribution of monogeneans on the gills, as a community of species, is presented in Figure 3. It would appear that *O. heterospina*, the only monogenean infecting the gills of A. spinifer, has an equal distribution across the left and right hemibranchs with no discernible preference for particular gill arches. The same situation appears to be the case of *A. filamentosus* which is infected by *Heteromicrocotyla sp*. and *O. heterospina*. The monogeneans on the gills of *R. sabra*, however, favour the first gill arch and whether this is skewed by the particular habitat preferences of the species of *Microcotyle* infecting this host is currently under investigation. Buchmann *et al.* (1987) and Buchmann (1988) suggested that the demonstrable preference by species of *Pseudodactylogyrus* for the first and fourth gill arches on European eels (*Anguilla anguilla*), is because of the lower flow over these gill arches. The morphology of the buccal and opercular cavities in these sparids is also under investigation and is it hoped that the data will help explain the microhabitat preferences displayed by these monogeneans on the gills of these three sparid hosts.

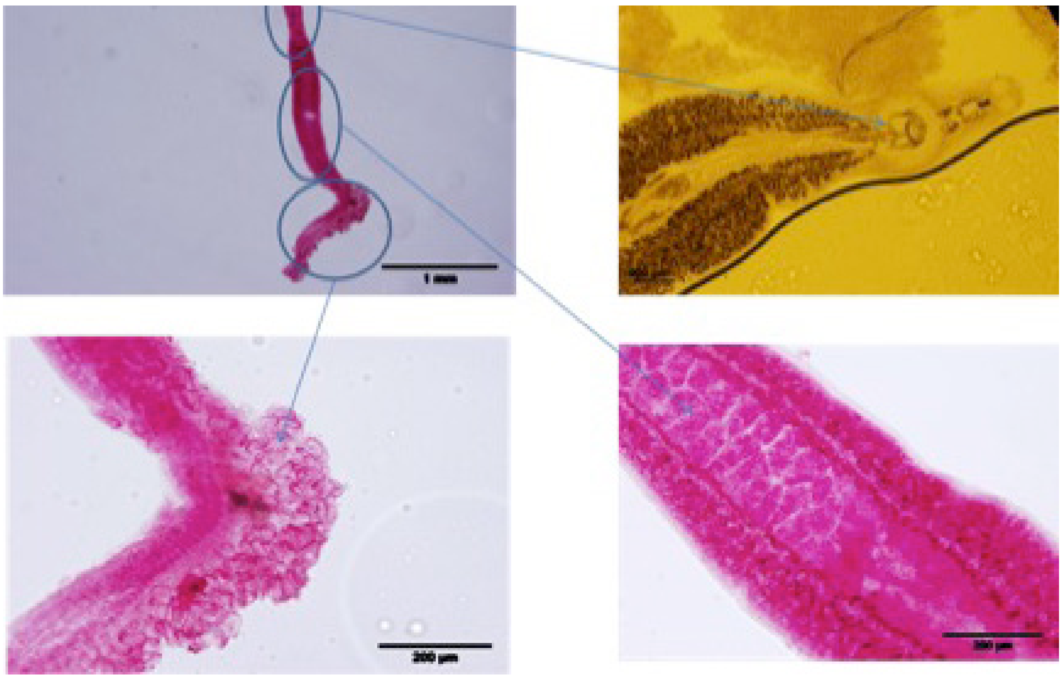


**Figure 2.** *Heteromicrocotyla* sp. collected from the gills of soldier bream, *Argyrops filamentosus*, and, from silver bream, *Rhabdosargus sabra*.

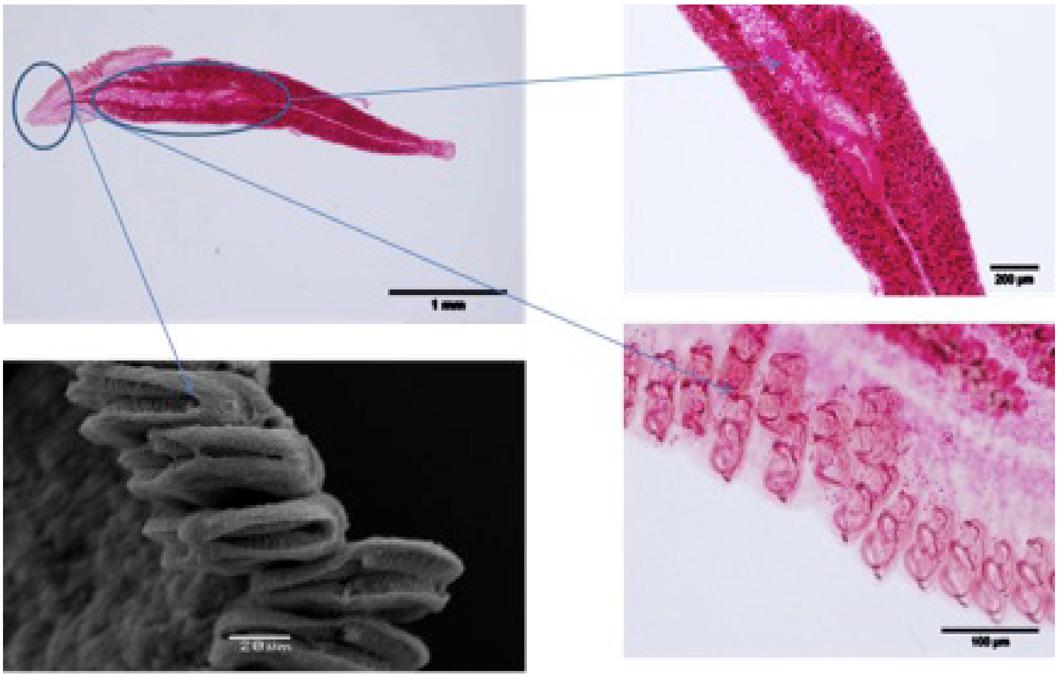


Figure 3. *Heteromicrocotyla* sp. collected from the gills of soldier bream, *A. filamentosus*, and, from silver bream, *R sabra*.

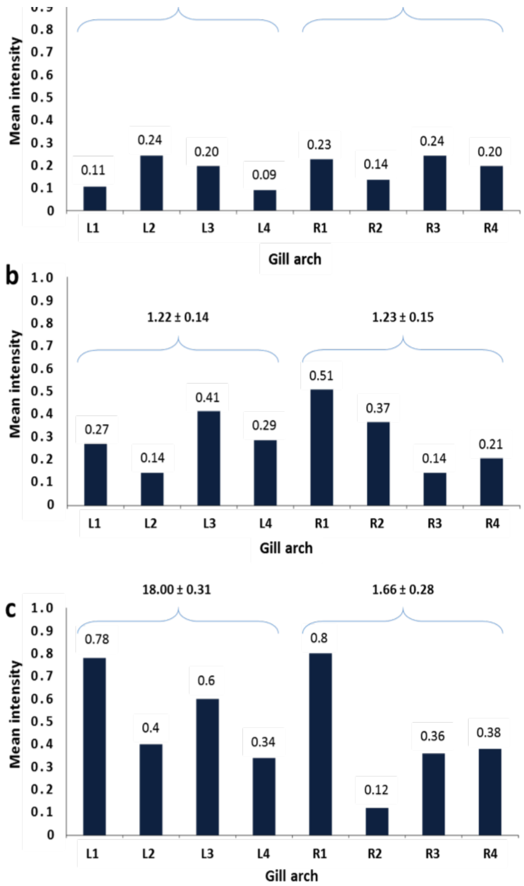


**Figure 4.** Mean intensity of monogenean infection on each gill arch and hemibranch from each population of sparids sampled from Omani waters. (a) soldier seabream, *Argyrops filamentosus* (Valenciennes, 1830); (b) the king soldier seabream, *Argyrops spinifer* (Forsskål, 1775); and (c) silver seabream, *Rhabdosargus sabra* (Forsskål, 1775).

# Conclusions

The polyopisthocotylean monogeneans *Omanicotyle heterospina*, an as yet unidentified species of *Heteromicrocotyla*, and an unidentified species of *Microcotyle* were recovered from the soldier bream, *Argyrops filamentosus*, the king soldier bream, Argyrops spinifer, and, the silver bream, *Rhabdosargus sabra*. The latter host was infected by all three monogeneans (100% prevalence of monogenean infection), whilst *A. filamentosus* was infected with *O. heterospina* and Heteromicrocotyla sp. (63.8% prevalence of infection), and, *A. spinifer* by only a single species *O. heterospina* (prevalent on 70.5% of hosts). Whilst there appears to be a fairly even distribution of monogeneans across the gills and hemibranchs on the two *Argyrops* hosts, the monogeneans on the silver bream show a marked preference for the first gill arch. To what extent this distribution is influenced by water current speed, morphology and efficiency of the parasite's attachment apparatus, parasite size, and / or by buccal/opercular/gill morphology is currently under investigation.

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