Arq. Bras. Med. Vet. Zootec., v.76, n.5, e13238, 2024 http://dx.doi.org/10.1590/1678-4162-13238
Original Article - Veterinary Medicine

Morphological identification tools of *Pseudodiscocotyla opakapaka* and *Kannaphallus raphidium* (Monogenea: Polyopisthocotylea) from *Acanthopagrus bifasciatus* (Spariformes: Sparidae)

[*Ferramentas de identificação morfológica de Pseudodiscocotyla opakapaka e Kannaphallus raphidium (Monogenea: Polyopisthocotylea) de Acanthopagrus bifasciatus (Spariformes: Sparidae)*]

G. *Alojayri*, E. *Al-Shaebi*, S. *Al-Quraishy*, R. *Abdel-Gaber*[*]

Department of Zoology, College of Science, King Saud University, P.O. 2455, Riyadh 11451, Saudi Arabia

ABSTRACT

Fish is considered one of the nutritive protein sources affected by various parameters including parasitism. Monogeneans are an ectoparasitic species infecting fish's skin, fins, and gills. During the present investigation, a total of 40 fish samples of the twobar seabream, *Acanthopagrus bifasciatus* (Perciformes: Sparidae) were collected from the coastal region along the Arabian Gulf (Saudi Arabia). The collected fish samples were dissected and examined for the presence of monogenetic parasites. The recovered parasite species were collected and identified by applying light microscopic examinations. Five out of 40 (12.5%) fish samples were found to be naturally infected with 2 monogenetic species belonging to two families within Polyopisthocotylea (order Mazocraeidea). They recorded two parasite species, namely, *Pseudodiscocotyla opakapaka* Yamaguti, 1965 and *Kannaphallus raphidium* Kritsky and Martin, 2023 belonging to families Discocotylidae and Heteraxinidae, respectively. Morphological and morphometric characterizations revealed some differences between the present species and others detected previously. The present findings of *P. opakapaka* and *K. raphidium* in *A. bifasciatus* (fish host) of the Arabian Gulf represent a new host and geographical record for these parasites. Furthermore, more studies are required to include the advanced molecular tools for these monogenetic species and their associated histopathological effects on the infection site.

Keywords: marine fish, discocotylidae, heteraxinidae, morphology, morphometry

RESUMO

O peixe é considerado uma das fontes de proteína nutritiva que é afetada por vários parâmetros, inclusive o parasitismo. Os monogenéticos são espécies ectoparasitas que infectam a pele, as barbatanas e as brânquias dos peixes. Durante a presente pesquisa, um total de 40 amostras de peixes da dourada Acanthopagrus bifasciatus *(Perciformes: Sparidae) foi coletado na região costeira ao longo do Golfo Arábico (Arábia Saudita). As amostras de peixes coletadas foram dissecadas e examinadas quanto à presença de parasitas monogenéticos. As espécies de parasitas recuperadas foram coletadas e identificadas por meio de exames de microscopia óptica. Cinco das 40 (12,5%) amostras de peixes estavam naturalmente infectadas com duas espécies monogenéticas pertencentes a duas famílias de Polyopisthocotylea (ordem Mazocraeidea). Foram registradas duas espécies de parasitas, a saber,* Pseudodiscocotyla opakapaka *Yamaguti, 1965 e* Kannaphallus raphidium *Kritsky e Martin, 2023, pertencentes às famílias Discocotylidae e Heteraxinidae, respectivamente. As caracterizações morfológicas e morfométricas revelaram algumas diferenças entre a espécie atual e outras detectadas anteriormente. As descobertas atuais de* P. opakapaka *e* K. raphidium *em* A. bifasciatus *(peixe hospedeiro) do Golfo Arábico representam um novo hospedeiro e registro geográfico para esses parasitas. Além disso, são necessários mais estudos para incluir ferramentas moleculares avançadas para essas espécies monogenéticas e seus efeitos histopatológicos associados no local da infecção.*

Palavras-chave: peixes marinhos, discocotylidae, heteraxinidae, morfologia, morfometria

INTRODUCTION

Sparid fish species have been identified as an important source of animal protein for trade and nutrition (Froese and Pauly, 2019). Seabreams, members of the family Sparidae, can be found in both tropical and temperate coastal waters. They are an important species for both commercial and recreational fisheries because they make great eating fish (Prakash, 2020). The twobar sea

[*]Corresponding author: rabdelgaber@ksu.edu.sa
Submitted: January 31, 2024. Accepted: March 11, 2024.

bream, *Acanthopagrus bifasciatus*, is found in the Western Indian Ocean, from South Africa's Natal to the Red Sea and Arabian Gulf.

In aquatic environments, fish play a significant role as parasite hosts (Whittington *et al*., 2000). The largest group of fish parasites are the monogeneans (Platyhelminthes) (Al-Azizz *et al*., 2017), a group of ectoparasitic flatworms that live on fish's skin, fins, and gills, which have a negative economic impact (Benovics *et al*., 2021). Purivirojkul (2008) stated that all monogeneans have a direct life cycle. According to their attachment organs, monogeneans are provided with hooks and hooklets and hence they are known as Monopistocotylea or with clamps and hence they are known as Polyopisthocotylea (Pečínková *et al*., 2007; Öztürk and Özer, 2014; Konstanzová *et al*., 2017).

The Discocotylidae Price, 1936 is a family of polyopisthocotylean monogeneans within the order Mazocraeidea. According to WoRMS (2023a), this family included 6 accepted genera. The genus *Pseudodiscocotyla* Yamaguti, 1965 (Discocotylidae) is distinguished from other genera by the following features: the elliptical and bulbous shape of the male copulatory organ and the armature of the genital atrium. There are 2 recognized species of the *Pseudodiscocotyla* species: *P. opakapaka* Yamaguti, 1965 infecting *Pristipomoides microlepis* (Hawaii) and *Pristipomoides filamentosus* (Japan) as well as *P. mikiae* Kamio *et al.*, 2023 infecting *P. filamentosus* (Japan).

The Heteraxinidae Unnithan, 1957 is also a family of polyopisthocotylean monogeneans (order Mazocraeidea). This family included 19 accepted genera, 1 preoccupied, 1 unjustified emendation, and 1 unaccepted (WoRMS, 2023b). The genus *Kannaphallus* Unnithan, 1957 (Heteraxinidae) is distinguished from other genera by the presence of asymmetric clamps, paired vaginas, and the male copulatory complex shape. The previously described *Kannaphallus* species were *K. virilis* Unnithan, 1957 infecting *Atropus atropos* (India), *K. lateriporis* Mamaev, 1988 infecting *Caranx sexfasciatus* (India), *K. mochimae* Zambrano, 1998 infecting *Acanthurus coeruleus* (Venezuela), *K. leptosomus* Nitta *et al.*, 2022 infecting *Scyris indica* (Malaysia), and *K. raphidium* Kritsky and Martin, 2023 infecting *Gnathanodon speciosus* (Australia).

Several investigations on monogenean parasites infecting marine fish species in Saudi Arabia have been undertaken to date (Bayoumy *et al*., 2012; Hassan *et al*., 2015; Bakhraibah, 2018; Dajem *et al*., 2019; Al-Nabati *et al*., 2021; Morsy *et al*., 2021; Alghamdi *et al*., 2022; Abdel-Gaber *et al*., 2023; Alshehri *et al*., 2023). Therefore, this investigation aimed to study the natural occurrence and describe the morphological traits of monogenean parasite species to validate their specificity within the twobar seabream fish (*Acanthopagrus bifasciatus*) for the first record in the Arabian Gulf fish (Saudi Arabia).

MATERIALS AND METHODS

Fish samples collection. Throughout January-June 2023, the twobar seabream *Acanthopagrus bifasciatus* Forsskål, 1775 (Family Sparidae), were purchased from the local fishermen in the coastal region along the Arabian Gulf, Dammam (Saudi Arabia). Samples were transferred using icebox to Parasitology Laboratory at Department of Zoology, College of Science, King Saud University (Saudi Arabia). They were identified using keys provided by Abu Shusha *et al*. (2010).

Parasite collection and preparation. Fish's gills were removed, placed in a Petri dish containing normal saline solution (0.9%), and observed under a dissecting microscope (Nikon SMZ18, NIS ELEMENTS software) to find the parasites. The monogenean parasites were detached from the gills using fine dissection needles and fixed in AFA (70% ethyl alcohol-formalin-acetic acid). Parasites were stained with Aceto carmine (Sigma-Aldrich, Missouri, USA), dehydrated in an ascending ethyl alcohol series (70%, 90%, and 100%), then cleared in xylene, and finally mounted on glass slides in Canada balsam (Palm, 2004). Some parasite specimens were mounted in glycerin ammonium picrate (GAP; Sigma-Aldrich, Burlington, MA, USA) to observe the sclerotized structures.

Morphology and morphometry. The mounted specimens were examined and photographed using a Leica DM 2500 microscope (NIS ELEMENTS software, ver. 3.8). Morphometric measurements (in micrometers) of 10 specimens were considered for statistical analysis and indicated as the mean followed by the range in parentheses using ImageJ 1.53e program (Wayne Rasband and contributors, National Institute of Health, USA).

Parasitological indexes. Sites and number of each parasite species from each fish were recorded. Parasitological terms of the prevalence ((number of infected fish/number of examined fish) × 100) and mean intensity (number of parasite species/number of infected fish) were calculated according to Bush *et al*. (1997).

RESULTS

Five out of 40 samples (12.5%) of the twobar seabream fish, *Acanthopagrus bifasciatus*, were found to have two monogenetic parasites. The recovered parasites were collected from the gill region of the infected fish samples, and all of them belonged to subclass Polyopisthocotylea. Two species found were *Pseudodiscocotyla opakapaka* Yamaguti, 1965 and *Kannaphallus raphidium* Kritsky and Martin, 2023 which were described morphologically as mentioned below.

Pseudodiscocotyla opakapaka Yamaguti, 1965 **(**Figure 1 and Table 1). The body was elongated, tapered at the anterior end, and measured 1580 (1400-1970) × 260 (170-340). The head was truncated and provided with a pair of two elliptical buccal suckers, each measuring 56 (50-59) × 76 (60-91). Gland cells were present at the anterior end of the body. The pharynx was globular and measured 54 (42-60) × 43 (39-49). The oesophagus was short and bifurcating just behind the muscular bulb. Branches of intestinal cecal with short inconspicuous diverticula, extending into haptor, terminating very close to each other near the wide posterior sinus between two lobes of the haptoral region.

The testes were irregular in shape, 65 (54-96) in number, occupying nearly the whole post-ovarian inter-cecal field and extending into lateral fields among intestinal branches. The copulatory organ was ellipsoidal with a muscular bulb [76 (71-82) × 63 (60-67)] provided with numerous spines. Genital atrium with a crown of two alternating rows of minute spines and opening mid-ventrally at a distance of 27 (19-34) from the anterior end. The germarium was situated on the right of the median line just in front of the middle of the body and its size was 154 (140-165) × 85 (53-105). The uterus was mid-ventral with no eggs observed. A pair of elliptical vaginae lined with corrugated cuticle was observed on the ventrolateral surface of the body, measured 56 (47-79) × 28 (25-37) and located at 277 (265-287) from the head end. Vitelline reservoir was Y-shaped, slender, median, ventral to germarium. The vitelline follicles commenced behind the vaginae and extended along the whole length of the intestinal ceca.

The haptor was not set off from the body proper, measured 243 (239-278) × 469 (421-489), and armed with a median pair of larval hooklets and two symmetrical lobes, each bearing an oblique row of symmetrical four clamps measured 53 (42-66) × 109 (94-114). Each clamp is made up of a pair of anterolateral sclerites and postero-lateral sclerites, small sclerites, and ventro mid-sclerite with bifid ends and dorsal mid-sclerite with bifid ends.

Taxonomic summary.
Type species: *Pseudodiscocotyla opakapaka* Yamaguti, 1965 (Discocotylidae Price, 1936)
Type of host species: Twobar seabream fish *Acanthopagrus bifasciatus* Forsskål, 1775 (Family Sparidae)
Type of habitat and infection site: Gills of the infected fish
Prevalence of parasitic infection: 2 (5%) out of 40 specimens were naturally infected
Mean intensity of infection: 5 (4-7)
Etymology: The specific name of the parasite is derived from the local name "*opakapaka*" for the host fish from which the parasite was isolated for the first time.

Remarks: *Pseudodiscocotyla* Yamaguti, 1965 is a genus within the family Discocotylidae Price, 1936 with two species that infect the gill lamellae of marine fish (Yamaguti, 1965; Kamio *et al*., 2023). This agreed with Ilgová *et al*. (2021) stated that gills are considered a preferred feeding and attachment site for monogeneans. The recovered specimens from *A. bifasciatus* in Saudi waters have the diagnostic morphological features of *Pseudodiscocotyla* genus provided by Yamaguti (1965), especially for the unjointed intestinal branches posteriorly and the armature of cirri and genital atrium. Few studies have been conducted on *Pseudodiscocotyla* species. The present species is compared morphologically and morphometrically with other *Pseudodiscocotyla* species such as *P. opakapaka* and *P. mikiae*. The appearance of the present species is closely related to that of *P. opakapaka* Yamaguti, 1965 from *P. microlepis* (Hawaii) and Kamio *et al*. (2023) from *P. filamentosus* (Japan) in having all

the characteristic generic features of that species but with a slight difference in the clamp structure from those in the original description. Clamps are considered the characteristic feature of polyopisthocotyleans and are the main organ used for attachment to the host, which is often armed with sclerotize elements (Hayward, 2006). Yamaguti (1965) indicated that the distal ends of the mid-sclerites were bifurcated in the *Pseudodiscocotyla* species. In the recovered *Pseudodiscocotyla* species, an accessory skeletal piece represented by a projecting V-shaped process was observed on the distal end of the dorsal mid-sclerite that was not mentioned in the original description, this coincided with Kamio *et al*. (2023). Also, it differs from *P. mikiae* Kamio *et al.*, 2023 infecting *P. filamentosus* (Japan) which is characterized by the absence of spines around the male genital pore (*vs.* two alternating rows of spines in *P. opakapaka*), circular vaginal pore (*vs.* elliptical with corrugated cuticle in *P. opakapaka*), and the spanner-shaped dorsal mid-sclerites (*vs.* V-shaped in *P. opakapaka*). Such differences between *Pseudodiscocotyla* species justify the need to extend the generic diagnosis.

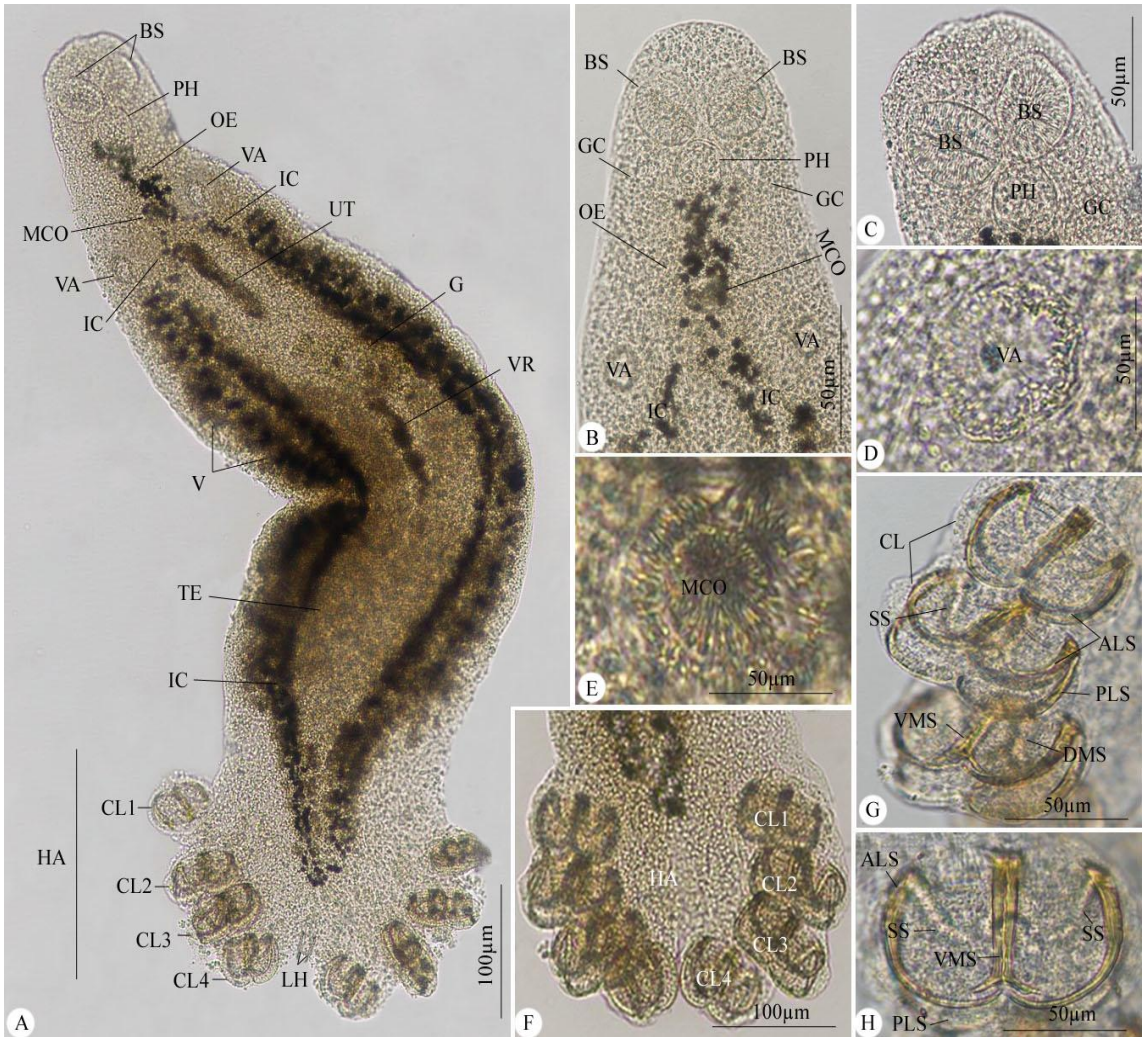

Figure 1. Photomicrographs of *Pseudodiscocotyla opakapaka* infecting *Acanthopagrus bifasciatus*. (A) Whole-mount preparation. (B-H) High magnifications for different body parts, as follows: (B-E) Anterior portion of the prohaptor. (F-H) Clamps in haptor. Note: BS, buccal sucker; PH, pharynx; GC, gland cells; OE, oesophagus; MCO, male copulatory organ; IC, intestinal crura; V, vitellaria; UT, uterus; VA, vagina; G, germium; TE, testes; CL, clamps; HA, haptor; ALS, antero-lateral sclerite; PLS, postero-lateral sclerite; SS, small sclerite; VMS, ventral mid-sclerite; DMS, dorsal mid-sclerite; LH, larval hooklets.

Table 1. Comparative metrical data for *Pseudodiscocotyla opakapaka* and their congeneric species

Comparable parameters		*Pseudodiscocotyla opakapaka*		*Pseudodiscocotyla mikiae*	Present study
Reference		Yamaguti, 1965	Kamio *et al.*, 2023	Kamio *et al.*, 2023	Present study
Host		*Pristipomoides microlepis*	*Pristipomoides filamentosus*	*Pristipomoides filamentosus*	*Acanthopagrus bifasciatus*
Location		Hawaii	Japan	Japan	Saudi Arabia
Body	Length	1600-2700	3875 (3200-4375)	5807 (4575-6600)	1580 (1400-1970)
	Width	220-600	425 (375-500)	1115 (750-1300)	260 (170-340)
Buccal sucker	Length	40-70	58 (50-70)	100 (70-120)	56 (50-59)
	Width	60-110	97 (40-100)	133 (50-150)	76 (60-91)
Pharynx	Length	30-60	53 (50-60)	79 (70-90)	54 (42-60)
	Width	30-45	43 (40-50)	59 (50-70)	43 (39-49)
Germarium	Length	100-170	190 (180-200)	303 (150-350)	154 (140-165)
	Width	60-112	150 (240-260)	467 (230-570)	85 (53-105)
Number of testes		50-100	108 (99-127)	127 (93-146)	65 (54-96)
Muscular bulb	Length	75	108 (99-127)	54 (50-62)	76 (71-82)
	Width	60	--	25 (17-32)	63 (60-67)
Distance of genital atrium from the anterior end		17-35	--	--	27 (19-34)
Vaginae	Length	42-82	62 (55-67)	30 (25-37)	56 (47-79)
	Width	26-42	29 (20-35)	25 (22-32)	28 (25-37)
Distance of vaginae from the anterior end		270-450	--	--	277 (265-287)
Haptor length		--	--	--	243 (239-278)
Clamp	Length	--	118 (100-145)	157 (65-260)	53 (42-66)
	Width	100-180	159 (100-205)	228 (147-300)	109 (94-114)

Genus *Kannaphallus* Unnithan, 1957. *Kannaphallus raphidium* Kritsky and Martin, 2023 (Figure 2 and Table 2). The body was elongated, measured at 3375 (3174-3577) × 501 (411-553). The mouth was subterminal with a tapered end. Prohaptoral suckers were two in number, oval, widely spaced, and measured 48 (46-50) × 53 (49-56). Gland cells were present in the anterior end of the body. The pharynx was oval and measured 59 (57-61) × 54 (52-56). The oesophagus was slender, bifurcated above the muscular bulb forming two intestinal ceca. Branches of ceca terminated blindly in haptor, with lateral and usually medial diverticula. The genital atrium was oval, measured 90 (87-93) × 71 (69-72), provided with a midventral common pore at the level of oesophageal bifurcation.

The testicular mass was intercaecal, occupying the whole post-ovarian space and extended into the anterior part of the haptor. The copulatory organ consisted of a muscular bulb measuring 39 (36-42) × 20 (18-24) connecting at the base with a sclerotized straight duct measured 122 (115-129) × 13 (10-15). The germarium was elongated in shape, intercaecal, and situated on the middle third of the body. The vitelline reservoir was Y-shaped and located ventrally to the germarium. The vitelline follicles coextensive with intestinal ceca and extend into the haptor.

The haptor was asymmetrical in two unequal rows of clamps; the long row was 1204 (1195-1243) in length with 28-31 clamps; the short row was 430 (412-453) in length with 12-15 clamps. Clamps of a microcotyle-type were measured 44 (41-48) × 51 (47-55) and consisted of a pair of anterolateral and postero-lateral sclerites, mid-sclerite, accessory sclerite, and thin muscular base. The eggs were spindle in shape, measured 177 (171-187) × 53 (49-57) with anterior and posterior filaments.

Taxonomic summary

Type species: *Kannaphallus raphidium* Kritsky and Martin, 2023 (Heteraxinidae Unnithan, 1957)

Type of host species: Twobar seabream fish *Acanthopagrus bifasciatus* Forsskål, 1775 (Family Sparidae)

Type of habitat and infection site: Gills of the infected fish

Prevalence of infection: Three (7.5%) out of 40 specimens were naturally infected.

Mean intensity of infection: 7 (5-9)

Etymology: The specific name of the parasite is derived from the Greek term “raphidium” which refers to the needlelike tip of the male copulatory organ.

Figure 2. Photomicrographs of *Kannaphallus raphidium* infecting *Acanthopagrus bifasciatus*. (A) Whole-mount preparation. (B-J) High magnifications for different body parts, as follows: (B and C) Anterior portion of the prohaptor. (D) Germarium. (E) Egg. (F) Testes. (G-I) Clamps. Note: Mo, mouth; BS, buccal sucker; PH, pharynx; GC, gland cells; OE, oesophagus; MCO, male copulatory organ; V, vitellaria; VR, vitelline reservoir; G, germarium; EG, egg; TE, testes; CL, clamps; HA, haptor; ALS, antero-lateral sclerite; PLS, postero-lateral sclerite; MB, muscular base; MS, median sclerite.

Table 2. Comparative metrical data for *Kannaphallus raphidium* and their congeneric species

Comparable parameters	*K. virilis*	*K. lateriporis*	*K. mochimae*	*K. leptosomus*	*K. raphidium*	Present study
Reference	Unnithan (1957)	Mamaev (1988)	Zambrano (1998)	Nitta *et al*. (2022)	Kritsky and Martin (2023)	Present study
Host	*Atropus atropos*	*Caranx sexfasciatus*	*Acanthurus coeruleus*	*Scyris indica*	*Gnathanodon speciosus*	*Acanthopagrus bifasciatus*
Location	India	India	Venezuela	Malaysia	Australia	Saudi Arabia
Body length	3500-3600	3980-4370	1511-1990	5441-8162	3210 (2770-3630)	3375 (3174-3577)
Body width	825-840	1000-1060	556-733	442-946	677 (583-753)	501 (411-553)
Buccal sucker length	45-60	-	40-51	50-69	45 (38-53)	48 (46-50)
Buccal sucker width	60-75	50	32-46	49-95	48 (39-56)	53 (49-56)
Pharynx length	45	60	40-41	50-76	-	59 (57-61)
Pharynx width	-	-	26-32	39-53	52 (47-58)	54 (52-56)
Genital atrium length	135-150	40-41	62-64	104-189	75 (58-94)	90 (87-93)
Genital atrium width	90-105	37-40	-	75-134	48 (40-59)	71 (69-72)
Number of genital spines	Absent	Absent	28	Absent	-	Absent
Number of testes	>100	110-130	15-20	100-151	Testicular mass	Testicular mass
Testicular zone length	1100	-	-	1864-2823	772 (574-943)	1423 (1356-1459)
Testicular zone width	255	-	-	201-420	231 (176-275)	289 (280-305)
Muscular bulb length	40	-	-	46-74	209 (175-265)	39 (36-42)
Muscular bulb width	20	-	-	24-32	-	20 (18-24)
Muscular duct length	150	74-82	-	199-228	196 (167-227)	122 (115-129)
Muscular duct width	15	-	-	20-26	-	13 (10-15)
Haptor length	1050-1100	-	-	625-1185	-	1123 (1105-1145)
Haptor width	-	-	-	346-1562	-	496 (469-518)
Length of the long row	-	1460-1580	1156-1378	1325-1874	1230 (963-1430)	1204 (1195-1243)
Number of clamps in a long row	28-31	29-38	47-51	24-32	29-39	29-39
Length of short row	-	400-500	489-578	632-1061	376 (291-444)	430 (412-453)
Number of clamps in short row	12-15	7-12	22-25	10-12	7-12	7-12
Clamp length	32-52	65	58-70	76-92	-	44 (41-48)
Clamp width	40-60	62	40-58	82-97	51 (41-57)	51 (47-55)

Remarks: *Kannaphallus* Unnithan, 1957 is a genus within the family Heteraxinidae Unnithan, 1957 with 5 species that infect the gill lamellae of marine fish (Unnithan, 1957; Mamaev, 1988; Zambrano, 1998; Nitta *et al*., 2022; Kritsky and Martin, 2023). The recovered specimens from *A. bifasciatus* in Saudi waters have the diagnostic morphological features of genus *Kannaphallus* provided by Unnithan (1957), especially for the vaginal opening position, the morphology of the clamp, and the genital atrium. Bouguerche *et al*. (2020) reported that the presence/absence and number of vaginae is a major feature of the systematics of monogeneans. The present species is compared morphologically and morpho-metrically with other *Kannaphallus* species such

as *K. virilis*, *K. lateriporis*, *K. mochimae*, *K. leptosomus*, *K. raphidium*. There are few studies have been conducted on *Kannaphallus* species. Appearance of present species is closely related to that of *K. raphidium* Kritsky & Martin, 2023 infecting *Gnathanodon speciosus* (Australia) in having all characteristic generic features of that *Kannaphallus* species. It is differentiated from other *Kannaphallus* species by the following: (1) the absence of genital spines (*vs.* 28 in *K. mochimae*), (2) the dorsal vaginal pores lateral to the intestinal ceca (*vs.* dorsal vaginal pores intercecal in *K. virilis* and *K. leptosomus*), (3) the male copulatory organ with a short sclerotized straight duct (*vs.* long sclerotized straight duct in *K. virilis* and *K. leptosomus* and apparently present in *K. lateriporis*), (4) copulatory canal surrounded by a large glandular bulb (*vs.* absence of glandular bulb in *K. virilis* and *K. leptosomus* and apparently present in *K. lateriporis*), (5) presence of testicular mass (*vs.* >100 in *K. virilis*, *K. lateriporis*, *K. leptosomus* and 15-20 in *K. mochimae*), (6) uterus is ventral to that portion of germarium and the entirety of male reproductive system (*vs.* uterus extends anteriorly from the öotype dorsal to transverse arm of germarium, the vas deferens, and the distal male genitalia), (7) bilaterally symmetrical haptoral clamps (*vs.* asymmetrical clamps in *K. lateriporis*), and (8) 3-pronged projection arising from the dorsal termination of the median clamp sclerite (*vs.* 1-pronged projection on median sclerite in *K. virilis*). Such differences between *Kannaphallus* species justify the need to extend the generic diagnosis.

CONCLUSION

Collectivelyy, the present findings enrich and update monogenean parasite list for the marine fish family Sparidae (*A. bifasciatus*) in the Arabian Gulf (Saudi Arabia). In addition, to our knowledge, this indicates the first report of the genera *Pseudodiscocotyla* and *Kannaphallus* in Saudi waters. This study was supported by morphological and morphometric criteria for the present monogeneans. Further studies are required to include the molecular phylogenetic analysis for these monogenetic taxa.

FUNDING

This study was supported by the Researchers Supporting Project (RSP2024R25), King Saud University, Riyadh, Saudi Arabia.

REFERENCES

ABDEL-GABER, R., ALGHAMDI, M.; AL QURAISHY, S. *et al*. A monogenean gill parasite within the genus *Argyrops filamentosus* fish: Morphology and molecular studies. *Animals*, v.13, p.1010, 2023.

ABU SHUSHA, T.L., KALANTAN, M.Z., AL-NAZRY, H.H. *et al*. Fishes from territorial Saudi Red Sea waters. Marine Research Centre-Jeddah, Deputy Ministry of fisheries affairs, Ministry of Agriculture, Saudi Arabia, 2010.

AL-AZIZZ, S.A.; AL-NIAEEM, K.S.; AL-HASSON, A.H. Seasonality of the monogenean from some perciform fishes in Iraqi marine waters. IOSR *J. Agric. Vet. Sci*., v.10, p.103-105, 2017.

ALGHAMDI, M.; AL-QURAISHY, S.; AL-SHAEBI, E.M.; ABDEL-GABER, R. Morphological and molecular analyses *Protolamellodiscus senilobatus* (Monogenea: Diplectanidae), a gill parasite infecting the soldier bream *Argyrops filamentosus* (Sparidae). *J. King Saud Unive. Sci*., v.35, p.102417, 2022.

AL-NABATI, E.; ALI, S.; AL-QURAISHY, S. *et al*. *Hetreomicrocotyla polyorchis* Unnithan, 1961 (Monogenea: Heteromicrocotylidae), a gill parasite of the yellow-spotted trevally, *Carangoides fulvoguttatus* (Carangidae) from Saudi Arabia: morphology and phylogeny. *Microb. Pathog*., v.160, p.105165, 2021.

ALSHEHRI, E.; ABDEL-GABER, R.; AL-QURAISHY, S.; ALGHAMDI, M.; AL-SHAEBI, E.M. Morphological and molecular characterization of the monogenean gill parasite, *Acleotrema maculatus*, infecting *Argyrops filamentosus* fish in the Red Sea, Saudi Arabia. *Arq. Bras. Med. Vet. Zootec*., v.75, p.673-681, 2023.

BOUGUERCHE, C.T., AZEROUTI, F.; GEY, D.; JUSTINE, J.L. No vagina, one vagina, or multiple vaginae? An integrative study of *Pseudaxine trachuri* (Monogenea, Gastrocotylidae) leads to a better understanding of the systematics of *Pseudaxine* and related genera. *Parasite*, v.27, p.50, 2020.

BAKHRAIBAH, A. Effect of locality, host species and sex on the metazoan parasitic infestation of two, species of Scarus fish from the Red Sea coast at Jeddah and Rabigh in Saudi Arabia. *Open J. Anim. Sci*., v.8, p.252-258, 2018.

BAYOUMY, E.M.; ABU-TAWEEL, G.M.; ALZAHABY, M.A. Metazoan parasites of some Arabian Gulf Fish, off Dammam, Saudi Arabia: 1-External and internal parasite-host associations. *Global Vet*., v.9, p.600-605, 2012.

BENOVICS, M.; NEJAT, F.; ABDOLI, A.; ŠIMKOVÁ, A. Molecular and morphological phylogeny of host-specific *dactylogyrus* parasites (Monogenea) sheds new light on the puzzling Middle Eastern origin of European and African lineages. *Parasit. Vectors*, v.14, p.372, 2021.

BUSH, A.O.; LAFFERTY, K.D.; LOTZ, J.M.; SHOSTAK, A.W. Parasitology meets ecology on its own terms: Margolis *et al*. revisited. *J. Parasitol*., v.83, p.575-583, 1997.

DAJEM, S.B.; MORSY, K.; SHATI, A. *et al*. *Bivagina Pagrosomi* Murray (1931) (Monogenea: Polyopisthocotylea), a microcotylid infecting the gills of the gilt-head sea bream *Sparus aurata* (Sparidae) from the Red Sea: Morphology and Phylogeny. *J. Vet. Res*., v.63, p.345-352, 2019.

ILGOVÁ, J.; SALÁT, J.; KAŠNÝ, M. Molecular communication between the monogenean and fish immune system. *Fish Shellfish Immunol.*, v.112, p.179-190, 2021.

FORSSKÅL, P. Descriptiones animalium avium, amphibiorum, piscium, insectorum, vermium; quae in itinere orientali observavit. Post mortem auctoris edidit Carsten Niebuhr. Hauniae. Post mortem auctoris. NIEBUHR, C. *Animalium Descriptiones animalium avium, amphibiorum, piscium, insectorum, vermium*; quae in itinere orientali observavit. Copenhagen: Mölleri, 1775. p.34,164p. (Pisces on p.10-19, 22-76).

FROESE, R.; PAULY, D. Fishbase. [s.l.]: World Wide Web Electronic Publication, 2019. Available in: www.fishbase.org. Accessed in: 1, March, 2023.

HASSAN, M.A.; OSMAN, H.A.M.; ASWATHAN, M. Infestation of cage-cultured fish with *Benedenia acanthopagri* (Monogenea: Capsalidae) in eastern province of Saudi Arabia. *Global Vet*., v.14, p.219-227, 2015.

HAYWARD, C. Monogenea Polyopisthocotylea (ectoparasitic flukes). In: ROHDE, K. (Ed.). *Marine parasitology*: CSIRO. Collingwood: CABI, 2006. p.55-63.

KAMIO, Y.; INOUE, A.; NITTA, M. Description of a new species, *Pseudodiscocotyla mikiae* n. sp. (Monogenea: Discocotylidae) parasitic on gills of *Pristipomoides filamentosus* from off Okinawa-Jima island in Japan, with redescription of *Pseudodiscicityla opakapaka*. *Syst. Parasitol*., v.100, p.657-671, 2023.

KONSTANZOVÁ, V.; KOUBKOVÁ, B.; KAŠNÝ. *et al*. An ultrastructural study of the surface and attachment structures of *Paradiplozoon homoion* (Bychowsky & Nagibina, 1959) (Monogenea: Diplozoidae). *Parasit.Vectors*, v.10, p.261, 2017.

KRITSKY, D.C.; MARTIN, S.B. *Kannaphallus raphidium* n. sp. (Monogenoidea: Mazocraeidea: Heteraxinidae) Parasitic on the Gill Lamellae of the Golden Trevally *Gnathanodon speciosus* (Carangiformes: Carangidae) Occurring in the Coastal Waters of Queensland and Western Australia. *J. Parasitol*., v.109, p.96-106, 2023.

MAMAEV, Y.L. *Kannaphallus lateriporis* n. sp. and its position within the system of higher monogeneans. *Parazitologiya*, v.22, p.345-358, 1988.

MORSY, K.; AL-MALKI, J.S.; DAJEM, S.B. *et al*. Morphology and molecular phylogeny of *Heterobothrium lamothei* (Monogenea: Diclidophoridae), a gill parasite infecting the tiger puffer fish *Lagocephalus sceleratus* (Tetraodontidae). *Arq. Bras. Med. Vet. Zootec*., v.73, p.1117-1127, 2021.

NITTA, M.; KONDO, Y.; OHTSUKA, S.; KAMARUDIN, A.S.; ISMAIL, N. *Kannaphallus leptosomus* n. sp. (Monogenea: Heteraxinidae: Cemocotylinae) parasitizing *Scyris indica* (Carangiformes: Carangidae) from Malaysia. *Syst. Parasitol*., v.99, p.587-599, 2022.

ÖZTÜRK, T.; ÖZER, A. Monogenean fish parasites, their host preferences and seasonal distributions in the lower Kızılırmak Delta (Turkey). *Turk. J. Fish. Aquat. Sci*., v.14, p.367-378, 2014.

PALM, H.W. *The Trypanorhyncha Diesing, 1863*. Bogor: PKSPL-IPB Press, 2004. 710p.

PEČÍNKOVÁ, M.; VØLLESTAD, L.A.; KOUBKOVÁ, B.; GELNAR, M. Asymmetries in the attachment apparatus of a gill parasite. J. Zool., v.272, p.406-414, 2007.

PRAKASH, M.S. Monogenetic trematode infentations in Indian cat fishes of River Gomati at district Sultanpur Uttar Pradesh, India. *Int. J. Modern Trends Sci. Technol*., v.6, p.120-124, 2020.

PRICE, E.W. *North American monogenetic trematodes*. 1936. Theses (doctoral) - George Washington University, USA. (Summaries of, 1934-6), 10-13).

WORLD REGISTER OF MARINE SPECIES (WoRMS), Available in: https://www.marinespecies.org/aphia.php?p=taxdetails&id =717464. Accessed in: 12 Mar. 2023a.

WORLD REGISTER OF MARINE SPECIES (WoRMS). Available in: https://www.marinespecies.org/aphia.php?p=taxdetails&id=518896. Accessed in: 12 Mar. 2023b.

PURIVIROJKUL, W. Distribution of Polyopisthocotyleans in some marine fishes from the gulf of Thailand, Chonburi Province. *Kasetsart Univ. Fish. Res. Bull*., v.32, p.19-28, 2008.

UNNITHAN, V. On the functional morphology of a new fauna of monogenean of fish from Trivandrum and environs. Part 1. Axinidae fam. nov. *Bull. Centr. Res. Inst. Univ. Kerala*, v.5, p.27-122, 1957.

WHITTINGTON, I.D.; CRIBB, B.W.; HAMWOOD, T.E.; HALLIDAY, J.A. Host-specificity of Monogenea (Platyhelminth) parasites: a role for anterior adhesive areas. *Int. J. Parasitol*., v.30, p.305-320, 2000.

YAMAGUTI, S. New monogenetic trematodes from Hawaiian fishes, 1. *Pac. Sci*., v.19, p.55-95, 1965.

ZAMBRANO, J.F. Descripción de dos nuevas especies de monogéneos microcotiloideos, parásitos de peces marinos de la costa noreste de Venezuela. *Sci. Mar.*, v.62, p.65-72, 1998.