

# A Checklist of Metazoan Parasites from Rainbow Trout (*Oncorhynchus mykiss*)

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**Buchmann, K., A. Uldal and H. Lyholt: A checklist of metazoan parasites from rainbow trout *Oncorhynchus mykiss*. Acta vet. scand. 1995, 36, 299-318.** – An extensive literature survey on metazoan parasites from rainbow trout *Oncorhynchus mykiss* has been conducted. The taxa Monogenea, Cestoda, Digenea, Nematoda, Acanthocephala, Crustacea and Hirudinea are covered. A total of 169 taxonomic entities are recorded in rainbow trout worldwide although few of these may prove synonyms in future analyses of the parasite specimens. These records include Monogenea (15), Cestoda (27), Digenea (37), Nematoda (39), Acanthocephala (23), Crustacea (17), Mollusca (6) and Hirudinea (5). The large number of parasites in this salmonid reflects its cosmopolitan distribution.

***helminths; Monogenea; Digenea; Cestoda; Acanthocephala; Nematoda; Hirudinea; Crustacea; Mollusca.***

## Introduction

The importance of the rainbow trout *Oncorhynchus mykiss* (Walbaum) in aquacultural enterprises has increased significantly during the last century. The annual total world production of this species has been estimated to 271,478 metric tonnes in 1990 exceeding that of *Salmo salar* (FAO 1991). In the year 1993 the Danish annual production of rainbow trout in freshwater culture systems reached 35,000 tonnes and in mariculture 6,600 tonnes. To optimize the Danish production a research programme on rainbow trout biology was implemented in 1993. As a part of this study parasite infections are monitored in selected farms and a literature survey on world records of metazoan parasites in rainbow trout has been conducted to establish data for comparison. The protozoan parasites from the rainbow trout was previously listed by Lom & Dy-

kova (1992) and the present paper lists the recorded metazoan parasites from this host.

In order to prevent a reference list being too extensive, priority has been given to reports compiling data for the appropriate geographical regions or early records in a particular area. Thus, a number of excellent papers on these parasites have been omitted only because the treated parasite species and their geographical distribution have already been presented by other authors in the list. Where possible, the classification of the Acanthocephala is in accordance with Amin (1985), who revised the taxonomy of fish acanthocephalans. In addition the recommendations on nematode taxonomy in Moravec (1971) and De & Moravec (1979) have been followed. Recent studies on cestode taxonomy conducted by Hanzelova & Scholz (1993) and Scholz & Hanzelova (1994) are also consid-

ered. *Oncorhynchus mykiss* is considered a synonym for *Salmo gairdneri*, *Salmo irideus* and *Salmo mykiss* in accordance with Kendall (1988) and Smith & Stearly (1989). The geographic regions are of practical rea-

sons conservative. Thus the former USSR territory is still designated USSR, the area of the former Yugoslavian republic is still called Yugoslavia and the area of the Czech and the Slovak republics are named CS.

Table 1. List of metazoan parasites from rainbow trout.

Species name	Country/region, and author (year)
<i>Monogenea</i>	
Discocotyle sagittata (Leuckart 1842, Diesing 1850)	UK (Kennedy 1974, Kennedy et al. 1991), Canada (Margolis & Arthur 1979).
Discocotyle salmonis (Schaffer 1916)	North America (Hoffman 1967).
Gyrodactylus sp.	UK (Poynton and Bennett 1985, McGuigan & Sommerville 1985), Canada (Hare & Frantsi 1974, Margolis & Arthur 1979), Germany (Rosengarten 1985), North America (Hoffman 1967, Muzzall 1993).
Gyrodactylus truttiae (Gläser 1974)	USSR (Gussev 1985), Bulgaria (Kakacheva-Avramova & Menkova 1979, 1982), Germany (Lux 1991).
Gyrodactylus derjavini (Mikailov 1975) (sensu Malmberg & Malmberg 1987)	Denmark (Malmberg 1989, 1993, Buchmann et al. 1985), Sweden (Malmberg 1973, 1989, 1993) Malmberg & Malmberg 1991), Poland (Prost 1991).
Gyrodactylus salmonis (Yin & Sproston 1948)	Canada (Cone et al. 1983, Wells & Cone 1990, Cone & Cusack 1988), USA (Cone et al. 1983).
Gyrodactylus lavareti (Malmberg 1957)	Finland, Sweden (Malmberg 1993).
Gyrodactylus gobii (Schulman 1953)	Germany (Lux 1991).
Gyrodactylus salaris (Malmberg 1957)	Sweden (Malmberg 1989, 1993, Malmberg & Malmberg 1991), Finland (Malmberg 1989, 1993), Denmark (Malmberg & Malmberg 1987, 1991, 1993, Buchmann et al. 1995), CS (Lucky 1963, Rehulka 1973), Germany (Lux 1991), Norway (Mo 1991, Bakke et al. 1991), Yugoslavia (Zitnan & Cankovic 1970), Spain (Tojo et al. 1992).
Gyrodactylus brevis (Crane et Mizelle 1967)	USA (Crane & Mizelle 1967).
Gyrodactylus colemanensis (Mizelle & Kritsky 1967)	USA (Mizelle & Kritsky 1967, Cone et al. 1983), Canada (Cone et al. 1983, Cusack 1986, Cone & Cusack 1988, Wells & Cone 1990).

Table 1 - continued

Species name	Country/region, and author (year)
<i>Gyrodactylus avalonia</i> (Hanek & Threllfall 1969)	Canada (Cone et al. 1983).
<i>Gyrodactylus bohemicus</i> (Ergens 1992)	CS (Ergens 1992).
<i>Gyrodactylus masu</i> (Ogawa 1986)	Japan (Ogawa 1986).
<i>Tetraonchus alascensis</i> (Price 1937)	USSR (Pavlovski 1964, Gussev 1985), North America (Hoffman 1967).
<i>Digenea</i>	
<i>Acrolichanus similis</i> (Wisniewski 1933)	Yugoslavia (Wisniewski 1933).
<i>Allocreadium lobatum</i> (Wallin 1909)	Canada (Margolis & Arthur 1979), North America (Hoffman 1967).
<i>Aponorus</i> sp.	North America (Hoffman 1967).
<i>Apatemon gracilis</i> (Rudolphi 1819) Szidat 1928 (metacercaria)	UK (Blair 1976, McGuigan & Sommerville 1985).
<i>Azygia lucii</i> (Müller 1776)	Yugoslavia (Zitnan & Cankovic 1970).
<i>Bolbophorus confusus</i> (Krause 1914) (metacercaria)	North America (Hoffman 1967).
<i>Bunodera luciopercae</i> (Müller 1776)	UK (McGuigan & Sommerville 1985.), Canada (Mudry & Anderson 1977, Margolis & Arthur 1979).
<i>Clinostomum</i> sp. (metacercaria)	Canada (Margolis & Arthur 1979).
<i>Clinostomum marginatum</i> (Rudolphi 1819) (metacercaria)	North America (Hoffman 1967).
<i>Crepidostomum farionis</i> (Müller 1780)	USSR (Pavlovski 1964, Pugachev 1984), Canada (Mudry & Anderson 1977, Margolis & Arthur 1979), North America (Hoffman 1967), USA (Jones & Hammond 1960, Mamer 1978, Wier et al. 1983), Yugoslavia (Wisniewski 1933), UK (Kennedy et al. 1991).
<i>Crepidostomum cooperi</i> (Hopkins 1931)	USA (Muzzall 1993), North America (Hoffman 1967).
<i>Crepidostomum metoecus</i> (Braun 1900)	UK (Kennedy et al. 1991), Yugoslavia (Zitnan & Cankovic 1970).
<i>Crepidostomum transmarinum</i> (Nicoll 1909)	North America (Hoffman 1967).
<i>Deropogus aspina</i> (McCauley et Pratt 1961)	North America (Hoffman 1967).
<i>Diplostomum</i> sp. (metacercaria)	UK (Kennedy 1974, McGuigan & Sommerville 1985, Kennedy et al. 1991), Canada (Margolis & Arthur 1979), Germany (Reimer 1985), Japan (Sato et al. 1976), USA (Mamer 1978),

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Table 1 - continued

Species name	Country/region, and author (year)
	North America (Hoffman 1967), Denmark (Buchmann & Uldal 1994), Poland (Reimer 1985).
Diplostomum spathaceum (Rudolphi 1819) (metacercaria)	UK (Rushton 1937, Betterton 1974, Kennedy 1974, Moody & Gaten 1982), Poland (Reimer 1985), Finland (Tainen 1966, Bylund & Sumari 1981), Germany (Fritzsche 1975), USA (Palmieri et al. 1976), Italy (Ghittino 1979), USSR (Shigin 1972), Sweden (Höglund 1991), North America (Hoffman 1967), Chile (Arata et al. 1977), Denmark (Rasmussen & Bregnballe 1962, Buchmann et al. 1995).
Diplostomum gasterostei (Williams 1966) (metacercaria)	UK (McGuigan & Sommerville 1985)
Diplostomum baeri bucculentum (Dubois et Rausch 1948)(metacercaria)	Canada (Lei Ching 1985).
Echinochasmus sp. (metacercaria)	USA (Uzmann & Hayduk 1964), North America (Hoffman 1967).
Ichthyocotylurus erraticus (Rudolphi 1809) Szidat 1928)(metacercaria)	UK (Wootten 1973, Betterton 1974, Kennedy 1974), Netherlands (Swennen et al. 1979).
Nanophyetus salmincola (Chapin 1926) (metacercaria)	USA (Uzmann & Hayduk 1964, Wilson & Foreyt 1985), North America (Hoffman 1967).
Neascus sp. (metacercaria)	Canada (Margolis & Arthur 1979), North America (Hoffman 1967).
Nicolla (= Coitocaecum) testiobliquum (Wisniewski 1932)	Yugoslavia (Wisniewski 1933, Zitnan & Cankovic 1970, Kasic 1978).
Nicolla (= Coitocaecum) proavitum (Wisniewski 1933)	Yugoslavia (Wisniewski 1933).
Phyllodistomum sp.	North America (Hoffman 1967).
Phyllodistomum umblae (Fabricius)	Canada (Bakke & Bailey 1987).
Phyllodistomum lachancei (Choquette 1947)	North America (Hoffman 1967).
Plagioporus angusticole (Hausmann 1896) Dobrovolny 1939	North America (Hoffman 1967).
Podocotyle shawi (MacIntosh 1939)	North America (Hoffman 1967).
Pseudechetosoma sp.	Bulgaria (Kakacheva-Avramova & Menkova 1982), Yugoslavia (Bristol et al. 1984).
Sanguinicola davisii (Wales 1958)	USA (Wales 1958, Rawstron 1971).
Sanguinicola idahoensis (Schell 1974)	USA (Schell 1974).

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Table 1 - continued

Species name	Country/region, and author (year)
<i>Sanguinicola</i> sp.	North America (Hoffman 1967).
<i>Sphaerostomum globiporum</i> (Rudolphi 1802)	Yugoslavia (Kazic 1978).
<i>Stephanostomum</i> sp. (metacercaria)	Canada (McGladdery et al. 1988).
<i>Tylodelphus podicipina</i> (Kozicka et Niewiadomska 1960)(metacercaria)	UK (Kennedy 1974).
<i>Tylodelphus clavata</i> (Nordmann 1832) (metacercaria)	UK (Betterton 1974, Kennedy 1974, Moody & Gaten 1982, McGuigan & Somerville 1985), Denmark (Buchmann et al. 1995).
<i>Cestoda</i>	
<i>Cyathocephalus truncatus</i> (Pallas 1781)	USSR (Pavlovskii 1964), Yugoslavia (Wisniewski 1933, Zitnan & Cankovic 1970), Germany (Hermanns & Körting 1986).
<i>Diphyllbothrium</i> sp. (Plerocercoid)	USSR (Konovalov 1971 cited by Pugachev 1984), Canada (Mudry & Anderson 1977, Margolis & Arthur 1979), North America (Hoffman 1967), USA (Mamer 1978, Muzzall 1993), Argentina (Conroy, 1981).
<i>Diphyllbothrium dendriticum</i> (Nitzsh 1824) (Plerocercoid)	UK (Kennedy 1974, Kennedy et al. 1991), Canada (Margolis & Arthur 1979), Norway (Halvorsen & Wissler 1973, Andersen 1979), Chile (Torres et al. 1989), Argentina (Revenga 1993).
<i>Diphyllbothrium ditremum</i> (Creplin 1825) (Plerocercoid)	Canada (Margolis & Arthur 1979), Norway (Halvorsen & Wissler 1973), UK (Kennedy et al. 1991).
<i>Diphyllbothrium latum</i> (Linnaeus 1758) (Plerocercoid)	Canada (Margolis & Arthur 1979), Argentina (Szidat & Soria 1952, Revenga 1993), Chile (Torres et al. 1989), Norway (Halvorsen & Wissler 1973).
<i>Diphyllbothrium cordiceps</i> (Leidy 1872) (Plerocercoid)	Canada (Margolis & Arthur 1979), North America (Hoffman 1967).
<i>Eubothrium crassum</i> (Bloch 1779)	Canada (Margolis & Arthur 1979), UK and Ireland (Ingham & Arme 1973, Kennedy 1974, Kennedy et al. 1991), Germany (Otto & Körting 1973, Engelhardt & Mirle 1993), Denmark (Buchmann et al. 1995).
<i>Eubothrium salvelini</i> (Schränk 1790)	USSR (Pugachev 1984), Canada (Mudry & Anderson 1977, Margolis & Arthur 1979), Germany (Otto & Körting 1973), USA (Muzzall 1989, 1993).
<i>Ichthyotaenia</i> sp. (plerocercoid)	Italy (Joyeux & Baer 1933).

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Table 1 - continued

Species name	Country/region, and author (year)
<i>Ligula intestinalis</i> (Linnaeus 1758) (plerocercoid)	New Zealand (Weekes & Penlington 1986), North America (Hoffman 1967).
<i>Paradilepis simoni</i> (Rausch 1949) (metacestode)	Canada (Lei-Ching 1982).
<i>Phyllobothrium</i> sp.	North America (Hoffman 1967).
<i>Proteocephalus</i> sp.	Canada (Margolis & Arthur 1979), Ireland (Ingham & Arme 1973), North America (Hoffman 1967, Muzzall 1993), Denmark (Buchmann et al. 1995).
<i>Proteocephalus neglectus</i> (La Rue 1911)	CS (Hanzelova & Spakulova 1992), Germany (Priemer 1980, Rosengarten 1985, Reimer 1985, Engelhardt & Mirle 1993, Engelhardt et al. 1988), Italy (Ghittino 1987), Denmark (Hanzelova & Scholz 1992).
<i>Proteocephalus parallacticus</i> (MacLulich 1943)	Ireland (Arme & Ingham 1972, Kennedy 1974).
<i>Proteocephalus percae</i> (Müller 1780)	UK (Kennedy 1974), Denmark (From & Hørlyck 1981, probably <i>P. neglectus</i> , see Hanzelova & Scholz 1992).
<i>Proteocephalus salmonidicola</i> (Alexander 1951)	Canada (Margolis & Arthur 1979), USA (Alexander 1951, Jones & Hammond 1960), North America (Hoffman 1967).
<i>Proteocephalus longicollis</i> (Zeder 1800)	Germany (Reichenbach-Klinke 1954).
<i>Proteocephalus exiguus</i> (La Rue 1911)	Germany (Priemer 1987), USSR (Konovalov 1971 cited by Pugachev 1984) (Note: according to Scholz & Hanzelova (1994) <i>P. fallax</i> is a synonym of this species).
<i>Proteocephalus tumidocollis</i> (Wagner 1953)	North America (Hoffman 1967), USA (Wagner 1953, Mamer 1978, Cox & Hendrickson 1991) (Note: according to Hanzelova & Scholz (1993) this North American species should be considered a synonym of <i>P. neglectus</i> ).
<i>Proteocephalus ambloplitis</i> (Leidy 1887) Benedict 1900) (Larva)	North America (Hoffman 1967).
<i>Proteocephalus pinguis</i> (La Rue 1911) (immature)	North America (Hoffman 1967).
<i>Schistocephalus</i> sp. (plerocercoid)	Canada (Margolis & Arthur 1979), North America (Hoffman 1967).
<i>Tetrahynchus</i> sp.	North America (Hoffman 1967).
<i>Trienophorus</i> sp. (plerocercoid)	Denmark (Rasmussen & Bregnballe 1962).
<i>Trienophorus nodulosus</i> (Pallas 1760)	USSR (Pavlovskii 1964), Romania (Georgescu et al. 1981), Germany (Engelhardt et al. 1988), Denmark (Buchmann et al. 1995).

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Table 1 - continued

Species name	Country/region, and author (year)
<i>Triaenophorus crassus</i> (Forel 1868)	Canada (Rosen & Dick 1984), USSR (Bauer & Solomatova 1984).
<i>Nematoda</i>	
<i>Anisakis</i> sp. (larva)	UK (Kennedy 1974, Wootten & Smith 1975), Denmark (Christensen & From 1978), North America (Hoffman 1967), USSR (Pugachev 1984 and Konovalov 1971 cited by Pugachev 1984).
<i>Ascarophis skrjabini</i> (Layman 1933)	USSR (Pavlovskii 1964).
<i>Camallanus lacustris</i> (Zoega 1776)	Ireland (Kane 1966, Kennedy 1974), UK (McGuigan & Sommerville 1985).
<i>Camallanus</i> sp.	Chile (Torres et al. 1991).
<i>Capillaria salvelini</i> (Polyanski 1952)	Yugoslavia (Zitnan & Cankovic 1970).
<i>Contraecum</i> sp. (larva)	Canada (Dick et al. 1987), Chile (Torres et al. 1991).
<i>Contraecum osculatum</i> (Rudolphi 1802) (larva)	Finland (Fagerholm 1982).
<i>Contraecum spiculigerum</i> (Rudolphi 1809) (larva)	North America (Hoffman 1967).
<i>Cucullanus</i> (= <i>Bulbodacnitis</i> ) <i>ampullastoma</i> (Maggenti 1971)	USA (Maggenti 1971).
<i>Cucullanus truttae</i> (Fabricius 1794) (= <i>C. globosus</i> , <i>C. occidentalis</i> , <i>Truttaedacnitis truttae</i> , <i>Dacnitis truttae</i> , <i>Bulbodacnitis globosa</i> , <i>Bulbodacnitis</i> <i>occidentalis</i> , <i>Bulbodacnitis truttae</i> )	USA (Jones & Hammond 1960), North America (Hoffman 1967), USSR (Pugachev 1984), Canada (Mudry & Anderson 1977, Margolis & Arthur 1979).
<i>Cystidicola</i> sp.	Canada (Margolis & Arthur 1979).
<i>Cystidicola cristivomeri</i> (White 1941)	Canada (Black & Lankester 1980).
<i>Cystidicola stigmatura</i> (Leidy 1886) Skinker, 1931	Canada (Mudry & Anderson 1977), North America (Hoffman 1967).
<i>Cystidicola farionis</i> (Fischer 1778)	Ireland (Kane 1966, Kennedy 1974), USSR (Pavlovskii 1964, Pugachev 1984), Canada (Margolis & Arthur 1979, Black & Lankester 1980), CS (Moravec 1971), Germany (Otto & Körting 1973), USA (Muzzall 1989, 1993).
<i>Cystidicoloides tenuissima</i> (Zeder 1800) (= <i>Sterliadachona tenuissima</i> , <i>S. pedispicula</i> , see De & Moravec 1979)	Canada (Margolis & Arthur 1979), CS (Moravec 1971, De & Moravec 1979), Bulgaria (Kakacheva-Avramova & Menkova 1979), Yugoslavia (Zitnan & Cankovic 1970, Kazic 1978, Bristol et al. 1984), USSR (Konovalov 1971 cited by Pugachev 1984),

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Table 1 - continued

Species name	Country/region, and author (year)
	Yugoslavia (Kazic 1978), USA (Maggenti 1973), Poland (Hoffman 1967).
<i>Cystidicoloides hardwoodi</i> (Chandler 1931)	North America (Hoffman 1967).
<i>Eustrongylides</i> sp. (larva)	New Zealand (Blair 1984), Canada (Margolis & Arthur 1979), North America (Hoffman 1967), USA (Kaeding 1981), Australia (Beumer et al. 1983).
<i>Eustrongylides mergorum</i> (Rudolphi 1809) (larva)	Finland (Fagerholm 1982).
<i>Goezia ascaroides</i> (Goeze 1782)	USSR (Pavlovskii 1964).
<i>Hepaticola bakeri</i> (Mueller et Van Cleave 1932)	North America (Hoffman 1967).
<i>Hysterothylacium</i> sp. (larva)	New Zealand (Blair 1984), Denmark (Christensen & From 1978).
<i>Hysterothylacium aduncum</i> (Rudolphi 1802)	Finland (Fagerholm 1982), Bulgaria (Kakacheva-Avramova & Menkova 1982), New Zealand (Blair 1984).
<i>Hysterothylacium gadi</i> (Müller 1776)	Germany (Reimer 1985).
<i>Metabronema salvelini</i> (Fujita 1922)	North America (Hoffman 1967).
<i>Philonema oncorhynchi</i> (Kuitunen-Ekbaum 1933)	USSR (Pavlovskii 1964, Pugachev 1984), Canada (Margolis & Arthur 1979), North America (Hoffman 1967).
<i>Philonema agubernaculum</i> (Simon et Simon 1936)	Canada (Margolis & Arthur 1979), North America (Hoffman 1967).
<i>Philometra</i> sp.	North America (Hoffman 1967).
<i>Pseudocapillaria salvelini</i>	UK (Kennedy et al. 1991).
<i>Raphidascaris acus</i> (Bloch 1779)	CS (Moravec 1971), Yugoslavia (Kazic 1978), Spain (Torres & Alvarez-Pellitero 1988).
<i>Rhabdochona</i> sp.	USA (Wier et al. 1983).
<i>Rhabdocona denudata</i> (Dujardin 1845)	USSR (Pavlovskii 1964), CS (Moravec 1971).
<i>Rhabdocona cascadilla</i> (Wigdor 1918)	Canada (Margolis & Arthur 1979), North America (Hoffman 1967).
<i>Rhabdocona milleri</i> (Choquette 1951)	Canada (Mudry & Anderson 1977, Margolis & Arthur 1979).
<i>Rhabdochona hellichi</i> (Sramek 1901)	Bulgaria (Kakacheva-Avramova & Menkova 1979).
<i>Rhabdochona oncorhynchi</i> (Moravec 1981)	Japan (Moravec et al. 1981).

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Table 1 - continued

Species name	Country/region, and author (year)
<i>Skrjabinocapillaria bakeri</i> (Mueller et Van Cleave 1932)	Canada (Margolis & Arthur 1979).
<i>Spinitectus</i> sp.	USA (Muzzall 1989).
<i>Spinitectus gracilis</i> (Ward et Magath 1917)	North America (Hoffman 1967).
<i>Spinitectus gordoni</i> (Cordero-del-Campillo 1976)	Spain (Cordero-Del-Campillo & Alvarez-Pellitero 1976).
<i>Acanthocephala</i>	
<i>Acanthocephalus anguillae</i> (Müller 1780)	USSR (Pavlovskii 1964), UK (Bates & Kennedy 1990).
<i>Acanthocephalus lucii</i> (Müller 1776)	UK and Ireland (Kane 1966, Kennedy 1974), Yugoslavia (Bristol et al. 1984).
<i>Acanthocephalus lucidus</i> (Van Cleave 1925)	Japan (Nagasawa & Egusa 1981).
<i>Acanthocephalus dirus</i> (Van Cleave 1931)	North America (Hoffman 1967), USA (Muzzall 1984, 1993).
<i>Acanthocephalus echigoensis</i> (Fujita 1920) (= <i>A. acerbus</i> )	North America (Hoffman 1967).
<i>Acanthocephalus opsariichthydis</i> (Yamaguti 1935)	Japan (Nakajima & Egusa 1975).
<i>Corynosoma villosum</i> (Van Cleave 1953)	USSR (Pugachev 1984).
<i>Echinorhynchus</i> sp.	Peru (Conroy 1981), USSR (Konovalov 1971 cited by Pugachev 1984).
<i>Echinorhynchus truttae</i> (Schrank 1788) (= <i>Metechinorhynchus truttae</i> )	UK and Ireland (Chubb et al. 1964, Kane 1966, Kennedy 1974), Germany (Reichenbach-Klinke 1954, Taraschewski et al. 1990), Italy (Bertocchi & Francalanci 1963, Ghittino 1979), USSR (Pavlovskii 1964), Bulgaria (Kakacheva-Avrnova & Menkova 1979, 1982), Yugoslavia (Zitnan & Cankovic 1970).
<i>Echinorhynchus cotti</i> (Yamaguti 1939)	Japan (Nagasawa & Egusa 1981).
<i>Echinorhynchus gadi</i> (Müller 1776)	Germany (Reimer 1985).
<i>Echinorhynchus salmonis</i> (Müller 1784) (= <i>Metechinorhynchus salmonis</i> )	North America (Hoffman 1967), USA (Muzzall 1989, 1993), USSR (Pavlovskii 1964, Pugachev 1984), Canada (Margolis & Arthur 1979), Yugoslavia (Zitnan & Cankovic 1970).
<i>Echinorhynchus leydyi</i> (Van Cleave 1924) (= <i>Metechinorhynchus leydyi</i> )	North America (Hoffman 1967), Canada (Margolis & Arthur 1979).
<i>Echinorhynchus lateralis</i> (Leydi 1851) (= <i>Metechinorhynchus lateralis</i> )	Canada (Margolis & Arthur 1979).

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Table 1 - continued

Species name	Country/region, and author (year)
<i>Neoechinorhynchus rutili</i> (Müller 1780)	UK and Ireland (Kane 1966, Kennedy 1974, Lassièrè & Crompton 1988, Kennedy et al. 1991), Canada (Margolis & Arthur 1979), North America (Hoffman 1967), USA (Mamer 1978), Yugoslavia (Bristol et al. 1984), Germany (Taraschewski et al. 1990).
<i>Neoechinorhynchus crassus</i> (Van Cleave 1919)	USSR (Pavlovskii 1964).
<i>Neoechinorhynchus salmonis</i> (Ching 1984)	Canada (Lei Ching 1984).
<i>Paralongicollum nemacheili</i> (Amin 1991)	USSR (Amin et al. 1991).
<i>Pomphorhynchus laevis</i> (Müller 1776)	UK (Kennedy 1974, Kennedy et al. 1978, Bates & Kennedy 1991), Israel (Paperna & Lahav 1971), Ireland (Kane 1966, Kennedy 1974), Yugoslavia (Zitnan & Cankovic 1970).
<i>Pomphorhynchus bulbocolli</i> (Van Cleave 1919)	Canada (Margolis & Arthur 1979), USA (Jones & Hammond 1960, Muzzall 1984), North America (Hoffman 1967).
<i>Pomphorhynchus patagoninus</i> (Trejo 1992)	Argentina (Trejo 1992).
<i>Pseudorhadinorhynchus samegaiensis</i> (Nakajima 1975)	Japan (Nakajima & Egusa 1975).
<i>Rhadinorhynchus</i> sp.	North America (Hoffman 1967).
<i>Crustacea</i>	
<i>Argulus foliaceus</i> (Linnaeus 1758)	UK and Ireland (Kane 1966, Kennedy 1974, Buchmann et al. 1995).
<i>Argulus pugettensis</i> (Dana 1852)	Canada (Margolis & Arthur 1979), North America (Hoffman 1967).
<i>Caligus</i> sp.	Denmark (Christensen 1980), Sweden (Lundborg & Ljungberg 1977)
<i>Caligus clemensi</i> (Parker et Margolis 1964)	Canada (Margolis & Arthur 1979).
<i>Caligus elongatus</i> (Nordmann 1832)	Canada (Margolis & Arthur 1979), Denmark (Buchmann et al. 1995).
<i>Caligus lacustris</i> (Steenstrup et Lütken 1861)	Poland (Reimer 1985).
<i>Caligus orientalis</i> (Gussev)	Japan (Urawa & Kato 1991).
<i>Ergasilus nerkae</i> (Roberts 1963)	Canada (Mudry & Anderson 1977, Margolis & Arthur 1979).
<i>Ergasilus caeruleus</i> (Wilson 1911)	North America (Hoffman 1967).
<i>Ergasilus sieboldi</i> (Nordmann 1832)	Poland (Hoffman 1967).
<i>Lepeophtheirus salmonis</i> (Krøyer 1873)	Canada (Margolis & Arthur 1979), Japan (Nagasawa & Sakamoto 1993), Denmark (Buchmann et 1995).

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Table 1 - continued

Species name	Country/region, and author (year)
<i>Lernaea cyprinacea</i> (Linnaeus 1758)	North America (Hoffman 1967).
<i>Lernaeopoda bicauliculata</i> (Wilson 1908)	North America (Hoffman 1967).
<i>Salmincola californiensis</i> (Dana 1852) Wilson 1915	Canada (Margolis & Arthur 1979), USSR (Pugachev 1984).
<i>Salmincola edwardsii</i> (Olsson 1869)	Canada (Margolis & Arthur 1979), North America (Hoffman 1967).
<i>Salmincola beani</i> (Wilson 1908)	North America (Hoffman 1967).
<i>Salmincola carpenteri</i> (Packard 1874)	North America (Hoffman 1967).
<i>Mollusca</i>	
<i>Glochidia</i> of <i>Hyridella</i> sp.	New Zealand (Blair 1984).
<i>Glochidia</i> of <i>Margaritana</i> sp.	North America (Hoffman 1967).
<i>Pisidium</i> sp.	North America (Hoffman 1967).
<i>Pisidium</i> (adult)	North America (Hoffman 1967).
<i>Glochicia</i> of <i>Unionidae</i> sp.	Canada (Margolis & Arthur 1979).
<i>Glochidia</i>	Colombia (Conroy 1981), UK (Kennedy 1974).
<i>Hirudinea</i>	
<i>Batrachobdella xenoica</i> (Ringuélet 1975)	Colombia (Ringuélet 1975).
<i>Illinobdella</i> sp.	Canada (Margolis & Arthur 1979), North America (Hoffman 1967).
<i>Piscicola milneri</i> (Verrill 1871)	Canada (Dies 1990).
<i>Piscicola geometra</i> (Linnaeus 1758)	USSR (Pavlovskii 1964), Denmark (From 1975).
<i>Piscicola salmositica</i> (Meyer 1946)	North America (Hoffman 1967).

### Discussion and conclusions

The rainbow trout is an easily maintained species in both freshwater and marine aquacultural enterprises. This fish species is readily held in ponds, fish tanks and netcage systems and the propagation of fry is a well established activity. The farming of rainbow trout has therefore expanded considerably during the latest decades and extensive stocking of free waters (natural lakes and marine areas) with fry or fingerlings of this salmonid is common practice throughout large parts of the world. The

number of metazoan parasites infecting *Onchorynchus mykiss* is huge and reflects the cosmopolitan habit of transplanting this species into new habitats and ecosystems all over the world. In addition the susceptibility of this host to various parasitic pathogens is accentuated by the checklist. Thus the present list includes a total of 169 taxonomic entities although some of these may turn out to be synonyms in thorough analyses. Thus *Hanzelova & Scholz* (1992, 1993) subjecting specimens of *Proteocephalus* from various sources

for a morphometric analysis have thrown doubt on the validity of the various species in the genus *Proteocephalus*. According to Amin (1985) who revised and analysed the acanthocephalan groups the genus *Metechinorhynchus* is now included in *Echinorhynchus* and the number of recorded acanthocephalans in the list is reduced accordingly. Likewise the work of Moravec (1971) and De & Moravec (1979) evaluating several nematode species synonymized many earlier records.

A total of 15 monogenean species have been recovered from *Oncorhynchus mykiss*. Except for 3 species these belong to the genus *Gyrodactylus*. Various aspects of this genus parasitizing salmonid hosts were treated by Malmberg (1993). It is a parasite group creating considerable problems in both cultured and feral salmonids but experimental evidence of a possible parasite pathogenicity to the host *Oncorhynchus mykiss* still lack for some species. Of special Eurasian interest is the effect of *G. salaris* and *G. derjavini* on rainbow trout. Bakke et al. (1991) demonstrated that *Oncorhynchus mykiss* is able to keep the infection with *G. salaris* at a relatively low level in contrast to the extremely susceptible Atlantic salmon. Likewise Cusack (1986) and Cone & Cusack (1989) elucidated the relative resistance of the rainbow trout to *Gyrodactylus colemanensis*. Heavy infections of the same host with *G. derjavini* need treatment in Denmark (Malmberg & Malmberg 1991, Malmberg 1993). Therefore, future controlled experiments should clarify the susceptibility of the rainbow trout to *G. derjavini*.

A wide selection of digenean trematodes (a total of 37 species) has been found in *Oncorhynchus mykiss* as adult forms or as metacercarial stages. The best investigated effects of digeneans on the fish host concern the impacts of diplostomid metacercariae on the fish intermediate host. Thus it is well known that

eyeflukes elicit parasitic cataract in rainbow trout (Rushton 1937, Sato et al. 1976, Shariff et al. 1980) and affect the growth of the fish (Buchmann & Uldal 1994). Through the removal of intermediate hosts (pulmonate freshwater snails) or elimination of final hosts (fish eating birds) it is possible to control this helminthosis. Further research on prophylactic measures should be conducted. However, if fish are infected they can be cured. Praziquantel (Droncit) was found to kill metacercariae in infected hosts (Bylund & Sumari 1981).

The pathogenicity of other digenean metacercariae in rainbow trout has indeed been elucidated. Thus, the negative parasitic impact on this fish host was reported for *Cotylurus erraticus* by Johnson (1971), for *Nanophyetus salmincola* by Butler & Millemann (1971) and for *Apatemon gracilis* by Tort et al. (1987).

Metacercariae of the genera *Clinostomum*, *Nanophyetus* and *Echinochasmus* recorded in rainbow trout are potentially infective to humans (Williams & Jones 1994). Thus ingestion of raw or undercooked fish from infected areas should be avoided.

Of the 27 species of cestodes recorded from rainbow trout many are pathogenic to this host. The weight reducing effects of *Eubothrium crassum* in salmonids were elucidated by Berland (1991). The devastating impact of *Triaenophorus* plerocercoid infections were stated by Bauer & Solomatova (1984) and by Engelhardt et al. (1988). The latter authors did also elucidate the pathogenicity of *Proteocephalus* cestodes. However, these tapeworms have complicated life cycles and management procedures (removal of intermediate copepod hosts) may reduce or eliminate infections in intensive systems. Thus, only fish from 1 of 5 trout farms in Denmark were found infected (at a low level) with cestodes. This infection was probably achieved through

ingestion of intermediate hosts (copepods) entering the farm with inlet water from a natural lake (Buchmann *et al.* 1995).

Public health aspects of cestode invasions in rainbow trout mostly concern the *Diphyllobothrium latum* plerocercoids which have been found in South America (Revenga 1993), Canada (Margolis & Arthur 1979) and Norway (Halvorsen & Wissler 1973). However, this and related species potentially infective to humans will be absent from intensive farm systems where infected copepods are eliminated.

The pyloric nematode *Cucullanus truttae* elicit damage to pyloric caeca in infected *Oncorhynchus mykiss* (Dunn *et al.* 1983). Such infections may reduce growth of this host (Hiscox & Brocksen 1973). However, human health aspects of nematode infections in fish may be of greater concern. Marine fish offals were previously used for fish feeding in freshwater trout ponds. In some cases marine nematode larvae (e.g. *Anisakis* sp.) were thereby transferred to the trout, which became infected with infective third stage nematode larvae (Wootten & Smith 1975). Humans eating raw or undercooked trout were in this way exposed to infection with anisakids with possibility of contracting anisakiasis (Smith & Wootten 1978). The use of pelleted dry feed in trout farming nowadays eliminate the risk of infecting trout with anisakids.

A number of reports have mentioned the occurrence and possible pathogenicity of the acanthocephalan *Echinorhynchus truttae* in rainbow trout culture (Reichenbach-Klinke 1954, Bertocchi & Francalanci 1963, Taraschewski *et al.* 1990). Also the rectum dwelling worm *Pomphorhynchus laevis* is known to elicit histopathological changes of the intestinal wall (Wanstall *et al.* 1986). A large number of other spiny headed worms have been found in rainbow trout. The life cycle of these acan-

thocephalans are primarily dependent on amphipods or isopods serving as intermediate hosts and the non-chemical control of these parasites should depend on elimination of these crustaceans.

The branchiuran *Argulus foliaceus* has not been recorded often in trout farms although the rainbow trout appear to be quite susceptible (Buchmann *et al.* 1995). Thus, heavily infected moribund 4 year old rainbow trouts from a natural lake on the island of Bornholm in the Baltic was examined by the author in 1992. This crustacean is a well known pathogen in other types of fish farms (Bauer *et al.* 1973). In addition, sea caged *Oncorhynchus mykiss* are often heavily infected with the parasitic copepods *Lepeophtheirus salmonis* and *Caligus elongatus*. These crustaceans are well known pathogens in salmonid culture (Wootten *et al.* 1982, Nagasawa & Sakamoto 1993).

Infestations with leeches are of great concern in both feral and cultured fish stocks due to their potential function as vectors for various pathogens. Transmission of flagellates (*Trypanosoma*, *Trypanoplasma*, *Cryptobia*) and sporozoans (*Haemogregarina*) are known hazards connected with leech feeding (Rohde 1984). An interesting non-chemical control method was mentioned by Kabata (1985). Perch (*Perca fluviatilis*) introduced into the ponds was found to predate on leeches and seemed to have some effect on the infection pressure. Such biological control methods deserve additional investigations.

The larval form of freshwater molluscs called glochidia parasitize the gills of fish. The glochidium which is a miniature bivalve attaches to a gill filament and starts feeding on the gill tissue which proliferates vigorously. Control is achieved through eradication or removal of molluscs from the ponds. In addition water inlet should be controlled for their content of larvae (Kabata 1985).

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### Sammendrag

Checkliste med flercellede snyltere fra regnbueørreden *Concorhynchus mykiss*.

En omfattende litteraturgennemgang er blevet gennemført med henblik på udarbejdelse af en liste over de i litteraturen registrerede flercellede snyltere på regnbueørreden (*Oncorhynchus mykiss*). Der anføres 169 parasitter i listen, hvoraf nogle sandsynligvis ved fremtidige analyser vil vise sig at være synonyme. Af monogener (haptororm) er fundet 15 arter, af cestoder (bændelorm) er registreret 27 arter, medens der er fundet ikke mindre end 37 arter af digener ikter, 39 nematoder (rundorme), 23 acanthocephaler (kradsere), 17 crustaceer (krebstdyrparasitter), 6 mollusker (bløddyr) samt 5 arter af igler i eller på regnbueørreden. De væsentligste arters patogenitet og betydning gennemgås kort. Desuden anvises enkelte kontrolmetoder.

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