SCI. MAR., 65 (3): 201-206 SCIENTIA MARINA 2001

Metazoan parasites of grey mullets (Teleostea: Mugilidae) from the Mistras Lagoon (Sardinia, western Mediterranean)*

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SUMMARY: A total of 127 specimens of grey mullets (Teleostea: Mugilidae) from the Mistras Lagoon (Sardinia – western Mediterranean) were examined for metazoan parasites. Five species of grey mullets were found: *Chelon labrosus*, *Liza aurata*, *L. ramada*, *L. saliens* and *Mugil cephalus*. Forty-one species of parasites were identified: 14 monogeneans, 5 crustaceans, 18 digeneans, 3 nematodes and 1 acanthocephalan; 26 of them being reported from Sardinia for the first time. Findings of faunal interest are: *Ergenstrema* sp. (Monogenea) in *L. saliens*; *Caligus pageti* (Crustacea) in *L. aurata* and *L. saliens*; *Saturnius* sp. (Digenea) in *C. labrosus*, *L. aurata* and *L. saliens*; *Capillaria* sp. (Nematoda) in *C. labrosus*, *L. aurata* and *M. cephalus*. The dynamics and distribution of ectoparasites were partially influenced by salinity, while the interpretation of the results for endoparasites was more complex. The data obtained show the richness of the parasite fauna of grey mullets from the Mistras Lagoon, providing additional environmental information on this body of water.

Key words: ectoparasites, endoparasites, Teleostea, Mugilidae, western Mediterranean, Sardinia.

INTRODUCTION

Grey mullets (family Mugilidae) are a cosmopolitan family of teleost fishes. Extensive and semi-intensive exploitation of these fishes has been practised for centuries in the Mediterranean region, south-east Asia, Taiwan, Japan and Hawaii, in lagoons and man-made ponds (Nash and Koningsberger, 1981). In the brackish waters of the western Mediterranean this family is represented by 5 species (Tortonese, 1975; Bauchot, 1987): *Chelon labrosus* (Risso, 1826), *Liza aurata* (Risso, 1810), *L. ramada* (Risso, 1826), *L. saliens* (Risso, 1810) and *Mugil cephalus* Linnaeus, 1758.

*Received November 3, 2000. Accepted January 22, 2001.

A comprehensive review of parasites of grey mullets world-wide has been published by Paperna and Overstreet (1981). Many data about the systematics of the parasites of mugilids are available in scientific papers, but works dealing with quantitative data and ecology are scarce; some research has been carried out in the United States (Rawson, 1973, 1976; Skinner, 1975), the Black Sea (Reshetnikova, 1955) and the Mediterranean (Ben Hassine, 1983; Radujkovic and Raibaut, 1989a; D'Amelio *et al.*, 1996; D'Amelio and Gerasi, 1997).

In the present paper the metazoan parasite fauna of grey mullets from the Mistras Lagoon (Sardinia, western Mediterranean) (Fig. 1) is described. The investigation was primarily concerned with parasites of the skin, gills and digestive tract. Most results of

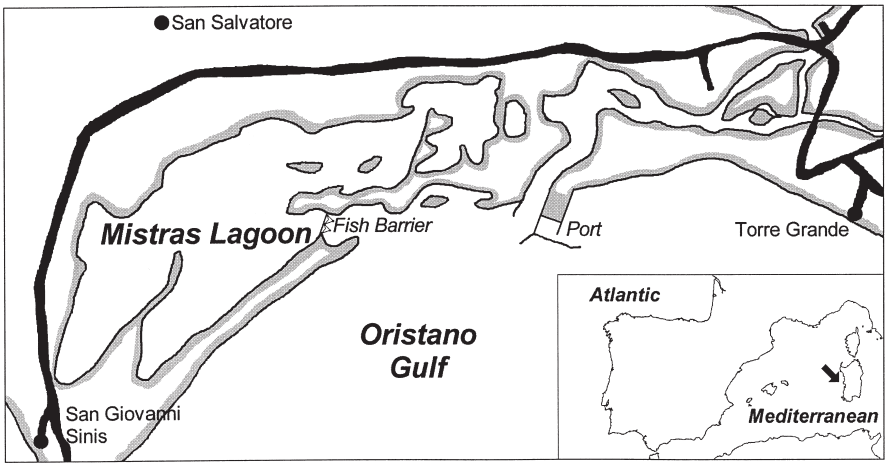

FIG. 1. – The Mistras Lagoon, site of study.

studies in the same area only report the occurrence, without providing quantitative data on infestation levels (Arru *et al*., 1988, 1995; Garippa *et al*., 1988; Sanna and Garippa, 1989; Merella and Garippa, 1998, 2000), so this research may be considered a first contribution to an understanding of the ecology of the parasites of mugilids from Sardinia.

TABLE 1. – Number and range of total length (TL) of the host species examined

Species	Number	Range of TL (cm)
Chelon labrosus	24	16-37
Liza aurata	43	21-32
Liza ramada	11	22-31
Liza saliens	38	18-30
Mugil cephalus	11	22-40

MATERIALS AND METHODS

The Mistras Lagoon (Fig. 1) is a brackish body of water of about 450 ha. The salinity is relatively high (30‰-40‰), due to the large entrance channel and to the limited inputs of fresh water; the average temperature is about 20°C, with values ranging from 10°C to 30°C.

Fishes were sampled in the fish barrier of the Mistras Lagoon, where this family is extensively exploited because of the natural recruitment of grey mullets in Mediterranean lagoons (Chauvet, 1988; Merella, 2000). Sampling was carried out in November and December 1997 and from May to August 1998; in January-April 1998 it was not possible to take samples due to lack of fish because of the low temperature. A total of 127 grey mullets belonging to the species *Chelon labrosus*, *Liza aurata*, *L. ramada*, *L. saliens* and *Mugil cephalus* were collected. The number of each species examined and the range of total length (TL) are given in Table 1.

Each fish was examined for skin parasites, then the gills and the digestive tract were extracted, stored in single bags and frozen at –20°C. Subsequently, the samples were placed in Petri dishes and examined under a stereoscope for parasites; all the specimens were counted and stored in 70% ethyl alcohol. For identification, monogeneans and digeneans were mounted in glycerine-jelly, digeneans and polyopisthocotylean monogeneans were prestained with borax carmine; crustaceans, acanthocephalans and nematodes were cleared with lactophenol and examined as temporary mounts. Illustrations of each parasite species were made with the aid of a camera lucida; drawings of specimens which could not be classified to species or genus level were given an identification code.

Among the papers consulted for the identification of parasite species were: Yamaguti (1963b), Euzet and Combes (1969), Euzet and Suriano (1977), Anderson (1981a) and Euzet and Sanfilippo (1983), for monogeneans; Yamaguti (1958), Farès and Maillard (1974), Overstreet (1977), Ramadan *et al*. (1989) and Dimitrov *et al*. (1998), for digeneans; Yamaguti (1961), Moravec (1982) and Orecchia and Paggi (1987), for nematodes; Petrotschenko (1956) and Yamaguti (1963c), for acanthocephalan; Russel (1925), Brian (1935), Yamaguti (1963a), Kabata (1979, 1992) and Ben Hassine (1983), for copepods; Trilles (1975) and Charti-Cheikhrouha *et al*. (2000), for isopods. Radujkovic and Raibaut monograph (1989a) was particularly useful for identifying almost all the parasitic groups.

TABLE 2. – Parasite-host list (Prev.=prevalence; Range Int. = range of intensity; M.Int. = mean intensity; Abund.= abundance; S.D. = standard deviation. Unidentified digeneans are listed by codes beginning with "dig")

Taxa - Species	Host	Prev.	Range Int.	M.Int.±S.D.	Abund.±S.D.
ECTOPARASITES					
Monogenea					
Ligophorus acuminatus Euzet *et* Suriano, 1977	*L. saliens*	100%	2-565	159.74±142.24	159.74±142.24
Ligophorus angustus Euzet *et* Suriano, 1977	*C. labrosus*	75%	2-114	27.89±33.14	20.92±31.04
Ligophorus chabaudi Euzet *et* Suriano, 1977	*M. cephalus*	100%	3-37	15.09±10.39	15.09±10.39
Ligophorus confusus Euzet *et* Suriano, 1977	*L. ramada*	64%	4-34	16.14±13.37	10.27±13.18
Ligophorus heteronchus Euzet *et* Suriano, 1977	*L. saliens*	97%	4-563	104.78±114.61	102.03±114.32
Ligophorus imitans Euzet *et* Suriano, 1977	*L. ramada*	91%	1-39	13.10±12.42	11.91±12.43
Ligophorus macrocolpos Euzet *et* Suriano, 1977	*L. saliens*	95%	9-223	58.25±50.15	55.18±50.53
Ligophorus minimus Euzet *et* Suriano, 1977	*L. saliens*	47%	2-67	19.67±17.91	9.32±15.70
Ligophorus szidati Euzet *et* Suriano, 1977	*L. aurata*	63%	1-197	32.37±49.70	20.33±42.19
Ligophorus vanbenedenii (Parona *et* Perugia, 1890)	*L. aurata*	98%	3-141	38.67±35.31	37.77±35.38
Ergenstrema labrosi Anderson, 1981	*C. labrosus*	21%	2-5	2.80±1.30	0.58±1.28
Ergenstrema mugilis Paperna, 1964	*L. ramada*	36%	2-4	2.75±0.96	1.00±1.48
Ergenstrema sp.	*L. saliens*	8%	4-26	13.33±11.37	1.05±4.50
Solostamenides mugilis (Vogt, 1878)	*C. labrosus*	4%	1	1.00	0.04±0.20
Crustacea					
Nipergasilus bora (Yamaguti, 1939)	*C. labrosus*	33%	2-5	2.88±1.13	0.96±1.52
"	*L. saliens*	16%	1-3	1.83±0.75	0.29±0.73
"	*M. cephalus*	27%	1-2	1.33±0.58	0.36±0.67
Caligus apodus (Brian, 1924)	*C. labrosus*	63%	1-8	2.53±2.00	1.58±2.00
"	*L. ramada*	64%	1-4	2.00±1.15	1.27±1.35
"	*L. saliens*	37%	1-6	2.29±1.44	0.84±1.41
"	*M. cephalus*	55%	1-2	1.17±0.41	0.64±0.67
Caligus mugilis Brian, 1935	*C. labrosus*	4%	1	1.00	0.04±0.2.00
Caligus pageti Russell, 1925	*L. aurata*	2%	1	1.00	0.02±0.15
"	*L. saliens*	3%	1	1.00	0.03±0.16
Nerocila orbignyi (Guérin-Méneville, 1832)	*L. aurata*	2%	1	1.00	0.02±0.15
ENDOPARASITES					
Digenea					
Dicrogaster contractus Looss, 1902	*C. labrosus*	54%	4-230	62.38±77.27	33.79±64.21
"	*L. aurata*	70%	1-1160	135.40±219.73	94.47±193.12
"	*L. ramada*	55%	2-40	11.67±14.40	6.36±11.87
"	*L. saliens*	87%	6-3208	265.12±586.55	230.24±552.99
Haploporus benedeni (Stossich, 1887)	*C. labrosus*	67%	3-737	290.81±232.76	193.88±234.40
"	*L. ramada*	36%	1-34	17.25±16.66	6.27±12.61
"	*L. saliens*	11%	1-45	16.25±19.62	1.71±7.53
Lecithobotrys putrescens Looss, 1902	*L. saliens*	34%	1-25	9.62±7.54	3.29±6.31
Saccocoelium obesum Looss, 1902	*C. labrosus*	13%	5-45	19.33±22.28	2.42±9.26
"	*L. aurata*	81%	1-47	13.31±13.28	10.84±13.05
"	*L. ramada*	9%	8	8	0.73±2.41
"	*L. saliens*	66%	1-45	7.24±9.26	4.76±8.23
Saccocoelium tensum Looss, 1902	*C. labrosus*	50%	6-152	44.33±40.02	22.17±35.76
"	*L. aurata*	72%	1-114	16.71±23.42	12.05±21.20
"	*L. ramada*	100%	4-70	19.36±20.21	19.36±20.21
"	*L. saliens*	5%	2	2.00±0.00	0.11±0.45
Haplosplanchnus pachysomus (Eysenhardt, 1829)	*L. ramada*	9%	1	1.00	0.09±0.30
"	*L. saliens*	16%	1-2	1.33±0.52	0.21±0.53
"	*M. cephalus*	82%	1-26	8.89±9.47	7.27±9.20
Schikhobalotrema sp.	*C. labrosus*	25%	4-213	111.50±86.07	27.88±63.58
"	*L. ramada*	9%	1	1.00	0.09±0.30
Saturnius papernai Overstreet, 1977	*M. cephalus*	91%	1-26	12.80±8.94	11.64±9.32
Saturnius sp.	*C. labrosus*	88%	4-310	58.52±71.12	51.21±69.20
"	*L. aurata*	42%	1-35	8.00±9.77	3.35±7.39
"	*L. ramada*	36%	1-6	4.00±2.16	1.45±2.34
"	*L. saliens*	24%	1-62	10.11±19.54	2.39±10.08
digcl1	*C. labrosus*	4%	43	43.00	1.79±8.78
digla1	*L. aurata*	12%	1-8	4.00±2.55	0.47±1.52
digls1	*L. saliens*	8%	2-40	17.33±20.03	1.37±6.64
digls2	*L. saliens*	29%	1-101	31.91±37.07	9.24±24.22
digmc1	*M. cephalus*	100%	9-2170	628.64±714.24	628.64±714.24
digmc2	*M. cephalus*	55%	1-78	22.00±30.94	12±24.71
digmc3	*M. cephalus*	45%	4-8	5.20±1.64	2.36±2.91
digmc4	*M. cephalus*	9%	8	8.00	0.73±2.41
digmc5	*M. cephalus*	9%	33	33.00	3.00±9.95
Nematoda					
Capillaria sp.	*C. labrosus*	4%	1	1.00	0.04±0.20
"	*L. aurata*	2%	1	1.00	0.02±0.15
"	*M. cephalus*	27%	1-3	2.00±1.00	0.55±1.04
Contracaecum sp.	*L. aurata*	9%	1-2	1.25±0.50	0.12±0.39
Cucullanus bioccai Orecchia *et* Paggi, 1987	*M. cephalus*	55%	1-4	1.67±1.21	0.91±1.22
Acanthocephala					
Neoechinorhynchus agilis (Rudolphi, 1819)	*C. labrosus*	54%	1-35	10.85±11.96	5.88±10.25
"	*L. aurata*	16%	1-6	3.00±2.16	0.49±1.39
"	*L. ramada*	18%	1	1.00±0.00	0.18±0.40
"	*L. saliens*	32%	1-5	2.92±1.56	0.92±1.62
"	*M. cephalus*	91%	1-25	5.60±7.52	5.09±7.33

The infection level of each parasite species was analysed by calculating prevalence, range of intensity, mean intensity and abundance (Margolis *et al*., 1982).

RESULTS

Parasites were found in 100% of the specimens examined. Table 2 summarises the parasite-host list with indications of prevalence, range of intensity, mean intensity (±standard deviation) and abundance (±standard deviation). A total of 41 species were identified: 19 ectoparasites and 22 endoparasites. All these specimens were adult stages, except some copepods of the genus *Caligus* and the nematodes belonging to the genus *Contracaecum*.

Among the ectoparasites, the genus *Ligophorus* was the most frequent and abundant, with prevalence ranging from 47% to 100% and intensity up to 565. Other ancyrocephalids, *Ergenstrema* spp. were fairly common, but not very abundant. *Caligus apodus* and *Nipergasilus bora* were the most prevalent crustaceans. Of the endoparasites, adult digeneans were most represented, and within this taxon haploporids were the most frequent and abundant family. In addition, other families, such as haplosplanchnids and hemiurids, were frequently found and abundant. Within the digeneans, nine taxa could not be classified to species or genus level because their morphometric characteristics did not seem to coincide with those of other existing species, and they are reported in Table 2 with an identification code (digcl1, digla1, digls1. digls2, digmc1, digmc2, digmc3, digmc4, digmc5). The nematodes *Capillaria* sp. and *Cucullanus bioccai* were well represented in *Mugil cephalus* and, among the acanthocephalans, *Neoechinorhynchus agilis* had relatively high prevalence in all 5 host species.

DISCUSSION

The results provided new data about the parasites of mugilids. Of the 41 species found, 26 are new records for Sardinia: 14 monogeneans (*Ligophorus* spp., *Ergenstrema* spp. and *Solostamenides mugilis*), 4 crustaceans (*Nipergasilus bora*, *Caligus mugilis*, *C. pageti* and *Nerocila orbignyi*), 4 digeneans (*Lecithobotrys putrescens*, *Saccocoelium tensum*, *Saturnius papernai*, *Saturnius* sp.), 3 nematodes (*Capillaria* sp., *Contracaecum* sp. and *Cucullanus bioccai*) and 1 acanthocephalan (*Neoechinorhynchus agilis*). In addition, 9 taxa of digeneans were not identified. All these species must be added to the others formerly recorded in the island (Arru *et al*., 1988, 1995; Garippa *et al*., 1988; Sanna and Garippa, 1989), 3 of which were not found in this study: *Metamicrocotyla cephalus* (Azim, 1939), *Ergasilus lizae* Krøyer, 1863 and *Floridosentis* sp.

Records of faunal interest, possibly findings of new species or new hosts, or else first reports of a parasite species for Italian marine fauna, are: *Ergenstrema* sp. in *Liza saliens*; *C. pageti* in *Liza aurata* and *L. saliens*; *Saturnius* sp. in *Chelon labrosus*, *L. aurata* and *L. saliens*; *Capillaria* sp. in *C. labrosus*, *L. aurata* and *Mugil cephalus*.

Parasites of the genus *Ergenstrema* have never been recorded in *L. saliens*. The morphometric characteristics of the specimens found do not match those of the congeners parasitising *C. labrosus* and in *Liza ramada*, particularly in the length and coiling of the vagina (Anderson, 1981a; Radujkovic and Euzet, 1989), and they probably represent a new species.

C. pageti is a new record for Italian marine fauna. This species has been found in Algeria, Tunisia and France (Ben Hassine, 1983). Brian (1935), after examining numerous mugilids from Italy, affirmed that *C. pageti* was present only in the eastern and southern Mediterranean.

Species of the genus *Saturnius* were formerly recorded only in *M. cephalus* (Overstreet, 1977; Dimitrov *et al*., 1998) and *L. ramada* (D'Amelio *et al*., 1996; Dimitrov *et al*., 1998). Overstreet (1977), who found *Saturnius* species only in *M. cephalus*, concluded that if new hosts for this genus exist, the species would have to be a new *Saturnius* one, due to the specialisation of this genus.

This is the first record of adult stages of capillariids in the digestive tract of mugilids from the Mediterranean; formerly, only Rawson (1973) and Moravec *et al*. (1999) found nematodes of this family in mugilids from Georgia and Mexico respectively, apart from the larval stages recorded in the Philippines (Paperna and Overstreet, 1981). Because of problems with identification of the fragmented specimens, and the unsatisfactory status of the taxonomy of capillariids (Moravec, 1982; Moravec *et al*., 1999), the individuals belonging to this family were generically assigned to the genus *Capillaria*.

The prevalence values of *Ligophorus* spp. were higher than those obtained in the Boka Kotorska Bay (Montenegro) from the same hosts, ranging from 28% to 83% (Radujkovic and Euzet, 1989) vs. 47%-100% (Table 2); while the prevalence values of

Ergenstrema spp. were lower, ranging 21% to 36% (Table 2) vs. 46% to 57% (Radujkovic and Euzet, 1989). These differences could be explained by the salinity of the lagoon, higher in the site of the study (30‰-40‰) than in the Boka Kotorska Bay, ranging from 1‰ to 37‰ (Stjepcevic, 1974). This may be a limiting factor for *Ergenstrema* and favour the *Ligophorus* species (Anderson, 1981b).

Prevalences of *N. bora* were similar to those obtained in the Boka Kotorska Bay by Radujkovic and Raibaut (1989b), while *C. apodus* showed higher prevalence values than those found by the same authors: 2%-3% vs. 37%-64% (Table 2), confirming the preference of this species for the brackish environments (Ben Hassine, 1983).

The only skin ectoparasite found was 1 specimen of *N. orbignyi*. The rarity of this species in the Mistras Lagoon is probably due to the high salinity. In the adjacent Cabras Lagoon, characterised by oligohaline waters, the prevalence and intensity of *N. orbignyi* is much higher (P. Merella, unpublished data).

Prevalence and mean intensity of digeneans were mostly higher than those reported from the Boka Kotorska Bay by Radujkovic *et al*. (1989). These values were also higher for *Contracaecum* sp. in *L. aurata* compared to the results of Rawson (1973) and Petter and Radujkovic (1989); while the prevalence of *Capillaria* sp. in *M. cephalus* was close to that reported by Rawson (1973).

The prevalence values of *N. agilis* were elevated in all 5 species of hosts, and higher than those indicated for other Mediterranean regions by Radujkovic (1989) and D'Amelio *et al*. (1996): 1%-30% vs. 16%-91% (Table 2).

Although fish were sampled during 6 months of the year, their number in each monthly sample was too low for any conclusions as to their possible seasonal patterns. However, ectoparasite distributions were partially influenced by salinity, while the interpretation of the results regarding endoparasites was more complex, because of numerous biotic and abiotic factors (Rawson, 1973).

Concerning the gill parasites of *C. labrosus*, it was observed that the prevalence of *L. angustus* was higher in July-August, when the salinity was about 40‰, while *E. labrosi* peaked in June, when salinity fell to about 30‰, supporting the hypothesis of Anderson (1981b) that *L. angustus* prefers higher salinities compared to *E. labrosi*. Analogously, *C. pageti* was found on *L. aurata* and *L. saliens* only in November, when salinity was about 40‰, confirming the preference of this species for hyperhaline waters (Ben Hassine, 1983). One single specimen of *N. orbignyi* appeared in June, when salinity was about 30‰, while, as mentioned above, in the adjacent Cabras Lagoon, characterised by oligohaline waters, the prevalence and intensity of this species was notably higher all the year round (P. Merella, unpublished data).

The results obtained show the richness of the parasite fauna of grey mullets from the Mistras Lagoon; and although the parasites of fish cannot at present be considered as reliable bioindicators, they provide useful additional environmental information on the body of water studied (D'Amelio and Gerasi, 1997; Kennedy, 1997; Overstreet, 1997).

The numerous new records for the mugilid parasite fauna, the possible finding of new parasite species and the difficulties encountered in the identification of some species, particularly digeneans, point to the need for further investigations, to extend knowledge of the biology and ecology of metazoan parasites of grey mullets.

ACKNOWLEDGEMENTS

We are grateful to: Prof. Lia Paggi and her research staff (Istituto di Parassitologia, Università degli studi di Roma "La Sapienza") for their useful suggestions; Dr. Fulvio Salati and his working group (Istituto Zooprofilattico Sperimentale della Sardegna "G. Pegreffi") for their collaboration; and Dr. Tomáš Scholz (Institute of Parasitology ASCR - Ceske Budejovice) for his helpfulness and the critical reading of the paper. Particular thanks are due to Mr. Salvatore Manca and all the fisherman of the Mistras Lagoon for their courtesy and help during the sampling. Mrs. Vera Walker revised the English version of the manuscript. This research was funded by MURST (60%).

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Scient. ed.: P. Oliver