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ENVIRONMENT, BIODIVERSITY AND HEALTH IN MOZAMBIQUE

Environment, biodiversity and health in university scientific cooperation in Mozambique

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Abstract
Mozambique and Italy share a history of academic cooperation spanning almost half a century. The topical collection "Environment, biodiversity and health in university scientific cooperation in Mozambique" stems from the desire to collect the scientific progress achieved through this alliance. Research papers in the collection cover themes including biodiversity conservation for the sustainable use of natural resources, diagnostics and molecular epidemiology of genetic and infectious diseases, and the anthropogenic impact on the environment under the one health principle. The sustainable growth of a country depends, to a large extent, on the establishment of solid research capacity, ensuring the ownership and full involvement of local institutions. The availability of adequate scientific research frameworks is critical to guarantee the integrated conservation of the ecological, socio-economic and cultural value of biodiversity. The works published within this collection emphasize the importance of international cooperation in scientific research.

Keywords International University copperation · Biodiversity conservation · One health

1 Background: 45 years of Italian university cooperation in Mozambique

In 1975, when Mozambique became independent, the country had a literacy rate of less than 10%; currently, the literacy rate stands at 58.8%. The government had to face great challenges for its development and modernization, which are only now being solved.

A strong relationship between Italy and Mozambique began with the solidarity networks set up in support of the liberation struggle against Portuguese colonialism, and has spanned from the 1960s to the present date. Through this alliance, Italy supported the constitution of the new independent country and, later was instrumental in promoting peace and political stability in Mozambique. The

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General Peace Agreement that ended a 20-year-long civil war was brokered by mediators of the Italian government and civil society, and the treaty was signed in Rome in October, 1992. Since then, the rate of economic growth has been steadily increasing. There has been a parallel increase in social inequalities within cities and between cities and rural areas. This rapid economic growth, accompanied by exponential urbanization, a significant population growth, and intensive exploitation of natural resources has posed a significant environmental threat, thus requiring an increased sensitivity towards environmental sustainability. Additionally, there is an urgent need to minimize the impact of climate change and its devastating effects to which the country is cyclically exposed (drought, flooding and cyclones among others). The current and future impacts of climate change pose a threat to the country's economic and sustainable development. Mozambique is ranked as the third most vulnerable country to climate change in Africa. Furthermore, the country is still tackling major socio-political issues including extreme poverty, the protection of basic human rights and the maintenance of peace.

In this context, to ensure the consolidation and sustainability of development processes, the Italian cooperation has implemented an inclusive and inter-sectorial approach based on three main axes of investment: human capital, diversification of the economy and the sustainable use of natural resources. Recognizing the importance of education as the basis for sustainable growth of a country, the Italian cooperation has attributed a preeminent role to university cooperation initiatives as one of the main instruments to promote development policies.

Italian university cooperation in Mozambique began in 1977, in support of the Eduardo Mondlane University (UEM) in Maputo, the only university existing in the country at the time. Initial interventions of this cooperation initiative consisted of sending Italian professors to instruct courses that lacked Mozambican lecturers. In the late 1990s, a profound reflection on the model of international cooperation brought about a radical change in the Italian academic cooperation strategy. This included the implementation of applied research to solve the country's priority problems, and consequently, the training of UEM lecturers and researchers and the introduction of advanced technologies. In the past 20 years, several initiatives funded by the Italian cooperation, and more recently by the Italian Agency for Development Cooperation (AICS), promoted applied research in bioscience in Mozambique. In addition, in 2010, a memorandum of understanding for collaboration in Sciences and Research was signed between the Italian "Accademia dei Lincei" and the newly established "Academia de Ciências de Moçambique". Initiatives have been carried out and are in progress for the evaluation and supervision of research projects, postgraduate training and organization of scientific meetings and conferences.

2 The topical collection

The topical collection was conceived to report the scientific work carried out within academic cooperation initiatives targeting biological research in Mozambique. Over the years, these initiatives were designed to promote the integrated One Health, One Medicine approach, where healthy environments, animals, plants, and humans together contribute to the well-being of the planet.

The first intervention implemented by academic cooperation initiatives was to support Mozambican Institutions in consolidating molecular diagnostics and molecular epidemiology protocols for infectious and non-infectious diseases affecting humans, animals and plants.

Within these initiatives, several studies have been conducted over the years, applying molecular methods for the characterization of major pathogens associated with human, plant and animal infections in Mozambique (Folgosa et al. 2001; Taviani et al. 2008; Langa et al. 2014; Sumbana et al. 2015; Mazivele et al. 2018; Sumbana et al. 2021; Manique et al. 2022). Molecular methods were also applied to the surveillance of nosocomial infections in order to contain and prevent the dissemination of major nosocomial pathogens and the spread of antimicrobial resistance, especially that of the beta-lactamases producing *E. coli*, and *mcr-9* carrying *Enterobacteriaceae* (Sumbana et al. 2022).

Hemoglobinopathies are monogenic diseases with a significant impact on public health. However, no information on the prevalence hemoglobinopathies and associated genotypes was available in the country. To fill this gap, a study successfully identified haemoglobinopathies of clinical significance such as α-thalassemia, hemoglobin S and their associated genotypes within the Mozambican population (Brito et al. 2022).

A molecular approach was also applied to the surveillance of the white spot syndrome virus (WSSV), which was first identified in 1992 and is now known to be one of the most contagious and lethal viral pathogens in crustacean aquaculture. In Mozambique, WSSV was first detected in 2011, in cultured shrimp after mass mortality in aquaculture ponds. Current data attest its high prevalence in both wild and aquaculture crustaceans, demonstrating the need for constant monitoring and implementation of preventive measures to preserve national aquaculture production (Mondlane-Milisse et al. 2022).

In the past decade, Mozambican researchers have demonstrated great interest towards the study of zoonoses,

aiming to support national initiatives to control their transmission at wildlife–livestock–human interface areas. Several studies supported by academic cooperation initiatives focused on vector transmitted diseases, which are considered major constraints to agriculture and livestock development in Mozambique, such as tick-borne rickettsioses and tsetse fly-transmitted trypanosomosis (Mulandane et al. 2018, 2020; Magaia et al. 2020). Thus, it is important to assess the distribution of both pathogens and vectors in areas where cattle are kept. An extensive study was conducted in the Matutuine district (Southern Mozambique), which represents the southernmost distribution of tsetse flies and trypanosomes in the African continent and the world. The data generated on both cattle and tsetse flies infection rates provide scientific evidence to support any future control measures in this region (Sigauque et al. 2022; Ofiço et al. 2022). As part of the initiatives for zoonoses research activities, a study was also carried out regarding cystic echinococcosis, a parasitic disease caused by cestodes, in livestock of rural communities living in Limpopo National Park and adjacent buffer zone. The study aimed to highlight the risks associated with the transmission of neglected parasitic zoonotic pathogens in wildlife/livestock/rural community interface areas (Zaffarano et al. 2023).

Moreover, academic cooperation with the Natural History Museum of Maputo led to the description of two new pollen beetle species in southern Mozambique (Sabatelli et al., 2020). Furthermore, for the first time in Mozambique, an approach based on mitochondrial DNA haplotyping was applied to study genetic diversity and geographical distribution of freshwater fish species in 4 main rivers of South Mozambique. The lack of information on native freshwater species in the country represents a constraint for biodiversity conservation.. The molecular barcoding approach revealed the presence of both the allochthonous and native species displaying sympatric conditions, and novel haplotypes were described for the first time, opening new perspectives on the taxonomy and conservation of Tilapiini in Mozambique (Ferrari et al. 2022).

Additionally, the widespread problem of water pollution is a threat to Mozambique rivers and other bodies of water into which potentially harmful biological and chemical contaminants are introduced as a consequence of human activities. The increasing eutrophication of the freshwater ecosystems of southern Mozambique increased the occurrence of cyanobacterial bloom and the consequent release of cyanotoxins, which can cause considerable hazards for human health (Pedro et al., submitted). Furthermore, the artisanal and industrial gold mining activities in Manica Province introduce mercury into the waters of the Revuè River making it one of the most threatened systems in Mozambique. For the first time in Mozambique, mercury pollution was monitored in water, sediments and fish through the measurement of both the concentration of contaminants and the expression of metallothionein (Monjane-Mabuie et al. 2022).

Biodiversity can also be an important asset to promote the fair and equitable sustainable development of the country. However, Mozambique's biodiversity richness remains underestimated and needs to be properly documented. As a case study for the effective implementation of the Nagoya Protocol, signed within the framework of the Convention of Biological Diversity, an ethnobotanical survey in the Limpopo National Park, Gaza Province, Mozambique, aimed at assessing the traditional knowledge related to the use of plants, was conducted(Nicosia et al. 2022). This study was part of a larger effort to improve the botanical knowledge of the country, which accounts for 7099 taxa (5957 species, 605, subspecies, 537 varieties), 87% of which are native to Mozambique (Odorico et al. 2022). The knowledge about biodiversity must be consolidated by means of an appropriate digitalization process. This is the case of the entomological collection of the Natural History Museum of Maputo, which is stored in a dataset containing geographical and taxonomical information on 409 species belonging to seven orders and 48 families (Sandramo et al. 2021). After digitalization, biodiversity data will be made available to decision-makers and planners, researchers, eco-tourists and the general public, through the Biodiversity Network of Mozambique (BioNoMo). This is the first infrastructure for the standardization, aggregation and publication of biodiversity information that has been created to aggregate occurrence records of plants and animals in the country (Malatesta et al., submitted), and currently contains about 180,000 records from 8 institutional datasets. However, biodiversity is under threat due to the impact of climate and land use change. Therefore, new technologies are needed to monitor such processes to develop effective management and conservation strategies (Cianciullo et al. 2016).

3 Way forward

Mozambique is facing several environmental issues that alone or in synergy can have a significant impact on the livelihood of local people and on the sustainable development of the country. These include climate change with increasing drought and extreme meteorological events, biological invasions, spread of transmissible diseases, overexploitation of marine and terrestrial natural resources, and loss of biological diversity. To develop appropriate policies and implement them in an effective way, relevant Mozambican institutions have been technically and scientifically supported by Italian Universities as this Topical Collection clearly demonstrates. Thanks to the commitment of the Italian Agency

for Development Cooperation, this support will continue in the future and will aim at strengthening existing training and research facilities and creating new ones to reinforce the scientific collaboration between Italy and Mozambique.

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Declarations

Conflict of interest The authors have no conflicts of interest to declare.

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