Proposta di assegno di ricerca

Project title:

Dynamic and epidemiological models for predicting and controlling the parasite outbreaks in Mediterranean farms

Supervisor of the project:

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Brief introduction:

This research project is partially funded by the Horizon 2020 Project called "*New Technologies, Tools and Strategies for a Sustainable, Resilient and Innovative European Aquaculture*" (NewTechAqua).
The department STAT of University of Bologna participates to NewTechAqua with reference to the working package related to the production systems and Big Data analyses.
The aim is to develop epidemiological disease models for predicting outbreaks and evaluating the final fish quality, using data analysis and advanced models that aggregate and combine spatiotemporal information.

Statement of the problem and background

Mediterranean sea farms must face with the difficulties to control parasitic infections in sea cages, that causes mortality and poor fish quality. In particular, *Sparicotyle Chrysophrii* represents one of the main parasitic threats in sea cage breeding of sea bream.

The goal of this research proposal is to analyze large data sets coming from the fish farm *Cromaris*, including ectoparasite counts and, environmental hydrographic variables (e.g. temperature, water currents, etc) at gilthead seabream farms. This data set will be complemented with environmental data and analysed in order to identify potential links between Sparicotyle outbreaks and environmental conditions. We aim to construct a pilot model to predict Sparicotyle outbreaks in different aquaculture areas of Europe, based on a set of innovative methodological tools and algorithms to support finfish and mollusk production system.
In the scientific literature, many mathematical and statistical models have been proposed with the aim of capturing the sea lice dynamics. Rittenhouse et al. (2016) derived a delay differential equation model able to incorporate the effects of seasonally varying temperature and salinity on the sea louse lifecycle. Myksvoll et al. (2018) developed a salmon lice model to measure the infestation pressure along the coast of Norwegian based on a hydrodynamical ocean model. Peacock et al. (2020) used time series and spatial models in order to study the parasite transmission of salmon aquaculture in Pacific Canada.

A schematic synthesis of the mathematical and statistical models that have been used to study the outbreaks, the transmission dynamics and epidemiology of wild and farmed fish is presented by Groner Maya et al. (2016). The families of models that have been used to this aim are: ordinary and partial differential equations, regression models, survival analysis, stochastic processes and complex dynamic system models.

Research question or hypothesis, aim, objectives and deliveries

We aim to develop a comprehensive strategy to monitor and predict the outbreaks of the ectoparasite Sparicotyle Chrysophrii infection in gilthead seabream Mediterranean farms.

Their most relevant aspects are detailed below:

1) A large data set concerning ectoparasite counts and, environmental hydrographic variables (e.g. temperature, water currents, etc) at gilthead seabream farms has been collected. Since the problem with gill parasites is the worst in the first year of growing, the monitoring of the gill parasite Sparicotyle chrisophrii on sea bream is carried out from stocking to cca. 100 g of average fish weight. Cages on farms are checked every month to measure the trend of infestation. A sample is 10-12 of fish is collected for each cage. In case of a lots of parasite anti-parasite baths with Aquacen Formaldehyde (Cenavisa) are done.
2) This data set will be complemented with environmental data publicly available on the EU portal Copernicus Marine Monitoring Environment Monitoring Service (CMEMS) and analysed in order to identify potential links between Sparicotyle outbreaks and environmental conditions. In particular, real time data concerning water quality variables, e.g. water temperature, dissolved oxygen and ammonia concentration, CO2 concentration, pH will be available.
3) Data-driven methodological tools will be applied, in order to construct a monitoring system able to predict sea-lice growth, disease factors and to improve the quality of farmed fish. The main challenging aspect of this task is due to the complex interactions among hosts, parasites and the environment, that correlate with temporal and spatial measures of temperatures, salinity, oxygen and various hydrographic and epidemiological parameters. The monitoring system will aggregate and combine spatiotemporal information in dynamic complex statistical and artificial intelligence models. To this purpose, we will compare to ordinary and partial differential equations, generalized regression models, stochastic processes and the most recent strategies of deep learning (LeCun et al., 2015, Viroli and McLachlan, 2019).
4) The final aim is to develop an innovative epidemiological model to understand the pathways by which pathogens (sea lice) are affecting farmed fish. A comprehension of the possible explanatory variables that have a statistical influence on the outbreaks and on the final quality of fish is also a core of this project.

The Post doc researcher is supposed to learn in detail the relevant aspects related to epidemiological models including spatio-temporal models and dynamic processes, to find original solutions to the research questions previously described and implement them in R, to analyze the farmed bream data provided by *Cromaris* and to tune the methods accordingly. The results will be presented at conferences and submitted for publication to scientific journals. Collaboration with the other NewTechAqua units belonging to several European countries will be required.

References

Groner Maya, L., et al. (2016) Lessons from sea louse and salmon epidemiology, *Phil. Trans. R. Soc. B*, vol. 371, no. 1689.

LeCun, Y., Bengio, Y., Hinton, G., 2015. Deep learning. *Nature*, 521(7553), 436.

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