Relazione finale del progetto:

Exploring the relative contribution of biological invasions and climate change on parasite-mediated decline of native mussels in Europe.

A variety of parasite taxa - protozoans, ergasilid copepods, oligocahetes, chironomids, nematodes, watermites, trematodes and fishes - is infecting freshwater mussels. Parasites have important negative consequences for freshwater mussels. Trematodes may decreases the production of glochidia (Taskinen & Valtonen 1995), causes partial or complete castration (Jokela et al. 2005, Müller et al. 2015), decreases growth rates and physiological condition (Gustafson et al. 2005) increases mortality (Taskinen et al. 1997) and causes changes in shell shape (Zieritz & Aldridge 2011). Adult water mites move about within the mantle cavity and some species consume host mucus and gill tissue (Fisher et al. 2000). Mite eggs which are deposited in mussel gill tissues, and larval mites also may occur encysted in mussel gill or mantle tissues prior to nymphal transformation (Gordon et al. 1979; Fisher et al. 2000). Nonetheless, increased parasite densities impair mussel physiological conditions. Additional stressor is the spread of non-indigenous species (NIS), that can introduce new parasites and/or alter the dynamics of endemic parasites.

Previous research (carried out in 2016, in the frame of the previous Short Term Mobility project) compered the prevalence and impact of parasites in southern (Italy) and northern (Poland) EU and showed 1) that parasite prevalence and intensity was higher in native than invasive species (null in *C. fluminea*) and 2) in the Southern than in the Northern sites. The previous studies have led to further hypotheses. As parasite densities can be expected to increase with global warming, has been proposed focusing on the southernmost location (Lake Maggiore) where native mussel populations declined by 75-90 % after *C. fluminea* introduction.

The project aims were exploring the hypothesis that southern native mussel populations are more impacted by parasite infection, due to both the thermal-induced increase of cercariae production and the increased competition by invasive species. To this aim parasite impact on native species as a function of temperature and presence/absence of alien species were compared in the same site using time and space as key variables. The project were directed at comparing prevalence and intensity of parasites in the native species dominant in Lake Maggiore in relation to:

1) presence/absence of stress due to competition with *Corbicula fluminea*: samples collected before (2002-2006) vs samples collected after *C. fluminea* introduction (2006-2017)

2) presence/absence of thermal stress: samples collected above vs those collected below the thermocline depth limit (15 meters).

The collected mussels from each site were dissected to detect the presence and quantify the number of parasites stages (eggs, larvae, adult) in the different animal organs (gonad, digestive gland, palps, gills, mantle). The following parasites were detected and counted: trematodes (Rhypidocotyle campanula, R. fennica, Bucephalus polymorphus, Aspidogaster conchicola), oligochaetes (Chaetogaster sp.) water mites (Unionicola spp.), bitterlings (Rhodeo spp.). The

obtained data are being analyzed statistically to draw conclusion. These data will be presented at the forthcoming FMCS meeting on mussels disease (La Crosse, Wisconsin, 12-15 March 2018; Abstract attached) and the manuscript will be submitted in the next months to ISI Journal.

Bibliography:

Fisher GR, Dimock RV Jr, Kuhn RE, 2000. The symbiotic water mite *Unionicola formosa* (Acari: Unionicolidae) ingests mucus and tissue of its molluscan host. J. Parasitol. 86:1254-8.

Gordon MJ, Swan BK, Paterson CG, 1979. The biology of *Unionicola formosa* (Dana and Whelpley): a water mite parasitic in the unionid bivalve, *Anodonta cataracta* in a New Brunswick Lake. Canadian Journal of Zoology 57: 1748–1756.

Gustafson LL, Stoskopf MK, Showers W, Cope G, Eads C, Linnehan R, Kwak TJ, Anderson B, Levine JF, 2005. Reference ranges for hemolymph chemistries from *Elliptio complanata* of North Carolina. Diseases of Aquatic Organisms 65: 167–176.

Jokela J, Taskinen J, Mutikainen P, Kopp K, 2005. Virulence of parasites in hosts under environmental stress: experiments with anoxia and starvation. Oikos 108:156-164.

Müller T, Czarnołęski M, Łabęcka AM, Cichy A, Zając K, Dragosz-Kluska D, 2015. Factors affecting trematode infection rates in freshwater mussels. Hydrobiologia 742:59-70.

Taskinen J, Mäkelä T, Valtonen ET, 1997. Exploitation of *Anodonta piscinalis* (Bivalvia) by trematodes: parasite tactics and host longevity. Annls. Zool. Fennici. 34:37-46.

Taskinen J, Valtonen ET, 1995. Age-, size-, and sex-specific infection of *Anodonta piscinalis* (Bivalvia: Unionidae) with Rhipidocotyle fennica (Digenea: Bucephalidae) and its influence on host reproduction. Can. J. Zool. 73:887-897.

Zieritz A, Aldridge DC, 2011. Sexual, habitat-constrained and parasite-induced dimorphism in the shell of a freshwater mussel (*Anodonta anatina*, Unionidae). J. Morphol. 272:1365-1375.

Disentangling the different role of parasites and invasive species in the decline of native mussels

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Parasites have important negative consequences for freshwater mussels, but in the past they have been regarded as non-lethal and without any drastic impact upon mussels populations. Nonetheless, increased parasite densities impair mussel physiological conditions, which causes an increased mortality rate in mussels exposed to other stressors. A recently reported stressor is the spread of non-indigenous species (NIS), that can introduce new parasites and/or alter the dynamics of endemic parasites. To explore the interaction between biological invasions and growing parasites presence we profited of the sharp decline of the dominant native mussel (*Unio elongatulus*) in Lake Maggiore (Northern Italy), after the arrival of *Corbicula fluminea* and *Sinanodonta woodiana*. This study addressed whether: 1) the native species decline was determined by NIS co-introduction of own parasites; 2) introduced species triggered endemic parasite emergence; 3) habitat characteristics affect the interacting impacts of NIS and parasites. To answer these questions we evaluated:
1) the occurrence of parasites (alien/endemic) and the frequency of shared parasites in invasive and native bivalve species;
2) the prevalence and intensity of parasitic diseases in native species:
a. before and after NIS arrival (task 2);
b. in different habitat types and at different depths (task 3)