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Crop wild relative

Issue 6 January 2008

The newsletter of the Crop Wild Relative Specialist Group

Conserving plant genetic diversity
for use now and in the future

CWRSG
Crop Wild Relative Specialist Group

Crop wild relative

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Front cover: *Vavilovia formosa* (Stev.) Fed., a wild relative of the pea, growing on scree slopes in Armenia. Photo: Ivan Gabrielyan, Institute of Botany, Armenian Academy of Sciences.

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IUCN
The World Conservation Union
SSC
Species Survival Commission

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Editorial

Readers of *Crop wild relative* will be aware that issues 1–5 of the newsletter were published under the auspices of the successful EC-funded PGR Forum project (http://www.pgrforum.org). Before the project ended in 2005, the seeds had already been sown for the establishment of the Crop Wild Relative Specialist Group (CWRSG) of the IUCN Species Survival Commission (SSC) and it was decided that *Crop wild relative* would become the CWRSG's regular newsletter. After a short hiatus in its publication, we are therefore extremely pleased to bring you this issue—the first to be published under the auspices of the CWRSG.

This is the longest issue of *Crop wild relative* to be published so far, and as we are now planning to publish the newsletter annually, we hope that future issues will be equally well packed with news about crop wild relative (CWR) conservation and use. In this issue, we have introduces some specific themes. First, we have two fascinating articles about the potential use of CWR in crop improvement—after all, the primary reason for conserving these species is because they are potential gene donors for crop improvement and future food security for the world's ever-increasing human population. This will be continued as a regular theme, so we will be seeking further articles on the use of CWR in crop improvement for future issues. We then have two pieces focusing on CWR diversity and conservation at regional level—one for the Pacific region and one for Europe. We will be publishing regional overviews in each issue and will therefore be contacting the CWRSG Regional Network Leaders, asking them to contribute to future issues. Following the regional perspectives, we have two commentaries on CWR diversity and conservation at national level, for India and Russia. Again, we will be seeking national reviews of CWR diversity and conservation for each future issue of *Crop wild relative*. The final section hosts a range of features on CWR diversity and conservation and the newsletter concludes with a note from the IUCN Species Programme, under which the CWRSG operates.

Those of you who are already members of the CWRSG will already be aware of current and planned CWRSG activities. Since the group was formally established in 2006, we have been working on building the foundations of the group—inviting members, including Regional Network Leaders, and producing the group's operational strategy. The operational strategy, which can be read online at http://www.pgrforum.org/documents/cwrsg/cwrsg_operational_strategy.pdf, provides the structure within which the CWRSG operates. It includes a detailed Strategic Plan for 2006–2010, listing the group's proposed actions and providing a benchmark from which to evaluate our progress. Some of the targets included in the Plan are quite ambitious, but we do have the expertise and power available to achieve them, given the will and drive to take them forward. Some of the actions are related directly to the targets included in the draft Global Strategy for Crop Wild Relative Conservation and Use (http://www.pgrforum.org/Documents/Conference/Global_CWR_Strategy_DRAFT_11-04-07.pdf), which was a major outcome of the First International Conference on Crop Wild Relative Conservation and Use held in Sicily, Italy in September 2005. We are exploring options for formalizing the Global Strategy as an add-on to the FAO International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) and in the context of the Convention on Biological Diversity (CBD). We urgently need to get governments on board and agree to the provisions of the Global Strategy to ensure that CWR are at least being formally recognized as a priority for conservation action. However, as we all know, it takes a long time for policy and legislation to become 'fixed' and we cannot afford to wait before taking action. The CWRSG can therefore be used as a vehicle for enacting and/or promoting many of the targets of the Global Strategy. The group can also act as a lobbying instrument, since the voices from many experts across the globe are louder than just one! We urge all readers of this newsletter to review both the Global Strategy and the CWRSG Strategic Plan (included in the operational strategy) to see where you can make a contribution. Please contact the CWRSG Co-Chairs, Dr. Ehsan Dulloo (e.dulloo@cgiar.org) or Dr. Nigel Maxted (n.maxted@bham.ac.uk) if you would like to offer to contribute to the work of the group or to discuss aspects of the CWRSG.

Recently, it has been estimated that there are around 216,000 CWR species globally; however, this includes the widest range of cultivated plants possible. If we narrow this list down to those that are wild relatives of the major and minor food crops, we are left with 10,739 species and if we remove all but the primary and secondary wild relatives, we are left with only 1200 species (Maxted and Kell, 2008). These are crude estimates based on our knowledge of the CWR flora of Europe and the Mediterranean region. Nonetheless, these figures do make the initial task of conserving global CWR diversity a little less daunting. If we can initially assess the conservation status of these 1200 species and secure their conservation both *in situ* and *ex situ*, we will have gone a long way towards ensuring that the highest priority genetic diversity is conserved and made available for use in crop improvement programmes as a contribution to future worldwide food security. Of course, we realize that the task is not a straightforward one and that there are many complex issues to be addressed; not least because of the varying priorities of individual nations. However, we now have the foundations in place to begin work in earnest to systematically conserve CWR genetic resources globally. By working together, we can make a real impact!

We hope you find this issue of *Crop wild relative* to be a stimulating read. Please let us know what you would like to see in future issues and please send us your contributions for the next issue!

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Pictured above: *Lathyrus latifolius*. Photo: Gabor Vörösváry

Using CWR in crop improvement
Daucus species promise a glossy future in carrot production

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The genus *Daucus* is mainly distributed in Europe and in the Mediterranean area (Saenz Lain, 1981) and according to Euro+Med PlantBase (data accessed via CWRIS – http://www.pgrforum.org/cwris/cwris.asp – date of query: 27 September 2007), divided into 26 European species. *D. carota* encompasses 16 subspecies including the cultivated form *D. carota* subsp. *sativus*. Altogether, they form a gene pool of which the value to agriculture is far from being fully investigated and understood.

The carrot is one of the most popular vegetable crops in the world, with a total production of 24.2 million tonnes worldwide in 2005 (ZMP, 2006) of which approximately 1/5 are produced within the European Union (EU-27) (EUROSTAT, 2007). As all crops, the carrot suffers from a range of diseases such as the leaf diseases *Alternaria dauci* and *Cercospora carotae,* root rot diseases caused by *Alternaria radicina*, *Botrytis cinerea* and *Mycocentrospora acerina* (BAZ, 2007), or pests such as *Meloidogyne javanica* (Simon *et al.*, 2000) and *Pratylenchus crenatus* (Hey and Pethybridge, 2005), just to mention some.

Lothar Frese

Figure 1. *Daucus carota* subsp. *hispanicus* photographed in Menorca, Spain.

The challenge to plant breeding today is to forecast the variety features required to cope with uncertain growing conditions tomorrow. Plant breeders—in particular, those working with biennial crops such as carrots—are used to anticipating the demand for novel varieties by market gardeners 10–20 years ahead. As climate models predict increasing drought stress conditions in agricultural production areas in the next few decades, it is only prudent and consequent to search for drought tolerant germplasm today.

A theoretical analysis of the impact of increasing temperatures in Europe on sugar beet (Pidgeon *et al.*, 2000) indicates that the yield will be dramatically affected due to water shortage in rain-fed production areas. As carrots are mainly grown on sandy or loamy soils, this crop may suffer even more from drought stress in future as compared to sugar beet. The Institute of Horticultural Crops of the BAZ therefore started to describe traits of wild species that might help to improve drought tolerance of the cultivated carrot.

The investigation began when wild and cultivated germplasm was screened for disease resistance in the field and greenhouse. The glossy leaf surface and the very healthy vital plant habit of the subspecies, *D. carota* subsp. *gummifer*, *D. carota* subsp. *commutatus*, *D. carota* subsp. *gadecaei* and *D. halophilus,* attracted the scientists' interest immediately. Fascinated by this feature, the Institute of Horticultural Crops (IGK) started to investigate the morphology of the leave surface.

The trait 'glossy leaf' of the wild species can be easily seen by eye. These crop wild relatives (CWR) are therefore well suited to demonstrate how traits are evaluated and how they are transferred from the wild to the cultivated form. Breeders order genetic resources from gene banks and botanic gardens, or collect material in the natural habitat when need arises and expect that resources are then available. Past experience could induce breeders to assume that CWR will be readily available forever. In view of the unabated species extinction rate, this is not necessarily the case. This paper was also written to assess and exemplify how well the genetic resources of the four taxa are managed *in situ* and *ex situ* and how plant breeders and conservation biologists could interact to improve the management of an important genetic resource .

The research work at the Institute of Horticultural Crops highlights the need for more systematic cooperation between the plant breeding sector as users of biological resources and the nature protection sector as providers of these resources. Cooperation will create a better understanding for the plant breeders needs which in turn will underpin the need for active species protection measures and thus support the efforts of conservation biologists.

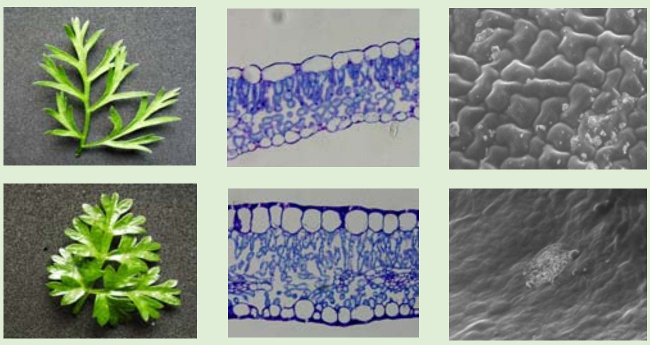

Figure 2. Comparison of leaf structures between *D. carota* subsp. *sativus* (first row) and *D. carota* subsp. *commutatus* (second row). From left to right: leaflet, sectional view of the leaf, surface of the adaxial epidermis cells.

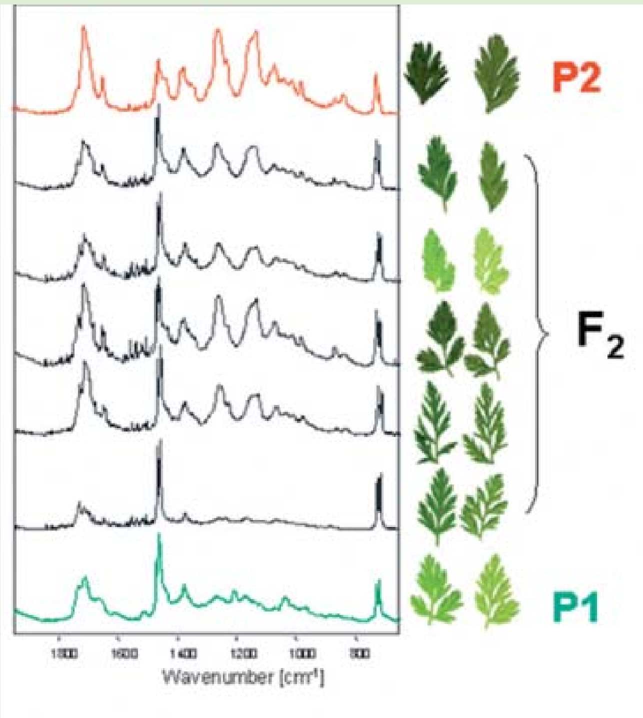

Figure 3. FT-Infrared spectra of the epicuticular waxes and leaf segments of F2 single plants obtained from a cross between cultivated carrot (P1, Yel-mutant, colour marker) and a wild relative (P2, *D. carota* subsp. *gadecaei*).

Description and use of the trait 'glossy leaf'

The glossy leaf trait is caused by a smooth waxy layer reflecting light. Epicuticular wax layers have been described for many plant species and are often considered a natural resistance barrier against pathogens. Furthermore, epidermis, cuticula and epicuticular wax layers play a central role in controlling assimilation, transpiration and respiration and act as protection from UV-radiation. Within the genus *Daucus* a large phenotypic variation of the leaf anatomy can be found which has never been investigated systematically. The Institute of Horticultural Crops (IGK, T. Nothnagel) along with Institute of Resistance Research and Pathogen Diagnostics (IRP, F. Ehrig) therefore studied leaf structures in a *Daucus* working collection by means of histo-morphological analysis and the raster electronic microscope. The differences between the two major groups are illustrated in Figure 2. Amongst other species, the first group encompasses the cultivated carrot with a matt surface and a leaf thickness less than 200 µm. The surface is characterized by the swell of epidermis cells overlaid by a comparatively thin cuticula and epicuticular wax layer. The second group is represented by *D. carota* subsp. *commutatus* having a smooth, very shiny leaf surface and leaves appearing succulent. Histological analysis revealed thickened outer walls of the epidermis cells, an armed cuticula and waxy layer, respectively, as well as sunken stomata and a partial coverage by 'cuticular vestibules'. All traits are typical for plants adapted to arid sites. The species *D. halophilus* and three subspecies of *D. carota* described in this paper all occur in arid and radiation-exposed habitats.

Crossing experiments have shown that the leaf traits can be transferred from the wild form to the crop species. The Institute of Horticultural Crops is further analysing the trait as to establish breeding methods and new breeding material. The transfer of the trait from the wild form into the breeding pool without changing the agronomic important features as well as the nutritional quality of the breeding material is the long term target.

A selection method was developed in cooperation with the Institute for Plant Analysis (IPA) making an effective characterization of the epicuticular wax layer possible. By means of Fourier-Transform-Infrared-Spectrometer, genotype specific fingerprints can be made for characteristic wax components (Fig. 3). In the meanwhile, plants showing the typical leaf traits of the wild relatives could be selected in offspring of different crosses of wild and cultivated carrots. A number of undesirable root traits of the wild relatives such as root branching are still present in these plants, which almost certainly can be eliminated by backcrossing and selection.

Distribution and conservation status of the taxon

The geographic distribution of the species and subspecies used as donors of the trait 'glossy leaf' is summarized in Table 1. Any breeding programme starts with the search for suitable donor parents within the breeding pool and if the breeding material lacks the required genetic variation, breeders screen exotic material, including wild species.

To ascertain how well the three subspecies of *D. carota* and *D. halophilus* are maintained *ex situ* and *in situ,* six information systems were queried using CWRIS as the starting point. CWRIS contains information on the valid nomenclature of CWR and information on their natural distribution area as well as links to other information systems. For each taxon, further information was searched in GBIF (specimens, records), EURISCO, EUDB and GRIN (*ex situ* accessions) and EUNIS (*in situ* stands in

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Table 1. Distribution of four *Daucus* taxa (data extracted from CWRIS – http://www.pgrforum.org/cwris/cwris.asp)

Country / region	Taxon			
	D. carota gummifer	*D. carota commutatus*	*D. carota gadecaei*	*D. carota halophilus*
Albania	-	+	-	-
Baleares	-	+	-	-
Corse	-	+	-	-
Croatia	-	+	-	-
Former Jugoslavia	-	+	-	-
France	+	+	+	-
Greece	-	+	-	-
Great Britain	+	-	-	-
Italy	+	+	-	-
Kriti (incl. Karpathos, Kasos, Gavdhos)	-	+	-	-
Libya	+	-	-	-
Malta	-	+	-	-
Portugal	-	-	-	+
Sardegna	+	+	-	-
Sicilia	+	+	-	-
Spain	+	+	-	-
Tunisia	+	+	-	-
Turkey-in-Europe	-	+	-	-

Figure 4. *D. carota* subsp. *gummifer* grows in protected sites. Only six of the eight site designations are depicted on the map.

Natura 2000, Biogenetic Reserves or Corine Biotopes) and the IUCN Red List of Threatened Species. The links to these information systems are provided below.

A summary of the query results is shown in Table 2. The four taxa are listed by CWRIS. No records were found in GBIF. The number of accessions held *ex situ* is very small, ranging from one to eight accessions. EUNIS contains no information on subspecies *commutatus* and *gadecaei*. Subspecies *gummifer* occurs in eight (Fig. 4) and *halophilus* in a single protected site. None of the taxa concerned are Red Listed; in fact none of the taxa in the genus *Daucus* are found in the Red List, presumably because their conservation status has never been systematically investigated.

Table 2. Search for data on four *Daucus* taxa in online information systems: summary of queries. + = records available, - = no records. Ciphers in boxes describe the number of accessions held *ex situ* (EURISCO, EUDB, GRIN) or occurrences (EUNIS).

Information system	Taxon			
	D. carota gummifer	*D. carota commutatus*	*D. carota gadecaei*	*D. carota halophilus*
CWRIS	+	+	+	+
GBIF	-	-	-	-
EURISCO	8	1	2	1
EUDB	3	5	2	1
GRIN	4	2	1	1
EUNIS	8	-	-	1
IUCN Red List	-	-	-	-

Perspective

As exemplified with the four *Daucus* taxa, wild carrots contain novel genetic variation useful for plant breeding that should either be maintained *in situ* or conserved as seed samples in *ex situ* holdings. Without a doubt, this type of germplasm is under-represented in gene banks and botanic gardens and its *in situ* protection status is undetermined.

EUNIS data refer to protected sites. Since the four taxa can also occur outside protected areas, we cannot conclude from the information contained in EUNIS that these CWR are threatened. Notwithstanding, it be can be noticed that the information systems visited lack data that are required to assess the threat status of the taxa. An inventory (i.e., inclusion of existing data not yet contained in the information systems or recording of fresh data in the habitats) of the exact distribution of the taxa and their populations would be a first step towards an improved management of theses genetic resources to ensure the future availability of this particular germplasm. Another species, *D. capillifolius*, is already in the focus of research at the BAZ. The only accession exists in the US gene bank and in the BAZ working collection. There is actually only one authentic report on the collection site of this species in Libya by Elfrid Gerhart, dating back to the year 1956, as cited by Mc Gollum (1975) and it is not known whether the species survives well. The interest of a breeder in CWR of the carrot expressed in this short communication may trigger the inventory of *Daucus* populations by botanists and may stimulate the interest of local nature protection agencies in the crop and its CWR. Both the cultivated and the wild form would have a glossy future if this happens.

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GBIF – http://data.gbif.org/species/
GRIN – http://www.ars-grin.gov/npgs/
IUCN Red List – http://www.iucnredlist.org/search/search-basic

Festulolium loliaceum, an understudied natural UK grass hybrid species that may provide benefits to UK grasslands withstanding the onsets of climate change

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Grassland agriculture predominates in the west and north of the United Kingdom (UK)—representing in total 65% of all agricultural land (Humphreys *et al*., 2006)—and far outweighs all other UK-based crops in its economic value (circa £6 billion/annum). These grasslands are generally poorly adapted to summer droughts as traditionally they represent the wettest areas of the UK and their persistence and yield are affected significantly by any onset of prolonged water deficit. Whilst summer droughts are increasing in the UK due to climate change, the opposite extremes are also occurring, with incidents of storms and heavy rainfall increasing both in their frequency and intensity, leading to the outpouring from upland river catchments and subsequent flooding of lowlands and urban areas. However, the UK's grasslands comprise outbreeding species that are genetically extremely diverse, including genotypes and ecotypes that have the potential to mitigate against both weather extremes. Ryegrasses (primarily *Lolium perenne*) are the agricultural species of choice in the high quality grasslands that support Britain's prime livestock agriculture, but their frequency diminishes as stresses increase in the permanent pastures common to the uplands. Researchers at the Institute of Grassland and Environmental Research (IGER) at Aberystwyth, in Wales, are exploring how to harness the forage quality of *Lolium* with genes for environmental traits found in related fescue (*Festuca* L.) species that are native to permanent UK grasslands. These tend to be more resilient against climatic extremes than the ryegrasses (Humphreys *et al*., 2003) and combining the attributes of ryegrasses and fescues together in one hybrid genotype would provide us with grasses for improved persistence and resilience to the perturbations of climate change. Whilst hybrids between ryegrasses and fescues should enhance grassland sustainability, new research is examining the indirect effects they may have on soil structure and hydrology.


IGER

Figure 1. Biodiverse English flood meadows that contain the hybrid grass species *Festuca loliaceum*, adapted to episodic flooding and waterlogged soils.

The presence and management of vegetation influences the soil water balance by trapping precipitation, controlling evaporation and uptake of water through its roots, and by bio-physical changes to the soil, including rhizosphere–soil porosity. There have been a number of laboratory studies published that describe how roots change soil hydraulic properties (e.g., Whalley *et al*., 2005). These have demonstrated a change to the water release characteristics of soils that tend to be associated with an increased number of larger pores in the rhizosphere, or an increase in water repellence. Root activity tends to increase the number of large soil pores. It is known that fescue species produce deeper rooting systems than ryegrass and this contributes to their greater drought resistance (Durand *et al*., 2007). It is hypothesized that generation of soil structure is related to root length and density, and by water uptake and the shrinkage characteristics of soil and its fracture during drying (Macleod *et al*., 2007). Some pilot studies in a new project, SuperGraSS (http://www.iger.bbsrc.ac.uk/SGF/) have indicated that compared with ryegrass, fescue species produce stronger roots more capable of penetrating hard compacted soils, and increase soil porosity, thereby enhancing soil water-holding capacity and mitigating against surface-run-off and flooding.

Whilst synthetic ryegrass x fescue species hybrids are being created at IGER and elsewhere in Europe (Zwierzykowski *et al*., 1998; Canter *et al*., 1999) with the objective of increasing grassland sustainability, nature has already taken a hand in the form of the little studied natural hybrid of *Lolium perenne* and *Festuca pratensis* called *Festulolium loliaceum* (Fig. 2). The natural hybrid species is found predominantly in mature meadows where they are concentrated on waterlogged anaerobic soils.

Despite their widespread occurrence in old permanent grasslands, little is known of the origins, age, and genetic composition of *Festulolium loliaceum*. They occur in soil prone to episodic flooding in lowland areas in old grassland and water meadows throughout the UK, but principally in England (Stace, 1975). As such, they are likely to be excellent sources of genes for adaptations for grass growth in waterlogged soils, an increasingly important plant breeding objective given increased occurrences of localized or widespread flooding exacerbated by climate change.

Peto (1933), Wit (1964), Essad (1966), and Gymer and Whittington (1973) concluded from the *F. loliaceum* they studied from the UK and France that they were of three types—diploid (2n = 2x = 14), or one of two types of triploids (2n = 3x = 21): Festucoid (with *Festuca*-like morphology) or Loloid (with *Lolium*-like morphology). The hybrids, especially the diploids, had very low fertility but backcrosses involving both diploid and triploid hybrids yielded a few progeny and may intercross with their parental or related species (Gymer and Whittington, 1975). As the parental species *L. perenne* and *F. pratensis* are diploids, it

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Figure 2. Inflorescences of the natural grass hybrid, *Festulolium loliaceum* (centre), adapted to the UK's flood and water meadows, together with its diploid parental progenitors, *Festuca pratensis* (left) and *Lolium perenne* (right) (both 2n = 2x = 14)

was considered highly likely that the triploid hybrids resulted from unreduced gametes produced by one or both of the parent species (Essad, 1966). The genome sizes of *L. perenne* (1C = 2,034 Mb) and *F. pratensis* (1C = 2,181 Mb) are close (RBG Kew Plant DNA C-values database: http://www.rbgkew.org.uk/cval/homepage.html). Their genomes are interchangeable by chromosome substitution and recombination, and the gene pools of the two genera are therefore accessible for genetic manipulation (Zwierzykowski, 1998). On the other hand, the relationship between the species of both genera is sufficiently distant that the dispersed repetitive DNA of *Festuca* can be distinguished in intergeneric hybrids using chromosome painting, referred to as genomic *in situ* hybridization (GISH) (Thomas *et al*., 1994).

The technologies available to the researchers cited above who undertook the early investigations into *F. loliaceum* made clear interpretations of their data difficult, but in recent cytological studies using GISH undertaken at IGER, supporting evidence for their conclusions has been achieved (Fig. 3). Natural hybrids were collected from ancient meadowland in waterlogged soils in the Thames valley near Oxford. The GISH analysis of a small number of the UK grasses supported earlier reports that *F. loliaceum* was diploid (LF) (Fig. 3a) or triploid (Fig. 3b,c). The genome composition of the triploids was either LLF (Loloid) (Fig. 3b), or LFF (Festucoid) (Fig. 3c). Although fertility was low, normal fertile pollen grains were recovered from both diploid and triploid hybrids (Fig. 3d). The occurrence of LFF and LLF triploid hybrids indicate that unreduced gametes from both parent species are possible and likely explanations for the origins of the two triploid genotypes. Synthetic LLF hybrids are more male fertile than LFF (Jauhar, 1993) but it was unknown until now whether this also applies to the natural *F. loliaceum.* In controlled glasshouse conditions, both triploid and the diploid hybrid genotype combinations produced viable seed and subsequent progeny when pollinated by both the parental species *L. perenne* and *F. pratensis* indicating that there is likely in the field to be regular gene flow and introgression between natural populations of the hybrids and their progenitor species. This raises the intriguing possibility that novel genes for flood tolerance may be sought from *F. loliaceum* and used in conventional plant breeding programmes to improve flood tolerance of ryegrass .

Hybrid formation and persistence is an important contributor to speciation and evolution. It frequently enables hybrids to colonize environments previously beyond the range of adaptation of either parent species. A good example was a relative of *F. loliaceum*, the hexaploid grass species *Festuca arundinacea* which arose following the hybridization of winter hardy *F. pratensis* (2x) with drought resistant *F. glaucescens* (4x) (Humphreys *et al*., 1995). As a hybrid, *F. arundinacea* was capable of colonizing climatically diverse European grasslands. Hybrid formation or the introduction of hybrids however can have a number of consequences: stabilization of the hybrid zone, hybrid speciation, introgression, or extinction of one of the parental species (Riesenberg and Wendel, 1993; Burke and Arnold, 2001). The outcome depends on a range of factors, including fitness and reproductive output of the hybrids, competition with the parental species and ability of the hybrid to introgress with the parental species. Thus, depending on these and other factors, hybrid formation can lead to introgression into the parental species enabling the colonization of different habitats or even the local extinction of the parental species (Carney *et al*., 2000). A good example of introgression leading to improved flooding-tolerance was in Iris, where genes transferred from flood-tolerant *I. fulva* into flood-sensitive *I. brevicaulis* led to the improved tolerance of the recipient species to submersion (Martin *et al*., 2006).

Permanent grasslands are biodiverse communities dominated by competing and highly heterogeneous outbreeding grass species. In suboptimal growing conditions novel genotypes and especially interspecific hybrids capable of providing an adaptive advantage will predominate. Stace (1975) lists twelve interspecific or intergeneric hybrids involving *Festuca*. The persistence of the hybrids is variable, but in some locations, interspecific and intergeneric hybrids are more numerous than the parental species. Hence our knowledge of how hybrid zones

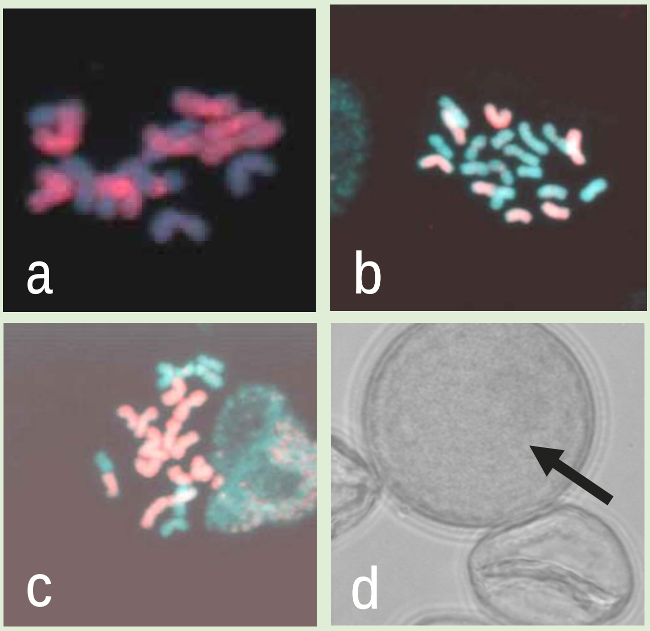

Figure 3. Pilot cytological study at IGER of *F. loliaceum* using GISH. (a) Diploid hybrid (2n = 2x = 14) with 7 *Lolium* and 7 *Festuca* chromosomes; (b) Triploid hybrid (2n = 3x = 21 with 14 *Lolium* chromosomes (blue) and 7 *Festuca* chromosomes (pink); (c) Triploid hybrid (2n = 3x = 21) with 7 *Lolium* chromosomes (blue) and 14 *Festuca* chromosomes (pink); (d) Fertile hybrid pollen (see arrowed) from diploid and triploid hybrids.

arise and spread is important for maintaining grassland communities with optimal characteristics for forage and pasture, in the face of climate change. It is hoped that studies of hybrid stability in natural hybrids such as *F. loliaceum* will provide insights of the requirements for constructing and stabilising genomes of synthetic ryegrass fescue hybrids for agricultural and environmental benefits.

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Conferences and events 2008

February

- IUCN/SSC Specialist Group Chairs' Meeting: 9–15 February 2008, Al Ain, Abu Dhabi
- SBSTTA 13 – CBD: 18–22 February 2008, Rome, Italy

April

- Systematics 2008, Göttingen, 7–11 April 2008 (http://www.systematics2008.com/)

May

- World Congress on the Future of Food and Agriculture: 12–16 May 2008, Bonn, Germany (www.planet-diversity.org)
- Biodiversity Research – Safeguarding the Future: 12–16 May 2008, Bonn, Germany (http://zfmk.de/preCOP9/Text_Home.html)
- COP 9 – Ninth Meeting of the Conference of the Parties to the Convention on Biological Diversity, Bonn, Germany, 19–30 May 2008

Regional reports

Crop wild relatives in the Pacific Region

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Major native crops in the region

A recent study using biomolecular markers (Lebot, 1999) showed that Banana (*Musa* spp.), breadfruit (*Artocarpus altilis*), sugarcane (*Saccharum* spp.), taro (*Colocasia esculenta*) and greater yam (*Dioscorea alata*) domestication has occurred in New Guinea and further east in Melanesia. This led to the production of the cultivated genotypes that were selected from the endemic wild gene pool. Other crops that that were domesticated in the region according to Lebot are:

- Some Aroid species
  - Giant swamp taro (*Cyrtosperma chamissonis*)
  - *Alocasia macrorrhiza* (Major importance in some Polynesian Islands)
- Coconut (*Cocos nucifera*)
- Sago palm (*Metroxylon sagu*)
- Kava (*Piper methysticum*)
- Pandanus (*Pandanus* spp.)
- Aibika/Bele or Island Cabbage (*Abelmoschus manihot*)

Crops endemic to the region

Endemism is very limited in crops when compared to other plant species and this is frequently observed at the subspecies level and even at the cultivar or variety level. Endemism is discussed in detail in the topic on gene pools of the major crops below.

Major economic CWR gene pools present

Banana

The Pacific and the Asian region have been classified to be the richest with wild and cultivated diversity of *Musa* (banana and plantain). *Musa acuminata* subsp. *banksii* is believed to be the ancestral parent of the majority of the edible banana cultivars, contributing what to is called the 'A' genome (INIBAP, 2006), and the distribution is restricted to the tropical area of Australia and New Guinea, and surprisingly to Samoa (Lebot, 1999). *Musa balbisiana* contributed to the 'B' genome to several banana cultivar groups and all plantain. The domestic banana spread widely within the Asia Pacific region and a large portion (70–85%) of the gene pool rests there in the form of 132 cultivar types or gene groups. Specifically, these are AA, AAA, AS, AAS, AAT and, ABBT. While the centres of diversity of AA are Indonesia–Philippines and Melanesia, there is an exceptionally high diversity in New Guinea. Cultivar type and wild species Maia, Maoli-Populu and Iholena with the genome group AAB have their centres of diversity in Polynesia, Melanesia and Micronesia. Also, the semi-wild type, Fe'i is mainly found in the Pacific. The last one, Australimusa, which is a wild type, is found in Asia and also in Melanesia (INIBAP, 2006).

Sugar Cane

The wild relative of sugar cane, *Saccharum robustum* is distributed from Borneo to Vanuatu, according to Daniel and Roach (1987), quoted by Lebot (1999). *Saccharum spontaneum*, a most primitive species, is widely distributed throughout Southeast Asia, New Guinea and the Solomon Islands.

Taro

Some wild populations of Taro are found in New Caledonia, Papua New Guinea, Solomon Islands and Vanuatu.

Yams

For Yams, *Dioscorea bulbifera* in the Pacific (Australia, New Guinea and Polynesia) of genomes C and D were found to be significantly different from E, from which Asian genomes were assumed to be derived.

Breadfruit

Breadfruit originated in the western Pacific. Bismarck Archipelago and New Guinea form the centre of diversity of wild seeded forms. Further east in Polynesia is the centre of diversity for the seedless and few seeded forms. Melanesia and Micronesia have the greatest diversity within cultivars and these are mainly seeded, outcrossing fertile diploids, while those of Polynesia represent a much narrower genetic base, and sterile triploids predominate. (Ragone 1997, 2001; Zerega *et al*., 2006).

Geographic location of CWR hotspots

The Pacific is the centre of diversity and origin for a small number of crops, but in general due to its history of colonization, crop genetic diversity in the mostly vegetatively propagated crops of the region declines markedly from the west to east (Global Crop Diversity Trust, 2006). The countries or territories in the region that have relatively high crop diversity are mainly Papua New Guinea with other Melanesian islands, plus New Caledonia. Polynesia and Micronesia are minor zones in the region for the diversity of CWR. A good number of countries in Micronesia are small atolls and one of the marked future of plants grown here are their salt and drought tolerance.

Major *ex situ* CWR activities in region

There were two major initiatives carried out on two crops at the regional level in the very recent past. *Ex situ* collections, both nationally and regionally, were a major focus of these two projects:

- South Pacific Yam Network (SPYN), where 1040 accessions were collected and also a core sample representative of the best varieties identified based on tuber shape and tolerance to anthracnose. The core collections of these accessions are kept as tissue culture at the Centre of Pacific Crops and Trees (CEPaCT), formerly known as the Regional Germplasm Centre (RGC) in the Secretariat of the Pacific Community at Suva, Fiji. The identification of male and female tetraploid accessions were also part of this work (Final Report, 2003).
- Taro Genetic Network (TAROGEN). The project involved working with more than 2000 accessions of Taro, mainly in the Melanesian countries, and they were characterized both morphologically and using molecular markers. From this work a core sample of 220 accessions were established. In fact, this project led to the establishment of the CEPaCT (Final Report, 2001).

Table 1. Number of *ex situ* germplasm accessions for each crop in each country in the region (PAPGREN, 2004).

	Bele / aibika	Bananas	Breadfruit	Cassava	Coconut	Cocoyam	Giant swamp taro	Kava	Sweet potato	Taro	Yams
Cook Islands	3	19		7	6	4		6		23	
FSM		78	6	8			20			34	10
Fiji			20	27	24	2		46	60	112	128
French Polynesia		16									
Kiribati		8	8		7					4	
RMI		17	6						15	24	
New Caledonia		71	5	25					17	80	150
Palau				50					22	98	
PNG	113	298		140	71				1399	878	348
Samoa		200	55		20	1				132	303?
Tonga											
Vanuatu				26	60	8		60	52	260	300?
Regional (SPC)	4	14		28	8				123	727	139
Regional (USP										141	
Regional										79	

Almost all of the countries in the region have *ex situ* germplasm collection(s). While the objective of these collections is not specifically targeted at CWR, they however form part of these collections. Table 1 gives a summary of the countries with their collections.

Major CWR *in situ* activities in region

This is an area in the region which needs to be strongly developed. It has been reported that some work is being carried out in some of the countries but is not comparable to the work carried out with *ex situ* collections.

Gaps and research requirements

In general, crop improvement work in the region is not as developed as it should be because of the low numbers of plant breeders in the region. Therefore, there is a need for human resources development in crop improvement. The same also applies to plant genetic resources. There is also a need to characterize the accessions that have been collected so their genetic diversity could be ascertained and in addition their properties important in nutrition, plant and human health, adaptation to climate change and production would be fully realized.

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Regional reports

Catalogue reveals stark statistics about crop wild relative conservation in Europe

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The combined European and Mediterranean region (the Euro-Mediterranean region) is an important centre for the diversity of crops and their wild relatives—a major socio-economic resource and the cornerstone of agrobiodiversity for the region (Maxted *et al*., 2008). Major food crops, such as wheat (*Triticum aestivum* L.), barley (*Hordeum vulgare* L.), cabbage (*Brassica oleracea* L.) and olive (*Olea europaea* L.), originated in the Euro-Mediterranean and the wild relatives of these crops, along with several other major crops that have wild relatives in the region, are an important genetic resource for crop improvement and food security. Many minor crops have also been domesticated and developed in the region, such as chickpea (*Cicer arietinum* L.), lentil (*Lens culinaris* Medik.), sugarbeet (*Beta vulgaris* L.), almond (*Prunus dulcis* (Mill.) D.A. Webb) and apple (*Malus domestica* Borkh.). Other crops of socio-economic importance with wild relatives in the region are forestry species such as *Abies alba* Mill., *Populus nigra* L. and *Quercus ilex* L., ornamentals such as species of *Dianthus* L., *Euphorbia* L., *Geranium* L. and *Primula* L. and medicinal and aromatic plants such as species of *Anemone* L., *Campanula* L., *Helianthemum* Mill., *Orchis* L. and *Verbascum* L. Although it is acknowledged that populations of crop wild relatives (CWR) are under threat in the Euro-Mediterranean region, their conservation has historically received relatively little systematic attention. However, recently, the EC-funded PGR Forum project (European crop wild relative diversity assessment and conservation forum – http://www.pgrforum.org/index.htm), began to tackle the issue of how to conserve these vital resources.

The need for crop wild relative inventories

As a first step in the conservation and effective use of CWR, we need to know how many taxa there are, what they are and where they are. Taxon inventories provide the baseline data critical for biodiversity assessment and monitoring, as required by the Convention on Biological Diversity (CBD) (CBD, 1992), the Global Strategy for Plant Conservation (GSPC) (CBD, 2002), the European Plant Conservation Strategy (EPCS) (Council of Europe and Planta Europa, 2002) and the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) (FAO, 2001). They provide the essential foundations for the formulation of strategies for *in situ* and *ex situ* conservation and on the species' current and potential uses as novel crops or gene donors. Some species may already be included in areas managed for conservation purposes, but their status as CWR may be unknown and they may not be actively monitored and managed. Inventories are needed to establish what diversity actually exists, which species are threatened and which already conserved, where the gaps are in their conservation and to provide the data needed for integrating CWR into existing conservation initiatives.

At regional level, a CWR inventory provides policy makers, conservation practitioners, plant breeders and other user groups with an international view of CWR species' distributions and a means of prioritizing conservation activities. A regional inventory provides the basis for monitoring biodiversity change internationally, by linking CWR information with information on habitats, policy and legislation and climate change. It also serves to highlight the breadth of CWR diversity available in the region, which may include important resources for CWR conservation and use in other parts of the world. Furthermore, a regional inventory provides the backbone for the creation of national CWR inventories (e.g., see Maxted *et al*., 2007; Scholten *et al*., 2008).

Beta maritima. Photo: Emilio Laguna

The Crop Wild Relative Catalogue for Europe and the Mediterranean

Within the context of the PGR Forum project, methodologies for establishing national and regional catalogues of crops and their wild relatives were developed and the Catalogue of Crop Wild Relatives for Europe and the Mediterranean (Kell *et al*., 2005, 2008a) was created. The Catalogue is available via the web-enabled Crop Wild Relative Information System (CWRIS – http://www.pgrforum.org/cwris/cwris.asp) (PGR Forum, 2005), which provides access to CWR information to a broad user community, including plant breeders, protected area managers, policy makers, conservationists, taxonomists and the wider public (see Kell *et al*., 2008b)—information that is vital for the conservation and use of CWR. The Catalogue has been created using a systematic approach that can accommodate changes in nomenclature and status, and can be applied at both regional and national levels in any part of the world.

The scope of the Catalogue is all species of direct socio-economic importance and their wild relatives—including food, fodder and forage crops, medicinal plants, condiments, ornamental and forestry species, as well as plants used for industrial purposes, such as oils and fibres. Applying the broad definition of a CWR proposed by Maxted *et al*. (2006), a CWR includes any taxon belonging to the same genus as a crop species—it is upon this premise that the methodology for the creation of the CWR Catalogue is based. In its simplest terms, the process of creating the Catalogue involves creating a list of genera containing crops, matching these with the genera contained in the flora of the country or region and selecting the taxa within the matching genera from the flora to create the Catalogue (see Kell *et al*., 2008a).

To create the Euro-Mediterranean Catalogue, two primary data sources were utilized—Euro+Med PlantBase (Euro+Med PlantBase, 2005), which provides the taxonomic core, and Mansfeld's World Database of Agricultural and Horticultural Crops (Hanelt and IPK Gatersleben, 2001; IPK Gatersleben, 2003), which provides lists of genera containing agricultural and horticultural crops and the crop species themselves. Additional data sources for lists of forestry and ornamental crop genera and wild-harvested medicinal and aromatic plants were also used (Kell *et al*., 2008a).

Prunus insititia. Photo: Emilio Laguna

What does the Catalogue tell us about crop wild relatives in the region?

The Euro-Mediterranean CWR Catalogue contains 25,687 of the 30,983 plant species recorded by Euro+Med PlantBase as present in the region; 90% (23,216 species) are native to the region and 58% (14,994) are endemic. Forty-nine percent of genera containing agricultural, horticultural, forestry and ornamental crops and medicinal and aromatic plants worldwide are found in the Euro-Mediterranean region and at least 2204 species in the CWR Catalogue (9%) are known to be cultivated worldwide. Looking at Europe alone (as defined by Hollis and Brummitt, 2001), there are 17,495 crop and CWR species; therefore, 68% of crop and CWR species found across the Euro-Mediterranean region are found in Europe alone. Of these, 15,656 species (89%) are native to Europe and 8624 (49%) are endemic. As many as 1078 (42%) worldwide crop genera are found in Europe.

Of the 28 major food crop genera of the world (as defined by Groombridge and Jenkins, 2002), 22 occur in the Euro-Mediterranean region—15 (54%) of these include wild relatives. There are 219 species and 100 subspecific taxa (subspecies and varieties) within these major food crop genera which can be found growing in the region. Four (11%) of the 38 major food crops of the world are native to the Euro-Mediterranean region: cereals – *H. vulgare* L. (barley) and *T. aestivum* L. (wheat); leaf vegetables – *B. oleracea* L. (cabbage); and oil crops – *O. europaea* L. (olive). Three of these crops are native to Europe: wheat, cabbage and olive.

Within the 28 major food crop genera of the world, 57 species are endemic to the Euro-Mediterranean region. Of these, at least 11 species are endemic to only one nation and many of these are limited to islands. For example, *Brassica balearica* Pers. is endemic to the Balearic Islands (Spain), *B. rupestris* Raf., *B. macrocarpa* Guss. and *B. villosa* Biv. are endemic to the islands of Sicily and Malta (Italy), *B. hilarionis* Post is endemic to Cyprus and *Solanum patens* Lowe and *S. trisectum* Dunal are endemic to Macaronesia. In addition, 46 subspecies within the 28 major food crop genera of the world are endemic to the Euro-Mediterranean region and at least 22 of these are endemic to only one nation—again, some of these taxa are limited to islands.

Of the 51 minor food crop genera of the world (listed by Groombridge and Jenkins, 2002), 39 (76%) occur in the Euro-Mediterranean region—35 (69%) of these encompassing wild relatives. Within these minor food crop genera, 938 species and 372 subspecific taxa (subspecies and varieties) can be found growing in the region. Of these, 382 species and 46 subspecies are endemic and at least 99 species and 41 subspecies are endemic to only one nation. Of the 69 minor food crops of the world, 23 (33%) are native to the Euro-Mediterranean region and 22 are native to Europe.

The major and minor food crop groups that can be found in the Euro-Mediterranean region, along with other crops of high socio-economic value that are not included in the above analysis, for example, forage and fodder crops, are an important genetic resource which may contribute to crop improvement in the future. Taxa that have limited distributions, particularly those that are endemic to one country should be a high priority for conservation and steps need to be taken to assess their conservation status, both *in situ* and *ex situ*.

Is crop wild relative conservation being addressed at regional level?

Analysis of the CWR Catalogue data indicate that we are not paying sufficient attention to CWR in current conservation endeavours within the region (Kell *et al.*, 2008a). For example, only 3% of the CWR flora of Europe is listed in the annexes of the EU Habitats Directive. Of these, only four species are wild relatives of major food crops (out of a total of 153 that occur in the EU territories) and a further 13 species are included in the minor food crop group, out of a total of 542. Taking another example, only 5% of the CWR flora of Europe is included in Important Plant Areas (IPAs) and, of these, only three species (out of a total of 152 in Europe) are within the major food crop genera, while none of the 559 species in the minor food crop genera are included. We should point out however, that IPAs only include 912 vascular plant species (4%) out of an estimated total of 20,590 in Europe and the Habitats Directive only lists 641 vascular plant species (3%) out of an estimated total of 19,020 in the EU territories. However, with very few wild relatives within the important food crops included in these initiatives, we can be confident that the conservation of CWR, in these contexts, is not being addressed.

Due to the general lack of availability of species checklists for protected areas it is not possible to match the full list of

> "Only 3% of the CWR flora of Europe is listed in the annexes of the EU Habitats Directive"

25,687 Euro-Mediterranean CWR species against those conserved in existing protected areas; this would not even be possible for those wild relatives of major and minor food crop genera listed by Groombridge and Jenkins (2002). However, it is likely that the existing networks of protected areas do contain significant Euro-Mediterranean CWR diversity, but that diversity is rarely being actively managed and so is more likely to be prone to erosion and even extinction. There is therefore an urgent requirement to systematically conserve Euro-Mediterranean CWR diversity *in situ*, whether in existing protected areas or by establishing new sites for their conservation. The methodological approach described by Maxted *et al.* (2007) for identification of the priority sites to establish genetic reserves to conserve *in situ* UK CWR diversity could equally well be applied at the European or Euro-Mediterranean scale.

The lack of attention being paid to CWR can be further illustrated by analysing which Euro-Mediterranean CWR are included in the IUCN Red List of Threatened Species. Kell *et al*. (2008a) found that only 250 taxa were listed in the 2006 Red List and, of these, only one taxon is a wild relative of a major food crop (*Olea europaea* subsp. *cerasiformis*), while 19 are wild relatives of minor food crops. The majority of the taxa listed are trees. The lack of CWR listed does not mean that these taxa are not threatened—rather, it highlights the fact that global threat assessment is not being systematically undertaken for CWR within the region, and most likely worldwide. The authors therefore recommend that CWR Red Listing is initially undertaken in three phases:

i. The CWR taxa listed in the 1997 IUCN Red List of Threatened Plants should be reassessed using the 2001 Criteria (IUCN, 2001) and assessments submitted for inclusion in the IUCN Red List of Threatened Species;
ii. Single country endemic taxa should be assessed and submitted for inclusion in the IUCN Red List;
iii. National PGR Coordinators could establish which CWR are included in national Red Lists and make these data available for regional and global assessments.

We also know that relative to the number of crops conserved *ex situ* in European gene banks, the number of CWR conserved are few. When analysing the European gene bank collections data held in EURISCO (http://eurisco.ecpgr.org/), O'Regan and Maxted (2007) found that 5.6% of European *ex situ* PGR accessions were CWR—in total 24,448 accessions of 1,095 species. However, this includes only 6% of the 17,495 CWR species in Europe.

Lessons learned for crop wild relative conservation worldwide

Further investigation can be carried out to provide an indication of to what extent CWR are already conserved, both within the Euro-Mediterranean region and elsewhere in the world. Many taxon data sets are available electronically—it is simply a matter of working together and making the data accessible. For example, global protected area data are available and, using the CWR Catalogue for Europe and the Mediterranean (or other regional CWR inventories as they become available), along with taxon location data, analysis can be undertaken to assess how many species are afforded some level of protection *in situ*. At national level, the data can also be compared with protected area inventories (where available) and *ex situ* collections, which would provide a more detailed picture of CWR conservation within any given region.

Sharing and cross-checking conservation data sets is one way of assisting CWR conservation gap analysis. Another way is to bring CWR information together through the Internet, which provides a unique opportunity to link any number of information sources together. CWRIS – http://www.pgrforum.org/cwris/cwris.asp (PGR Forum, 2005; Kell *et al*., 2008a) goes some way towards achieving this goal. The Catalogue data housed in CWRIS is linked to a number of selected online information resources, such as the Germplasm Resources Information Network (GRIN) (USDA, ARS, National Genetic Resources Programme, 2006), IUCN Red List of Threatened Species (IUCN, 2006), Survey of Economic Plants for Arid and Semi-Arid Lands (SEPASAL) (Royal Botanic Gardens, Kew, 1999), International Legume Database and Information Service (ILDIS, 2007) and FAO Worldwide Information System on Forest Genetic Resources (REFORGEN) (FAO, no date). With the appropriate financial resources, the opportunity exists to develop CWRIS further as a sophisticated online tool to provide access to CWR information at both taxon and geographic level.

Trifolium alpestre. Photo: Gabor Vörösváry

We urge policy makers and conservationists to give greater credence to the inclusion of CWR within existing or new conservation initiatives (including legislation), both at regional and national level. For example, by creating a priority list of CWR for the Euro-Mediterranean region (see Ford-Lloyd *et al*., 2008), combined with the formulation of national priority lists, the conservation status of these taxa could initially be assessed and a more detailed gap analysis undertaken. Building on the data that are now available, networks of national genetic reserves can be established, following the guidelines provided by the draft Global Strategy for CWR Conservation and Use (see Heywood *et al*., 2008).

Lists of crop and CWR taxa for each nation in the Euro-Mediterranean region can be extracted from the Catalogue (national crop and CWR lists have already been sent to each National PGR Coordinator in the region). Individual nations can then use these lists as a basis for conservation planning, once the list has been checked and verified to account for any potential errors. At regional level, the Catalogue can be used to estimate the distribution of crops and their wild relatives across the region—for example, to aid regional conservation planning within the EU. Furthermore, the data can be used to target those taxa that have limited distributions (i.e., they occur in one to a few nations or sub-national regions). For example, of the 25,687 crop and CWR species in the Euro-Mediterranean region, at least 2873 (11%) are endemic to one nation. The Catalogue

“Only 6% of Europe’s CWR species are conserved *ex situ* in European gene banks”

also provides the information needed for plant breeders to source new material and for conservationists to collect material from as wide a range of a taxon’s distribution as possible.

A more systematic approach to complementary CWR conservation is needed. Looking, for example, at the number of species included in botanic gardens’ living collections, we find that there are a significant number of CWR in cultivation around the world (Kell *et al*., 2008a). However, it is likely that these were collected for diverse reasons, rather than specifically because of their value as gene donors for crop improvement. National PGR Coordinators and regional and international conservation organizations could do more to put in place a coordinated approach to CWR conservation. If the CBD target of achieving a significant reduction of the current rate of biodiversity loss by 2010 is to be met, a combined approach targeting existing protected areas and establishing new *in situ* conservation sites where necessary, and encouraging managers of *ex situ* collections (gene banks and botanic gardens’ living collections) to take a more systematic approach to CWR conservation is required. Without taking steps to conserve CWR diversity now, the pool of genetic resources needed for food security and poverty alleviation may not be available for future generations.

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Country reports

Conservation of crop wild relatives in India

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The Indian gene centre is rich in diversity of crop plants and their wild relatives (Arora, 1991, 1993, 1996; Pandey and Arora, 2004). Realizing the importance of wild relatives in crop improvement, domestication and use of native diversity, over the last three decades, the National Bureau of Plant Genetic Resources (NBPGR), as a national nodal organization, has been actively engaged in germplasm collecting and conservation of such biodiversity as its on-going programme and also collaborating with concerned crop-based institutes of the Indian Council of Agricultural Research (ICAR). This report briefly highlights such national efforts.

Figure 1. Fruits of *Cucumis sativus* var. *hardwickii*, a wild relative of cucumber

Enumerating floristic/ species richness

With an emphasis to assess the floristic richness of wild relatives of crop plants and related species and their distribution, so as to plan effectively their germplasm collecting, conservation and use, during the 1980s, NBPGR put in efforts to synthesize such information from different floras, exploration/floristic survey reports, etc., and brought out a publication on 'Wild Relatives of Crop Plants in India' (Arora and Nayar, 1984). The synthesis of information in this scientific monograph, and subsequent status papers (Arora 1996, 2000; Arora and Nayar, 1999) pointed out that:

- About 320 species of wild relatives and related taxa occur in India and these are distributed in different phytogeographical regions; namely, Western Himalayas (125); Eastern Himalayas (82); Northeastern region (132); Gangetic Plains (66); Indus Plains (45); Malabar/ Western Peninsular region/ Western Ghats (145), and Deccan/ Eastern Peninsular region/ Eastern Ghats (91). Of these species, 60 are endemic and rare taxa.
- Floristic analysis of 116 genera of wild relatives points out the following pattern of species richness:
  - Genera represented by one species only: *Aegle, Aegilops, Hygroryza, Trilobachne, Cicer, Lablab, Euphoria, Punica, Coccinia, Neoluffa, Colocasia* and *Myrica.*
  - Genera represented by two species: *Fagopyrum, Chionachne, Eleusine, Elymus, Narenga, Sclerostachya, Polytoca, Glycine, Docynia, Duchesnea, Brassica, Carthamus, Citrullus, Ensete, Mimusops* and *Carum.*
  - Genera represented by three to four species: *Coix, Hordeum, Miscanthus, Eremopyrum, Canavalia, Lepidium, Malus, Fragaria, Madhuca, Manilkara, Spondias, Lilium* and *Urena.*
  - Genera represented by >5, <10 species: *Avena, Echinochloa, Dolichos, Lathyrus, Erianthus, Coffea, Camellia, Cucumis, Coleus, Phoenix, Pyrus, Morus, Elaeagnus, Amomum, Myristica*, *Malva, Momordica, Abelmoschus, Alpinia, Corchorus, Sesamum, Sorbus, Amaranthus* and *Chenopodium.*
  - Genera represented by > 10, < 20 species: *Prunus, Rubus, Cinnamomum, Curcuma, Zingiber, Rumex, Boehmeria, Ziziphus, Paspalum, Pennisetum, Setaria, Saccharum,Vigna, Atylosia, Mucuna, Trigonella, Artocarpus, Carissa* and *Citrus.*
  - Genera with > 20 – < 30 species: *Digitaria, Trichosanthes, Garcinia, Elaeocarpus, Moghania* and *Allium.*
  - Genera with > 30 – < 40 species: *Panicum* and *Hibiscus.*
  - Genera with more than 40 species: *Piper, Diospyros, Syzygium, Dioscorea, Rubus, Ficus, Grewia, Crotalaria* and *Solanum.*
- This diversity for different economic crop group(s) belongs to the categories: cereals and millets (51), legumes (31), fruits (109), vegetables (54), oilseeds (12), fibres (24), spices and condiments (27) and others (26).

Collection and conservation

Though these activities have been going on at NBPGR in a collaborative mode since the establishment of the Bureau in 1976, these got further impetus during 1999–2004 with implementation of a mission-mode sub-project on 'Sustainable Management of Plant Biodiversity' under the National Agricultural Technology Project (NATP). The programme implemented with crop-based institutes and well coordinated by NBPGR, resulted in publication of 'Wild Relatives of Crop Plants in India: Collection and Conservation' based on 5-year activities under NATP (Pandey *et al*., 2005). Updated information in this, pointed out that:

Germplasm collection

- During 1976–2004, collective national efforts have resulted in germplasm collecting from diverse phytogeographical regions/ habitats, of 23, 118 accessions of wild species (including wild/ weedy relatives of crop plants) belonging to 124 genera and 389 species. The diversity collected revealed species richness in genera *Piper* (18 species), *Dioscorea* and *Vigna* (16 species each), *Curcuma* (14 species), *Solanum* (12 species), *Citrus, Syzygium* and *Zingiber* (11 species each), *Cinnamomum* (10 species), *Allium* (9 species), *Momordica, Oryza* and related genera, *Trichosanthes* and *Sesamum* (6–7 species each).

- Major thrust in collections was made under the National Agricultural Technology Project (NATP) during 1999–2004 and a total of 16,712 accessions of a large number of wild species (including wild/ weedy relatives of crop plants) belonging to 120 genera and 373 species were collected through 1,718 explorations from different phytogeographical regions of India. The diversity collected was classified into different crop-groups (species given in parenthesis) as cereals and millets (17), legumes (26), oilseeds (16), fibres (19), vegetables (59), tubers (24), fruits (111), spices and condiments (71), medicinal and aromatic plants (26) and others (16).
- The germplasm collection of wild species (including wild relatives) showed an increase from 6,406 accessions (125 species) during 1976–1999 to 16,712 (373 species) during 1999–2004.

Germplasm conservation under medium-term storage

As of March 2004, the national gene bank (NGB) holdings in the base collection represented 7,381 accessions of wild relatives of crop plants belonging to 186 species, which included 2,364 of indigenous germplasm of 63 species. Besides, 3030 accessions of 261 species of *ex situ* germplasm of wild/weedy relatives of crop plants in different crop-groups (accessions given in parenthesis): cereals and millets (201), legumes (76), oilseeds (106), fibres (146), vegetables (480), tubers (262), fruits (655), spices and condiments (741), medicinal and aromatic plants (202) and others (161), and 37 accessions of multi-purpose types were conserved in medium-term storage and in field gene banks during 1999–2004 (Pandey *et al*., 2005).

National networking/ coordination

NBPGR networks this activity with its 11 regional stations and 58 National Active Germplasm Sites (NAGS) representing crop-based institutes, national research centres (NRCs), State Agricultural Universities (SAUs), to handle diverse activities of multiplication, evaluation and conservation of active collection and their distribution to users. The germplasm of significant/ interesting diversity in wild relatives is given in the Box 1. (adapted from Pandey *et al*., 2005).

In situ conservation of crop wild relatives and other economic plants

In situ conservation of wild relatives and other economic plants is an integral part of the biodiversity conservation programmes run by the Government of India. The Biosphere reserves programme launched by the Ministry of Environment and Forests (MoEF) with the objective of identifying representative ecosystems to strengthen conservation efforts has established 14 biosphere reserves in India. Of these, four biosphere reserves, namely Nilgiris, Nanda Devi, Sunderbans and Gulf of Mannar are included in the World Network of Biosphere Reserves. Conservation efforts with establishment of Tura range in Garo hills of Meghalaya for native diversity of wild *Citrus* and *Musa,* and for rhododendron and orchids in Sikkim, have promoted the *in situ* conservation of economically important species.

Some states in the north-eastern region have been identified for survey of crops and their wild relatives of local importance for immediate conservation efforts. They are: Arunachal Pradesh for *Citrus jambhiri*, Assam for species of bamboos, Manipur (Loktak lake area) for wild rice, *Zizania latifolia*, Tripura for various species of *Ziziphus* and Mizoram for wild *Musa* and *Ensete* and Zingiberaceae (SPGRFAI, 2007).

Also, the national programme efforts have been initiated to update the revised status of CWR in India. The Botanical Survey of India under the MoEF has taken the lead in this direction to inventory the range of species diversity in primary, secondary and tertiary gene pools of CWR in India. Basic studies are in progress in different parts of the country to develop *in situ* conservation modalities for CWR linked to autecology, biology, community ecology, interspecific association and their interdependence with other components of ecosystems, with overall empha-

Continued over page

Box 1. Significant diversity collected and/or conserved of wild relatives in different crop groups

Cereals and millets: *Oryza nivara, O. rufipogon, Porteresia coarctata*

Legumes: *Vigna radiata* var. *sublobata, V. mungo* var. *silvestris, V. vexillata, V. hainiana, V. bourneae, V. khandalensis; Cajanus cajanifolia, C. scarabaeoides, Cicer microphyllum*

Oilseeds: *Sesamum mulayanum, S. prostratum, S. laciniatum, Brassica quadrivalvis, Carthamus oxyacanthus*

Fibres: *Corchorus depressus, C. pseudo-olitorius, C. tridens, C. trilocularis, C. urticifolius*

Vegetables: *Abelmoschus tuberculatus, A. manihot; Cucumis callosus, C. sativus* var. *hardwickii* (Fig. 1), *C. prophetarum, Momordica dioica, M. denudata, M. balsamina*

Tubers: *Dioscorea tomentosa, D. wallichii*

Fruits: *Citrus assamensis, C. indica, C. ichangensis, Musa balbisiana, Ensete glauca, E. superbum, Mangifera andamanica, M. sylvatica, Pyrus jacquemontii, P. pashia*

Spices and condiments: *Piper bababudani*, *P. bantamense, P. beddomei, P. hapnium, P. nigrum, Allium carolinianum, A. humile, A. tuberosum, A. wallichii*

Sugarcane: *Erianthus munja, E. arundinaceus, Saccharum spontaneum* sis on continuous monitoring of ongoing ecological changes and appropriate management of habitats (Gadgil *et al*., 1996; Singh and Gadgil, 1996).

Community-based management of wild relatives in non-protected areas, with the help of governmental and non-governmental departments, are involved in undertaking these *in* situ conservation activities. Significant progress has been made on *in situ* conservation of some species such as *Acorus calamus, Costus speciosus, Rauvolfia serpentina, Pyrus pyrifolia, P. pashia, Juglans regia, Docynia indica, Punica granatum* (wild form). This can be achieved through a participatory approach at village level/ community level.

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Country reports

Major crops and crop wild relatives of Russia

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Conservation of plant genetic resources (PGR), especially conservation of crops typical for various regions of the country in the areas of their traditional cultivation, as well as their wild relatives (CWR) within natural ecosystems in the sites of their natural occurrence (*in situ*), constitutes one of the highest priorities for Russia. For many decades, the N. I. Vavilov Research Institute of Plant Industry (VIR) has been involved in the study, collection and conservation of cultivated plants and their wild relatives. Major aspects of such work include CWR inventorying, development of criteria for prioritizing conservation action, selection of conservation areas, and conducting complex botanical, geographic, phytocoenological, population and other types of research.

At present, the full list of CWR species in Russia comprises 1680 species, which constitutes about 14% of the total diversity of the Russian flora. All Russia's CWR species belong to 48 families and 170 genera of higher plants. Among the richest in CWR species are the families Poaceae (468 spp.), Fabaceae (273), Rosaceae (193) and Alliaceae (103). The maximum number of CWR are found in the following genera: *Allium* (103 spp.), *Poa* (95), *Festuca* (82), *Rosa* (76), *Vicia* (68) and *Lathyrus* (52). When ranked according to the type of utilization, the highest ranking groups are forage plants (384 spp.) and food (346 spp.). Analysis of the degree of use of CWR in plant breeding showed that 222 species have cultivars (i.e., may be regarded as cultivated); 61 spp. are used in crosses or as seedling stock; 163 spp. are closely related to the cultivated ones and promising for agricultural utilization; and 305 spp. are attractive for gatherers and amateur breeders (no cultivars available). As for the remaining 929 spp., their economic properties are as yet poorly known. These results highlight that agricultural production in Russia employs little more than 16% of the utilizable plant genetic diversity available in the country.

Geographic analysis shows that the distribution of CWR species between different regions of Russia is irregular. From the floristic viewpoint, the European part of Russia is very diverse and contains the largest number of CWR species (834). The Caucasus aggregately is one of the richest regions for plant species in Russia (780 CWR spp.) The Russian Far East ranks third in the number of CWR species (589), many of which are endemic (223). The least number of CWR may be observed in West Siberia (523). CWR species also demonstrate dissimilarities in the degree of their rarity, vulnerability, threat of extinction, etc. 44 spp. of CWR are listed in the RSFSR Red Book; while six spp. have been registered in the IUCN Red List of Threatened Species. Such species are prioritized for conservation within the Russian territory. The maximum diversity of CWR species is concentrated in the Russian Caucasus and the south-east of Russia. We compiled the list of 56 endemic and sub-endemic species of CWR for Russia. Among them are *Allium altyncolicum* Friesen, *A. flavescens* Bess., *A. grande* Lipsky; *Crambe cordifolia* Stev., *C. grandiflora* DC., *C. litwinowii* K.

Gross, *Lathyrus litvinovii* Lljin, *Medicago cancellata* Bieb., *Ribes dicuscha* Fisch. ex Turcz., *R. fontaneum* Boczkarnicova, *Elytrigia jacutorum* (Nevski) Nevski, *Poa altaica* Trin., *P. filiculmis* Roshev., *P. ircutica* Roshev., *Rheum compactum* L. CWR species endemic for the Russian territory are prioritized for *in situ* conservation.

Russia is the centre of origin for a number of cultivated crops (Bologovskaya *et al*., 1936; Vavilov, 1926, 1960, 1965; Sinskaya, 1969; Shebalina and Sazonova, 1985). Today many of them are more or less widely cultivated in various parts of the country. Among them are northern races of Timothy grass (*Phleum pretense* L.), aboriginal forms of alfalfa (*Medicago falcata* s.l.), melilot (*Melilotus albus* L.) and other forage plants. According to E.N. Sinskaya (1969), the Russian north is the centre of initial domestication for Timothy grass. From there this crop was later transported to America. North Russian forms of yellow alfalfa are so peculiar that botanists quite justifiably isolated them into a separate species (*Medicago borealis* Grossh.). Maslin, the mixture of rye and wheat, locally known as 'surzha', quite recently was typical for the southern areas of Russia, especially for the Ante-Caucasian steppes. With the advancement of this mixture to the north, the environments turned more and more favourable for rye, and thus the pure rye crop evolved in the northern areas of Russia. Cultivated oat is also Slavonic in its origin (*Avena sativa* L.). Geographically this crop is East European/Asian; historically it is Slavo-Chinese. West European regions introduced into the world agriculture another oat species: *A. strigosa* Schreb. Among ancient Russian crops are hemp (*Cannabis sativa* L.) and flax forms of *Linum usitatissimum*. An unusual northern variety of hemp (var. *praecox* Serebr.) was cultivated in the northernmost areas of Russia. Dwarfish and early-ripening, it was utilized not for hempstring, as most of the local varieties in Russia, but to produce oil. One of the most ancient vegetable orchard plants in the Russian plain was turnip (*Brassica rapa* subsp. *europaea* Sinsk.). Within this territory, two endemic groups of turnip were identified, differing from each other in morphological traits, with different foci of origin. The group of "Petrovian" turnips was developed by Finnish and Slavonic tribes; another group of endemic Russian turnips is referred to as "Karelian". In the European north, on the territory of today's Finland and the north-western part of Russia, local forms of another representative of the cruciferous family, swede (*Brassica napobrassica* Mill.), originated. These forms are characterized by yellow flesh colour. Wild horseradish (*Cochlearia armoracea* L.) is widespread over the whole Russia, from the northern areas to Astrakhan. Its cultivated forms have their homeland in Eastern Europe. The North-West of Russia and Finland are distinguished for a maximum diversity of cultivated forms of this crop. For Eastern Europe, this species is an indigenous crop. Western Europe hosted horseradish forms that had turned wild, but not wild-growing in nature. The north-western areas of Russia also gave origin to vegetatively propagated local varieties of various *Allium* spp. For example, Welsh onion (*A. fistulosum* L.) is represented in the north of the Russian plain by a separate subspecies: ssp. *ruthenicum* Troph. Red currant (*Ribes rubrum* L.) was mentioned in the texts of ancient songs and epics, and, according to old chronicles, had been cultivated at monasteries since the 11th century. None of the ancient varieties of small-fruited red currant has retained its practical importance; however, they are still maintained in the collection as the sources of resistance to unfavourable environmental factors. Black currant has been known in Russia since approximately the same time. In 1701, when monastery and palace orchards were inventoried, black currant was included in the lists as a berry-yielding crop of no less importance than red currant. In the same 11th century, when fruit gardens were set up in the vicinities of present-day Moscow, a significant area was earmarked for gooseberry plantings (old Russian name of this berry was "bersen"). This area later received the name of "Bersenevka", under which it has been known up to now.

Major part of old forage, grain, industrial and fruit landraces are preserved in the collections of VIR. For separate crops, still maintained by local communities in the areas of traditional cultivation, VIR develops recommendations concerning their *in situ* conservation. However, significant part of the ancient crop diversity in traditional cultivation areas was lost. Some of these extinct forms are preserved in the VIR herbarium (WIR).

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Diversity and conservation of crop wild relatives growing on Arailer Mountain (Armenia)

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Crop wild relatives (CWR) are crop ancestors and other species more or less closely related to cultivated varieties. They are important sources of genes for resistance to diseases, pests and stress such as drought and temperature extremes. Comprehensive study of crop wild relatives is getting priority now, when climate change, overexploitation of natural resources and degradation of habitats threatens natural genetic resources, thus jeopardizing food security worldwide.

The Caucasus in general and Armenia in particular are notable for the diversity and abundance of CWR. One important site in Armenia that can be considered a hotspot for such plants is Arailer Mountain. This mountain of volcanic and sedimentary origin is located in Central Armenia, 30–40 km northwest of Yerevan (Fig. 1).

Due to its favourable geographical and geo-botanical location and unique geomorphology, Arailer boasts extremely rich and unique flora and fauna with many rare species. The flora of Arailer comprises about 650 vascular plants. The site is also notable for the diversity of plant communities. The major vegetation types of the Armenian plateau, namely semi-desert, steppe, meadow and forest are represented here. Well-developed subalpine zone and small patches of alpine meadows can also be found here. Petrophilous vegetation is abundant on the mountain as well. Forests cover northern slopes of the mountain on altitudes ranging from 1600–2400m and are represented by mixed stands of *Quercus macranthera* in association with species such as *Acer platanoides*, *A. campestre*, *Betula pendula*, *Populus tremula*, *Sorbus aucuparia*, *S. hajastana*, *S. takhtajanii* and *S. luristanica*. Undergrowth is of medium thickness, with the domination of *Viburnum lantana*, *Lonicera caucasica*, *Euonymus latifolia*, *Rhamnus cathartica*, *Padus racemosa*, *Grossularia reclinata*, *Spiraea crenata* and species of *Rosa* and *Rubus*.

Ivan Gabrielyan

Figure 1. Arailer Mountain in central Armenia; home to a wide diversity of CWR

Being a storehouse of genetic resources for many edible, medicinal, fodder and other valuable plants, the area has been supplying raw material for the local population from ancient times. The complete set of wild edible leafy vegetables traditionally collected in Armenia grows here. Starting from April, people from local villages start collection of young shoots of species such as *Falcaria vulgaris*, *Chaerophyllum aureum*, *C. bulbosum*, *Polygonatum orientale*, *Eremurus spectabilis* and *Urtica dioica*. In the autumn, forests and bushlands are rich in wild fruits and berries, among them wild pear, apple, plum, hawthorn, mountain ash, barberry, dogrose are noteworthy. Other economically important plants occurring here include ornamental and medicinal plants, aromatic herbs, dye-bearing, resiniferous, gummiferous, tanning, fibre and fodder plants.

From the list of valuable plants growing on Arailer mountain, CWR merit special attention. From the scientific and practical standpoint the following groups of CWR are of interest:

- Vegetables: *Beta corolliflora*, *Chaerophyllum bulbosum*, *C. aureum*, *Rumex acetosa*, *R. crispus*, *Allium atroviolaceum*, *A. rotundum* and *Heracleum trachiloma*.
- Cereals: *Aegilops columnaris*, *A. triuncialis*, *Avena fatua*, *Hordeum bulbosum*, *H. violaceum* and *Secale montanum*.
- Edible legumes: *Cicer anatolicum* and *Lens orientale*.
- Fodder legumes: *Lathyrus pratensis*, *Trifolium pratense*, *Medicago lupulina*, *M. sativa* and *Onobrichis transcaucasica*.
- Fruits and berries: *Pyrus caucasica* (Fig. 2), *Prunus divaricata*, *Malus orientalis* (Fig. 3), *Cerasus avium, Sorbus aucuparia*, *S. subfusca*, *S. takhtajanii*, *Ribes biebersteinii*, *Rubus idaeus*, *Crataegus orientalis* and *Rosa canina*.

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Figure 2. *Pyrus caucasica*, a wild relative of cultivated pears

Field surveys conducted in 2006–2007 within the framework of the UNEP/GEF project on '*In-situ* Conservation of Crop Wild Relatives Through Enhanced Information Management and Field

Application' have made a valuable contribution by furnishing up-to-date information for assessing current status, threats and trends of populations of the CWR at this unique site.

The flora of Arailer mountain has been sustaining the population of local villages for many years. In the months when vitamins are in shortage, and years of hardship (wars, drought), the forest was a valuable source of micronutrient-rich food, serving as an alternative and additive to the food from cultivated varieties. Not surprisingly, in western countries the price for the food collected from the wild has higher value in the market than similar produce derived from cultivated varieties.

Unfortunately, uncontrolled exploitation, and global changes (e.g. climate change) led to habitat degradation, thus threatening populations of this interesting area. Given this, along with the value these plants posses on local, national, and global scales, and the suitability of geographical location and environmental factors, this site is recommended for initiating a set of conservation activities.

Under *ex situ* conservation, establishment of experimental plantations under conditions close to native is being considered on the plots adjacent to the Mountain. This will help to ensure their protection, conservation, regeneration and availability of stock for reintroduction activities. At present, small experimental plantations of CWR are established on northwestern slopes of Arailer mountain, with a prospect to enrich the collection in the future. Young plants of *Pyrus caucasica*, *Prunus divaricata* (Fig. 4), *Crataegus orientalis*, *Rubus idaeus*, *Sorbus hajastana*, *Allium atroviolaceum* and *Fragaria vesca* were successfully transplanted from the forest and established on the experimental plots.


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Figure 3. Fruits of the cultivated apple wild relative, *Malus orientalis*


Ivan Gabrielyan

Figure 3. *Prunus divaricata*, a wild relative of cultivated plums

With the international practice of establishing regional gene banks in mind, one should consider the possibility of establishing such an institution in the proximity of Arailer mountain. This gene bank will ensure effective conservation and use of both wild representatives of the regional flora and cultivated varieties.

However, *ex situ* conservation alone is not enough to ensure effective conservation. Given the relative proximity of the mountain to Yerevan and its significance as a possessor of genetic resources important for humankind, especially richness in CWR, the whole area of the mountain needs special conservation measures. So, one should consider adding this site to the network of specially protected areas of Armenia. This is a unique nature monument with specific geomorphology and surprisingly rich and unique flora and fauna.

News from the Faculty of Biology of Yerevan State University, Armenia

Development of new approaches and strategies for the conservation of wild plant biodiversity are in progress at the Department of Ecology and Nature Protection of the Faculty of Biology of the Yerevan State University. Currently, *in vitro* tissue culture systems are under development for important wild medicinal, ornamental and horticultural plants, such as *Hypericum perforatum*, *Iris elegantissima*, *Lilium armenum* and *Apocynum armenum*.

In January 2008, within the context of the UNEP/ GEF project, '*In situ* conservation of crop wild relatives through enhanced information management and field application', we will begin a study of the conservation and breeding potential of wild species of *Rubus* and *Ribes.* The results will be discussed with Bioversity International and international collaborators of USDA–ARS, and systems for the exchange of genetic resources and information in world germplasm repositories will be improved. This will include establishing links with germplasm breeders and researchers, particularly with the USDA–ARS germplasm system.

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The impact of climate change on crop wild relatives in Bolivia

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Bolivia is a mega-diverse country with a rich diversity of animals, plants and ecosystems that span Andean, Amazon and others landscapes and cross many climatic zones. Forty-three percent of Bolivia's population depends on agriculture (to a large extent subsistence agriculture) for its livelihood, but only about 3% of the country's area is under cultivation. Bolivia is the centre of diversity of a number of the world’s staple crops, including potatoes, pumpkins, peanuts and beans. Lesser known crops with traditional uses like quinoa, and domestic animals such as llamas and alpacas, are now attracting world attention. Bolivia also possesses incredible cultural wealth: more than 30 ethnic groups have developed their millenary culture over centuries, and have domesticated wild plants to create traditional cultivars from which today’s modern varieties have been developed. However, this rich biodiversity and the potential it represents for sustainable agriculture in Bolivia and other countries could be under threat from climate change.

Researchers from Bolivian partner institutions of the UNEP/GEF Global Project ‘*In situ* conservation of crop wild relatives through enhanced information management and field application’ are analyzing the effects of climatic change on present and future potential distribution of crop wild relatives (CWR) that are important for national and global food security. Preliminary results of the analysis indicate that within ten years, the survival of populations of wild cassava (*Manihot tristis*) and wild peanut (*Arachis duranensis*) could be at risk in Bolivia. These wild species have been used to improve the resistance of their related crops to disease.

Manihot tristis can be found from dry transition forests to humid forests. Its current potential distribution is restricted and influenced by variations in rainfall and temperature. The areas suitable for this species will become fragmented and shrink in size, placing further pressure on the survival of populations (Fig. 1). However, suitable areas may become available in the south-east of the country, near Brazil. Given the expected changes, increasing variability in climate into the foreseeable future, this species should be a priority for conservation actions.

Arachis duranensis (wild peanut) is found in dry to sub-humid forests in the sub-Andean region of southern of Bolivia (Chuqisaca and Tarija). Recent research has shown that *A. duranensis* and *A. ipaensis* are probably the parents of the cultivated peanut. The model predicts that the potential distribution range of *A. duranensis* will shift further into Argentina within ten years (Fig. 2), and its range in Bolivia will reduce. If the trend continues, it is possible that this species will eventually disappear from Bolivia.

The final results of the impact analysis of the potential impact of climatic change on CWR over the next ten years in Bolivia will provide vital information for the development of national plans for the effective *in situ* and *ex situ* conservation of plant genetic resources of importance to the world.

Maps elaborated by consultants of national partner institutions involved in the UNEP/GEF CWR Project – Bolivia Component:

- *José Taquichiri, Moisés Mendoza, Museo de Historia Natural*
- *Noel Kempff Mercado, Margoth Atahuachi, Centro de Investigaciones Fitoecogenéticas de Pairumani*
- *Saúl Cuellar, Fundación Amigos de la Naturaleza – Bolivia*

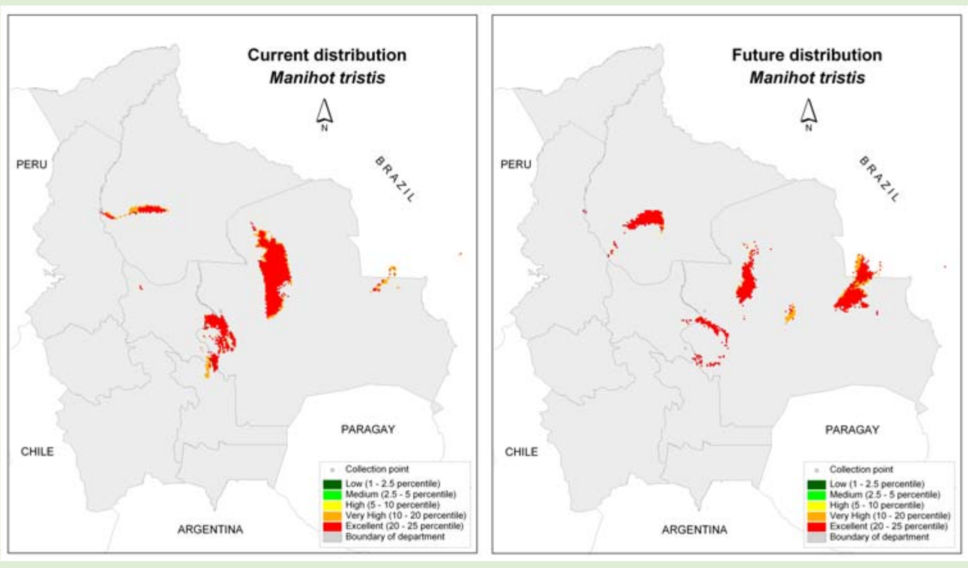

Figure 1. Projected impact of climate change on the distribution of *Manihot tristis.* The red and orange areas are those most suitable for the species.

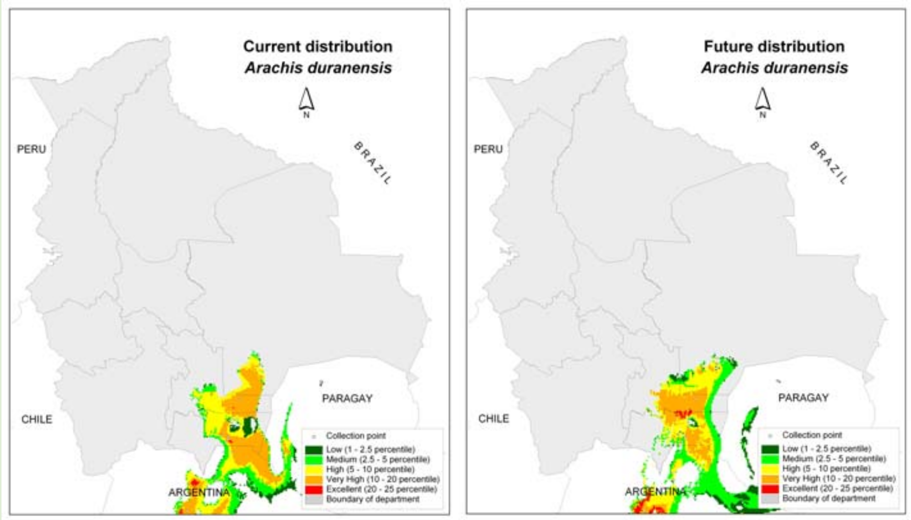

Figure 2. Projected impact of climate change on the distribution of *Arachis duranensis*. Red indicates areas most suitable for the species and dark green indicates areas least suitable.

Spice and medicinal plants in the Nordic and Baltic countries

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The report from the Nordic / Baltic project *Spice and medicinal plants in the Nordic and Baltic countries. Strategies for conservation of genetic resources in minor crops* (SPIMED) is published. The project has been funded by the Nordic Gene Bank, and the printed report can be ordered from NGB.

The project has been divided into two parts. The main part of the report deals with eight prioritized plant species, which have been collected and examined. General information about botany, distribution and valuable medicinal or aromatic properties is given and data about established collections and observed morphological variation is presented for the species. The 8 target species, which has been collected in 1-3 of the countries, are *Acorus calamus, Arnica* Montana, *Helichrysum arenarium, Hypericum* sp., *Origanum vulgare, Rhodiola rosea, Thymus* sp. and *Valeriana officinalis.*

The report recommends that specimens covering genetic variation of all target species should be collected in all Nordic and Baltic countries and included in national collections. Further investigations of the accessions conserved should also be carried out, especially chemical analysis of valuable compounds in the plants.

The SPIMED-group has also given recommendations to future programmes for conservation and use of PGR in medicinal and aromatic plants (MAP) in the Nordic and Baltic countries. A mandate taxon list consisting of 134 wild growing MAP species is suggested, and current and foreseen threats to the species are discussed. Serious threats can be grouped as:

1. Habitat alteration and loss due to change of agricultural practice.
2. Habitat loss due to change of land use, construction of buildings, new infrastructure etc.
3. Environmental pollution.
4. Over-exploitation due to harvesting of material and destructive harvesting techniques.
5. Climate change.
6. Invasive species.

Further recommendations imply activities and projects regarding:

- Criteria for prioritizing species in projects and conservation efforts;
- New inventories and collecting missions;
- Establishing collections and use of accessions;
- Characterization and evaluation of the accessions in collections;
- *In situ* conservation initiatives.

The report concludes with a list of defined projects related to certain MAP species ranging from inventories and evaluation of accessions to *in situ* initiatives and development of techniques and methods for conservation. It is also recommended to develop guidelines for harvesting of material from nature and to develop methods for commercial production of raw material of MAP species in order to prevent harvest of material from wild populations of vulnerable species.

The report was recently printed, and the reference is:

Asdal, Å., Olsson, K. Wedelsbäck, K., Radusiene, J., Galambosi, B., Bjørn, G.K., Zukauska, I., Thorvaldsdottir, E.G. and Pihlik, U. (2006). Spice and medicinal plants in the Nordic and Baltic countries. Conservation of genetic Resources. Nordic Gene Bank, Sweden.

Towards improved *in situ* management of Europe's crop wild relatives

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The kick-off meeting of the project 'An integrated European *in situ* management workplan: implementing genetic reserves and on farm concepts' (AEGRO) funded by the EU programme on the conservation, characterization, collection and utilization of genetic resources in agriculture was hosted in Evershot (UK), 2–3 November 2007, by the University of Birmingham. The project was initially launched by the ECPGR *In Situ* and On-farm Conservation Network to facilitate *in situ* management of crop wild relatives (CWR) as well as to promote the cultivation of landraces in Europe.

Plant breeders have used related wild species in crop enhancement programmes with great economic success for many decades. The target-oriented protection of these valuable sources of novel genetic variation in their natural habitat however was lagging behind for several decades in spite of early calls for actions in the 1970s. With the extinction of populations and species, donors of resistance genes and many other valuable agricultural traits may be lost forever. Today, there is a growing awareness that genetic erosion within these species is to be considered as a potential threat to yield stability and breeding progress and may affect the resilience of agricultural production systems. Preserving the diversity of CWR for agriculture is now in the lime-light of the public expert debate and is accepted as an important task for both the plant genetic resources for food and agriculture conservation community and the plant conservation sector. To be successful, it is crucial that both sectors regularly liaise either with the Ministries of Agriculture or the Ministries of Environment to improve their collaboration and work closely together along the lines described in European and national strategies such as the European Plant Conservation Strategy (EPCS). To take a recent example for national strategies, the National Biodiversity Strategy of the German Federal Ministry of Environment, Nature Protection and Nuclear Power Safety (BMU), approved only a few days after the AEGRO kick-off meeting on 7 November 2007, aims at the establishment and improvement of the infrastructural, organizational and informational requirements for *in situ* and on-farm management.

AEGRO relies on existing concepts, knowledge, data and organizational infrastructures such as the Global Biodiversity Information Facility (GBIF) or the European Nature Information System (EUNIS). But how effectively and efficiently can these structures support ECPGR working groups deciding to practice the *in situ* management concept? Where are the weaknesses and strengths in the European plant conservation system with respect to the establishment of genetic reserves? AEGRO will address these and other aspects of *in situ* and on farm management.

The objectives of the action are:

- To develop crop specific *in situ* management work plans based on the genetic reserve concept;
- To identify sites in Europe suited to organize genetic reserves;
- Case crop studies to reveal constraints impairing the application of the genetic reserve concept;
- A geographic information system (GIS) analysis of genetic reserve sites will discover the most appropriate areas where a high amount of diversity can be maintained at good cost–value ratio;
- To develop generic technical guidelines and quality standards for genetic reserves;
- To develop database tools required for population management and monitoring and integration of these tools in existing information systems.

Above: Participants at the AEGRO start-up meeting, Evershot, UK. *Photo: Brian Ford-Lloyd*

Results will be used to improve the generic concepts and methodologies elaborated by the accomplished PGR Forum project (http://www.pgrforum.org) and to establish a web-based help-desk function for the development of national CWR and landrace *in situ* management strategies. The landrace strategy will be developed by the University of Perugia (Italy).

The action is being implemented by eight partners and is composed of four cross-cutting tasks and five crop-specific work packages. It is coordinated by the Federal Centre for Breeding Research on Cultivated Plants (BAZ, Germany). The University of Birmingham will provide generic concepts and methodologies, a web-based help function for case studies and is also responsible for the case study on *Prunus*. This partner will also provide training and assist the leaders/partners in data sourcing, planning and implementation of their work packages. The case study on *Beta* is jointly implemented by the University of Madeira (Portugal) and the BAZ, while *Brassica* is studied by the University of Catania (Italy) and the University of Aarhus (Denmark). In particular, the work on *Brassica* is closely followed by the ECPGR working group on *Brassica*. It is a good example for the strong interaction between AEGRO and the ECPGR programme. The case study on *Avena* is led by the University of Athens (Greece) representing the ECPGR working group on *Avena*. This work package can be considered as a first step towards the implementation of the Global Strategy for the *Ex situ* Conservation of Oats (*Avena*

> “With the extinction of populations and species, donors of resistance genes and many other valuable agricultural traits may be lost forever”

spp.) (see below). All crop-specific work packages will provide two kinds of deliverables: a European-wide list of recommended genetic reserve sites, and a detailed work plan for the organization of a single to a few genetic reserves by genus. The University of Madrid will synthesize the results of the case crop studies and identify the Most Appropriate Areas from the biological and cost–value ratio point of view, develop quality standards for genetic reserves and provide a basis for a genetic reserve network in the EU Member States. Similar to the help-desk organized by the UK partner, the documentation and information work package provides a backbone function. The projected development of European Central Crop Databases (ECCDBs) as central coordination instruments for *in situ* management of CWR is a prominent task of this work package led by the BAZ. Software tools developed by AEGRO will be made available via CropForge under public license for re-use by any of the 52 ECCDBs existing in Europe.

The chair of the ECPGR working group on Medicinal and Aromatic Plants and the chair of the ECPGR Oilseed and Protein Network participated in the meeting, as well as a representative from the Botanic Garden of Tenerife. All expressed their desire for regular information on the project progress and planned meetings in order to explore possible joint follow-up actions.

For further information about AEGRO, visit the project website at: http://aegro.bafz.de/index.php?id=95 or contact the Project Coordinator, Lothar Frese at: l.frese@bafz.de

Below: Oat wild relatives, *Avena prostrata* (left) and *A. sterilis* (right) growing in southern Spain.

Andreas Katsiotis

Andreas Katsiotis

Global Strategy for Conservation of Oats (*Avena* spp.)

The Federal Centre for Breeding Research on Cultivated Plants (BAZ), Germany, facilitated the implementation of the study, Global Strategy for the *Ex Situ* Conservation of Oats (*Avena* spp.). The study was co-funded by the Global Crop Diversity Trust and elaborted by an international group of experts between 2006 and 2007. A comprehensive paper of approximately 190 pages was handed over to the Trust by the expert group last year. Although the study sets focus on *ex situ* conservation, the need for complementary *in situ* conservation actions for wild oats was stressed. Experts from Morocco expressed the view that extreme genetic erosion within wild species distributed in Algeria, Tunisia and Morocco is to be expected under changing climatic conditions. Marked genetic differentiation has been found within all analysed species. Thus, a loss of populations implies a loss of genetic diversity. The development of an *in situ* management strategy as a complementary way to safeguard especially the highly threatened taxa was recommended. There is an urgent need to set up or improve conservation programmes for wild oats in northwest Africa and southern Spain where the highest number of crop wild relatives of oat occur.

Contributed by Lothar Frese (l.frese@bafz.de)

On high-mountain pea, *Vavilovia formosa* (Stev.) Fed. (Fabaceae) in Armenia

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Wild perennial high-mountain pea was first described by Steven in 1813 and originally assigned to the genus *Orobus* L. After that, this species was in turn associated with two other genera of the family Fabaceae: *Lathyrus* L. and *Pisum* L. In the first half of the 20th century, An. Fedorov critically revised the taxonomy of the mountain pea in his famous monograph 'Wild mountain peas of the Caucasus' (1939). Based on morphological characteristics, such as shape of the flower and stipule, absence of tendrils, presence of creeping, thread-like rhizomes, as well as characteristics of disjunctive distribution range, ecology and perennial habit, he separated the species into a monotypic genus *Vavilovia* Fed. The genus was named to honour N.I. Vavilov, the prominent Russian scientist, who pioneered the study of cultivated plants and first recognized the importance of their wild relatives.

Vavilovia is a separate branch in the pea group and its origin is associated with upper-alpine, high-mountain zones of great and small Caucasus (Armenia, Azerbaijan, Georgia and northern Caucasus of the Russian Federation), north and northwestern Iran, northern Iraq, Anatolia and Lebanon. Unlike *Vavilovia*, annual wild peas from the genus *Pisum* are evolutionally younger and mainly occur in sites with xerophytic vegetation, particularly in the Mediterranean region. By its peculiarities of origin and ecology, the high-mountain pea markedly differs from wild and cultivated peas of the genus *Pisum*. In this respect, interspecific crosses of *Vavilovia* with species from *Pisum* are of theoretical and practical interest as a potential source of new cultivars of pea.

In Armenia, *V. formosa* occurs at altitudes ranging from 3000 to 3500m, on slopes with sparse vegetation coverage, on Kapudjugh mountain (alpine zone of Zangezur), on the volcanic summit of Sevsar (Geghama mountain ridge), as well as Syunik Plateau on Mets Ishkhanasar and Ukhtasar mountains (Gabrielyan, 1962). The distribution of the taxon in Armenia is shown in Figure 1. Within the framework of UNEP/GEF project on '*In situ* conservation of crop wild relatives through enhanced information management and field application', two populations of *V. formosa* were studied. One of the populations inhabits the southern slopes of Geghama mountain ridge in the vicinity of Akna Lich (Fig. 2). The population size was about 1200 individuals, growing in an area of about 2 ha. Another population on the big concavity of Ughtasar mountain was smaller (Fig. 3 and front cover). It occupies an area of 0.1 ha with 35 individuals. Within the populations studied, both single individuals and small plant groups were observed. *V. formosa* is a rare representative of the alpine upper-mountain flora of Armenia and its distribution here is confined to small areas of moving detritus and scree or black volcanic slags. The size of the particles can range from as small as sand to 20cm in diameter.

Figure 1. Distribution of *Vavilovia formosa* in Armenia (orange spots).

Ivan Gabrielyan

Figure 2. Habitat and location of a population of *Vavilovia formosa* in Armenia (southern slopes of Geghama mountain ridge in the vicinity of Akna Lich).

V. formosa is very ornamental (see front cover photo); it flowers from June to August and bears fruit from August to September. Fruits are not produced every year, since flowers often fall, damaged by night frosts, which at such an elevation are common even in August.

Due to the specificity of habitat requirements of the high-mountain pea—that is, narrow specialization to high-mountain scree—its distribution range is considered to be regressing. Among factors limiting expansion of the distribution range of *V. formosa* are low competitiveness and severe fragmentation of populations. In addition, *V. formosa* is an autochorous plant; that is, it doesn't depend on an external agent for seed dispersal. Seeds usually fall not far from the parental plant, within the boundaries of the habitats that agree with their requirements for ecology and life forms. Streams and wind cannot contribute to seed dispersal due to the specificity of the substrate on which the high-mountain pea grows. *V. formosa* can also propagate asexually by creeping rhizomes. Within each isolated population the mountain pea can propagate asexually through rooted shoots that penetrate deep into the substrate.

The main human-induced threat contributing to population decline is grazing (Gabrielyan, 1990). As a rare taxon with a disjunct, severely fragmented distribution and isolated populations, *Vavilovia formosa* was listed in the Red Data Book of the USSR (1984), Red Data Book of Russian Federation (Popov, 1988) and Red Data Book of Armenia (Gabrileyan, 1990). Within the framework of the aforementioned UNEP/GEF project, the taxon was regionally assessed against the IUCN Categories and Criteria (IUCN, 2001) as Endangered. Although most of the Armenian populations are declining, it should be noted that the populations inhabiting inaccessible sites, particularly steep slopes, are protected from the main threat (i.e., grazing), and are therefore able to reproduce more successfully. For *in situ* conservation of V. *formosa* in Armenia, the following measures are recommended: strong protection of all known sites, monitoring of known populations and identification of new ones, grazing control at the sites known to be most affected by this threatening factor.

Figure 3. *Vavilovia formosa* growing in scree on Ughtasar mountain, Armenia. *Photo: Ivan Gabrielyan*

Another possible threat to *V. formosa* is global warming. Being restricted to a narrow environmental niche of high mountains, its chances of survival are very low once the climate gets warmer. As models predict, species may respond to temperature increase by moving to higher altitudes, which is hard for the high-mountain pea that already occurs at the elevations of 3000–3500m. An exercise modelling climate change in DIVA-GIS by using Bioclim has shown that in 50 years time there will not be a suitable habitat for *Vavilovia* in Armenia.

Last but not least, biological peculiarities of flowering and fruit-bearing of the high-mountain pea can be considered as a natural cause of population decline. As mentioned before, early frosts can damage the developing fruits and seeds of the plant. Moreover, not all individuals in the populations flower and fruit every year. All these factors reduce the reproductive potential of the whole population. Further research is needed in the biology of *V. formosa* under *in situ* and *ex situ* conditions.

Several individuals of *V. formosa* from the Akna Lich population (Geghama mountain ridge) were planted in the 'Flora and Vegetation of Armenia' demonstration plot at Yerevan Botanic Garden (National Academy of Sciences of the Republic of Armenia), which is located at 1200m above sea level in the semi-desert zone. It was successfully grown in the rock garden of the demonstration plot and allowed biological and phenological observations to be made of this unique and very interesting representative of the flora of Armenia under *ex situ* conditions. The success of this transplantation shows that under conditions close to natural (alpine hill with artificial scree), *V. formosa* can be cultivated and propagated under *ex situ* conditions and hence is recommended for cultivation in botanic gardens. This will contribute to the conservation of the genetic resources of this rare monotypic genus, represented by *V. formosa*.

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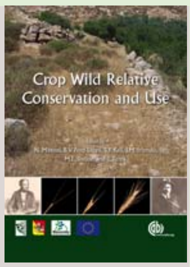
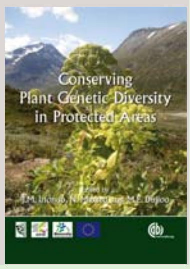
New publications

Two new publications from CABI (http://www.cabi.org/):



Crop Wild Relative Conservation and Use. Edited by Nigel Maxted, Brian Ford-Lloyd and Shelagh Kell, School of Biosciences, University of Birmingham, UK; José Iriondo, EUIT Agricolas, Universidad Politécnica de Madrid, Spain; Ehsan Dulloo and Jozef Turok, Bioversity International, Italy. 720 pages. Hardback 978 1 84593 099 8. *This text presents methodologies and case studies that review and provide national, regional and global recommendations for global CWR conservation and use. Contains 49 chapters from 126 contributors.*



Conserving Plant Genetic Diversity in Protected Areas. Edited by José Iriondo, EUIT Agricolas, Universidad Politécnica de Madrid, Spain; Nigel Maxted, School of Biosciences, University of Birmingham, UK; Ehsan Dulloo, Bioversity International, Italy. 288 pages. Hardback 978 1 84593 282 4. *This book presents a practical set of management guidelines that can be used for the conservation of plant genetic diversity of crop wild relatives in protected areas.*

A note from the IUCN Species Programme

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The Crop Wild Relative Specialist Group (CWRSG) is one of the newest in the Species Survival Commission (SSC). Arguably the world's largest network of species experts, the SSC's members are all dedicated to a common cause: fighting the extinction crisis. IUCN has six volunteer commissions and a number of other thematic programmes and the SSC is certainly the largest of the commissions and perhaps one of the most well-known.

IUCN is a complicated machine sometimes referred to as a 'the triple helix', meaning the interlinked partnership of members, commission members and secretariat staff. In addition to the Species Programme, there are five other global thematic programmes. IUCN now has 1043 Members including 83 States, 110 Government Agencies, 736 National NGOs, 82 International NGOs and 32 Affiliates. This does not include commission members, who in the SSC alone number approximately 7000; and with the combined membership of other commissions the total adds up to 10,000. All of this is supported by 1000 secretariat staff spread over 68 countries worldwide (approximately 130 in headquarters in Gland, Switzerland).

Although IUCN SSC and the Species Programme are famous for contributing to and producing the IUCN Red List of Threatened Species™, they also carry out a variety of other work. Between the various units of the Species Programme and the Specialist Groups, the network covers wildlife health, species trade and use, links to livelihoods, contributions to CITES, work on the Biodiversity Convention and much more. In the realm of plant conservation the work covers all the areas embraced by the CBD's Global Strategy for Plant Conservation.

The plant Specialist Groups' work ranges from species red listing, to conservation action planning, input to CITES, conservation–restoration projects and more. CWRSG members may find it particularly helpful to learn from the work of the Medicinal Plant SG, Palm SG and Global Tree SG.

The Species Programme staff includes 23 staff who work from three different offices: Gland, Cambridge, U.K., and Washington, D.C., USA. The SSC Commission chair, Holly Dublin, is located in South Africa. The Species Programme works in close association with the SSC and individual Specialist Groups, as well as leading on global species conservation initiatives such as the Global Marine Species Assessment. A key goal is to build resources to increase the level of support provided to the SSC network.

A number of technical units in the programme cover Species Trade and Use, the Red List, Freshwater Biodiversity Assessments, (all located in Cambridge, UK), and the Biodiversity Assessment Unit (located in several locations in and around Washington DC, USA). The staff support the Specialist Groups through information provision, communications (Lynette.lew@iucn.org), technical support, and fundraising where possible. Julie Griffin (Julie.griffin@iucn.org) and Dena Cator (Dena.cator@iucn.org) are the SSC Network Support Officers dedicated to supporting SSC members and their work. For online information relevant to SSC members, please visit the 'For Members' page which includes a toolkit of downloadable resources. http://www.iucn.org/themes/ssc/for_members/for_members.htm

The plant conservation agenda is of particular importance to IUCN. The institution played a key role in the development of the CBD Global Strategy for Plant Conservation, and is now helping to facilitate implementation of the 16 targets of the strategy—notably target 2, concerned with species conservation assessments (red listing), and target 5, identifying areas of importance for plant diversity. Target 9, embracing the conservation of crop wild relatives is a key challenge to which we must rise, and indeed the work the Crop Wild Relative Specialist Group is doing towards this encompasses bold new approaches which the whole of IUCN can learn from. IUCN is increasingly concerned with protecting nature for people, and work on crop wild relatives that brings together both the *in situ* and *ex situ* plant conservation communities, farmers, and many others, is to be saluted.

DIVERSEEDS: Networking on conservation and use of PGR in Europe and Asia

The European Union funded project, DIVERSEEDS, now in its second and final year, aims to open the European plant genetic resources (PGR) networks to Asian research colleagues working in centres of origin, to establish a communication platform and to promote knowledge exchange on genetic resources, and assist in the implementation of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) and contribute to overcome its gaps. European and Asian partners have met for both intra-regional and intra-regional discussions with the goal of jointly elaborating a list of recommendations and strategies to improve the sustainable use of PGR, especially in centres of origin. These recommendations will be disseminated to researchers, but also to policy-makers, farmers and the general public.

For further information, visit the project website (http://www.diverseeds.eu/) or contact the Project Coordinator, Markus Schmidt (markus.schmidt@idialog.eu).