Biodiversity Journal, 2016, 7 (2): 233–240

First records of digenean trematodes of two fishes (Teleostei Sparidae) from the West Algerian coast and comparative study with Tunisian coast (Mediterranean Sea)

Amel Bellal*, Naouel Amel Brahim Tazi, Zakia Hadjou & Zitouni Boutiba

Laboratoire Réseau de Surveillance Environnementale (LRSE), Département de Biologie, Faculté des Sciences de la nature et de la vie, Université d'Oran1 - Ahmed Ben Bella, Algérie; e-mail: bellalamel@yahoo.fr
*Corresponding author

ABSTRACT Two species of the Teleostean *Diplodus* Rafinesque, 1810 Sparidae fish, *Diplodus sargus* (Linnaeus, 1758) (n = 134) and *D. annularis* (Linnaeus, 1758) (n = 60), from the Algerian west coast were examined with regards to Digenea parasites occurrence between March 2013 and December 2014. This investigation led to inventory 12 species of Digenea (*Lepidauchen stenostoma*, *Arnola microcirrus*, *Magnibursatus bartolii*, *Proctoeces maculatus*, *Holorchis pycnoporus*, *Lepocreadium album*, *Wardula sarguicola*, *Monorchis* sp., *Macvicaria crassigula*, *Pseudopycnadena fischtali*, *Diphterostomum brusinae* and *Zoogonus rubellus*). These species are reported in the selected locality situated in Oran bay for the first time. Furthermore, *Lepidauchen stenostoma* in *D. annularis* is reported for the first time in the western Mediterranean. The majority of the recorded digeneans colonize one or two parts of the host digestive tract, the intestine being the most parasitized site. The calculation of epidemiologic indices provides information on the occurrence of digeneans identified in these two hosts. The diversity of Digenea is compared with that of the Gulf of Tunis, the Bizerte lagoon and another locality in the western Mediterranean. The Algerian west coast shows the highest value in the species richness of digeneans as compared to that of all the Mediterranean coasts.

KEY WORDS Digenea; *Diplodus*; Diversity; Epidemiologic indices; Oran bay.

Received 22.04.2016; accepted 11.06.2016; printed 30.06.2016

INTRODUCTION

The Sparidae form the most representative fishing family in Algeria. This is one of the largest currently recognized families that the perciforms order counts (Tortonese, 1973). Their importance is related to their specific richness and high commercial value (Fischer et al., 1987). Indeed, during these last decades the digenean parasites of the Sparidae family from the northern shores of the Mediterranean sea have been the subject of numerous studies (Bartoli, 1987a, 1987b; Bartoli & Gibson, 1989; Bartoli & Bray, 1996; Bartoli et al., 1989a, 1989b; 2005; Sasal et al., 1999; Ternengo et al., 2005a; Pérez -del Olmo et al., 2006, 2007a, 2008; Kostadinova & Gibson, 2009; Sanchez et al., 2013, 2014). Whereas, on the southern Mediterranean, little work has been done (Gargouri & Maamouri, 2008; Gargouri et al., 2011; Derbel et al., 2012; Bayoumy & Abu-Taweel, 2012; Antar & Gargouri, 2013; Antar et al., 2015). In particular, along the Algerian coasts the digenean fauna of sparid fishes is poorly known (Merzoug et al., 2012 and Abid Kachour et al., 2013) and no study has been carried out on the genus *Diplodus* Rafinesque, 1810. The purpose of this work is to establish a database of these Trematodes as collected in these fishes from the Oran bay (north western Algeria). Among the Sparidae family representatives, the *Diplodus sargus* (Linnaeus, 1758) and *D. annularis* (Linnaeus, 1758) species were selected for this study. The results obtained are compared with those of the Gulf of Tunis and the Bizerte lagoon. The species richness is appraised with respect to that of the Scandola nature reserve (Corsica) in the northern Mediterranean.

MATERIAL AND METHODS

From March 2013 to December 2014, a total of 194 sparid fishes of *D. sargus* and *D. annularis* were caught in the Oran bay. The fish nomenclature is taken from Fischer et al. (1987). The investigated sample of *D. sargus* comprised 134 individuals while that of *D. annularis* was constituted of 60 individuals. The trematodes were collected from fresh fish, fixed by being pipetted into nearly boiling saline, stained with iron acetocarmine, dehydrated through a graded alcohol series, cleared in dimethyl phthalate and finally examined as permanent mounts in Canada balsam. The population descriptors, namely, prevalence, mean intensity and abundance were calculated as described by Buch et al. (1997).

RESULTS

A total of 12 digenean species belonging to 8 distinct families were found in the two sparid fishes studied. As seen on the Table 1 where the main results are assembled, they are: Acanthocolpidae Luhe, 1906; Derogenidae Nicoll, 1910; Fellodistomidae Nicoll, 1909; Lepocreadiidae Odhner, 1905; Mesometridae Poche, 1926; Monorchiidae Odhner, 1911; Opecoelidae Ozaki, 1925 and Zoogonidae Odhner, 1902. Most recorded digeneans colonize one or two parts of the host digestive tract. It should be noted that *Lepidauchen stenostoma* Nicoll, 1913, *Holorchis pycnoporus* Stossich, 1901 and *Diphterostomum brusinae* Stossich, 1889, seem to show clear ecological preferences and limit their distribution to only one niche, in this case the intestine. Moreover, all parasites in both hosts revealed that the majority of the parasitic species occupies the intestine. Hosting 12 trematodes, *D. sargus* has the most diverse fauna whereas only 8 species were found in *D. annularis*. The distribution of the parasitic indices of the different digenean species vary from one host species to another. The most striking gap is observed for the prevalence of *Arnola microcirrus* (Vlasenko, 1931) between that in *D. sargus* and that in *D. annularis*, being equal respectively to 18.65% and 1.33%. Very similar cases are registered for *Lepocreadium album* Stossich, 1904 and *Zoogonus rubellus* Looss, 1901.

The calculation of epidemiologic indices shows that the highest rates of infestation are found for *Macvicaria crassigula* (Linton, 1910) in *D. sargus* and for the species *Monorchis* sp. in *D. annularis* at the level of 33.58% and 40%, respectively. *Lepidauchen stenostoma*, *Proctoeces maculatus* (Looss, 1901), *Wardula sarguicola* Bartoli et Gibson, 1989 and *Pseudopycnadena fischtali* Saad-Fares et Maillard, 1986 in *D. sargus* and *Arnola microcirrus* in *D. annularis* infest less than 5% of the population of their respective hosts. The other species recorded a prevalence ranging from 5 to 36.66%. The highest mean intensity of infestation exceeds 5 parasites per fish for *D. annularis* by *Diphterostomum brusinae* and abundance value is recorded by *Diphterostomum brusinae* (1.93) in *D. annularis*.

DISCUSSION

As already mentioned, this investigation showed that the *Lepidauchen stenostoma*, *Diphterostomum brusinae* and *Holorchis pycnoporus* collected within the digestive systems of *D. sargus* and *D. annularis* are limited to the intestine. Various authors have discussed the factors that can influence the processes that lead to niche restriction in helminthes species and have proposed hypotheses regarding the adaptive value of this restriction.

		Present Work				Gulf of Tunis - Gargouri & Maamouri (2008)				Bizerte Lagoon - Antar & Gargouri (2013)			
Species	**Families**	**Site**	**P(%)**	**A**	**MI**	**Site**	**P(%)**	**A**	**MI**	**Site**	**P(%)**	**A**	**MI**
Diplodus sargus n= 134													
Lepidauchen stenostoma	Acanthocolpidae	E	1.49	0.01	1								
Arnola microcirrus	Derogenidae	BC	18.65	0.25	1.36	B	1.42	0.01	1				
Magnibursatus bartolii	Derogenidae	AI	14.92	0.34	2.3								
Proctoeces maculatus	Fellodistomidae	E	2.98	0.02	1	GH	8.57	0.19	2.17	GH	15.8	0.10.	1.0
Holorchis pycnoporus	Lepocreadiidae	E	11.19	0.20	1.86	DF	7.14	0.11	1.6				
Lepocreadium album	Lepocreadiidae	CE	20.14	0.56	2.81	D	2.86	0.06	2				
Lepocreadium pegorchis	Lepocreadiidae									CD	10.5	0.10	1.5
Wardula sarguicola	Mesometridae	B	2.23	0.02	1	H	4.29	0.07	1.66				
Monorchis parvus	Monorchiidae					C	1.43	0.04	3				
Monorchis sp.	Monorchiidae	CE	13.43	0.53	4								
Macvicaria crassigula	Opecoelidae	CE	33.58	0.58	1.73	DF	18.57	0.34	1.87	F	5.3	0.05	1.O
Peracreadium characis	Opecoelidae					DF	1.43	0.17	12				
Pseudopycnadena fischtali	Opecoelidae	E	1.49	0.02	2	F	4.29	0.04	1				
Diphterostomum brusinae	Zoogonidae	E	17.91	0.59	3.33	H	12.86	0.50	3.89	G	5.3	0.10	3.0
Zoogonus rubellus	Zoogonidae	E	5.97	0.08	1.37	H	7.14	0.11	1.6				
Diplodus annularis n= 60													
Lepidauchen stenostoma	Acanthocolpidae	E	5	0.05	1								
Arnola microcirrus	Derogenidae	B	1.33	0.16	1.25					B	0.8	0.01	1.0
Steringotrema pagelli	Fellodistomidae									D	0.8	0.01	1.0
Lecithocladium excisum	Hemiuridae					B	2.94	0.04	1.5				
Holorchis pycnoporus	Lepocreadiidae	E	15	0.25	1.66					DG	3.8	0.08	2.2
Lepocreadium album	Lepocreadiidae	E	5	0.06	1.33	DF	2.94	0.07	2.5	ACG	11.5	0.40	3.8
Lepocreadium pegorchis	Lepocreadiidae					C	4.41	0.10	2.33	CD	2.3	0.03	1.7
Prodistomum polonii	Lepocreadiidae									G	0.8	0.02	3.0
Monorchis parvus	Monorchiidae					CD	44.12	4.11	9.63	CD	8.5	0.30	3.9
Monorchis sp.	Monorchiidae	CE	40	1.81	4.54								
Macvicaria crassigula	Opecoelidae	CE	21.66	0.38	1.76	DF	10.29	0.19	1.85	DFG	13.1	0.4	3.3
Pseudopycnadena fischtali	Opecoelidae					F	2.94	0.07	2.5				
Diphterostomum brusinae	Zoogonidae	E	36.66	1.93	5.27	H	16.17	0.51	3.18	DGH	14.6	0.50	3.5
Zoogonus rubellus	Zoogonidae	EH	11.66	0.11	1	H	1.47	0.01	1	H	0.8	0.01	2.0

Table 1. Epidemiologic parameters: prevalence (P), abundance (A) and mean intensity (MI) of Digenea in sparid fishes from the Oran bay and Gulf of Tunis (Gargouri & Maamouri, 2008) and from the Bizerte Lagoon (Antar & Gargouri 2013) for the esophagus (A), stomach (B), pyloric caeca (C), duodenum (D), intestine (E), mid-intestine (F), posterior intestine (G), rectum (H) and Gills (I) sites.

According to Holmes (1990), apart from the physicochemical gradient in the intestine, factors as specialization, reproductive efficiency, competition and host immune mechanisms influence the selection site. The study of Ricklefs & Schluter (1993) suggested that the fact that some parasites are limited to a single microbiotope generates the presence of a physical or chemical barrier that prevents other digeneans to cross it. Indeed, a key factor in niche restriction processes is intra- and inter-specific competition (Holmes, 1990; Sukhdeo & Sukhdeo, 1994; Dezfuli et al., 2002). Rohde (1994) reported that competition, probability of finding mates, reinforcement of reproductive barriers and adaptation to environmental complexity are selective pressures causing niche restriction. On the other hand, the data shown on the Table indicate that the stomach is among the sites that are very little parasitized. This is explained by the inhospitality of the physical and chemical conditions in the stomach towards the parasites (Crompton, 1973). It could also be invoked that this absence of parasites at this site results from the lack of niche saturation (Stock & Holmes, 1988).

The distribution of parasitic species shows that *Lepocreadium album* does not occupy the same microbiotope in the two host species. Indeed, this parasite colonizes the intestine and pyloric caeca in *D. sargus* whereas it is limited to intestine in *D. annularis*. This fact is probably related to the digestive tube polymorphism of the hosts and their differential resistance to parasites (Crompton, 1973). The same situation is observed for the species *Arnola microcirrus* and *Zoogonus rubellus*.

It is also noted that the intestine is the most parasitized site by *Lepidauchen stenostoma*, *Holorchis pycnoporus*, *Lepocreadium album*, *Proctoeces maculatus*, *Monorchis* sp., *Macvicaria crassigula* and *Pseudopycnadena fischtali*. In fact, the intestine is the nutrient-richest site and seems to influence the parasite specificity towards the host. Holmes (1990) also stated that the use of nutrients by parasites is an important factor which regulates competition among the intestine parasites. According to Sasal et al. (1999) each parasite species which shows this tolerance is generalist.

The distributions of digeneans parasitic indices in both hosts show inequality towards parasitism. Indeed, important differences appear with regards to the prevalence of some parasites: *Arnola microcirrus* (18.65–1.33%), *Lepocreadium album* (20.14–5%) and *Zoogonus rubellus* (5.97–11.66%). However, these epidemiological values are generally higher in the Sparidae from the Oran bay than those from the Gulf of Tunis (Gargouri Ben Abdallah & Maamouri, 2008) and Bizerte lagoon (Antar & Gargouri Ben Abdallah, 2013) (Table 1). The causes of these variations according to Combes (1995) and Khan (2012) are numerous and may be related to the genetics, life environment, energy consumption, age of the host, potential host proximity, presence of other parasites, biogeography, environmental changes, host ethology and immune system. Ternengo et al. (2005b) suggested that each fish species has a characteristic parasitac fauna and particular levels of infestation. Some parasites recorded in the Oran bay in *D. sargus* (*Lepidauchen stenostoma*, *Magnibursatus bartolii* Kostadinova, Power, Fernandez, Balbuena, Raga et Gibson, 2003 and *Monorchis* sp.) and *D. annularis* (*Lepidauchen stenostoma*, *Arnola microcirrus*, *Holorchis pycnoporus* and *Monorchis* sp.) were not collected in either one of these two fishes in the Gulf of Tunis (Gargouri Ben Abdallah & Maamouri, 2008) (Table 1). However, *Lepidauchen stenostoma* was described as a parasite of *D. annularis* in the Adriatic Sea off the coast of Montenegro (Bray & Bartoli, 1996) and reported in *D. sargus* from Scandola nature reserve (Corsica) by Bartoli et al. (2005). Hence, we report it for the first time in the western Mediterranean in *D. annularis*. Similarly, *Magnibursatus bartolii* was encountered in another sparid species, *Boobs boobs* (Linnaeus, 1758), from the North-east Atlantic coast, Spain (Kostadinova et al., 2003), in *Oblada melanura* (Linnaeus, 1758) (Gargouri Ben Abdallah & Maamouri, 2008) in the Gulf of Tunis, in *Sparus aurata* Linnaeus, 1758 from the Bizerte Lagoon (Gargouri Ben Abdallah et al., 2011) and in *D. sargus* off the coast of Buriana, Spain (Kostadinova & Gibson, 2009). *Arnola microcirrus* was described as a parasite of *D. annularis* in the Black Sea (Gaevskaya & Korniychuk, 2003) and reported in Corsica (Kostadinova et al., 2004). *Holorchis pycnoporus* was recorded in many different regions of the Mediterranean (Bray & Cribb, 1997). By contrast, some parasite species as *Peracreadium characis* Bartoli, Gibson et Bray, 1989, *Lecithocladium excisum* (Rudolphi, 1819) Lühe, 1901, *Lepocreadium pegorchis* (Stossich, 1901), *Monorchis parvus* Looss, 1902 and *Pseudopycnadena fischtali* that were found in the Gulf of Tunis were not collected during this research in the Oran bay. Several factors may influence the parasite community. One is probably related to the low frequency of intermediate hosts in the biotope due to a harmful effect of pollution on them and parasite free stages. Others are linked to environmental parameters (MacKenzie 1999, Khan 2012), the geographical distance (Pérez- Del Olmo, 2008) and the sampling site (Ternengo et al., 2009). Pérez- Del Olmo (2007) demonstrated that significant changes were noted in the structure of parasite communities in *Boops boops* after the Prestige oil spill in 2002. However, it should be noted that *Lecithocladium excisum* and *Lepocreadium pegorchis* were reported respectively in *Boops boops* (Merzoug et al., 2012) and in *Pagellus erythrinus* Linnaeus, 1758 from the in Oran bay (Abid Kachour, 2014).

Our results compared to those from the Bizerte Lagoon (Antar et al., 2013) show variations with respect to the diversity of the digenean (Table 1). Indeed, in *D. sargus*, nine species of Trematodes (*Lepidauchen stenostoma*, *Arnola microcirrus*, *Magnibursatus bartolii*, *Holorchis pycnoporus*, *Lepocreadium album*, *Wardula sarguicola*, *Monorchis* sp., *Pseudopycnadena fischtali* and *Zoogonus rubellus*) are recorded only in the present study, although their absence of representation in the Bizerte lagoon could be explained by the small number of hosts studied (n = 19). It should be noted that *Lepocreadium album* was found for the first time in the Oran bay in *Boobs boobs* (Merzoug et al., 2012). Furthermore, *Lepidauchen stenostoma* and *Monorchis* sp. are observed only among *D. annularis* from the Oran bay. On the other hand, *Steringotrema pagelli* (Van Beneden, 1871) Odhner, 1911, *Lepocreadium pegorchis*, *Prodistomum polonii* Bray et Gibson, 1990 and *Monorchis parvus* are recorded in the Bizerte lagoon but absent in the Oran bay. And more recently, Antar et al. (2015) revealed the presence of *Macvicaria bartolii* Antar, Gorgieva, Gargouri Ben Abdallah et Kostadinova, 2015 in *D. annularis* from the Bay of Bizerte whereas this parasite was not collected in this investigation. This fact might be connected with the successful completion of life cycles of these parasites in the Bizerte Lagoon, a confined environment limiting the dispersal of the larval stages. Indeed, Maillard (1976) showed that a digenean which completes its life cycle in the ponds and the lagoons has a higher chance of completion than that having a marine life cycle.

As compared to the data of digenean species in the sparid fishes from Scandola nature reserve (Corsica) in the western Mediterranean (Bartoli et al., 2005), our results show a significant richness in *D. sargus* and *D. annularis* from the Oran bay. Altogether, seven species of digenean parasites were not mentioned in Corsica: *Lepidauchen stenostoma*, *Arnola microcirrus*, *Holorchis pycnoporus*, *Lepocreadium album*, *Monorchis* sp., *Zoogonus rubellus* and *Magnibursatus bartolii*. In the Oran bay, the first six ones were found in *D. sargus* and the last three in *D. annularis*. Similarly, in the Tunisian coast as well as the Bizerte Lagoon, *Lepidauchen stenostoma*, *Magnibursatus bartolii*, and *Monorchis* sp. were not reported in *D. sargus*, whereas *Lepidauchen stenostoma* and *Monorchis* sp. were not found in *D. annularis* (Table 1).

The causes of this species diversity may be related to the passage of the Atlantic waters. Indeed, the Oran bay is undoubtedly under the influence of these Atlantic currents through the Straits of Gibraltar which can periodically convey nutrients (fish, invertebrates, etc ...) between the Mediterranean and the Atlantic. This mixing process increases the probability of intermediate hosts transfer. Consequently, the life cycle of various taxa may explain this parasite biodiversity in the two investigated hosts in the Western Algerian coast. The wider digenean diversity observed in the Scandola Nature reserve is probably related to the equilibrium stability of the ecosystem that is devoid of major pollutants and opens directly to the Western Mediterranean basin (Bartoli et al., 2005). Thus, the Digenea diversity is related to the high general level of biodiversity reported in that region (Miniconi et al., 1990; Verlaque, 1990; Merella, 1991; Verlaque et al., 1999). On the other hand, Gargouri Ben Abdallah & Maamouri (2008) suggested that the relatively important digenean diversity of sparidae off the Tunisian coasts is related to the geographical situation of Tunisia. The latter, representing also a transition zone between the Western and Eastern Mediterranean, undergoes the influence of both the Atlantic through the Straits of Gibraltar and the Red Sea via the Suez Canal. Furthermore, Thieltges et al. (2008) mentioned that the origin of this differential distribution of digenean frequencies between the different Mediterranean environments may be related to the frequency of the intermediate hosts and the variation in physical and chemical parameters of the biotope that can influence the host as well as the free-living larval stages of parasites.

Finally, in this study, all the parasites exposed in Table 1 are recorded for the first time in *D. sargus* and *D. annularis* from the Oran bay although they were already described in the same hosts in other regions of western Mediterranean (Bartoli et al., 1989a; Bartoli et al., 1989b; Bartoli & Gibson, 1989; Bartoli & Bray, 1996; Bray & Bartoli, 1996; Lepommel et al., 1997; Jousson et al., 1998; Jousson et al., 1999; Sasal et al., 1999; Jousson et al., 2000; Kostadinova et al., 2004; Bartoli et al., 2005; Ternengo et al., 2005a; D'Amico et al., 2006; Gargouri Ben Abdallah & Maamouri, 2008; Kostadinova & Gibson, 2009; Derbel et al., 2012; Antar & Gargouri, 2013).

REFERENCES

Abid-Kachour S., Mouffok S. & Boutiba Z., 2013. Description of a New Species of *Sphincteristomum* from Sparid Fishes of the Algerian Coast (Western Mediterranean). Journal of Environmental Protection, 4, 1129–1136.

Abid-Kachour S., 2014. Contribution à l'étude des parasites Digènes chez trios Poissons téléostéens Merlu (*Merluccius merluccius*); Pageot (*Pagellus erythrinus*) et Chinchard (*Trachurus trachurus*) de la côte oranaise. These. Doc, Univ Oran1 - Ahmed Ben Bella, Oran, Algeria.

Antar R., Georgieva S., Gargouri L. & Kostadinova A., 2015. Molecular evidence for the existence of species complexes within *Macvicaria* Gibson & Bray, 1982 (Digenea: Opecoelidae) in the western Mediterranean, with descriptions of two new species. Systematic Parasitology, 91: 211–29.

Antar R. & Gargouri Ben Abdallah L., 2013. Trematodes in fishes of the genus *Diplodus* (Teleostei, Sparidae) from Bizerte Lagoon (Northern coast of Tunisia). European association of Fish Pathologists, 33: 44–52.

Bartoli P., 1987a. Les Trématodes digénétiques parasites des poissons Sparidés de la Reserve Naturelle de Scandola. Travaux Scientifiques du Parc Naturel Régional et des Réserves Naturelles de Corse, 10: 1–158.

Bartoli P., 1987b. Caractères adaptatifs originaux des Digènes intestinaux de *Sarpa salpa* (Teleostei, Sparidae) et leur interprétation en termes d'évolution. Annales de Parasitologie Humaine et Comparée, 62: 542–576.

Bartoli P. & Bray R.A., 1996. Description of three species of *Holorchis* Stossich, 1901 (Digenea: Lepocreadiidae) from marine fishes off Corsica. Systematic Parasitology, 35: 133–143.

Bartoli P., Bray R.A. & Gibson D.I., 1989a. The Opecoelidae (Digena) of sparid fishes of the wester Mediterranean. II. *Pycnadenoides* Yamaguti, 1938 and *Pseudopycnadena* Saad Fares & Maillard, 1986. Systematic Parasitology, 13: 35–51.

Bartoli P., Bray, R.A. & Gibson D.I., 1989b. The Opecolidae (Digenea) of sparid fishes of the western Mediterranean. III. Macvicaria Gibson & Bray, 1982. Systematic Parasitology, 13: 167–192.

Bartoli P. & Gibson D.I., 1989. *Wardula sarguicola* n. sp. (Digenea, Mesometridae), a rectal parasite of *Diplodus sargus* (Teleostei, Sparidae) in western Mediterranean. Annales de Parasitologie Humaine et Comparée, 64: 20–29.

Bartoli P., Gibson D.I. & Bray R.A., 2005. Digenean species diversity in teleost fish from a nature reserve off Corsica, France (Western Mediterranean), and a comparison with other Mediterranean regions. Journal of Natural History, 39: 47–70.

Bray R.A. & Bartoli P., 1996. A redescription of *Lepidauchen stenostoma* Nicoll, 1913 (Digenea), and a reassessment of the status of the genus *Lepidauchen* Nicoll, 1913. Systematic Parasitology, 33: 167–176.

Bray R.A. & Cribb T.H., 1997. The subfamily Aephnidiogeninae Yamaguti, 1934 (Digenea: Lepocreadiidae), its status and that of the genera *Aephnidiogenes* Nicoll, 1915, *Holorchis* Stossich, 1901, *Austroholorchis* n. g., *Pseudaephnidiogenes* Yamaguti, 1971, *Pseudoholorchis* Yamaguti, 1958 and *Neolepocreadium* Thomas, 1960. Systematic Parasitology, 36, 47–68.

Bayoumy E.M. & Abu-Taweel G.M., 2012. *Magnibursatus diplodii* n. sp. (Derogenidae: Halipeginae) from white sea bream, *Diplodus sargus*, Off Sirt, Libya. Life Science Journal, 9: 939–945.

Bush A.O., Lafferty K.D., Lotz J.M. & Shostak A.W., 1997. Parasitology meets ecology on its own terms: Margolis et al. Revisited. Journal of Parasitology, 83: 575–583.

Combes C., 1995. Interactions durables. Écologie et évolution du parasitisme. Collection écologie No. 26. Ed. Masson, Paris, 524 pp.

Crompton D.W.T., 1973. The sites occupied by some parasitic helminths in the alimentary tract of vertebrates. Biology Reviews, 48: 27–83.

D'Amico V., Canestri Trotti G., Culurgioni J. & Figus V., 2006. Helminth parasite community of *Diplodus annularis* L. (Osteichthyes, Sparidae) from Gulf of Cagliari (Sardinia, South Western Mediterranean). European association of Fish Pathologists, 26: 222–228.

Derbel H., Chaari M. & Neifar L., 2012. Digenean species diversity in teleost fishes from the Gulf of Gabes, Tunisia (Western Mediterranean). Parasite, 19: 129–135.

Dezfuli B.S., Volponi S., Beltrami L. & Poulin R., 2002. Intra- and interspecific density-dependent effects on growth in helminth parasite of the cormorant, *Phalacrocorax carbo sinensis*. Parasitology, 124: 537–544.

Fischer W., Seneider M. & Bauchaut M .L., 1987. Fiches F.A.O. d'identification des espèces pour les besoins de la pêche. Méditerranée et Mer noire (zone de pêche 37) Vertébrés. Vol. II, Rome, FAO, 1359–1361.

Gaevskaya A.V. & Korniychuk Y.M., 2003. Parasitic organisms as a component of ecosystems of the Black Sea near-shore zone of Crimea. In "Modern condition of biological diversity in near shore zone of Crimea (Black Sea sector)" Eremeev V.N. & Gaevskaya A.V. (Eds.), Sevastopol: EKOSI Gidrophizika, 425–490.

Gargouri Ben Abdallah L., Antar R. & Maamouri F., 2011. Diversity of the digenean fauna in sparid fishes from the Lagoon of Bizerte in Tunisia. Acta Parasitologica, 56: 34–39.

Gargouri Ben Abdallah L. & Maamouri F., 2008. Digenean fauna diversity in sparid fish from Tunisian coasts. European association of Fish Pathologists, 28: 129–136.

Holmes J.C., 1990. Competition, contacts and other factors restricting niches of parasitic helminthes. Annales de Parasitologie Humaine et Comparée, 65: 69–72.

Jousson O., Bartoli P. & Pawlowski J., 1998. Molecular phylogeny of Mesometridae (Trematoda, Digenea) with its relation to morphological changes in parasites. Parasite, 5: 365–369.

Jousson O., Bartoli P. & Pawlowski J., 2000. Cryptic speciation among intestinal parasites (Trematoda: Digenea) infecting sympatric host fishes (Sparidae). Journal of Evolutionary Biology, 13: 778–785.

Jousson O., Bartoli P. & Pawlowski J., 1999. Molecular identification of developmental stages in Opecoelidae (Digenea). International Journal Parasitology, 29: 1853–1858.

Khan R.A., 2012. Host-parasite interactions in some fish species. Journal Parasitology Research, 2012: ID 237280.

Kostadinova A., Bartoli P., Gibson D.I. & Raga J.A., 2004. Redescriptions of *Magnibursatus blennii* (Paggi & Orechhia, 1975) n. comb. and *Arnola microcirrus* (Vlasenko, 1931) (Digenea: Derogenidae) from marine teleosts off Corsica. Systematic Parasitology, 58: 125–137.

Kostadinova A. & Gibson D.I., 2009. New records of rare derogenids (Digenea: Hemiuroidea) from Mediterranean sparids, including the description of a new species of *Magnibursatus* Naidenova, 1969 and redescription of *Derogenes adriaticus* Nikolaeva, 1966. Systematic Parasitology, 74: 187–198.

Kostadinova A., Power A.M., Fernández M., Balbuena J.A ., Raga J.A. & Gibson D.I., 2003. Three species of Magnibursatus Naidenova, 1969 (Digenea: Derogenidae) from Atlantic and Black Sea marine teleosts. Folia Parasitologica, 50: 202–210.

Le Pommelet E., Bartoli P. & Silan P., 1997. Biodiversite des digenes et autres helminthes intestinaux des rougets: synthese pour *Mullus surmuletus* (Linnè, 1758) et *M. barbatus* (L., 1758). Annales des Sciences Naturelles. Zoologie et Biologie Animale, 18: 117–133.

MacKenzie K., 1999. Parasites as pollution indicators in marine ecosystems: a proposed early warning system. Marine Pollution Bulletin, 38: 955–959.

Maillard C., 1976. Distomatose de poissons en milieu lagunaire. Dsc, University of Science and Techniques of Languedoc, Montpellier.

Marzoug D., Boutiba Z., Kostadinova A. & Pérez-del-Olmo A., 2012. Effects of fishing on parasitism in a sparid fish: Contrasts between two areas of the Western Mediterranean. Parasitology International, 61: 414–420.

Merella P., 1991. Ricerche sulla malacofauna della Riserva naturale di Scandola (Corsica nord occidentale).Dsc, University of Sassari Italy, 138 pp.

Miniconi R., Francour P. & Bianconi C.H., 1990. Inventaire de la faune ichthyologique de la Reserve Naturelle de Scandola (Corse, Mediterranee nord-occidentale). Cybium, 14: 77–89.

Pérez-del Olmo A., Gibson D.I., Fernández M., Sanisidro O., Raga J.A. & Kostadinova A., 2006. Descriptions of *Wardula bartolii* n. sp. (Digenea: Mesometridae) and three newly recorded accidental parasites of *Boops boops* L. (Sparidae) in the NE Atlantic. Systematic Parasitology, 63: 99–109.

Pérez-del Olmo A., Fernández M., Gibson D.I., Raga J.A. & Kostadinova A., 2007a. Descriptions of some unusual digeneans from *Boops boops* L. (Sparidae) and a complete checklist of its metazoan parasites. Systematic Parasitology, 66: 137–157.

Pérez-del Olmo A., Raga J.A., Kostadinova A. & Fernàndez M., 2007b. Parasite communities in *Boops boops* (L.) (Sparidae) after the Prestige oil-spill: Detectable alterations. Marine Pollution Bulletin, 54: 266–276.

Pérez-del Olmo A., Fernández M., Raga J.A., Kostadinova A. & Poulin R., 2008. Halfway up the trophic chain: development of parasite communities in the sparid fish *Boops boops*. Parasitology, 135: 257–268.

Pérez-del Olmo A., 2008. Biodiversity and structure of parasite communities in *Boops boops* (Teleostei: Sparidae) from the western Mediterranean and off the northeast Atlantic coasts of Spain. Dsc, University of Valencia, 133 pp.

Ricklefs R.E. & Schluter D., 1993. Species Diversity in Ecological communities. Ed. University of Chicago Press, Chicago, 414 pp.

Rohde K., 1994. Niche restriction in parasites: proximate and ultimate causes. Parasitology, 109: S69–S84.

Sánchez-García N., Raga J.A. & Montero F.E., 2014. Risk assessment for parasites in cultures of *Diplodus puntazzo* Risk assessment for parasites in cultures of *Diplodus puntazzo* (Sparidae) in the Western Mediterranean: prospects of cross infection with *Sparus aurata*. Veterinary Parasitology, 204:120–33.

Sánchez-García N., Ahuir-Baraja A., Raga J.A. & Montero F.E., 2013. Morphometric, molecular and ecological analyses of the parasites of the sharpsnout sea bream *Diplodus puntazzo* Cetti (Sparidae) from the Spanish Mediterranean: implications for aquaculture. Journal of Helminthology, 89: 217–231.

Sasal P., Niquil N. & Bartoli P., 1999. Community structure of digenean parasites of sparid and labrid fishes of the Mediterranean Sea: a new approach. Parasitology, 119: 635–648.

Stock T.M. & Holmes J.C., 1988. Functional relationships and microhabitat distributions of enteric helminths of grebes (Podicipedidae): The evidence for interactive communities. Journal of Parasitology, 74, 214–227.

Sukhdeo M.V.K. & Sukhdeo S.C., 1994. Optimal habitat selection by helminths within the host environment. Parasitology, 109: S41–S55.

Ternengo S., Levron C. & Marchand B., 2005a. Metazoan Parasites in Sparid fish in Corsica (Western Mediterranean). European association of Fish Pathologists, 25: 262–269.

Ternengo S., Levron C., Desideri F. & Marchand B., 2005b. Parasite communities in European eels *Anguilla anguilla* pisces, teleostei from a corsican coastal pond. Vie et Milieu, 55: 1–6.

Ternengo S., Levron C., Mouillot D. & Marchand B., 2009. Site influence in parasite distribution from fishes of the Bonifacio Strait Marine Reserve (Corsica Island, Mediterranean Sea). Parasitology Research, 104: 1279–1287.

Thieltges D.W., Jensen K.T. & Poulin R., 2008. The role of biotic factors in the transmission of free-living endohelminth stages. Parasitology: 135, 407–426.

Tortonese E., 1973. Catalogue des poissons de l'Atlantique du Nord-Est et de la Méditerranée. CLOFNAM I Hureau JC, Monold TH. Ed., Paris, UNESCO, 405–4015.

Verlaque M., 1990. Flore marine de la région de Galeria. Travaux Scientifiques du Parc Naturel Régional et des Réserves Naturelles de Corse, 29: 77–88.

Verlaque M., Francour P. & Sartoretto S., 1999. Evaluation de la valeur patrimoniale des biocénoses marines de la face ouest de l'îlot de Gargalu (Réserve intégrale de Scandola). Travaux Scientifiques du Parc Naturel Régional et des Réserves Naturelles de Corse, 59: 121–168.