Monogeneans (Platyhelminthes) from marine fishes of Tongyeong, Korea

B. A. Venmathi Maran · Sung-Yong Oh · Seong Yong Moon ·
Ho Young Soh · Chong-Kwan Kim · Jung-Goo Myoung

Received: 13 December 2012 / Accepted: 29 December 2012 / Published online: 19 January 2013
© Indian Society for Parasitology 2013

Abstract Monogeneans (Platyhelminthes) mostly parasitize on fins, skin and gills of fishes. In Korea, the study on monogeneans is limited, although, fishes are frequently encountered with severe infection of monogeneans. Hence, some of ranches and wild fishes were collected from Tongyeong marine living resources research and conservation center, southern part of Korea to screen and understand the infection of monogeneans. All three fish hosts were found with the infection of monogeneans including five species from four different families. They are: (1) *Anoplodiscus spari* Yamaguti (Publ Seto Mar Biol Lab Kyoto Univ 7:53–88, 1958) (Anoplodiscidae) from the fins and body surface of blackhead seabream *Acanthopagrus schlegelii schlegelii* (Bleeker); (2) *A. tai* Ogawa (Fish Pathol 29:5–10, 1994) from the fins of red seabream *Pagrus major* (Temminck and Schlegel); (3) *Benedenia sekii* Yamaguti (Studies on the helminth fauna of Japan. Part 19. Fourteen new ectoparasitic trematodes of fishes. Published by the author, Kyoto, 1937), Meserve (Rep Allan Hancock Paci Exped (1932–1937) 2:31–89, 1938) (Cap-salidae) from the body surface of *P. major*; (4) *Choricotyle elongata* Goto (J Coll Sci Imp Univ Tokyo 8:1–273, 1894) (Diclidophoridae) from the gills of *P. major*; (5) *Udonella fugu* Freeman and Ogawa (Int J Parasitol 40:255–264, 2010) (Udonellidae) hyperparasitized on the body of

parasitic copepod *Pseudocaligus fugu* (Yamaguti 1936) (Caligidae) infecting the wild grass puffer *Takifugu niphobles* (Jordan and Snyder). Capsalids are commonly reported in Korea, except *B. sekii*, however, other reported genera are uncommon. Hence, all reported monogeneans are considered as a first record from Korea.

Keywords Monogenean · Parasitize · Infection · Gills · Marine fish · Seabream · Pufferfish · Hyperparasitize · First record · Korea

Introduction

Monogeneans (Platyhelminthes) are ectoparasites on body and gills of freshwater and marine fish, and exhibit high host-specificity (Rhode 1984; Whittington et al. 2000) and are sometimes hyperparasitic (Kabata 1973). They cause serious problems in fish aquaculture worldwide (Rhode 1984; Hayward et al. 2001; Park 2009). Aquaculture in Korea is flourishing with the development of advanced aquaculture scientific technology for important marine finfish such as, olive flounder *Paralichthys olivaceus* (Temminck and Schlegel, 1846), Korean rockfish *Sebastes schlegelii* Hilgendorf, 1880, red seabream *Pagrus major* (Temminck and Schlegel, 1843), blackhead seabream *Acanthopagrus schlegelii schlegelii* (Bleeker, 1854), and flathead grey mullet, *Mugil cephalus* Linnaeus, 1758 (Kim 2000). However, in recent years, production losses are increased due to infections by various diseases (Park 2009) and the information on monogenean infection in fish aquaculture is scarce.

Recently, blackhead and red seabreams (Sparidae) culture attracted considerable attention as a result of severe problems affecting the culture of yellowtail (Kim 2000; MOMAF 2007). Considering its ongoing and future

B. A. Venmathi Maran (✉) · S.-Y. Oh · C.-K. Kim ·
J.-G. Myoung
Marine Ecosystem Research Division, Korea Institute of Ocean
Science & Technology, P.O. Box 29, Ansan, Seoul 425-600,
South Korea
e-mail: bavmaran@gmail.com; bavmaran@kiost.ac

S. Y. Moon · H. Y. Soh
Faculty of Marine Technology, Chonnam National University,
Yeosu, Jeollanam-do 550-749, South Korea

potential importance, we thoroughly checked the presence of metazoan parasites on seabream (Venmathi Maran et al. 2012a), black scraper and rockfish (Venmathi Maran et al. 2012b) at Tongyeong marine living resources research and conservation center (TMRC), Korea. At TMRC, several commercially important fishes are ranched under the marine ranching program by the Korea Institute of Ocean Science and Technology (KIOST) from 1998 (MOMAF 2007). Nearby TMRC aquaculture facilities, through fishing, the grass puffer *Takifugu niphobles* (Jordan and Snyder, 1901) (Tetraodontidae) was captured.

Despite an increasing threat of parasites in aquaculture, information on parasites and diseases are largely lacking from farmed fishes in Korea. Hayward et al. (2001) reported spread of a monogenean *Neoheterobothrium hirame* Ogawa, 1999 to Korea from its neighbouring country. It is considered as a serious pest for olive flounder aquaculture in Japan as well in Korea (Hayward et al. 2001). In relation to that we predict our reported monogeneans might have been spread from outside or not studied in detail in Korea. Hence, to bridge the gap in research on this group, we report the infection of monogeneans on some of the important marine fishes which are considered as a first report from Korea.

Materials and methods

Monogeneans were obtained from the body surface, gills and fins of ranched fish *A. schlegelii schlegelii* and *P. major* at TMRC (Fig. 1). The toxic puffer *T. niphobles* was captured by fishing gear near TMRC, Gyeongsangnam-do, Korea (Table 1). The monogeneans were removed using fine forceps from the fins of the above fish host under a dissecting microscope and preserved in 70 % ethanol. To prevent the loss of mobile and temporary ectoparasites, some fish were preserved immediately after capture. Some fresh fish were analysed to get the live monogeneans. The external surfaces of skin and fins were examined for attached parasites. The isthmus was then incised to open the operculum and expose the gills, and the surfaces of the gills and inner walls of the operculum were examined grossly for infections with large, adult worms. To detect small and immature parasites, the gills were then dissected out and separated into the 4 arches and examined in Petri dishes. All sediments (scales, mucous and dissection debris) settling in solutions were also retained and checked for any detached parasites under the microscope.

Worm identification was confirmed by mounting specimens on slides in drops of ammonium picrate glycerine under coverslips, and examining hard parts using light microscopy; Selected specimens were stained in Semichon's

Fig. 1 Map showing the fish collected locality, Tongyeong marine living resources research and conservation center (TMRC), Tongyeong, Gyeongsangnam-do, Korea

acetocarmine (Humason 1979), and mounted in Canada balsam after dehydration in a graded ethanol series and clearing in methyl salicylate. Copepod (monogenean attached) was identified directly under a dissecting microscope. Specimens were measured intact using an ocular micrometer. Since, all reported monogeneans were described in Japan and elsewhere, we did document them other than by photomicrographs. The common and scientific names of host fishes follow FishBase (Froese and Pauly 2012). Voucher specimens are deposited at the Marine Biodiversity Institute of Korea (MABIK), Seochon, Korea.

Results and discussion

Class **Monogenea** van Beneden, 1838

Subclass **Monopisthocotylea** Odhner, 1912

Order **Gyrodactylidea** Bychowsky, 1937

Family **Anoplodiscidae** Tagliani, 1912

Genus *Anoplodiscus* Sonsino 1890

Anoplodiscus spari (Yamaguti 1958) (Fig. 2)

Synonyms:

Pseudomicrobothrium spari Yamaguti (1958, p. 53).

Anoplodiscus spari Ogawa and Egusa (1981, p. 253);

Paraguassú et al. (2002, p. 1197).

Material examined

10 specimens, (3 individuals, MABIK IV00141923) ex fins and body surface of *A. schlegelii schlegelii*, 14 September 2012.

Table 1 Hosts and localities of five species of monogeneans (Platyhelminthes) from Korea and Japan

Monogenea: Family	Host	Infected site	Host order: family	Country	Reference
<i>Anoplodiscus spari</i> (Yamaguti 1958) (Fig. 2) (= <i>Pseudomicrobothrium spari</i>) (Anoplodiscidae)	<i>Acanthopagrus schlegelii schlegelii</i> (= <i>Sparus macrocephalus</i>)	Fins	Perciiformes: Sparidae	Japan	Yamaguti (1958)
	<i>Acanthopagrus schlegelii schlegelii</i>	Fins and Body surface		Japan	Ogawa and Egusa (1981)
	<i>Acanthopagrus schlegelii schlegelii</i>	Fins		Korea	Present study
<i>Anoplodiscus tai</i> Ogawa, 1994 (Fig. 3)	<i>Pagrus major</i>	Fins	Perciiformes: Sparidae	Japan	Ogawa (1994)
	<i>Pagrus major</i>	Fins		Korea	Present study
<i>Benedenia sekii</i> (Yamaguti 1937), Meserve 1938 (Fig. 4) (= <i>Epibdella</i> (<i>Epibdella</i>) <i>sekii</i>) (Capsalidae)	<i>Pagrus major</i>	Body surface		Japan	Yamaguti (1937)
	<i>Pagrus major</i>	Body surface		Korea	Present study
<i>Choricotyle elongata</i> (Goto 1894) (Fig. 5) (Diclidophoridae) (= <i>Diclidophora elongata</i>)	<i>Evychnis tumifrons</i> (= <i>Chrysophrys tumifrons</i>); <i>Sparus aurata</i> Linnaeus (= <i>Chrysophrys auratus</i>)	Oral cavity	Perciiformes: Sparidae	Japan	Goto (1894)
	<i>Pagrus major</i>	Oral cavity		Japan	Yamaguti (1938, 1963)
	<i>Cymothoa</i> or <i>Meinertia</i>	Oral cavity	Isopoda: Cymothoidae	Japan	Goto (1894); Llewellyn (1941)
	<i>Pagrus major</i>	Gill/opercular cavity		Korea	Present study
<i>Udonella fugu</i> Freeman and Ogawa 2010 (Fig. 6, a, b) (= <i>U. caligorum</i>) (Udonellidae)	<i>Takifugu niphobles</i> ; <i>Takifugu rubripes</i>	Body surface of <i>Pseudocaligus fugu</i> (Copepoda: Caligidae)	Tetraodontiformes: Tetraodontidae	Japan	Yamaguti (1958); Freeman and Ogawa (2010); Okawachi et al. (2012)
	<i>Takifugu niphobles</i>	Body surface of <i>P. fugu</i>		Japan	Present study

Diagnostic features

Body 2.6–2.9 mm long, fusiform, 1.04–1.63 mm wide. Opisthaptor disc-shaped, unarmed. Head truncated, with pair of bothria having several irregular folds at margins. 2 pairs of eye spots located anterodorsally. Pharynx well developed. Intestine runs along the left side of the testis, terminating in front of opisthaptor. Intestine bearing side branches, of which two are conspicuously developed and occupy at right side of body, both terminating blindly. Chitinous accessory piece attached ventrally to cirrus. Ovary located at right side of body, sometimes overlapping with testis. Vaginal opening ventrally on right side; simple opening without any armature. Oviduct at centre of ovary and unites with vaginal duct. Ootype with three expansions, leading to short uterus bearing genital opening. Vitelline follicles distributed between both sides of body from copulatory organ level to that of posterior end of intestine.

Remarks

Anoplodiscus spari was identified based on Yamaguti (1958) and Ogawa and Egusa (1981). Originally, it was reported as *Pseudomicrobothrium spari* by Yamaguti

(1958) collected from *Sparus macrocephalus* (= *Acanthopagrus schlegelii schlegelii*) in Japan. However, Ogawa and Egusa (1981) found the same monogeneans from the fins of *A. schlegelii schlegelii* and after examined the type specimens, they concurred that the specimens mentioned by Yamaguti (1958) belonged to the genus *Anoplodiscus* and denoted as *A. spari*, since it followed all the characteristic features of *P. spari* and redescribed in detail.

It bears a superficial resemblance to members of the family Microbothriidae Price, 1936, but members of this family differ from the species of *Anoplodiscus* in the structures of intestine and prohaptor. Currently, the genus *Anoplodiscus* consists of six nominal species, such as: *Anoplodiscus australis* (Johnston 1930), *A. cirruspiralis* Roubal et al. (1983), *A. longivaginatus* Paraguassú et al. (2002), *A. richiardi* (Sonsino 1890), *A. spari* (Yamaguti 1958), and *A. tai* Ogawa 1994. All six species were collected from marine fishes of Sparidae.

Most of *A. schlegelii schlegelii* hosts were found infected with *A. spari* on the fins and body surface, but not found from gills. So far, there is no report on this monogenean in Korea, and is considered as a first report of occurrence.

Fig. 2 Light photomicrograph of a preserved, unstained, unmounted specimen, *Anoplodiscus spari* (Yamaguti 1958) from *Acanthopagrus schlegelii schlegelii*, ventral view, showing pigment contained in the body, haptor and anterior attachment organs. Scale bar 0.5 mm

Fig. 3 Light photomicrograph of a preserved, unstained, unmounted specimen, *Anoplodiscus tai* Ogawa 1994 from *Pagrus major*, ventral view, showing haptor. Scale bar 1 mm

Distribution

Japan (Yamaguti 1958; Ogawa and Egusa 1981) and currently from Korea (Table 1).

Anoplodiscus tai Ogawa 1994 (Fig. 3)

Synonyms:

Anoplodiscus tai Ogawa (1994, p. 5); Paraguassú et al. (2002, p. 1197).

Material examined

4 specimens, (1 individual, MABIK IV00141924) ex fins of *P. major*, 14 September, 2012

Diagnostic features

Body, 3.14–3.20 mm long, elongated, large, dorsoventrally flattened, slightly tapering at both ends. Opisthaptor sucker-like, without hamuli, bars or marginal hooks. Anterior end truncated, with 1 pair of bothria. Four eye spots dorsal to anterior bulb of pharynx. Intestine single with numerous short, irregular side branches, directing posteriorly in median line, passing on left side of testis, terminating blindly anterior to opisthohaptor. Testis single, rounded, located in anterior part of body in median line. Prostatic cells, in two masses, distributed transversely at

level of ejaculatory bulb. Ovary, antero-dextral to testis, rounded and transversely wide. Vagina opening antero-dextrally to ovary on ventral side of body, from lateral margin. Vaginal duct soon forming receptaculum seminis. Oviduct, ascending in median line to ootype, which has two prominent lateral expansions, opening almost directly to genital pore in median line between pharynx and ovary. Vitelline follicles large.

Remarks

Anoplodiscus tai was identified based on the description and illustration of Ogawa (1994). It closely resembles with two species such as *A. richiardii* and *A. cirruspidalis* by a considerable smaller body size and a larger cirrus accessory piece. However, both characters are opposite for its congeners (Monticelli 1905; Roubal et al. 1992). The present species was first identified from Japan from the fins of the same sparid host *P. major* (Ogawa 1994). The congeners *A. richiardii* was collected from red porgy *Pagrus pagrus* (Linnaeus, 1758) from the Mediterranean (Sonsino 1890; Monticelli 1905) and *A. cirruspidalis* from the caudal fin of the gilthead seabream *Sparus aurata* Linnaeus, 1758 from New Zealand and Australia (Roubal et al. 1992). According to Ogawa (1994), 5-year-old fish of *P. major* were rejected in the market because of the presence of *A. tai* infection on the fins.

Distribution

Japan (Ogawa 1994) and currently from Korea (Table 1).

Order **Capsalidea** Lebedev, 1988

Family **Capsalidae** Baird, 1853

Genus *Benedenia* Deising, 1858

Benedenia sekii (Yamaguti 1937), Meserve 1938 (Fig. 4)

Synonyms:

Epibdella (*Epibdella*) *sekii* (Yamaguti 1937, p. 25)

Benedenia sekii (Yamaguti 1937), Meserve (1938, p. 31),

Roubal et al. (1983, p. 1, 1996, p. 585), Sharples and

Evans (1995, p. 143), Whittington et al. (2001, p. 726).

Material examined

10 specimens, (1 individual, MABIK IV00141925) ex body surface of *P. major*, 14 September, 2012

Diagnostic features

Body 3.1–6.2 mm long, broad. Body margin extending to anterior edge of anterior attachment organs. Pharynx larger than anterior attachment organs. Haptor larger, circular and equipped with relatively small accessory sclerites lying just posterior to haptor centre. Haptoral tendons visible. Anterior hamuli small and slender with submarginal, laterally directed spike and overlap posterior hamuli for half to two-thirds of

Fig. 4 Light photomicrograph of a preserved, unstained, unmounted specimen, *Benedenia sekii* (Yamaguti 1937), Meserve 1938 from *Pagrus major*, ventral view, showing pigment contained in the body, haptor and anterior attachment organs. Scale bar 1 mm

their length. Posterior hamuli are small with broad root and recurved tip. Both anterior and posterior hamuli on posterior edge of haptor. Marginal valve bearing single large lobe between each hooklet around haptor but each large lobe comprises several smaller, fused lobes. Reproductive system with long slender penis, small accessory gland reservoir, relatively small testes and narrow vaginal opening close to common genital pore. Uterus winds between sperm duct and posterior part of cirrus pouch, enlarges and opens into common gonopore. Seminal receptacle anterior to and left of ovary, connected by thin vaginal duct to vaginal opening just left of common gonopore. Vitellaria distributed throughout most of body proper.

Remarks

Benedenia sekii was identified based on Whittington et al. (2001) and Yamaguti (1937). It can be distinguished from other species by a combination of the following characters: broad body; tiny anterior and posterior hamuli relative to accessory sclerites; all median sclerites located posteriorly on haptor; details of marginal valve; long thin penis; and close proximity of common genital pore and vaginal pore. It was originally identified by Yamaguti (1937) from the body surface of *P. major* collected from Otyo, the Seto Inland Sea, Hiroshima Prefecture, Japan. After that, it was misidentified from Australia (Roubal et al. 1983) and New Zealand (Sharples and Evans 1995). Both have reported with considerable differences between the Japanese material and their own materials collected from *S. aurata* (= *Pagrus auratus*; *Chrysophrys auratus*) (Table 1). The main differences are larger specimens, accessory sclerites are larger and slight differences in the shape of the anterior hamuli in the Japanese specimens. In the recent revision of *Benedenia* by Whittington et al. (2001), it was concurred that the species collected by Roubal et al. (1983) and by Sharples and Evans (1995) as *B. sekii*. According to Whittington and Deveney (2011), there are 27 species under the genus *Benedenia*.

Sparus aurata is widely distributed in the Eastern Atlantic: British Isles, Strait of Gibraltar to Cape Verde and around the Canary Islands. Also in the Mediterranean, New Zealand and Australia. However, the type host *P. major* is distributed in the Northwest Pacific: northeastern part of South China Sea (Philippines excluded) northward to Japan (Froese and Pauly 2012). It appears, therefore, that the Japanese, Australian and New Zealand material of *B. sekii* was found on the hosts (*P. major* and *S. aurata*) belong to the same family Sparidae.

Distribution

The Seto Inland Sea, Japan (Yamaguti 1937); New South Wales; Gulf of St. Vincent and Wallaroo, South Australia

(Roubal et al. 1983); Port Hacking, New South Wales, Australia (Roubal et al. 1996); Kawau Bay, northern New Zealand (Roubal et al. 1983); north-eastern New Zealand (Sharples and Evans 1995), currently from Korea (Table 1).

Subclass **Polyopisthocotylea** Odhner, 1912

Order **Mazocraeidea** Bychowsky, 1937

Family **Diclidophoridae** Cerfontaine, 1851

Genus *Choricotyle* Beneden and Hesse, 1863

Choricotyle elongata (Goto 1894) (Fig. 5)

Synonyms:

Choricotyle elongata (Goto 1894, p. 10), Yamaguti (1938, p. 139)

Diclidophora elongata (Goto 1894): Llewellyn (1941, p. 416); Yamaguti (1963, p. 600)

Material examined

4 specimens, (1 individual, MABIK IV00141928) ex gills/opercular cavity of *P. major*, 14 September, 2012.

Diagnostic features

Body 5.9–6.3 mm long, pointed anteriorly. Pedicels having equal angle with each other; consisting a branch of intestine and a portion of vitellarium. Oesophagus short. Two intestinal trunks with long lateral branches outward, and connected with each other by cross units; which joined at

Fig. 5 Light photomicrograph of a preserved, unstained, unmounted specimen, *Choricotyle elongata* (Goto 1894) from *Pagrus major*, whole animal, ventral view, showing pigment contained in the body, haptor and clamps. Scale bar 1 mm

posteriorly, forming loop-like structure, with four pairs of branched clamps, long, each penetrating into pedicel. Common genital opening. Penis bearing eight hooks. Ovary occupying posterior end, long, cylindrical, bending on itself forming double V. Oviduct arising from front end of larger half of ovary. Oviduct proceeding backwards, and approaching posterior end of body bends towards right, and continued into ootype, positioned on right side of body nearby trunk of intestine. Vitellaria distinct on both sides. Paired yolk-ducts slightly asymmetrical; ducts directed obliquely across long axis of body, and uniting each other on same level as front end of smaller half of ovary. Unpaired yolk-duct on itself and proceeds toward right side, and finally opens into intestine. Testes numerous, small, extending from behind ootype of pedicels of foremost pair of suckers.

Remarks

Choricotyle elongata was identified based on Goto (1894) and Yamaguti (1938). It was originally described by Goto (1894). *Choricotyle elongata* was collected from the oral cavity of yellowback seabream *Evynnis tumifrons* Temminck and Schlegel, 1843 (= *Chrysophrys tumifrons*) and *S. aurata*. Later, it was reported by Yamaguti (1938), and also accidentally it was found from the mouth cavity of isopod *Cymothoa* or *Meinertia* (Goto 1894; Llewellyn 1941). According to Yamaguti (1963), severe infection of *C. elongata* (= *Diclidophora elongata*) caused injuries on the fingerlings of *P. major* at Nagasaki Prefecture, Japan. This is the first report on the infection of *C. elongata* from Korea. There are 22 nominal species on the genus *Choricotyle* (Gibson and Bray 2012).

Distribution

Japan (Goto 1894; Yamaguti 1938, 1963) and currently from Korea (Table 1).

Subclass **Monopisthocotylea** Odhner, 1912

Order **Gyrodactylidea** Bychowsky, 1937

Family **Udonellidae** Taschenberg, 1879

Genus *Udonella* Johnston, 1835

Udonella fugu Freeman and Ogawa 2010 (Fig. 6a, b)

Synonyms:

Udonella caligorum Johnston, 1835: Yamaguti (1958, p. 53).

Udonella fugu Freeman and Ogawa 2010, p. 255; Okawachi et al. (2012, p. 181).

Material examined

6 specimens, (3 individuals, MABIK IV00141930) ex body of 2 *Pseudocaligus fugu* (Copepoda: Caligidae) infecting *T. niphobles*, 20 September, 2012.

Fig. 6 Light photomicrographs of *Udonella fugu* Freeman and Ogawa 2010 from *Pseudocaligus fugu* Yamaguti, 1936 infecting *Takifugu niphobles*: A. lateral view of a preserved, unstained, unmounted *U. fugu*, showing haptor. B. showing the attachment of *U. fugu* on *P. fugu*, larger and smaller arrows indicate the larger and smaller sized monogeneans, respectively. C. showing the attachment of large number of *U. fugu* eggs at urosome of *P. fugu*. Scale bar a 0.5 mm; b, c 1 mm

Diagnostic features

Body 1.4–2.4 mm long, flat, subcylindrical. Opisthaptor unarmed, transversely widened, pair of adhesive glands on each side of body. Collecting ducts of adhesive gland joining leading to centre of opisthaptor. Pair of head organs opening anteriorly. Gland cells of head organs extending on each side of body; ducts entering paired vesicles, oval-shaped. Anteriorly, four pairs of conical sensory papillae. Mouth opening subterminally. Pharynx rounded and transversely wide. No oesophagus. Intestine a wide tubular sac, running posteriorly in dorsal median field, extending to end of vitellaria. Testis single, spherical, wide. Vas deferens narrow, running anteriorly on left side of ovary and uterus. Vesicula seminalis elliptical, situated alongside prostatic reservoir behind pharynx. Ovary single, spherical, located in front of testis. Common vitelline duct on ventral side of ovary, with sphincter immediately before joining germiduct. Egg provided with long polar filament. Uterus opening directly into genital atrium. Vitellaria with many follicles, large, extending laterally from level of genital pore to near posterior end of intestine.

Remarks

Udonella fugu was identified based on Freeman and Ogawa (2010). Twelve *T. niphobles* were collected using fishing gears and observed that 15 copepods of *Pseudocaligus fugu* Yamaguti, 1936 (12 females and 3 males) were infected on the skin. Off which, 10 females were found with the infection of *U. fugu* (Fig. 6b). Three copepods were found

with the attachment of eggs in high number around the urosome (Fig. 6c).

The genus *Udonella* is considered as a unique monogenean, because of its hyperparasitism on the body surface of parasitic crustaceans such as caligiform copepods and branchiurans on the skin of marine fish host (Carvajal and Sepúlveda 2002; Kearn 2004; Freeman and Ogawa 2010). It feeds on host mucus and epithelium, attaching themselves on the crustacean hosts (Freeman 2005). At present, there are seven recognized species of *Udonella* such as *U. australis* Carvajal and Sepúlveda 2002, *U. caligorum* Johnston, 1835, *U. murmanica* Kornakova and Timofeeva 1981, *U. myliobati* (Guberlet, 1936), *U. ophiodontis* Kay, 1945, *U. papillifera* Van der Land, 1967 and *U. fugu* Freeman and Ogawa 2010 (Freeman and Ogawa 2010).

Yamaguti (1958) reported *U. caligorum* on *P. fugu*, however, recently it was newly described as *U. fugu*, after understanding through molecular and phylogenetic aspects that it completely deviated from *U. caligorum* (Freeman and Ogawa 2010). It was collected from the same caligid copepod infecting *T. niphobles* and the tiger puffer *T. rubripes* (Temminck and Schlegel, 1850) from Shizouka and Oita Prefectures, Japan. Further, the authors inferred that this monogenean is pathogenic to puffer. Recently, we reported the ecology of *U. fugu* from *P. fugu* occurring in Japanese waters (Okawachi et al. 2012) and revealed that prevalence and intensity of monogenean showed a high correlation with copepod infection. Even though, the copepod *P. fugu* bears the toxin known as tetrodotoxin (TTX) (Venmathi Maran et al. 2007; Venmathi Maran et al. 2011), the prevalence of *U. fugu* was high (Okawachi et al. 2012).

Distribution

Japan (Yamaguti 1958; Freeman and Ogawa 2010; Okawachi et al. 2012) and currently from Korea (Table 1).

Acknowledgments We thank technicians at TMRC for the access in fish sampling. Senior author is thankful to KRCF and this work was formed part of KIOST projects (PK08080, PE98785, PE98747). This work was partially supported by the National Institute of Biological Resources (NIBR), Korean project on the survey of Korean indigenous species and National Marine Life Collection program (project) sponsored by the Ministry of Land, Transport and Maritime Affairs, Korea (MABIK 2012-001-03) to SYM, HYS.

References

- Carvajal J, Sepúlveda F (2002) *Udonella australis* n. sp. (Monogenea), an epibiont on sea-lice from native fish off southern Chile. *Syst Parasitol* 52:67–74. doi:10.4067/S0301-732X2001000100003
- Freeman M (2005) Marine hyperparasites. In: Rhode K (ed) *Marine parasitology*. CSIRO Publishing, Collingwood, pp 293–298
- Freeman M, Ogawa K (2010) Variation in the small subunit ribosomal DNA confirm that *Udonella* (Monogenea: Udonellidae) is a species-rich group. *Int J Parasitol* 40:255–264. doi:10.1016/j.ijpara.2009.08.006
- Froese R, Pauly D (2012) FishBase. World Wide Web electronic publication. www.fishbase.org. Accessed on 01.12.12
- Gibson D, Bray R (2012) *Choricotyle* Beneden & Hesse, 1863. World Register of Marine Species at <http://www.marinespecies.org/aphia.php?p=taxdetails&id=119337>. Accessed on 01.12.12
- Goto S (1894) Studies of the ectoparasite fauna of Japan. *J Coll Sci Imp Univ Tokyo* 8:1–273
- Hayward CJ, Kim J-H, Heo G-J (2001) Spread of *Neoheterobothrium hirame* (Monogenea), a serious pest of olive flounder *Paralichthys olivaceus* to Korea. *Dis Aquat Org* 45:209–213
- Humason GL (1979) Animal tissue techniques. Freeman WH & Company, San Francisco 641
- Kabata Z (1973) Distribution of *Udonella caligorum* Johnston, 1835 (Monogenea: Udonellidae) on *Caligus elongatus* Nordmann, 1832 (Copepoda: Caligidae). *J Fish Res B Can* 30:1793–1798
- Kearn GC (2004) Leeches, lice and lampreys. Springer, Dordrecht 432
- Kim IB (2000) Cage aquaculture in Korea. In: Liao IC, Lin CK (eds) *Cage aquaculture in Asia*. Proceedings of the First International Symposium on Cage Aquaculture in Asia. Asian Fisheries Society and World Aquaculture Society–Southeast Asian Chapter, Manila & Bangkok, pp 59–73
- Llewellyn J (1941) A revision of the monogenean family Diclidophoridae Fühmann, 1928. *Parasitology* 33:416–430
- Meserve FG (1938) Some monogenetic trematodes from the Galapagos Islands and the neighbouring Pacific. *Rep Allan Hancock Pac Exped (1932–1937)* 2:31–89
- MOMAF (2007) Studies on the development of marine ranching program in Tongyeong, Korea. KORDI Report, BSPM40600-1884-3, Korea Ocean Research and Development Institute, p 1082
- Monticelli FS (1905) Osservazione intorno ad alcune specie di Heterocotylea. *Boll Soc Natur Napoli* 18:65–80
- Ogawa K (1994) *Anoplodiscus tai* sp. nov. (Monogenea: Anoplodiscidae) from cultured red sea bream *Pagrus major*. *Fish Pathol* 29:5–10
- Ogawa K, Egusa S (1981) The systematic position of the genus *Anoplodiscus* (Monogenea: Anoplodiscidae). *Syst Parasitol* 2:253–260
- Okawachi H, Ohtsuka S, Ismail NB, Venmathi Maran BA, Ogawa K (2012) Seasonal occurrence of and microhabitat of the hyperparasitic monogenean *Udonella fugu* on the caligid copepod *Pseudocaligus fugu* infecting the grass puffer *Takifugu niphobles* in the Seto Inland Sea, Japan. *Ocean Sci J* 47:181–187
- Paraguassú AR, Luque JL, Alves DR (2002) A new species of *Anoplodiscus* (Monogenea: Anoplodiscidae) parasitic on *Pagrus pagrus* (Osteichthyes: Sparidae) from the coastal zone of the state of Rio de Janeiro, Brazil. *Mem Inst Oswaldo Cruz Rio de Janeiro* 97:1197–1199
- Park SI (2009) Disease control in Korean aquaculture. *Fish Pathol* 44:19–23
- Rhode K (1984) Diseases caused by metazoans: helminths. In: Kinne O (eds) *Diseases of marine animals*, Vol. IV, Part 1, Introduction, Pisces, Biologische Anstalt Helgoland, Hamburg, pp 193–320
- Roubal FR, Armitage J, Rohde K (1983) Taxonomy of Metazoan ectoparasites of Snapper, *Chrysophrys auratus* (Family Sparidae), from Southern Australia, Eastern Australia and New Zealand. *Aust J Zool* 94:1–68
- Roubal FR, Quartararo N, West A (1992) Infection of captive *Pagrus auratus* (Bloch & Schneider) by the monogenean, *Anoplodiscus cirrusspiralis* Roubal, Armitage & Rohde (Anoplodiscidae) in Australia. *J Fish Dis* 15:409–415
- Roubal FR, Quartararo N, West A (1996) Spatial and temporal variation in populations and community of ectoparasites on young snapper, *Pagrus auratus* (Bloch & Schneider) (Sparidae), from the wild and captivity at Port Hacking, Sydney, Australia. *Mar Fres Res* 47:585–593
- Sharples AD, Evans CW (1995) Taxonomy of the metazoan parasites of the snapper *Pagrus auratus* in New Zealand. 1. Ectoparasites. *New Zealand J Zool* 22:143–161
- Sonsino P (1890) Di un nuovo trematode raccolto dal *Pagrus orphus*. Cenno preliminare. *Atti Soc Toscana Sci Nat, Pisa* 7:172
- Venmathi Maran BA, Iwamoto E, Okuda J, Matsuda S, Taniyama S, Shida Y, Asakawa M, Ohtsuka S, Nakai T, Boxshall GA (2007) Isolation and characterization of bacteria from the copepod *Pseudocaligus fugu* ectoparasitic on the panther puffer *Takifugu pardalis* with the emphasis on TTX. *Toxicon* 50:779–790
- Venmathi Maran BA, Ohtsuka S, Takami I, Okabe S, Boxshall GA (2011) Recent advances in the biology of the parasitic copepod *Pseudocaligus fugu* (Siphonostomatoida, Caligidae), host specific to pufferfish of the genus *Takifugu* (Actinopterygii, Tetraodontidae). In: Asakura A et al (eds) *Crustaceana Monographs* 15: new frontiers in crustacean biology. Brill, Leiden, pp 31–45
- Venmathi Maran BA, Oh S-Y, Soh HY, Choi HJ, Myoung J-G (2012a) *Caligus sclerotinosus* (Copepoda: Caligidae), a serious pest of cultured red seabream *Pagrus major* (Sparidae) in Korea. *Vet Parasitol* 188:355–361
- Venmathi Maran BA, Moon SY, Oh S-Y, Soh HY, Myoung J-G (2012b) Redescription of two pennellids (Copepoda; Siphonostomatoida) from Korea with a key to species of *Peniculus* von Nordmann, 1832. *Zookeys* 243:1–14
- Whittington ID, Deveney MR (2011) New *Benedenia* species (Monogenea: Capsalidae) from *Diagramma labiosum* (Perciformes: Haemulidae) on the Great Barrier Reef, Australia, with oncomiracidial descriptions and a report of egg attachment to the host. *J Parasitol* 97:1026–1034
- Whittington ID, Cribb BW, Hamwood TE, Halliday JA (2000) Host-specificity of monogenean (platyhelminth) parasites: a role for anterior adhesive areas? *Int J Parasitol* 30:305–320. doi:10.1016/S0020-7519(00)00006-0
- Whittington ID, Deveney MR, Wyborn SJ (2001) A revision of *Benedenia* Diesing, 1858 including a redescription of *B. sciaenae* (van Beneden, 1856) Odhner, 1905 and recognition

- of *Menziesia* Gibson, 1976 (Monogenea: Capsalidae). J Nat Hist 35:663–777
- Yamaguti S (1937) Studies on the helminth fauna of Japan. Part 19. Fourteen new ectoparasitic trematodes of fishes. Published by the author, Kyoto, p. 28
- Yamaguti S (1938) Studies on the helminth fauna of Japan. Part 21. Trematodes of fishes IV. Published by the author, Kyoto, p 139
- Yamaguti S (1958) Studies on the helminth fauna of Japan. Part 53. Trematodes of fishes, XII. Publ Seto Mar Biol Lab Kyoto Univ 7:53–88
- Yamaguti S (1963) Systema Helminthum. Vol IV. Monogenea and Aspidocotylea. InterScience Publishers, New York, p 699