Zootaxa 3887 (2): 157–190
www.mapress.com/zootaxa/

Article

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

http://dx.doi.org/10.11646/zootaxa.3887.2.3
http://zoobank.org/urn:lsid:zoobank.org:pub:B697D6BA-836B-44E2-A8D9-07661554FE59

New observations on Myxozoa of the goldline sea bream *Sarpa salpa* L. 1758 (Teleostei : Sparidae) from the Mediterranean coast of Tunisia

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Abstract

A member of the Sparidae family, the goldline sea bream *Sarpa salpa* (Linnaeus, 1758) collected from the Gulf of Tunis and the Bay of Bizerte in Northeast Tunisia, Western Mediterranean, were examined for the myxozoan parasites. During the parasitological exposure, a total of 7 myxosporean are found including 6 coelozoic species belong to the genus *Ceratomyxa* Thélohan, 1892 infected the gallbladder of their host of which 3 known species have been previously described, *C. arcuata* Thélohan, 1892, *C. pallida* Thélohan, 1895 and *C. herouardi* Georgévitch, 1916 and 3 species seem different in morphology to *Ceratomyxa* spp already known from Mediterranean Sea or from other localities in the wide world. These species are *Ceratomyxa* **sp. 1**, *Ceratomyxa* **sp. 2** and *Ceratomyxa* **sp. 3**. Only one histozoic species belongs to the genus *Henneguya* Thélohan, 1892, *Henneguya* **sp.** identified for the first time infecting the mesentery vessels of *S. salpa*. The myxosporean parasite *C. arcuata* Thélohan, 1892 is reported for the first time in Tunisian waters from the goldline sea bream which represents as new host records. In addition to the Monoparasitism, the phenomenon of Polyparasitism was observed between the current species in both sampling sites with two types: Biparasitism and Triparasitism. The most frequent Polyparasitism was a Biparasitism-type between *C. herouardi* and *C. pallida* with frequency 16.97%. For all the species, no serious pathogenic changes have been recorded in the host organ or in the outward appearance of the fish. Morphological features, site of infection into the host, parasite prevalence and mean intensity of each myxosporean found during this survey are determined and their taxonomic affinities to other species are discussed.

Key words: Myxozoan fauna, *Ceratomyxa*, *Henneguya*, Morphology, Taxonomy, Biparasitism, Triparasitism, *Sarpa salpa,* Sparidae, Mediterranean coast, Tunisia

Introduction

The goldline sea bream, Salema or Strepie, *Sarpa salpa* (Linnaeus, 1758), is a benthopelagic oceanodromous sparid fish widely distributed throughout the Mediterranean and the Eastern Atlantic coast (round South Africa to South of Mozambique including the Azores and Canary Islands), living on sandy and seagrass bottoms ranging from 0 to 70 m depth (Bouchot & Hureau 1990). In the Mediterranean Sea, during the last 15 years, the goldline sea bream has attracted research interest because of first, its ecological key role as mainly vertebrate of the seagrass *Posidonia oceanica* (L.) (Peirano *et al*. 2001; Jadot *et al*. 2006; Prado *et al*. 2008) and representing a considerable part of the ichthyofauna in these habitats (40–70% in biomass) (Francour 1997, 2000), second, its biology in order to develop a management strategy (Méndez-Villamil *et al*. 2001, 2002), and finally for its Ichthyosarcotoxism (Spanier *et al*. 1989; Chevaldonne 1990; De Haro & Pommier 2006; Bellassoued *et al*. 2012). In the Atlantic coast especially in Canary Island, *S. salpa* has an important commercial value and constitutes one of the most important fishes taken by the local artisan fleet (Méndez-Villamil *et al*. 2002). In Tunisia, the goldline sea bream is commonly consumed as fresh fish for its desirable aroma and quality (Boubaker *et al*. 2013). Statistical data revealed that the total production of this fish, along the Tunisian coast, has increased between 1980 and 2001 about 70.3% where in 2001, the production has reached 1024 tons, which constitute 57% of the total catch that was taken in Mediterranean Sea (Froese & Pauly 2014).

Myxozoans are a phylum of microscopic metazoan endoparasites belonging to the Cnidaria (Holland *et al*. 2011; Nesnidal *et al*. 2013). They represent a major group of fish parasites and their impact on wild and cultured

Accepted by S. Adl: 28 Oct. 2014; published: 24 Nov. 2014

America with infracommunity community richness vary between 0–3 species and mean infracommunity richness from 0 to 1.2. Among all the described species here, no myxosporean appears to be so frequent in this study (Prevalence > 50%). Generally, except *C.* **sp. 3**, the prevalence of infection of all species are higher in Gulf of Tunis compared to those from the Bay of Bizerte (Fig. 9). This may be explicated by the unequal number of host examined in both localities. During the investigation, differences in prevalence and infection intensity between species were detected (Figs. 9,10). Overall, the infection occurred throughout the period of sampling with the highest prevalence occurring in spring and earlier summer (May and June) and the lowest prevalence last summer (August) (see Table 4), similar to the pattern reported for C. *sparusaurati* Sitjá-Bobadilla, Palenzuela & Alvarez-Pellitero, 1995 (Palenzuela *et al*. 1997), a myxosporean of the sparid *Sparus aurata* (Linnaeus, 1758). However, Alama-Bermejo *et al*. (2013) recently noted two peaks of high infection rate for *C. puntazzi*, the first one was determined in spring (April–May) and the second peaks was detected from August to October. In this study, the greatest prevalence was noted for *Ceratomyxa herouardi* Georgévitch, 1916 with prevalence (33.3%) at Gulf of Tunis whereas the histozoic species *Henneguya* **sp.** was the least frequent species with prevalence 0.83% in the Bay of Bizerte (see Table 4). Likewise, *C. herouardi* presented the highest infection intensity with average up to 211.7 parasites per host whereas the mean intensity of *Ceratomyxa* **sp. 3** did not reach a value more than 35.5 spores per infected fish (Fig. 9). According to Poulin (2006), parameters as prevalence, intensity and abundance used to qualify populations of parasites or the severity of the parasitic infection are not stable. For a given species of parasite, the proportion of the infested hosts is not fixed through its geographical distribution range. Overally, transmission of myxozoan parasites are known to be influenced by ecological factors and host immune response. In addition, the presence of an alternate host and the density of actinospores in the water sea appear to be decisive for the infection rate into fishes. In the same regard, El-Tantawi (1989) and Brummer-Korvenkontio *et al*. (1991) declared that prevalence of myxosporean species varies according to environmental conditions and hosts species. Mackenzie *et al*. (2005) provided that myxosporeans are highly sensitive to environmental change. Abiotic factors such as water temperature, salinity and pH are really important in the proliferation of these parasites. In fact, it was well demonstrated that increased water temperature has particularly a crucial effect on the development of myxozoans and allow more rapidly proliferation in both, their vertebrate and invertebrate hosts, leading to modifications in prevalence rate of infection (Ferguson 1981; McGeorge *et al*. 1996; Kent *et al*. 2001; Yokoyama 2003; Tops *et al*. 2006; Ray *et al*. 2012). In the same regard, El-Matbouli *et al*. (1999) determined that temperature can affect the development, release and longevity of the myxosporean in an alternate host as well as the development of the fish host. Likewise, Özer & Wootten (2000) showed a significant progressive development of both myxosporean and actinosporean stages in the life cycle of *Spheropsora truttae* with the water temperature. Soon after, kerans *et al*. (2005) exposed the positive influence of water temperature on Host-parasite interaction and dynamics transmission in the life cycle of myxosporean *Myxobolus cerebralis*.

In this study, both *Ceratomyxa* and *Henneguya* species did not seem to cause any inflicted external clinical signs of disease or visible abnormalities, neither in the host organ nor in the outward appearance of the fish. However, the pathogenic potentials of the coelozoic parasites, in particular their possible relationship with the dark green color of the bile and contraction in some part of the heavy infected gall bladder, should be further studied. For the histozoic *Henneguya* sp., the existence of large cysts into the mesentery can provoke occlusion for the vessels and cause nutrition and digestion troubles for the host fish. As a supplementary work, further investigations on the specific identities, such as phylogeny position and fine structure may help to enlarge the current knowledge.

Acknowledgments

This work complies with the current laws of Tunisia country in where it was performed. The constructive critic and suggestions of the editor Dr. Adl Sina and anonymous reviewers are gratefully acknowledged. The author declare the absence of any conflicts of interest regarding this study.

References

Alama-Bermejo, G., Raga, J.A. & Holzer, A.S. (2011) Host–parasite of *Ceratomyxa puntazzi* n. sp. (Myxozoa: Myxosporea) and sharpsnout seabream *Diplodus puntazzo* (Walbaum, 1792) from the Mediterranean with first data on ceratomyxid host

specificity in sparids. *Veterinary Parasitology*, 182, 181–192.
http://dx.doi.org/10.1016/j.vetpar.2011.05.012
Alama-Bermejo, G., Šima, R., Raga, J.A. & Holzer, A.S. (2013) Understanding myxozoan infection dynamics in the sea: Seasonality and transmission of *Ceratomyxa puntazzi*. *International Journal for Parasitology*, 43 (9), 771–780.
http://dx.doi.org/10.1016/j.ijpara.2013.05.003
Alvarez-Pellitero, P. & Sitjá-Bobadilla, A. (1993a). *Ceratomyxa* spp. (Protozoa: Myxosporea) infections in wild and cultured sea bass (*Dicentrarchus labrax*) from the Spanish Mediterranean area. *Journal of Fish Biology*, 42, 889–901.
http://dx.doi.org/10.1111/j.1095-8649.1993.tb00398.x
Alvarez-Pellitero, P. & Sitjá-Bobadilla, A. (1993b) Pathology of myxosporea in marine fish culture. *Diseases of Aquatic Organisms*, 17, 229 –238.
http://dx.doi.org/10.3354/dao017229
Aseeva, N.L. (2003) New species of myxosporean (Myxozoa: Myxosporea) parasites of *Ceratomyxa* from fishes of Peter the Great Bay (Japan Sea). *Journal of Parasitology*, 89, 1172–1180.
http://dx.doi.org/10.1645/GE-2995
Auerbach, M. (1912) Studien über die Myxosporidien der Norwegischen Seefische und ihre Verbreitung. *Zoologischer Jahrbücher, Abteilung I. Systematik (Ökologie), Geographie und Biologie*, 34, 1–50.
Bahri, S., Hassine, O.K.B. & Marques, A. (1996) *Henneguya* sp. (Myxosporea, Bivalvulida) infecting the gills of wild gilthead sea bream *Sparus aurata* L., from the coast of Tunisia. *Bulletin of the European Association of Fish Pathologists*, 16, 51–53.
Bartošová, P. & Fiala, I. (2011) Molecular evidence for the existence of cryptic species assemblages of several myxosporeans (Myxozoa). *Parasitolology Research*, 108, 573–583.
http://dx.doi.org/10.1007/s00436-010-2100-y
Bellassoued, K., Hamza, A., Abdelmouleh, A., Makni, F.A., Pelt, J.V. & Abdelfattah, E. (2012) Toxicity assessment of dreamfish *Sarpa salpa* from the Gulf of Gabes (Tunisia, Eastern Mediterranean Sea). *Journal of Food Agriculture and Environment*,10 (2), 1308–1313.
Bauchot, M.L. & Hureau, J.C. (1990) Sparidae. *In*: Quero, J.C., Hureau, J.C., Karrer, C., Post, A. & Saldanha, L. (Eds.), *Check-list of the Fishes of the Eastern Tropical Atlantic, Clofeta II*, UNESCO, Paris, pp. 790–812.
Boubaker, K., Achour, S., Abdelkarim, M. & Souheil, B.M. (2013) Assessment of the freshness state of preserved *Sarpa salpa* under ice. *International Food Research Journal*, 20 (4), 1877–1881.
Brickle, P., Kalavati, C. & MacKenzie, K. (2006) *Henneguya shackletoni* sp. nov. (Myxosporea, Bivalvulida, Myxobolidae) from the Falklands mullet, *Eleginops maclovinus* (Cuvier) (Teleostei, Eleginopidae) in the Falklands Islands. *Acta Parasitologica*, 51, 36–39.
http://dx.doi.org/10.2478/s11686-006-0004-x
Brummer-Korvenkontio, H., Valtomen, T. & Pugachev, O.N. (1991) Myxosporea parasites in roach, *Rutilus rutilus* (Linnaeus) from four lakes in Central Finland. *Journal of Fish Biology*, 38, 573–586.
http://dx.doi.org/10.1111/j.1095-8649.1991.tb03144.x
Bush, A.O., Lafferty, K.D., Lotz, J.F. & Shostak, A.W. (1997) Parasitology meets ecology on its own terms. Margolis *et al*. revisited. *Journal of Parasitology*, 83, 575–583.
Caffara, M., Marcer, F., Florio, D., Quaglio, F. & Fioravanti, M.L. (2003) Heart infection due to *Henneguya* sp. (Myxozoa, Myxosporea) in gilthead sea bream (*Sparus aurata*) cultured in Italy. *Bulletin of the European Association of Fish Pathologists*, 23, 108–112.
Chevaldonne, P. (1990) Ciguatera and the saupe, *Sarpa salpa* (L.), in the Mediterranean: a possible misinterpretation. *Journal of Fish Biology*, 37, 503–504.
http://dx.doi.org/10.1111/j.1095-8649.1990.tb05883.x
Cone, D.K., Marcogliese, D.J. & Russell R. (2004) The myxozoan fauna of spottail shiner in the great lakes basin: membership, richness, and geographical distribution. *Journal of Parasitology*, 90 (5), 921–932.
http://dx.doi.org/10.1645/GE-3313
Cone, D.K., Marcogliese, D.J., Barse, A.M. & Burt, M.D.B. 2006 The myxozoan fauna of *Fundulus diaphanous* (Cyprinodontidae) from freshwater localities in eastern North America: prevalence, community structure, and geographic distribution. *Journal of Parasitology*, 92 (1), 52–57.
http://dx.doi.org//10.1645/GE-590R.1
Davis, H.S. (1917) The Myxosporidia of the Beaufort region, a systematic and biological study. *Bulletin of the United States Bureau of Fisheries*, 35, 199–252.
De Haro, L. & Pommier, P. (2006) Hallucinatory Fish Poisoning (Ichthyoallyeinotoxism): Two Case Reports From the Western Mediterranean and Literature Review. *Clinical Toxicology*, 44, 185–188.
http://dx.doi.org/10.1080/15563650500514590
Diamant, A., Lom, J. & Dyková, I. (1994) *Myxidium leei* n. sp., a pathogenic myxosporean of cultured sea bream *Sparus aurata*. *Diseases of Aquatic Organisms*, 20, 137–141.
Dunkerly, J.S. (1921) Fish Myxosporidia from Plymouth. *Journal of Parasitology*, 12, 328–333.
Eiras, J.C. (2002) Synopsis of the species of the genus *Henneguya* Thélohan, 1892 (Myxozoa: Myxosporea: Myxobolidae).*Systematic Parasitology*, 52, 43–54.

http://dx.doi.org/10.1023/A:1015016312195
Eiras, J.C. (2006) Synopsis of the species of *Ceratomyxa* Thélohan, 1892 (Myxozoa: Myxosporea: Ceratomyxidae). *Systematic Parasitology*, 65 (1), 49–71.
http://dx.doi.org/10.1007/s11230-006-9039-5
Eiras, J.C. & Adriano, E.A. (2012) A checklist of new species of *Henneguya* Thélohan, 1892(Myxozoa: Myxosporea, Myxobolidae) described between 2002 and 2012. *Systematic Parasitology*, 83, 95–104.
http://dx.doi.org/10.1007/s11230-012-9374-7
El-Matbouli, M., McDowell, T.S., Antonio, D.B., Andree, K.B. & Hedrick, R.P. (1999) Effect of water temperature on the development, release and survival of the triactinomyxon stage of *Myxobolus cerebralis*, the causative agent of whirling disease, in its oligochaete host. *International Journal for Parasitology*, 29, 627–641.
http://dx.doi.org/ 10.1016/S0020-7519(99)00009-0
El-Tantawi, S.A.M. (1989) Myxosporidian parasites of fishes in lakes Dgal Wielki and Warniak (Mazurian Lakeland, Poland). I. Survey of parasites. *Acta Parasitologica*, 34 (3), 203–219.
Feist, S.W. & Ronga, E. (1996) Distribution and prevalence of gall bladder myxosporean parasites in dab (*Limanda limanda* L.) and whiting (*Merlangius merlangus* L.) in UK coastal waters. *Bulletin of the European Association of Fish Pathologists*, 16, 176–180.
Ferguson, H.W. (1981) The effects of water temperature on the development of proliferative kidney disease in rainbow trout, *Salmo gairdneri* Richardson. *Journal of Fish Diseases*, 4, 175–177.
http://dx.doi.org/10.1111/j.1365-2761.1981.tb01122.x
Francour, P. (1997) Fish assemblages of *Posidonia oceanica* beds at Port-Cros (France, NW Mediterranean): Assessment of composition and long-term fluctuations by visual census. *Marine Ecology*,18 (2), 157–173.
http://dx.doi.org/10.1111/j.1439-0485.1997.tb00434.x
Francour, P. (2000) Evolution spatio-temporelle à long terme des peuplements de poissons des herbiers à *Posidonia oceanica* de la réserve naturelle de Scandola (Corse, Méditerranée, Nord-occidentale). *Cybium*, 24 (3), 85–95
Freeman, M.A., Yokoyama, H. & Ogawa, K. (2008) Description and phylogeny of *Ceratomyxa anko* sp. n. and *Zschokkella lophii* sp. n. from the Japanese anglerfish, *Lophius litulon* (Jordan). *Journal of Fish Diseases*, 31, 921–930.
http://dx.doi.org/10.1111/j.1365-2761.2008.00965.x
Froese, R. & Pauly, D. (2014) FishBase. World Wide Web electronic publication. FAO Capture Production of *Sarpa salpa*. Available from: http://www.fishbase.org (accessed 1 June 2014)
Georgévitch, J. (1916) Note sur les Myxosporidies recueillies a Roscoff. *Bulletin de la société zoologique de France*, 41, 86–95.
Georgévitch, J. (1916a) Note sur les myxosporidies des poissons de la baie de Ville franche et de Monaco. *Bulletin de l'Institut Océanographique de Monaco*, 322, 1–7.
Georgévitch, J. (1916b) Sur les diverses formes de *Ceratomyxa herouardi* Georgevitch. . *Comptes rendus hebdomadaires des séances de l'Académie des sciences*, 163, 717–719.
Georgévitch, J. (1916c) Sur le cycle évolutif de *Ceratomyxa herouardi* Georgevitch. *Comptes rendus hebdomadaires des séances de l'Académie des sciences*, 163, 983–985.
Georgévitch, J. (1917) Recherches sur le développement de *Ceratomyxa herouardi* Georgévitch. *Archives de zoologie expérimentale et générale*, 56, 375–399.
Gómez, D., Bartholomew, J. & Sunyer, J.O. (2013) Biology and mucosal immunity to myxozoans. *Developmental and Comparative Immunology*, 43 (2), 243–256.
http://dx.doi.org/10.1016/j.dci.2013.08.014
Gunter, N.L. & Adlard, R.D. (2008) Bivalvulidan (Myxozoa: Myxosporea) parasites of damselfishes with description of twelve novel species from Australia's Great Barrier Reef. *Journal of Parasitology*, 135, 1165–1178.
http://dx.doi.org/10.1017/S0031182008004733
Gunter, N.L., Whipps, C.M. & Adlard, RD (2009a) *Ceratomyxa* (Myxozoa: Bivalvulida): robust taxon or genus of convenience?. *International Journal for Parasitology*, 39, 1395–1405.
http://dx.doi.org/ 10.1016/j.ijpara.2009.04.008
Gunter, N.L. & Adlard, R.D. (2009b) Seven new species of *Ceratomyxa* Thélohan, 1892 (Myxozoa) from the gall-bladders of serranid fishes from the Great Barrier Reef, Australia. *Systematic Parasitology*, 73, 1–11.
http://dx.doi.org/10.1007/s11230-008-9162-6
Heiniger, H., Gunter, N.L. & Adlard, R.D. (2008) Relationships between four novel ceratomyxid parasites from the gall bladders of labrid fishes from Heron Island, Australia. *Parasitology International*, 57, 158–165.
http://dx.doi.org/10.1016/j.parint.2007.11.006
Heiniger, H. & Adlard, R.D. (2013) Molecular identification of cryptic species of *Ceratomyxa* Thélohan, 1892 (Myxosporea: Bivalvulida) including the description of eight novel species from apogonid fishes (Perciformes: Apogonidae) from Australian waters. *Acta Parasitologica*, 58 (3), 342–360.
http://dx.doi.org/10.2478/s11686-013-0149-3
Holland, J.W., Okamura, B., Hartikainen, H. & Secombes, C.J. (2011) A novel minicollagen gene links cnidarians and myxozoans. *Proceedings of the Royal Society B: Biological Sciences*, 278, 546–553.
http://dx.doi.org/10.1098/rspb.2010.1301

Holzer, A.S., Stewart, S., Tildesley, A., Wootten, R. & Sommerville, C. (2010) Infection dynamics of two renal myxozoans in hatchery reared fry and juvenile Atlantic cod *Gadus morhua* L. *Parasitology*, 137, 1501–1513. http://dx.doi.org/10.1017/S0031182010000247

Jadot, C., Donnay, A., Acolas, M.L., Cornet, Y. & Begout-Anras, M.L. (2006) Activity patterns, home-range size and habitat utilization of *Sarpa salpa* (Teleostei: Sparidae) in the Mediterranean Sea. *ICES Journal of Marine Science*, 63 (1), 128–139. http://dx.doi.org/10.1016/j.icesjms.2005.06.010

Jakowska, S. & Nigrelli, R.F. (1953) The pathology of myxosporidiosis in the electric eel, *Electrophorus electricus* (Linnaeus) caused by *Henneguya visceralis* and *H. electrica* spp. nov. *Zoologica*, 38, 183–191.

Jameson, A.P. (1913) A note on some Myxosporidia collected at Monaco. *Bulletin de l'Institut Océanographique de Monaco*, 273, 1–4.

Kabata, Z. (1967) Whiting stocks and their gall-bladder parasites in British waters. *Marine Research*, 2, 1–11.

Kalavati, C. & MacKenzie, K. (1999) The genera *Ceratomyxa* Thélohan,1892, *Leptotheca* Thélohan, 1895 and *Sphaeromyxa* Thélohan,1892 (Myxosporea: Bivalvulida) in gadid fish of the Northeast Atlantic. *Systematic Parasitology*, 43, 209–216. http://dx.doi.org/10.1023/A:1006144721096

Katharios, P., Garaffo, M., Sarter, K., Athanassopoulou, F. & Mylonas, C.C. (2007) A case of high mortality due to heavy infestation of *Ceratomyxa diplodae* in sharpsnout sea bream (*Diplodus puntazzo*) treated with reproductive steroids. *Bulletin of the European Association of Fish Pathologists*, 27, 43–47.

Kent, M.L., Andree, K.B., Bartholomew, J.L., El-Matbouli, M., Desser, S.S., Devlin, R.H., Feist, S.W., Hedrick, R.P., Hoffmann, R.W., Khattra, J., Hallett, S.L., Lester, R.J., Longshaw, M., Palenzuela, O., Siddal, M.E. & Xiao, C. (2001) Recent advances in our knowledge of the Myxozoa. *Journal of Eukaryotic Microbiology*, 48 (4), 395–413. http://dx.doi.org/10.1111/j.1550-7408.2001.tb00173.x

Kent, M.L. & Hoffman, G.L. (1984) Two New Species of Myxozoa, *Myxobolus inaequus* sp. n. and *Henneguya theca* sp. n. from the Brain of a South American Knife Fish, *Eigemannia virescens* (V.). *Journal of Protozoology*, 31 (1), 91–94

Kerans, B.L., Stevens, R.I. & Lemmon, J.C. (2005) Water temperature affects a host-parasite interaction: *Tubifex tubifex* and *Myxobolus cerebralis*. *Journal of Aquatic Animal Health*, 17, 216–221. http://dx.doi.org/10.1577/H04-053.1

Khlifa, S., Miller, T.L., Adlard, R.D., Faye, N. & Sasal, P. (2012) *Henneguya mauritaniensis* n. sp. (Myxozoa) from the arterial bulb of *Pagrus caeruleostictus* (Valenciennes, 1830) off Mauritania. *Parasitology Research*, 111, 1287–1294. http://dx.doi.org/10.1007/s00436-012-2963-1

Kim, W.S., Kim, J.H. & Oh, M.J. (2013) Morphologic and Genetic Evidence for Mixed Infection with Two *Myxobolus* Species (Myxozoa: Myxobolidae) in Gray Mullets, *Mugil cephalus*, from Korean Waters. *Korean journal of Parasitology*, 51 (3), 369–373. http://dx.doi.org/ 10.3347/kjp.2013.51.3.369

Køie, M., Karlsbakk, E. & Nylund, A. (2007) A new genus *Gadimyxa* with three new species (Myxozoa, Parvicapsulidae) parasitic in marine fish (Gadidae) and the two-host life cycle of *Gadimyxa atlantica* n. sp. *Journal of Parasitology,* 93, 1456–1467. http://dx.doi.org/10.1645/GE-1256.1

Kpatcha, T.K., Faye, N., Diebakate, C., Fall, M. & Toguebaye, B.S. (1997) Nouvelles espèces d'*Henneguya* Thélohan, 1895(Myxozoa, Myxosporea) parasites des poissons marins du Sénégal: Étude en microscopie photonique et électronique. *Annales des Sciences Naturelles, Zoologie*, 18, 81–91.

Kudo, R. (1920) Studies on Myxosporidia. A synopsis of genera and species of myxosporidia. *Illinois Biological Mongraphs*, 5, 1–265.

Labbé, A. (1899) Sporozoa. Das Tierreich. Deutschen Zoologischen Gesellschaft. 5. Lieferung. Berlin: R. *Friedländer und Sohn Verlag*, pp. 180.

Lom, J. & Arthur, R. (1989) A guideline for the preparation of species descriptions in Myxosporea. *Journal of Fish Diseases*, 12, 151–156. http://dx.doi.org/10.1111/j.1365-2761.1989.tb00287.x

Lom, J. & Dykova, I. (1992) *Protozoan parasites of fishes*. *Elsevier*, Amsterdam, 315 pp.

Lom, J. & Dyková, I. (2006) Myxozoan genera: definition and notes on taxonomy, life-cycle terminology and pathogenic species. *Folia Parasitologica*, 53, 1–36.

Lom, J. & Noble, E.R. (1984) Revised classification of the class Myxosporea Bütschli, 1881. *Folia Parasitologica*, 31, 193–205.

Lubat, V., Radujkovic B., Marques, A. & Bouix, G. (1989) Parasites de poissons marins du Montenegro: Myxosporidies. *Acta Adriatica*, 30, 31–50.

MacKenzie, K., Kalavati, C., Gaard, M. & Hemmingsen, W. (2005) Myxosporean gall bladder parasites of gadid fishes in the North Atlantic: Their geographical distributions and an assessment of their economic importance in fisheries and mariculture. *Fish Research*, 76, 454–465. http://dx.doi.org/10.1016/j.fishres.2005.07.014

Magurran, A.E. (1988) *Ecological diversity and its measurement*. New Jersey, Princeton University Press, 179 pp.

McGeorge, J., Sommerville, C. & Wootten, R. (1996) Transmission experiments to determine the relationship between *Sphaerospora* sp. from Atlantic salmon, *Salmo salar*, and *Sphaerospora truttae*: a revised species description for *S. truttae*. *Folia Parasitologica*, 43, 107–116.

Meglitsch, P.A. (1960) Some coelozoic Myxosporidia from New Zealand fishes. I. General, and family Ceratomyxidae.

Transactions of the Royal Society of New Zealand, 88, 265–356.
Méndez-Villamil, M., Lorenzo, J.M., Pajuelo, J.G., Ramos, A. & Coca, J. (2002) Aspects of the live history of the salema, *Sarpa salpa* (Pisces, Sparidae) of the Canarian Archipelago (central-east Atlantic). *Environmental Biology of Fishes*, 63, 183–192. http://dx.doi.org/10.1023/A:1014216000459
Méndez-Villamil, M., Pajuelo, J.G., Lorenzo, J.M., Coca, J. & Ramos, A.G. (2001) Age and growth of the salema, *Sarpa salpa* (Osteichthyes, Sparidae), off the Canary Islands (East-central Atlantic). *Archive of Fish Marine Research*, 49, 139–148.
Mladineo, I., Šegvić, T., Bočina, I. & Grubišić, L. (2009) Redescription of *Myxidium sphaericum* Thélohan, 1895 and *Ceratomyxa beloneae* Lubat *et al*., 1989 from the gall bladder of the garpike, *Belone belone* in the Adriatic Sea. *Acta Parasitologica*, 54 (4), 289–294.
http://dx.doi.org/ 10.2478/s11686-009-0055-x
Moser, M., Kent, M.L. & Dennis, D. (1989) Gallbladder Myxosporea in coral reef fishes from Heron Island, Australia. *Australian Journal of Zoology*, 37, 1–13.
Nesnidal, M.P., Helmkampf, M., Bruchhaus, I., El-Matbouli, M. & Hausdorf, B. (2013) Agent of Whirling Disease Meets Orphan Worm: Phylogenomic Analyses Firmly Place Myxozoa in Cnidaria. *Plos One*, 8, 1–6.
http://dx.doi.org/10.1371/journal.pone.0054576
Noble, E.R. (1957) Seasonal variations in host-parasite relations between fish and their Protozoa. *Journal of the Marine Biological Association of the United Kingdom*, 36, 143–155.
Özer, A. (2003) *Sphaerospora elegans* Thélohan, 1892 and *Myxobilatus gasterostei* Davis, 1944 (Phylum: Myxozoa) Infections in the Three-Spined Stickleback, *Gasterosteus aculeatus* L., 1758 in Turkey. *Turkish Journal of Zoology*, 27, 163–169.
Özer, A. & Wootten, R. (2000) The life cycle of *Sphaerospora truttae* (Myxozoa, Myxosporea) and some features of the biology of both the actinosporean and myxosporean stages. *Diseases of Aquatic Organisms*, 40, 33–39.
http://dx.doi.org/10.3354/dao040033
Özer, A., Wootten, R. & Shinn A.P. (2002) Infection prevalence, seasonality and host specificity of actinosporean types (Myxozoa) in an Atlantic salmon fish farm located in Northern Scotland. *Folia Parasitologica*, 49, 263–268.
Padrós, F., Palenzuela, O., Hispano, C., Tosas, O., Zarza, C., Crespo, S. & Alvarez-Pellitero, P. (2001) *Myxidium leei* (Myxozoa) infections in aquarium-reared Mediterranean fish species. *Diseases of Aquatic Organisms*, 47, 57–62.
http://dx.doi.org/10.3354/dao047057
Palenzuela, O. (2006) Myxozoan infections in Mediterranean mariculture. *Parassitologia*, 48, 27–29.
Palenzuela, O., Sitjá-Bobadilla, A. & Alvarez-Pellitero, P. (1997) *Ceratomyxa sparusaurati* (Protozoa: Myxosporea) infections in cultured gilthead sea bream *Sparus aurata* (Pisces: Teleostei) from Spain: aspects of the host-parasite relationship. *Parasitology Research*, 83, 539–548.
http://dx.doi.org/ 10.1007/s004360050295
Parisi, B. (1912) Primo contributo alla distribusione geografica dei missosporidi in Italia. *Atti della Societá Italiana de Scienza Naturalle*, 50, 283–290.
Peirano, A., Niccolai, I., Mauro, R. & Bianchi, C. (2001) Seasonal gazing and food preference of herbivores in a *Posidonia oceanica* meadow. *Scientia Marina*, 65 (4), 367–374.
Poulin, R. (2006) Variation in infection parameters among population within parasite species: Intrinsic properties versus local factors. *International Journal of Parasitology*, 36, 877–885.
http://dx.doi.org/10.1016/j.ijpara.2006.02.021
Prado, P., Farina, S., Tomas, F., Romeo, J. & Alcoverro, T. (2008) Marine protection and meadow size alter fish herbivory seagrass ecosystems. *Marine Ecology Progress Series*, 371, 11–21.
http://dx.doi.org/10.3354/meps07662
Rácz, O.Z., Eszterbauer, E. & Molnár, K. (2005) Hungactinomyxon, a new actinosporean type and collective group (Myxozoa) from *Branchiura sowerbyi* Beddard (Oligochaeta). *Systematic Parasitology*, 61, 107–113.
Ray, R.A., Holt, R.A. & Bartholomew, J.L. (2012) Relationship between temperature and *Ceratomyxa shasta*-induced mortality in Klamath River salmonids. *Journal of Parasitology*, 98, 520–526.
http://dx.doi.org/10.1645/JP-GE-2737.1
Reiczigel, J. (2003) Confidence intervals for the binomial parameter: some new considerations. *Statistics in Medicine*, 22, 611–621. http://dx.doi.org/10.1002/sim.1320
Reiczigel, J. & Rózsa, L. (2005) Quantitative Parasitology 3.0. Budapest (Distributed by the authors).
Rigos, G., Grigorakis, K., Christophilogannis, P., Nengas, I. & Alexis, M. (1997) *Ceratomyxa* spp. (Myxosporea) infection in cultured common dentex from Greece. *Bulletin of the European Association of Fish Pathologists*, 17, 174–176.
Shotter, R.A. (1970) Note on myxosporidian parasites of whiting, *Odontogadus merlangus* (L.) from the northern Irish Sea. *Reports of the Marine Biological Station of Port Erin*, 83, 51–54
Sitjá-Bobadilla, A., Palenzuela, O. & Alvarez-Pellitero, P. (1995) *Ceratomyxa sparusaurati* n.sp. (Myxosporea: Bivalvulida), a new parasite from cultured gilthead seabream (*Sparus aurata* L.) (Teleostei: Sparidae): light and electron microscopic description. *Journal of Eukaryotic Microbiology*, 42, 529–539.
http://dx.doi.org/10.1111/j.1365-2761
Spanier, E., Finkelstein, Y. & Raikhlin-Eisenkraf, B. (1989) Toxicity of the saupe, *Salpa sarpa* (Linnaeus, 1758), on the Mediterranean coast of Israel. *Journal of Fish Biology,* 34, 635–636.
http://dx.doi.org/10.1111/j.1095-8649.1989.tb03342.x

Shulman, S.S. (1966) Myxosporidia of the USSR. *In*: *Nauka*, pp. 1–504.
Styer, E.L., Harrison, L.R. & Burtle G.J. (1992) Six new species of actinomyxids from *Dero digitata*. International workshop on myxosporeans, October 6–8, 1992, České Budějovice, Czech Republic (abstract only).
Thélohan, P. (1892) Myxosporidies de la vésicule biliaire des poissons. *Compte Rendu Hebdomadaire des Séances de l'Académie des Sciences*, 115, 1091–1094.
Thélohan, P. (1895) Recherches sur les Myxosporidies. *Bulletin Scientifique de la France et de la Belgique*, 26, 100–394.
Théodoridès, J. (1955) Myxosporidies et Microsporidies parasites de poissons marins de Banyuls. *Vie et Milieu*, 6, 60–66.
Tops, S., Lockwood, W. & Okamura, B. (2006) Temperature-driven proliferation of *Tetracapsuloides bryosalmonae* in bryozoan hosts portends salmonid declines. *Diseases of Aquatic Organisms*, 70, 227–236. http://dx.doi.org/10.3354/dao040033
Yokoyama, H. (2003) A review: gaps in our knowledge on myxozoan parasites of fishes. *Fish Pathology*, 38, 125–136. http://dx.doi.org/10.3147/jsfp.38.125
Yokoyama, H. & Fukuda, Y. (2001) *Ceratomyxa seriolae* n. sp. and *C. buri* n. sp. (Myxozoa: Myxosporea) from the gallbladder of cultured yellowtail *Seriola quinqueradiata*. *Systematic Parasitology*, 48, 125–130. http://dx.doi.org/10.1023/A:1006432526089
Yokoyama, H., Itoh, N. & Tanaka, S. (2005) *Henneguya pagri* n. sp. (Myxozoa: Myxosporea) causing cardiac henneguyosis in red sea bream, *Pagrus major* (Temminck & Schegel). *Journal of Fish Diseases,* 8, 479–487. http://dx.doi.org/10.1111/j.1365-2761.2005.00655.x
Yokoyama, H., Kawakami, H., Yasuda, H. & Tanaka, S. (2005) *Henneguya lateolabracis* sp. n. (Myxozoa: Myxosporea), the causative agent of cardiac henneguyosis in Chinese sea bass *Lateolabrax* sp. *Fisheries Science*, 69, 1116–1120. http://dx.doi.org/ 10.1111/j.0919-9268.2003.00736.x
Zaika, V.E. (1966) The protozoan parasite fauna of fish of the Black Sea. *In*: Delyamure, S.L. (Eds.), *Helminth fauna of animals in Southern Seas*. Kiev: Naukova Dumka, pp. 13–31.