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

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## 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

forms) and is a small freshwater fish which is distributed in  
ea, 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; Ponpornpisit *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 nycitoracis* 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 Griffn and Pidgeon, 1833) (Bivalvia); and
8. *Pronodularia japonensis* (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*.

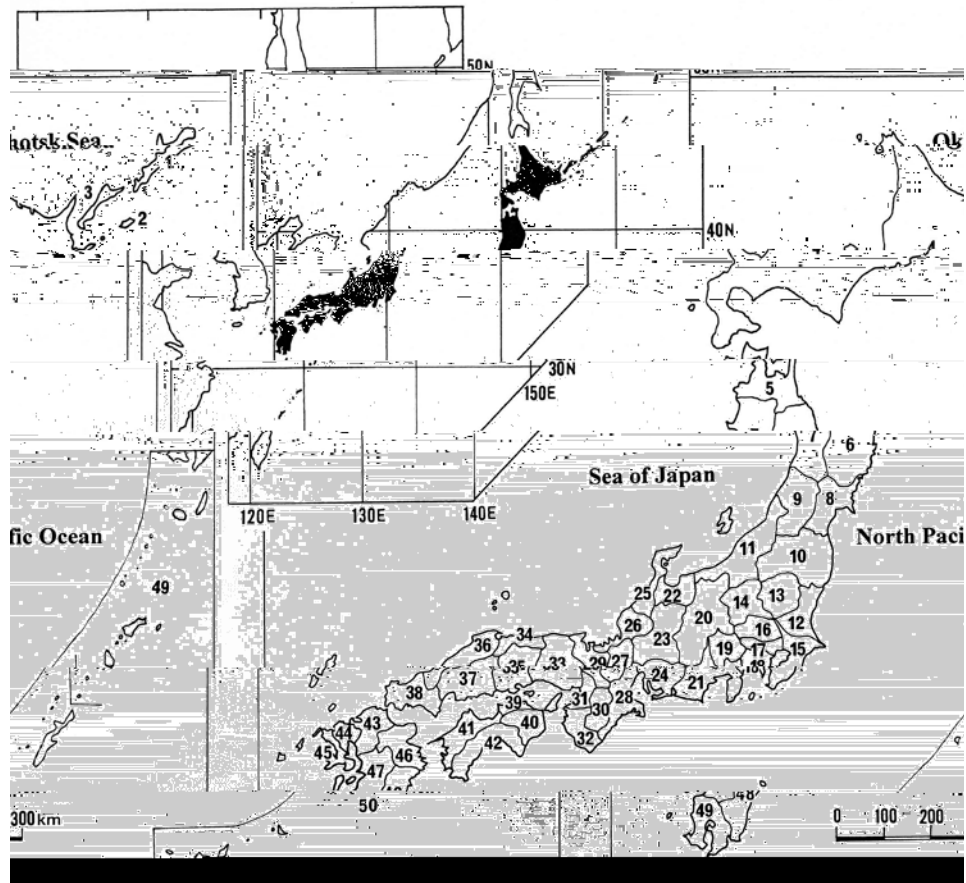


Fig. 1. Map of Japan showing the prefectural boundaries. The following prefectural names are arranged in alphabetical order: Aichi-24; Akita-7; Aomori-5; Chiba-15; Ehime-41; Etorofu Island-1; Fukui-26; Fukuoka-43; Fukushima-10; Gifu-23; Gunma-14; Hiroshima-37; Hokkaido-4; Hyogo-33; Ibaraki-12; Ishikawa-25; Iwate-6; Kagawa-39; Kagoshima-49; Kanagawa-18; Kochi-42; Kumamoto-47; Kunashiri Island-3; Kyoto-29; Mie-28; Miyagi-8; Miyazaki-48; Nagano-20; Nagasaki-45; Nara-30; Niigata-11; Oita-46; Okayama-35; Okinawa-50; Osaka-31; Saga-44; Saitama-16; Shiga-27; Shikotan Island-2; Shimane-36; Shizuoka-21; Tochigi-13; Tokushima-40; Tokyo-17; Tottori-34; Toyama-22; Wakayama-32; Yamagata-9; Yamaguchi-38; and Yamanashi-19.

## A LIST OF THE PARASITES OF MEDAKA OF JAPAN

### Phylum CILIOPHORA

#### *Chilodonella* sp.

Sites of infection: body surface, gills

Distribution: -

Records: Iwamatsu 1993, 1997, 2006 ( - )

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.

## Fouquet, 1876

Including: *Ichthyophthirius* of Kinoshita *et al.*, 2009

Sites of infection: body surface, gills

Distribution: -

Records: Iwamatsu 1993, 1997, 2006 (-); Kinoshita *et al.* 2009 ( - )

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, fns

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)

Previous identification: *Cyclochaeta fujitai* of Iwamatsu, 1993, 1997, 2006

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 fns 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 dyspnoea (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: fns, gills

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

Sites of infection: body surface, fins, gills

Distribution: -

Records: Iwamatsu 1993, 1997, 2006 ( - ); Kinoshita *et al.* 2009 ( - )

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 ( Ta, Morodomi-ch 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, fns, 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 kawa 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, fns

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 parasiluri* Wang, 1985**

Site of infection: [fns]

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, fns

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 cotti* Fujita, 1927**

Site of infection: digestive tract

Distribution: -

Records: Iwamatsu 1993, 1997, 2006 ( - )

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**

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: [fns, 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: fns, 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 Griffn and Pidgeon, 1833)

Previous identification: *Cristaria tenuis* of Itoh *et al.*, 2014, 2016a

Sites of infection: fns, 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: fns, 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: fns

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: -

Records: Iwamatsu 1993, 1997, 2006 (-); Kinoshita *et al.* 2009 (-)

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

Records: Nakai 1927 (Tokyo: Shimoi Town; -); Matsui and Kumada 1928 (Aichi: vicinity of Toyohashi City: -); Nakai and Koumi 1931 (-); Matsumura 1933 (Shizuoka: canals near Yoshida Fisheries Training Station); Kasahara 1957, 1959 (-); Kasahara 1962 (Nagano: Lake Suwa; Aichi: Toyohashi City, Atsumi Town, Isshiki Town); Suzuki 1965 (-); Tsutsumi 1978 (-); Iwamatsu 1993, 1997, 2006 (-); Beatte *et al.* 2008 (Nagano: a pond in Matsumoto City); Nagasawa *et al.* 2012 (Nara: Ide, Yamato Takada City; Osaka: Tanagawa-nishibata, Misaki Town; Fukuoka: Honj, Kitakyushu City; Saga: K hoku Town)

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

Previous identification: "fish louse" of Iwamatsu, 1993, 1997, 2006

Site of infection: [body surface]

Distribution: -

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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：織毛虫類（6種），糸虫類（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織毛虫類，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



