Meeting report

Challenges in the conservation and sustainable use of genetic resources

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The meeting on ‘Genetic Resources in the Face of New Environmental, Economic and Social Challenges’ held in Montpellier (France) from 20–22 September 2011 brought together about 200 participants active in research and management of the genetic diversity of plant, animal, fungal and microbial species. Attendees had the rare opportunity to hear about agronomy, botany, microbiology, mycology, the social sciences and zoology in the same conference. The research teams presented the results of about 50 projects funded by the French Foundation for Research on Biodiversity to preserve genetic diversity carried out in Africa, Asia, Europe and the Americas. These projects aimed to better understand and manage genetic resources in a rapidly changing world (e.g. structural changes in the agricultural industry, the need for climate change mitigation and adaptation, the challenge of achieving food security despite the growing world population and changing dietary habits, the opportunities provided by the many new molecular biology tools, the problems caused by widespread scientific budget cuts). The meeting also hosted some roundtables open to all participants which provided a forum to establish a much needed dialogue between policy-makers, managers and researchers.

Keywords: crop biodiversity; genetic tools; in situ conservation; intra-specific diversity; population fragmentation; seed exchange networks

1. INTRODUCTION

The conservation and sustainable use of genetic diversity are essential to meet a number of challenges facing humanity, from coping with the predicted climate changes to achieving food security despite a still growing world population. A meeting held in Montpellier (France) from 20 to 22 September 2011 provided an overview of issues related to managing genetic resources in the face of new environmental, economic and social challenges. About 200 attendees (scientists, students, practitioners and policy-makers) discussed a series of projects funded by the French Foundation for Research on Biodiversity (or by its predecessors). The meeting was of high quality and international relevance, not only because the projects presented have been or are being carried out in all continents and on a wide range of taxa, but also because the issues and approaches discussed are important for everybody involved in interdisciplinary research on biodiversity and sustainable development. The following report presents some highlights from the meeting, pointing out common themes among the talks.

Human beings have made use of genetic resources since the agricultural revolution, long before the concepts underlying modern genetic theory became available (A. Charrier). The development of our understanding of genetics over the past decades was made possible by advancements in scientific tools, but was also accompanied by loss of genetic resources, e.g. owing to mechanization of agriculture and fragmentation and degradation of natural ecosystems. At the same time, there has been a heightened perception of the value of genetic diversity. This has led to attempts to offset the trends towards, e.g. the loss of tree genetic diversity and traditional crop varieties. For example, a project aimed to reconstruct the evolution of the genetic diversity of bread wheat grown across France over the last century. The study showed one progressive loss over the last decades particularly for regions at the margins of the country, whereas wheat grown in central regions had already been homogenized by the beginning of the study period (R. Goffaux). Similar processes are occurring with livestock genetic diversity. Worldwide, there about 8000 breeds of livestock, of which approximately 7000 are local. Many of these local cattle breeds are imperilled by the cosmopolitan and more productive breeds, although the latter are generally less adapted to local and changing conditions (I. Hoffmann).

2. INTRA-SPECIFIC DIVERSITY AND ENVIRONMENTAL CHANGE

There is a consensus that genetic resources should not be studied in isolation, but in parallel with issues in applied conservation, e.g. the maintenance of disease resistance. Much progress has been made in identifying the genetic basis of population adaptation (Y. Vigouroux). For example, a study of the relations between tolerance of various Citrus species to salinity and their phenotypic and genetic diversity identified four gene candidates for salt tolerance in F₂ populations obtained from Citrus reshni (tolerant) and Poncirus trifoliata (susceptible). In the case of the European ash species Fraxinus excelsior and Fraxinus angustifolia, natural hybrids are already found in woodlands. A study is underway to assess the adaptability of this species complex to drought (R. Joseph). A major additional challenge to F. excelsior in Europe is now posed by the emerging fungal pathogen Chalara fraxinea [1]. Studies of the differential susceptibility to the pathogen of various ash species are needed. Interestingly, intra-specific variation in the susceptibility of F. excelsior to C. fraxinea has been reported [2], underlining the importance of genetic diversity as an insurance against new diseases [3]. Emerging pathogens are likely to be facilitated by the co-occurrence of climate shifts, land-use change and increasing international trade [4]. Newly introduced pathogens often show reduced intra-specific variation owing to founder effects. For C. fraxinea in Poland (where ash dieback has been observed since the 1990s), it was possible to distinguish between
pathogen populations in the lowlands and in the uplands, the latter showing reduced intra-population variability [5]. Markers have been developed to study the genetic structure of a more generalist plant pathogen, *Botrytis cinerea*, which is causing damage worldwide to a wide range of plant species (C. Neema) and whose genome has been recently been compared with the one of another aggressive and widespread pathogen (*Sclerotinia sclerotiorum*) [6].

3. NEW APPROACHES AND TOOLS TO STUDY AND MANAGE GENETIC RESOURCES

Tighter European Union rules on the use of chemical pesticides are likely to increase the role of genetic diversity in order to keep many pathogen of crops under control [7]. Nonetheless, a more environmentally friendly management of diseases is just one of the reasons to preserve genetic diversity. Diversity at the level of landraces (locally grown varieties with a history of use) is also important from a cultural point of view, as shown by a series of participatory breeding projects aiming at the *in situ* conservation of wheat landraces in France (I. Goldringer). For both crop and animal husbandry, there is the need to better integrate *ex* and *in situ* conservation (e.g. use of reintroduction simulations), so that farmers and breeders can take advantage of the available collections and that these are not kept as a museum without visitors (C. Danchin-Burge). Conversely, for invasive species such as *Alexandrium tamarense*, a dinoflagellate whose toxins can result in paralytic shellfish poisoning, newly developed microsatellites can provide insights on invasion routes and control methods (E. Masseret). A meta-proteomic approach was instead used to characterize the functional diversity of bacterial communities in ecosystems contaminated by arsenic (F. Arséne-Ploetz). Integrating the many new molecular tools available (e.g. pyrosequencing) with applied field research as well as the use of scenarios remains a challenge for a successful management of genetic diversity (L. Doyen).

4. MANAGEMENT OF GENETIC RESOURCES AT THE WILD–DOMESTIC INTERFACE

Most genetic research on agrobiodiversity has focused on cultivated and farmed species, with insufficient attention to the wild relatives of crops and domesticated animals (G. Wilcox). This is a problem made particularly acute by the frequent endangerment of wild relatives (owing to human activities such as overgrazing). At the same time, domestication has inevitably resulted in the loss of some genetic diversity, so that preserving crop wild relatives in their natural ecosystems is essential to maintain genes which may prove important in adapting crops to environmental change. The necessity of preserving wild relatives also applies to cultivated fungi (e.g. *Agaricus bisporus*), whose study is under-resourced, in spite of the growing role of cultivated mushrooms in many developing countries (P. Callac). For salmonids, domestication for aquaculture results in the evolution of fish unable to thrive again in natural, much tougher conditions. This process reduces the disruption to the highly structured genetic diversity of natural populations caused by the reintroduction of domesticated fish into lakes and streams, because only a small percentage of reintroduced fish is able to reproduce (P. Berrebi).

5. NEW USES OF GENETIC DIVERSITY

Genetic diversity is the ultimate basis for higher levels of biodiversity, such as species richness and ecosystem variation. In turn, genetic and specific diversity enable the functional adaptation of ecosystems to their environment. Therefore, the many ecosystem services, we human beings often take for granted would not be available without genetic diversity [8]. In many cases, the connections between genetic diversity and ecosystem services are rather cryptic. For example, a study showed that bacterial diversity in the soil can be used to reduce the use of chemicals in the protection of legume cultivation (D. Faure). Similarly, it is now well-known that crop species diversity at the field level can provide a strategy to reduce disease outbreaks, although implementation by farmers is still too limited to make a difference at the landscape level (S. Saint-Jean). Among the innovative uses of genetic diversity presented at the meeting, the development of batteries using microbial biofilms obtained from mangrove ecosystems in Guyana received praise but also raised some concern, owing to the vulnerability of mangrove forests to human disturbance (F. Robert).

6. GOVERNANCE OF GENETIC DIVERSITY

A common theme throughout the meeting was the importance of stakeholder engagement in projects to conserve genetic diversity. The term ‘governance’ reflects this wider variety of involvements from engagement of farmer communities in collaborative research projects to an enhanced dialogue between scientists and policymakers (e.g. to identify research questions that would need answers as a matter of priority; [9]). The last session of the meeting was specifically devoted to governance aspects. One project monitored the development of markets for improved crop varieties in Vietnam; despite some success in developing *ex situ* collections on which to base the breeding programme, there is still little knowledge about the exchange flows of the varieties (F. Thomas). The key role of circulation networks among farmers in the conservation of *Manihot esculenta* and *Chenopodium quinoa* was demonstrated for Brazil and Chile (L. Emperaire). Holistic understanding and management of seed exchange networks need interdisciplinary research, with involvement of anthropologists, agronomists, conservation biologists, geneticists and modellers (D. McKey). Similarly, given the expected impacts of climate change on agricultural systems, there is a need for datasets on seed exchange networks and intra-specific diversity to be coupled with climate change models, as shown by a study of maize landraces along an altitudinal gradient in eastern Mexico (M. Bellon).

7. CONCLUSION

There are many challenges in achieving sustainability in relation to genetic diversity. The interactions among these challenges further complicate the issue: land-use
intensification not only has direct effects on grown varieties, but also results in human migrations from rural to urban areas, which may lead to further loss of landraces and knowledge about them. The effects on genetic resources of a still growing human population, of evolving dietary habits and of globalization of trade will not act in isolation, but operate at the same time as those of climate change, including our responses to it.

The picture is not completely gloomy: there are now opportunities to manage genetic diversity that were undreamt of only a few decades ago, thanks to the many new tools of molecular biology. However, this machinery often results in amounts of data that are difficult to manage, particularly in times of increased specialization and scientific budget cuts. The meeting was a rare opportunity to exchange views on all these issues thanks to roundtables open to all participants, which were attended not only by researchers, but also by some policy-makers. The main message of the concluding session was an increased need for interdisciplinarity in research on genetic resources and for more participative approaches in their management.


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