REVIEW

A synopsis of the parasites of medaka (Oryzias latipes) of Japan (1929-2017)

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Abstract  Information on the protistan and metazoan parasites of medaka, Oryzias latipes (Temminck and Schlegel, 1846), from Japan is summarized based on the literature published for 89 years between 1929 and 2017. This is a revised and updated checklist of the parasites of medaka published in Japanese in 2012. The parasites, including 27 nominal species and those not identified to species level, are listed by higher taxa as follows: Ciliophora (no. of nominal species: 6), Cestoda (1), Monogenea (1), Trematoda (9), Nematoda (3), Bivalvia (5), Acari (0), Copepoda (1), and Branchiura (1). For each parasite species listed, the following information is given: its currently recognized scientific name, any original combination, synonym(s), or other previous identification used for the parasite from medaka; site(s) of infection within or on the host; known geographical distribution in Japanese waters; and the published source of each record. A skin monogenean, Gyrodactylus sp., has been encountered in research facilities and can be regarded as one of the most important parasites of laboratory-reared medaka in Japan.

Key words: bibliography, medaka, Oryzias latipes, parasites, synopsis

INTRODUCTION

Medaka, also known as Japanese rice fish, Oryzias latipes (Temminck and Schlegel, 1846), belongs to the family Adrianichthyidae (order Beloniformes) and is a small freshwater fish which is distributed in Asian Far East including Japan, Taiwan, Korea, and China (Kinoshita et al., 2009). In Japan, this species was commonly found in inland waters, but, recently, its wild populations have declined markedly and it has thus been designated as “vulnerable” (Hosoya, 2015). Medaka is also reared in many research facilities in Japan and other countries because the species is an important model animal for biomedical research (e.g., Yamamoto, 1975; Egami et al., 1990; Iwamatsu, 2006; Kinoshita et al., 2009).

A checklist of the parasites of medaka of Japan was published in 2012 based on the literature published between 1929 and 2012 (Nagasawa et al., 2012). This checklist contained the information on both protistan and metazoan parasites reported from medaka in Japan, and 18 nominal species of parasites were listed by higher taxa as follows: Ciliophora (5 spp.), Cestoda (1 sp.), Trematoda (7 spp.), Nematoda (2 spp.), Bivalvia (1 sp.), Copepoda (1 sp.), and Branchiura (1 sp.). The checklist also contained the information on unidentified species of Ciliophora, Trematoda, Monogenea, and Acari. Since the checklist was published in Japanese, it is almost impossible for scientists in countries other than Japan to use it.

The checklist is revised and updated herein based on three sources of the literature: 1) the papers
and books cited by Nagasawa et al. (2012); 2) 14 papers overlooked by these authors (Ichioka, 1930; Matsumura, 1933; Okabe, 1936; Mizumoto and Kobayashi, 1956; Ikuyama, 1960a, 1960b; Furukawa et al., 1965; Furukawa and Kobayashi, 1966; Suhama, 1968; Saito and Moriyama, 1993; Ponponpisit et al., 2000; Miyabe et al., 2007; Beatte et al., 2008; Baba and Urabe, 2011); and 3) five currently published papers (Nagasawa et al., 2012; Ito et al., 2014, 2016a, 2016b; Nitta and Nagasawa, 2017). In this synopsis, the following eight species of parasites are newly added:

1. **Tetrahymena pyriformis** (Ehrenberg, 1830) (Ciliophora);
2. **Dactylogyrus oryziasi** Nitta and Nagasawa, 2017 (Monogenea);
3. **Centrocestus nycticoracis** Izumi, 1935 (Trematoda);
4. **Parabucephalopsis parasiluri** Wang, 1985 (Trematoda);
5. **Cristaria plicata** (Leach, 1815) (Bivalvia);
6. **Hyriopsis schlegeli** (Martens, 1861) (Bivalvia);
7. **Pletholophus tenuis** (Gray in Griffin and Pidgeon, 1833) (Bivalvia); and
8. **Pronodularia japanensis** (Lea, 1859) (Bivalvia).

Information is herein assembled in a *List of the Parasites of Medaka of Japan*. In this list, parasites are arranged by higher taxa in the following order: Ciliophora, Cestoda, Monogenea, Trematoda, Nematoda, Bivalvia, Acari, Copepoda, and Branchiura. Within each higher taxa, genera and species are listed alphabetically. For each species of parasite, the following information is provided:

1) The current **scientific name**, including author(s) and date(s), followed by any previous or other identifications that have been used in establishing records from medaka in Japan. The scientific names of unionid bivalves used in this paper follow those recommended by Kondo (2015).

2) The **Site(s)** of infection of the parasite in or on its host. When the site was not given in the original record, the likely site was determined from other records and is enclosed in square brackets.

3) The **Distribution** of the parasite is indicated by prefecture (boundaries shown in Fig. 1), in geographical order from northeast to southwest in Japan. When no prefectural name was given in the original reports, the distribution is shown by a dash (–).

4) The **Record(s)**. The authors responsible for the records are listed in chronological order. Each reference is followed by the locality or localities given in two parts, first the prefecture and then the detailed collection locality or localities from which the parasite was reported. When no locality record was given, the geographical locality is shown by a dash (–). When all records are from the same prefecture, only the detailed collection locality or localities are listed.

5) Under **Remarks**, comments are given on nomenclature and the infection of the parasite on wild-caught or laboratory-reared medaka.

The **References** section includes works directly cited in a *List of the Parasites of Medaka of Japan*. If only a Japanese title was given by the original author(s), my translation of the title into English is provided in square brackets.

In Japan, *Oryzias sakaizumii* Asai, Senou and Hosoya, 2011, also occurs (Asai et al., 2011) and was previously recognized as medaka of the “Northern Population” occurring along the Sea of Japan coast of the northern half of Honshu Island (Sakaizumi, 1986). A trematode, *Exorchis oviformis*, has been reported from this population (= *O. sakaizumii*) (Saito et al., 1964). Also, glochidia of a unionid bivalve, *Pletholophus tenuis* (reported as *Cristaia tenuis*) can experimentally infect *O. sakaizumii* in tanks (Itoh et al., 2016a). No further published information is available on the parasites of *O. sakaizumii*. 
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Phylum CILIOPHORA

Chilodonella sp.

Sites of infection: body surface, gills
Distribution: –
Remarks: This species induces dyspnoea, and the affected skin looks whitish (Iwamatsu, 1993, 1997, 2006). No taxonomic study has been done using material from medaka.
**Ichthyophthirius multifiliis** Fouquet, 1876

Including: *Ichthyophthirius* of Kinoshita et al., 2009
Sites of infection: body surface, gills
Distribution: –
Remarks: Laboratory-reared medaka get infected by this species, which induces “white spot disease” (Kinoshita et al., 2012). Infected medaka become weakened and finally die (Iwamatsu, 1993, 1997, 2006). No taxonomic study of material from medaka has been conducted.

**Tetrahymena pyriformis** (Ehrenberg, 1830)
Site of infection: body surface
Distribution: –
Record: Ponpornpisit et al. 2000 (–)
Remarks: This species can experimentally infect laboratory-reared medaka (Ponpornpisit et al., 2000).

**Trichodina domerguei** (Wallengren, 1897)
Previous identification: *Cyclochaeta (=Trichodina) domerguei* of Sanchez-Bayo and Goka, 2005
Sites of infection: body surface, fins
Distribution: –
Record: Sanchez-Bayo and Goka 2005 (–: a paddy field)
Remarks: An infection of this species has been reported from medaka experimentally reared in paddy fields with a photograph of a heavily infected fry (Sanchez-Bayo and Goka, 2005). Nevertheless, this identification of the species needs verification because it infects marine, brackish-water, and freshwater fishes and is a taxonomically problematic species (e.g., Lom and Laird, 1969; Lom, 1970).

**Trichodina fujitai** (Suzuki, 1950)
Including: *Cyclochaeta* sp. of Suhama (1968)
Sites of infection: body surface, gills
Distribution: Hiroshima
Records: Suhama 1968 (Hiroshima: a pond in Hiroshima University); Iwamatsu 1993, 1997, 2006 (–)
Remarks: This species was originally described as *Cyclochaeta fujitai* by Suzuki (1950) based on material from the fins and gills of three species of freshwater fishes (*Carassius auratus* [as *Cyprinus auratus*], *Cyprinus carpio*, *Tribolodon hakonensis* [as *Leuciscus hakuensis*]) and the gills and branchial chamber of tadpoles of a frog (*Glandirana rugosa* [as *Rana rugosa*]). Recently, Nagasawa et al. (2012) transferred the species to the genus *Trichodina*. Like *Chilodonella* sp. and other *Trichodina* spp., this parasite induces dyspnœa (Iwamatsu, 1993, 1997, 2006). The specimens reported as *Cyclochaeta* sp. from the body surface of wild medaka were almost identical as *Cyclochaeta fujitai* (Suhama, 1968), which is currently a junior synonym of *T. fujitai*.

**Trichodina gotoi** Ariake, 1929
Sites of infection: fins, gills
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Distribution: –
Record: Ariake 1929 (–)
Remarks: This species is known to infect crucian carp (*Carassius auratus*), goldfish, and common carp (*Cyprinus carpio*) as well as medaka (Ariake, 1929). No paper has been published on this parasite since its original description.

*Trichodina mirabilis* Ariake, 1929
Site of infection: [fins]
Distribution: –
Record: Ariake 1929 (–)
Remarks: This species has also been reported from goldfish, crucian carp (*Carassius auratus*), and common carp (*Cyprinus carpio*) (Ariake, 1929). It has not been found since its original description.

*Trichodina* sp.
Sites of infection: body surface, gills, eyes, mouth
Distribution: –
Remarks: Various pathological changes are induced by this species in laboratory-reared medaka (Kinoshita *et al.*, 2009). Photographs of the species are shown by Iwamatsu (1993: fig. 35, 1997: fig. 47, 2006: fig. 58) and Kinoshita *et al.* (2009: fig. 2-29).

**Phylum PLATYHELMINTHES**

**Class Cestoda**

*Schyzocotyle acheilognathi* (Yamaguti, 1934)
Previous identification: *Diphyllobothrium* sp. of Nakai, 1930; *Bothriocephalus acheilognathi* of Fukui, 1964
Site of infection: intestine
Distribution: Tokyo, Shizuoka
Records: Nakai 1930 (Tokyo: Suna Town); Fukui 1964 (Shizuoka: Fujieda City)
Remarks: Hoshina *et al.* (1965: 307-309) regarded *Diphyllobothrium* sp. reported by Nakai (1930) as *B. acheilognathi*, which is currently treated as a junior synonym of *S. acheilognathi*.

**Class Monogenea**

*Dactylogyrus oryziasi* Nitta and Nagasawa, 2017
Site of infection: gills
Distribution: Tokushima
Record: Nitta and Nagasawa 2017 (an irrigation canal in Tokushima City)

*Gyrodactylus* sp.
Including: *Gyrodactylus* of Kinoshita *et al.*, 2009
Sites of infection: body surface, fins, gills
Distribution: –
Remarks: The gyrodactylid parasitic on medaka was reported as *G. elegans* by Iwamatsu (1993, 1997, 2006), but since this identification was not based on morphological study using material from medaka, the species is reported herein as *Gyrodactylus* sp. According to Harris et al. (2004: 8), "many host records are erroneous." This monogenean is sometimes heavily found on laboratory-reared medaka in Japan and one of the most important parasites of those medaka (Nitta and Nagasawa, unpublished). Monogeneans including this species have direct a life cycle without using any intermediate host and can easily proliferate in laboratory tanks. An unidentified gyrodactylid-like monogenean is also known to parasitize medaka kept in home aquaria (Nishikawa, 2016a, 2016b, 2017). One and two photographs of gyrodactylid reported as *G. elegans* and *Gyrodactylus* from and on medaka are shown by Iwamatsu (1993: fig. 35, 1997: fig. 47, 2006: fig. 58) and Kinoshita et al. (2009: fig. 2-32), respectively.

**Class Trematoda**

*Azygia gotoi* (Ariake, 1922)
Site of infection: intestine
Distribution: –
Record: Shimazu 1979 (–)
Remarks: When cercariae of this species are eaten by medaka in an aquarium, they are not encysted but found as juveniles in the host’s intestine (Shimazu, 1979). Medaka is regarded as a transport or paratenic host of this parasite (Shimazu, 1979, 2014).

*Centrocestus formosanus* (Nishigori, 1924)
Sites of infection: gill filaments, spaces between cartilaginous tissues
Distribution: Tokushima
Record: Toyo-oka 1965 (Naruto City)
Remarks: Metacercariae of this species are found encysted in wild medaka (Toyo-oka, 1965).

*Centrocestus nycticoracis* Izumi, 1935
Sites of infection: –
Distribution: Saga
Record: Ikuyama 1960a (Ōta, Morodomi-chō in Saga City)
Remarks: Metacercariae of this species are found in wild medaka (Ikuyama, 1960a).

*Clinostomum* sp.
Site of infection: muscle
Distribution: Fukuoka
Record: Ichihara and Takeishi 1998 (Kitakyushu City)
Remarks: Metacercariae of this species are found encysted in wild medaka (Ichihara and Takeishi, 1998).
Diplostomatidae gen. sp.
Previous identification: *Ornithodiplostomum* or *Neodiplostomum* of Toyo-oka and Okada, 1954
Site of infection: body cavity
Distribution: Tokushima
Records: Toyo-oka and Okada 1954 (vicinity of Tokushima City); Toyo-oka 1961 (lower reaches of the Yoshino River)
Remarks: Metacercariae of this species are found unencysted in wild medaka (Toyo-oka and Okada, 1954; Toyo-oka, 1961). When metacercariae removed from medaka are artificially given to a pigeon, they become adults (Toyo-oka and Okada, 1954).

*Exorchis oviformis* Kobayashi, 1915
Sites of infection: scales, fins, muscle
Distribution: Yamaguchi, Fukuoka
Records: Okabe 1936 (Fukuoka: Katakusu in Fukuoka City); Okabe 1940 (Fukuoka: Umi River); Takabayashi 1953 (Yamaguchi: Yoshida River); Ikuyama 1960b (Fukuoka: Gebayashi in Ōkawa City; Yanagawa City)
Remarks: Metacercariae of this species are found encysted in wild medaka (Okabe, 1936, 1940; Takabayashi, 1953, Ikuyama, 1960b).

*Metagonimus miyatai* Saito, Chai, Kim, Lee and Rim, 1997
Previous identification: *Metagonimus* Miyata type of Saito, 1984
Site of infection: scales
Distribution: –
Record: Saito 1984 (–)
Remarks: Cercariae of this species can experimentally infect medaka but most of them do not become encysted (Saito, 1984: table 7).

*Metagonimus takahashii* Suzuki, 1930
Site of infection: scales
Distribution: –
Record: Saito 1984 (–)
Remarks: Like *M. miyatai*, this species can experimentally infect medaka but does not become encysted (Saito and Moriyama, 1973; Saito, 1984: table 7).

*Metagonimus yokogawai* (Katsurada, 1912)
Sites of infection: scales, fins
Distribution: Toyama, Yamaguchi
Records: Ichioka 1930 (Toyama: Ishizutsumi Village); Takabayashi 1953 (Yamaguchi: Ube City, Yoshida River); Saito and Moriyama 1973 (–); Saito 1984 (–)
Remarks: Metacercariae of this species are found encysted in wild medaka (Ichioka, 1930; Takabayashi, 1953). However, when cercariae of the species experimentally infect laboratory-reared medaka, they do not become encysted (Saito and Moriyama, 1973).
**Ornithodiplostomum podicipitis** Yamaguti, 1939
Site of infection: surface of visceral organs (liver, kidney, gonads, mesentery, heart, gall bladder)
Distribution: Hiroshima, Tokushima, Ehime
Records: Toyo-oka and Okada 1954 (Tokushima: vicinity of Tokushima City; Ehime: vicinity of Matsuyama City; Hiroshima: vicinity of Hiroshima City); Toyo-oka 1961 (Tokushima: Tokushima City, Naruto City, lower reaches of the Yoshino River)
Remarks: Metacercariae of this species are found encysted in wild medaka. When they are experimentally given to a pigeon, they become adults (Toyo-oka and Okada, 1954).

**Parabucephalopsis parasiliuri** Wang, 1985
Site of infection: [fins]
Distribution: –
Record: Baba and Urabe 2011 (–)
Remarks: Cercariae of this species can experimentally infect laboratory-reared medaka (Baba and Urabe, 2011). Medaka was reported as *Oryzias* sp. by Baba and Urabe (2015).

**Unidentified trematodes**

**Tetracotyle** sp.
Previous identification: Tetracotyle of Tokyo-oka, 1951, 1961
Site of infection: body cavity
Distribution: Tokushima
Records: Toyo-oka 1957 (near Nikenya Town, Tokushima City); Toyo-oka 1961 (lower reaches of the Yoshino River)
Remarks: Encysted metacercariae of this species are found in wild medaka (Tokyo-oka, 1951, 1961).

**Unidentified species**
Sites of infection: skin, fins
Distribution: Shimane
Records: Iga 1964, 1965 (Matsue City)
Remarks: Metacercariae of this species are found encysted in wild medaka (Iga, 1964, 1965).

**Phylum NEMATODA**

**Camallanus cottii** Fujita, 1927
Site of infection: digestive tract
Distribution: –
Remarks: No paper has been published on this species from wild medaka. It is highly likely that the species infects laboratory-reared medaka and can complete its life cycle because “it can proliferate countlessly in tanks” (Iwamatsu, 1993, 1997, 2006).

**Gnathostoma nipponicum** Yamaguti, 1941
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Site of infection: muscle
Distribution: –
Record: Ando et al. 1992 (–)
Remarks: Medaka can experimentally get infected by this nematode by eating copepods harboring its larvae (Ando et al., 1992).

Phylum MOLLUSCA
Class Bivalvia

Cristaria plicata (Leach, 1815)
Sites of infection: [fins, gills]
Distribution: Aomori
Record: Itoh et al. 2016b (experimental infection)
Remarks: Glochidia of this species can experimentally infect Oryzias sp., which is O. latipes and/or O. sakaizumii, or a hybrid of both species, in tanks (Itoh et al., 2016b).

Hyriopsis schlegeli (Martens, 1861)
Sites of infection: fins, gills
Distribution: Shiga
Records: Mizumoto and Kobayashi 1956 (experimental infection); Furukawa et al. 1965 (experimental infection); Furukawa and Kobayashi 1966 (experimental infection)
Remarks: Glochidia of this species can experimentally infect medaka in tanks (Mizumoto and Kobayashi, 1956; Furukawa et al., 1965; Furukawa and Kobayashi, 1966).

Pletholophus tenuis (Gray in Griffin and Pidgeon, 1833)
Previous identification: Cristaria tenuis of Itoh et al., 2014, 2016a
Sites of infection: fins, gills
Distribution: Okinawa
Records: Itoh et al. 2014 (experimental infection); Itoh et al. 2016a (experimental infection)
Remarks: Glochidia of this species can experimentally infect medaka (Itoh et al., 2014, 2016a) and a closely related species, Oryzias sakaizumii, in tanks (Itoh et al., 2016a).

Pronodularia japonensis (Lea, 1859)
Previous identification: Inversidens japonensis of Miyabe et al., 2007
Sites of infection: fins, gills
Distribution: Chiba
Record: Miyabe et al. 2007 (experimental infection)
Remarks: Glochidia of this species can experimentally infect laboratory-reared medaka (Miyabe et al., 2007).

Sinanodonta japonica (Clessin, 1874)
Previous identification: Anodonta woodiana of Fukuhara et al., 1986
Site of infection: fins
Distribution: Osaka
Record: Fukuhara et al. 1986 (a pond in Toyonaka City)
Remarks: Glochidia of this species can temporally attach to wild medaka because this fish species is not a preferred host (Fukuhara et al., 1986). The pond mussel reported as Anodonta woodiana in Japan has recently been separated into two distinct species, Sinanodonta japonica (Clessin, 1874) and Sinanodonta lauta (Martens, 1877) (Tabe et al., 1994; Kondo et al., 2006; Kondo, 2015), and Fukuhara (2014: 350-351) states that A. woodiana reported by Fukuhara et al. (1986) might be identical as A. japonica, whose scientific name is currently Sinanodonta japonica. No glochidia of the species experimentally infect medaka in tanks (Akiyama, 2011).

Phylum ARTHROPODA

Class Arachnida, Subclass Acari

Unidentified species

Previous identification: “water mites” of Iwamatsu, 1993, 1997, 2006; Kinoshita et al., 2009
Sites of infection: body surface, fins
Distribution: –
Remarks: Water mites are found on laboratory-reared medaka: one and two photographs of water mites are shown by Iwamatsu (1993: fig. 35, 1997: fig. 47, 2006: fig. 58) and Kinoshita et al. (2009: fig. 2-31), respectively. No paper has been published on water mites from medaka.

Class Crustacea, Subclass Copepoda

Lernaea cyprinacea Linnaeus, 1758

Previous identification: Lernaea elegans of Nakai, 1927; Matsui and Kumada, 1928; Nakai and Koumi, 1931; Suzuki, 1965
Site of infection: head embedded in the host’s tissues with body protruding externally
Distribution: Tokyo, Nagano, Shizuoka, Aichi, Nara, Osaka, Fukuoka, Saga
Remarks: An excellent study on the life cycle of this species using laboratory-reared medaka as its host was made by Kasahara (1962).

Class Crustacea, Subclass Branchiura

Argulus japonicus Thiele, 1900

Site of infection: [body surface]
Distribution: –
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Remarks: While this species was figured as a parasite of medaka by Iwamatsu (1993: fig. 34, 1997: fig. 46, 2006: fig. 57), this author did not mention its occurrence on laboratory-reared medaka. No published information is available on the species from wild medaka.

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日本産メダカの寄生虫目録（1929-2017年）

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要 旨 1929-2017年に出版された文献を用いて，日本産メダカの寄生虫目録を作成した。本目録は2012年に日本語で出版した同名目録の追補改定版である。本目録では，メダカから報告された各寄生虫の情報を最新の学名，異名，寄生部位，地理的分布，記録（報告書と報告年）に整理した。その結果，2017年までに日本産メダカから27名義種の寄生虫が次の分類群からで報告されていたことが明らかになった：繊毛虫類（6種），条虫類（1種），単生類（1種），吸虫類（9種），線形動物（3種），二枚貝類（5種），カイアシ類（1種），エラオ類（1種）。また本目録では，それらに加えて，種まで同定されなかった繊毛虫類，単生類，吸虫類，ダニ類の各種に関する情報も含めた。日本のメダカ研究施設で問題になる寄生虫として，体表に寄生する単生類の1種 Gyrodactylus sp. があり，注意を要する。

キーワード：寄生虫，文献集，メダカ，目録