1. **CURRICULUM ECOLOGY AND ETHOLOGY – University of Florence**

Position with scholarship

Research title: Gut microbiome dynamics in primates across a tropical ecosystem

Supervisor: prof. Francesco Rovero

Human and non-human animal gastrointestinal tracts have co-existed with microbes (bacteria, viruses and fungi) and worm-like parasites (helminths) over millennia. Such communities have co-evolved with their hosts by serving essential functions and providing them with numerous benefits. A variety of factors, including physiology, social interactions, diet, natural and anthropogenic environmental changes are known to shape gut microbiome patterns. Using existing and newly-collected samples and data from a biodiversity hotspot in Tanzania (Udzungwa Mountains), the candidate will investigate the overall gut community interactions, including the structure and function of each gut component, as well as the interplay between each component within hosts and between host and the surrounding environmental microbiome (e.g. soil), in a model ecosystem centred on non-human primates living in tropical forest habitats. The candidate will use uniform high-throughput sequencing platform and bioinformatics pipelines for assessing either micro- and macro-parasite communities of target primate species, as well as that of soil samples from different land uses and forest types, and characterize the dynamics, acquisition and crosstalk within and between hosts, as well as between hosts and their close environments. The candidate will also integrate data on ecological metrics of primate populations to assess their relationships with microbiome dynamics across different forests.

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2. CURRICULUM GENETICS AND EVOLUTION – **University of Florence**

Position with scholarships

Research title: Bioinformatics tools for the reconstruction of the dynamics of human populations of the past

Supervisor: prof David Caramelli

In recent years, the increasingly widespread use of new generation sequencing technologies (NGS) in the archeogenetic field has changed the way we approach the study of human history and evolution. In particular, the ability to obtain millions of sequences per run requires the use of special bioinformatic tools that allow to process and analyze these data with the aim of extracting relevant biological information. The doctoral project involves, through the recovery of genomes of ancient populations produced by our laboratory or stored in the appropriate databases, the reconstruction of the genetic history and lifestyle of human populations of the past. In particular, the candidate must use bioinformatics tools specially developed for the analysis of ancient and degraded DNA, starting from the management of the raw data of sequencing, mapping and annotation of the variants, up to the evaluation of the authenticity of the final data and the estimation of modern contamination . The candidate will also carry out exploratory and descriptive analyzes of the genetic characteristics of the analyzed findings, such as: call of the mitochondrial haplogroups, analysis of the principal components, admixture, molecular determination of sex, paleopathologies and reconstruction of the microbial profile in case of metagenomic analysis.

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3. CURRICULUM GENETICS AND EVOLUTION – **University of Florence**

Position with topic bound scholarship

Research title: The symbiotic plant microbiome as a tool for forage legume improvement

Supervisor: prof. Alessio Mengoni

Mutualistic associations between microorganisms and plants play a fundamental role in the ability of plants to adapt to terrestrial environments. In particular, the symbiosis between plants and nitrogen fixing bacteria is one of the main inputs of organic nitrogen in terrestrial ecosystems and allows host plants, including many economically important leguminous plants, to grow without the use of nitrogen fertilization. This PhD project aims to develop synthetic microbial communities and investigate the genetic determinants responsible for the improvement the host plant growth performance. The model system is made up of alfalfa, a species of high economic value for the production of fodder (it is the fourth crop in temperate climate countries) and as a green manure plant in organic agriculture. Alfalfa can establish through the formation of root nodules, a symbiotic relationship with nitrogen-fixing bacterial microorganisms, called rhizobia. Rhizobia are present in many agricultural soils, however their symbiotic potential is extremely variable, and this can result in the formation of symbioses that are not very effective for the productivity of the plant, especially in stressful conditions, such as those deriving from drought. This project plans to develop and genetically characterize synthetic communities consisting of rhizobia capable of promoting the growth of host plants and improving their tolerance to drought. The research activities will therefore concern the genomic selection and characterization of the strains, the analysis of the microbiome of the soil and the plant after inoculation and the analysis of the transcriptional response of the rhizobia strains and of the plant following the symbiotic interaction.

PhD project financed by MICRO4Legumes grant from the Italian Ministry of Agriculture - http://www.sinab.it/ricerca/il-microbioma-vegetale-simbionte-come-strumento-il-miglioramento-delle-leguminose-foraggere

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4. CURRICULUM PLANT BIOLOGY AND BIOTECHNOLOGY – University of Florence.

Postion with scholarship

Research title: Relationship between macroclimate, microclimate and functional traits in *poikilohydric* organisms: an instrument for the investigation of climate change effects with potential applications in astrobiology

Supervisor: prof. Alessio Papini

P*oikilohydric* organisms, such as lichens and mosses are extremely sensitive to climatic factors since the hydration level of thalli (from which metabolisms depends) is largely influenced by external conditions. This fact has an impact on the distribution patterns of many species as direct response to macroclimate change. However, there is a growing knowledge about the relationship between the distribution of these organisms and the microclimatic factors determining heterogeneity conditions at small spatial level. Under this point of view, the analysis of heterogeneity at microclimatic level is fundamental to understand how *poikilohydric* organisms respond to climate change and how this overlooked component of biodiversity will react. A central point is the analysis of functional traits. Object of the investigation will be the physiological traits linked to the influence of climate climate factors, such as the parameters describing the photosynthetic efficiency of these organisms and the regulation of their hydric metabolism. The link between climate influence and anatomical traits will be investigated and also the effect at the cellular level with microscopic analysis and methods of the 3-D reconstruction of the external shape. This analysis will allow to explore the mechanism influencing the observed distribution patterns allowing the development of forecast methods for the interpretation of climate change. The use of altitude and biogeographical gradients will build the necessary operating framework for developing the research aims.
The understanding of the physiological mechanism of *poikilohydric* organisms will be also useful for potential astrobiology projects dealing with the isolation of organisms able to survive in extreme conditions such as those of other planets of the solar systems.

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5. CURRICULUM GENETICS AND EVOLUTION – University of Ferrara

Position with scholarship

Research title: Inferring demographic history from patterns of modern DNA, ancient DNA and linguistic variation

Supervisor: prof. Guido Barbujani

Recent advances in technologies for genomic analysis, even from degraded samples, have provided us with an unprecedented power to investigate complex aspects of the human past (see e.g. Agranat-Tamir et al. 2020; Antonio et al. 2019). In recent years, the population genetics group of Ferrara has contributed to the assembling of a more detailed, general picture of human demographic history with new data (Tucci et al. 2018), the development of new biostatistical approaches (Ghirotto et al. 2020) and broad analyses of genomic diversity (Reyes-Centeno et al. 2014). We now plan to build on previous research by proceeding in three directions, namely: 1. Characterizing additional ancient human samples at nuclear level, with a particular emphasis on the Iberian peninsula and on a so-far poorly explored prehistoric period, the Mesolithic, where little is known about the genomic background and demographic contacts of the hunter-gatherer populations (see Gonzàlez-Fortes 2017, Gonzàlez-Fortes et al 2019); 2. Analysis of the existing ancient DNA databases for inference of phenotypic traits, such as blood group, or skin and eye colour, in past populations (Breslin et al. 2019); and 3. Comparative analyses of genomic and linguistic variation, looking for either zones in which their patterns coincide, or do not coincide (Longobardi et al. 2015). This way, we hope to cast light on the relative weight of adaptation processes and migratory movements in shaping human diversity in Europe, and on the timing of such evolutionary events.

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6. CURRICULUM ECOLOGY AND ETHOLOGY – University of Ferrara

Position with scholarship

Research title: Temporal evolution of anthropogenic disturbance factors in the Po delta

Supervisor: prof Giuseppe Castaldelli

In the Po delta, numerous factors of anthropogenic disturbance, including eutrophication (Viaroli et al., 2018), to name one of the most relevant, have for decades exerted strong effects on ecosystems, in the scenario of climate change (Milardi et al. , 2018). Another example of generalized anthropic disturbance is that given by invasive alien species (Lanzoni et al., 2018). In the Po delta and, more precisely in its freshwater portion, eutrophication, invasive alien species and climate change may have synergic interactions. However, there are not many reference studies available on these topics. The causal relationship between the introduction of an alien fish species and eutrophication has recently been highlighted (Milardi et al., 2020), and it is possible to hypothesize that there are similar or even synergistic effects, between other species of cyprinids and eutrophication, on the rarefaction and disappearance of plant and animal native species.
Faced with the multiplicity of terms and the complexity of relationships, the most promising investigation strategy to highlight interactions and effects, is the large-scale meta-analysis of ecological data. An example is the recent analysis of fish communities and of the most relevant environmental features, also carried out in the delta area (Milardi et al., 2019). For application purposes, the results of these investigations are completed in the approach of the study of Ecosystem Services (Fisher et al., 2009; Gaglio et al., 2019) which in the Po delta area it is one of the most promising tools to identify the operational lines of contrast and mitigation of these disrupting factors and of climate change effects.

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7. CURRICULUM ECOLOGY AND ETHOLOGY – University of Ferrara

Position with scholarship

Research title: Immune cells of elasmobranchs and teleosts, uninfected and infected

Supervisor: prof. Bahram Sayyaf Dezfuli

The above project will study different type of immune cells of elasmobranchs and infected/uninfected teleosts. Fish from phylogenetic view are an excellent model for study of Vertebrates immune system because they have relatively a simple immune system. Fish immune system protects the organism against pathogens by use of specialized cells called leukocytes which occur in blood and lymphatic system (timo, kidney, intestine, spleen). Leukocytes are divided in two major groups, granulocytes and agranulocytes. As contrary as immune system of teleosts, that of the elasmobranchs is not well known, thus it is worth to have an investigation on this topic. This project will see the cooperation between national universities (Milan, Sassari, Perugia, Rome) and international partners (Bergen, New York).

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8. CURRICULUM ECOLOGY AND ETHOLOGY – University of Ferrara

Position reserved to employees of industrial companies "industrial doctorate" - 1

Research title: Development and assessment of a low-impact sanitization method for various environments and urban contexts based on the use of electrolyzed water: evaluation of biological sustainability.

Supervisor: prof. Elena Tamburini

GATE operates in the R&D sector of devices for sanitizing water and environments based on the in situ production of hypochlorous acid at physiological pH. Pending the development of effective vaccines, the only solution against the spread of COVID-19 seems to be prevention by sanitizing surfaces and environments, and hypochlorous acid has proven to be effective against viruses, bacteria, fungi and spores. The aim of the research is to contribute to the reduction of the risk of contamination and to guarantee the safety of people and operators in the workplace (i.e., public offices, schools, hospitals) by dry spraying of dilute solutions of hypochlorous acid. Sanitization with hypochlorous acid is an innovative technique and still not widespread compared to other systems (ie, ozone, peroxide, hypochlorite). It is therefore necessary to confirm the antimicrobial efficacy (against environmental microbial agents and pathogens, with particular attention to contaminants antibiotic-resistant) and antiviral, human toxicity (through in-vitro studies on cell lines and ex-vivo on 2D and 3D human organs models), and stability in indoor and outdoor environments, at different treatment **times** and different concentration of hypochlorous acid.

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9. CURRICULUM ECOLOGY AND ETHOLOGY – University of Ferrara

Position reserved to employees of industrial companies "industrial doctorate" - 2

Research title: Development and assessment of a low-impact sanitization method for various environments and urban contexts based on the use of electrolyzed water: evaluation of chemical sustainability.

Supervisor: prof. Elena Tamburini

GATE operates in the R&D sector of devices for sanitizing water and environments based on the in situ production of hypochlorous acid at physiological pH. Pending the development of effective vaccines, the only solution against the spread of COVID-19 seems to be prevention by sanitizing surfaces and environments, and hypochlorous acid has proven to be effective against viruses, bacteria, fungi and spores. The aim of the research is to contribute to the reduction of the risk of contamination and to guarantee the safety of people and operators in the workplace (i.e., public offices, schools, hospitals) by dry spraying of dilute solutions of hypochlorous acid. Sanitization with hypochlorous acid is an innovative technique and still not widespread compared to other systems (i.e., ozone, peroxide, hypochlorite), it is therefore necessary to verify the chemical stability of hypochlorous acid, the concentration of secondary species and their impact on the environment and humans. In the sanitization of environments, in particular sanitary environments, the safety and safeguarding of surfaces is of fundamental importance, in particular with regard to electrical materials and metals, with regard to the corrosion processes due to salt and chlorine. The sustainability of the sanitization method will be confirmed through environmental impact analysis via life cycle assessment (LCA), in comparison with the main sanitizing agents currently used.

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10. CURRICULUM ECOLOGY AND ETHOLOGY – University of Parma

Position with scholarship

Research title: The role of ants in Mediterranean agro-ecosystems: ecological, ethological and applicative aspects

Supervisor: prof. Donato A. Grasso

Trophic interactions occurring among the components of terrestrial ecosystems constitute a complex network in which the impact of insects represent a key element. Ants are dominant organisms in most of the terrestrial habitats and may establish a complex network of interactions with virtually every components of their ecosystems at every trophic level. However, the study of their ecological role still appears to be highly deficient within the agro-ecosystems of the Mediterranean region, although these environments are considered hotspots of diversity both as regards ants and for crops and agricultural practices. In some agroecological contexts, some ant species have proved to be promising allies in the biological fight against phytophagous insects, weeds or pathogens. Nevertheless, in most cases, measures aimed at ant control are used to limit the damages attributed to them and which directly concern the crops or populations of biological control agents. However, evidences are limited in the number of cases examined and in the degree of in-depth study conducted so far. The present project aims to deepen the ecological, ethological and evolutionary aspects of the multitrophic relationships established by ants in Mediterranean agro-ecosystems, in order to obtaining useful indications for new management plans. The sustainable management of agro-ecosystems is in fact an essential issue for combining human interests and welfare with the protection of biodiversity and the ecosystem services associated with it. The candidate who will deal with this line of research will have to gather multidisciplinary information useful to clarify various aspects of these interactions in order to develop new biological/integrated pest control programs. For this purpose, an important point will be to check whether ants represent a useful tool for ecologically sustainable agriculture that favors conservative biological control or a potential problem for the environments they colonize. Since at least 270 species of ants have been described so fare in Italy, it is likely that there is no unequivocal answer to these questions and that for the different species the balance needle can move from "potential resource" to "disturbing element" or vice versa depending on the context. Therefore, for the aims of the study it will be necessary to characterize the myrmecological community of some representative agro-ecosystems and verify the impact of some species chosen as a model system to test the above-mentioned hypotheses. Hence, to this line of research a multidisciplinary approach aimed at integrating taxonomic, ecological, ethological and applicative aspects will be essential.

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11. CURRICULUM ECOLOGY AND ETHOLOGY – University of Parma

Position with scholarship

Research title: Nutrient loads and eutrophication of water bodies in the Po river watershed

Supervisor: prof. Daniele Nizzoli

Anthropic activities, such as urban development and agriculture, have considerably affected the transformation, retention and transport of nitrogen (N), phosphorus (P) and silicon (Si) in watersheds, leading to increased N and P loads and decreased Si loads to aquatic ecosystems, also changing their stoichiometry. The resulting eutrophication of waterbodies is generating major changes in the structure and functioning of aquatic ecosystems and has impacts on the goods and services they provide. In recent years, the concept of running water eutrophication has attracted major attention. However, a clear understanding of the factors that influence river eutrophication and its consequences still suffers from uncertainties, due to the complex interactions between nutrient loadings and abiotic (i.e. temperature regime, hydrology) and biotic factors. In this context, the assessment of factors generating N and P loads, the relationship with water quality and ecosystem processes, the identification of criteria for the trophic state classification of river ecosystems and the identification of eutrophic running water ecosystems or at risk of eutrophication, are fundamental actions to understand their responses to anthropic pressure and to plan suitable measures to achieve a good ecological status. The aims of this project are to identify factors that contribute to the formation of N, P and Si loads exported from watersheds and their stoichiometric ratios, and to evaluate the response of river ecosystem processes to nutrient loads. The activities will be mainly focused on watersheds located in the Po river catchment and will include collection and processing of historical series of data of anthropic pressures, nutrient loads and water quality, and specific research activities aimed at investigating the effect of anthropogenic loads on ecosystem processes in running water environments.

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12. CURRICULUM PLANT BIOLOGY AND BIOTECHNOLOGY - University of Parma

Position with scholarship

Research title: Interaction of sulfate metabolism and chromium tolerance in unicellular freshwater green algae

Supervisor: prof. Rossano Bolpagni, prof. Anna Torelli

Sulfate reductive assimilation pathway plays a fundamental role in plant cell defence and in tolerance mechanisms to stress induced by heavy metals. This phenomenon is known as SED (Sulfur Enhanced Defence) and it is mainly based on an increased synthesis of cysteine and GSH, molecules directly involved in the chelation of various metallic ions, chromium included, and in the reduction of oxidative stress. The candidate will evaluate if a different expression/activity of the enzyme of sulfate pathway could be at the basis of the chromium sensitivity. The project aims at 1) the study of sulfite reductase (SIR) and of the enzymes of the cysteine synthase complex, SAT and OASTL, in the two strains of *Scenedesmus acutus* with different chromium sensitivity, used as model organism; 2) verify if an increased cysteine production could represent a mechanism of environmental stress adaptation, through the analysis of microalgae collected in environments with different stress exposure. Microalgae collected in field will be cultured in laboratory and identified with molecular methods. The analyses on the enzyme of the sulfate pathway will be conducted through gene expression analyses by RT-PCR, and enzymatic assays on algae grown in different experimental conditions.

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13. CURRICULUM ECOLOGY AND ETHOLOGY – University of Parma

Position without scholarship

Research Title: Census and assessment of sand and gravel pit lakes in the Po river basin: integrating satellite images with limnological studies

Supervisor: prof. Pierluigi Viaroli, Mariano Bresciani (CNR-IREA)

In the last fifty years, a great number of pit lakes have been formed by gravel and sand quarrying in heavily exploited river basins. After cessation of extraction activities, pit lakes can evolve into valuable aquatic ecosystems that can be managed for the ecological restoration of river margins, i.e. wetlands and biodiversity and related ecosystem services. However, despite their importance they are still understudied and inadequate management preclude the provision of key processes and services. River ecosystems and their lateral aquatic ecosystems respond rapidly to climate-induced and land use changes, often loosing biological components and functions. This project has two main aims: 1) to identify and map the pit lakes in the Po river basin and 2) to assess their hydro-morphology and water quality status in relation to local pressures and climate change. To achieve goal 1), satellite images with high spatial resolution (e.g. Sentinel-2, Rapid Eye) will be elaborated for the realization of a thematic cartography showing the location and evolution of the pit lakes and related aquatic ecosystems. To achieve goal 2) colour and transparency/turbidity of lake waters will be evaluated by satellite images. Changes in land use and riparian vegetation, as well as weather and climate data will also be analysed. Additionally, a sub-sample of pit lakes, representative of the different water colours and morphological conditions, will be sampled and water analysed for conventional chemical parameters. The accuracy of the methods applied will be then handled with appropriate statistical analysis. The satellite derived data along with on site limnological analysis will provide a scientific support for assessing how local pressures and climate changes are impacting on pit lakes, in order to promote a sustainable management of such aquatic ecosystems, e.g. for restoring ecosystem services previously provided by natural ecosystems which have disappeared.

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