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Drafting a prioritized checklist of Crop Wild Relatives and Wild Harvested Plants of Italy: problems and solutions

Abstract

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The National checklists of Crop Wild Relatives (CWR) and Wild Harvested Plants (WHP) are the basic tools for the development of in situ and ex situ conservation strategies of plant genetic resources. Here we discuss the methodologies and the prioritization process we previously used in the preparation of the prioritized checklist of CWR and WHP for Italy.
The starting point were the most up-to-date Italian checklists of native and alien flora with their updates used as a nomenclatural and distributive source of data. Sardinia and Sicily were kept separate from peninsular Italy to perform detailed analyses focused on the taxa of the two major islands. The origin, the endemic status, cultivation, economic importance, uses, gene pool or taxon group, and the Red List status information were added. The WHP status was attributed to all the taxa with known direct uses. A qualitative approach was adopted in the prioritization process, the main criteria used were: 1) the inclusion of wild relative taxa of crops listed in Annex I of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) and/or by the Italian Institute of Statistics (ISTAT) for cultivated areas and yield in the last 5 years; 2) the threatened taxa occurring in national or global Red lists; 3) the endemism.
This prioritization process generated 102 taxa as most in need of specific protection and /or monitoring measures, 57 taxa requiring monitoring because of their restricted distribution although not requiring specific protection measures and 735 taxa not requiring any specific protection. However, different prioritization processes could have been applied to the Italian checklists yielding different results. Here we discuss the matter.

Key words: conservation, useful plants, Mediterranean flora.

Introduction

Crop Wild Relatives (CWR) are plants closely related to socio-economically important crops used as food, fodder, ornamentals, materials or other uses. According to Maxted & al. (2006), a broad definition of CWR would include any wild taxon belonging to the same genus as a crop.

Thanks to their genetic closeness to crops and their high diversity, which was not eroded during domestication and successive selection process, CWR are a source of beneficial alleles that can be relevant for crop improvement and to attain food security (Harlan & de Wet 1971; Maxted & al. 2006, 2010). Indeed, CWR have been used for long time and are still used nowadays to breed new crop varieties (Hajjar & Hodgkin 2007; Maxted & Kell 2009; Vincent & al. 2013; Dempewolf & al. 2014; Zhang & al. 2017). However, CWR genetic diversity still needs to be fully explored often representing a relevant and 'untapped source of genetic material' (Okie 2006).

Wild Harvested Plants (WHP) are those plants that are part of the local traditional knowledge because collected in the wild and used as additional source of food, medicine, combustible, and materials. When locally used as a food source or additional familiar income, they have the potential to increase food security and nutrition of those populations living in harsh environments and developing countries (Asprilla-Perea & Díaz-Puente 2019; Ulian & al. 2020). Overexploitation, habitat degradation and climate change are among the main factors determining biodiversity loss, in general, and of CWR and WHP, in particular. For this reason, the compilation of inventories emerges as one of the first steps to be carried out in the development of monitoring plans and more comprehensive *in situ* and *ex situ* protection policies (Corlett 2016). In fact, diversity of crop wild relatives is poorly represented in gene banks; at this regard, over 70% of wild relatives has been identified as high priority for further collations according to Castañeda-Álvarez & al. (2016). Finally, CWR and WHP play an essential role in the ecosystems providing several services both to natural and semi-natural environments (FAO 2019).

According to Maxted & al. (2007), several key topics need to be addressed when attempting to formulate an effective national conservation strategy for CWR diversity including i) creating a national CWR inventory, ii) analysing the CWR inventory content, national patterns of CWR distribution and threat status for CWR diversity, iii) assessing current conservation actions, iv) identifying priority sites for conservation, and v) creating CWR conservation action plans.

In 2021, considering the recently updated checklist of the vascular native and exotic flora of Italy (Bartolucci & al. 2018; Galasso & al. 2018) and the last Italian Red Lists (Rossi & al. 2016; Orsenigo & al. 2018, 2020), we decided to update the previous inventory of the CWR and WHP of Italy of Landucci & al. (2014) whose taxonomy, taxa distribution, threat status, use categories and genetic data for CWR and WHP needed to be reviewed and integrated. A national CWR checklist is a list of the taxa found among the national flora and related to crops; however, being the number of CWR taxa in their broad concept too high to actively conserve all of them, it is often necessary to establish a methodology to select those most in need of conservation. This is done by the integration of these checklists with additional data which allows the construction of prioritised inventories (Maxted & al. 2013).

Starting from the previous work and methodologies of Landucci & al. (2014), and based upon the considerations above, a CWR and WHP priority list has been drafted for Italy. Based on our experience in the preparation of this updated Italian checklist and inventory of CWR and WHP we will focus our discussion on some of the methodological aspects and their related issues.

Materials and methods

In order to properly discuss the problems related to the development of a CWR/WHP prioritized list for an entire country and the relative solutions, a summary of the method we applied in Ciancaleoni & al. (2021) - whose results are the starting point of this new investigation - follows.

In Ciancaleoni & al. (2021) we applied a floristic approach to draft the CWR and WHP checklist of Italy; giving a wide point of view on a country's diversity, this approach provides the best foundation for developing a National Strategic Action Plan for the conservation and sustainable use of CWR and WHP. The checklist was then annotated following the same approach of Landucci & al. (2014), instead of the suggested layout produced by Thormann & al. (2017), to allow an easier comparison of the new with the old one. Information related to origin (i.e., native or introduced, archaeophyte or neophyte status), the indication of the national or infra-national endemic status, cultivation, economic importance, ethnobotanical, medicinal or other uses, gene pool or taxon group for CWR (Euro+Med 2006-; Vincent & al. 2013; Pignatti & al. 2017; IPNI 2021; USDA 2021) were included for each taxon in the checklist. Finally, the need for monitoring or protection was integrated following the most recent Red Lists available (Rossi & al. 2016; Orsenigo & al. 2018, 2020; IUCN 2020). In the end, three distinct annotated checklists were produced for the Italian Peninsula, Sardinia, and Sicily, respectively.

The CWR status was then attributed to all those taxa related to a cultivated species (i.e., same genus following Maxted & al. 2006) according to the data used as source of information (Vincent & al. 2013; ISTAT 2019; USDA 2021) while the WHP to those (taxa) with one or more known direct uses regardless of the actual commercialization of their products (Magos Brehm & al. 2008). Furthermore, due to the observation that some CWR are found both in cultivation and in the wild, cultivated plants have been included in the inventory, as well alien species, considering the possibility that the latter could have adapted to new environments developing interesting traits.

The prioritization methodology we adopted in Ciancaleoni & al. (2021) consisted of a qualitative approach based on the combination of the following criteria (Khoury & al. 2013; Landucci & al., 2014): i) the socioeconomic value, based on the presence of the related crop in the Annex I of the ITPGRFA (FAO 2001) and/or in the list of the Italian Institute of Statistics for cultivated areas and yield in the last 5 years (ISTAT 2019); ii) the need of protection, based on the inclusion of the taxa in a threatened category of national and global Red lists. Endemism was used as an additional indicator to determine threat.

The combination of the above mentioned criteria was used to define three priority categories, namely "A", "B" and "C" from the highest to the lowest need of protection: "A" category, includes native and alien taxa related to an important crop for food and agriculture that needs specific protection and/or monitoring measures; taxa in this group are present in at least one of the most recent National Red Lists (Rossi & al. 2016; Orsenigo & al. 2018, 2020) or in the IUCN Red List (IUCN, 2021) with a pertaining threat category; "B", includes national endemic or sub endemic taxa that require monitoring because of their restricted distribution, although they do not necessarily require specific protection measures; 'C', all the remaining native taxa that, on the grounds of current knowledge, do not need any specific protection measure.

With the present paper we aim at developing a critical view of the list we proposed in Ciancaleoni & al. (2021), starting from figures resulting from the process, and taking into account strengths/weaknesses of the available sources and the entire decision-making structure, also based on the comparison with similar lists produced in other countries.

Results and Discussion

The described approach we adopted in Ciancaleoni & al. (2021), which identifies CWR in a broad sense including all taxa belonging to the same genus of a crop, resulted in the identification of 8,766 CWR/WHP taxa for Italy belonging to 7,334 species (https://www.optima-bot.org/index.php/es/8-category-en-gb/217-the-italian-cwr-whp-database). In particular: 6,839 taxa (5,516 species) are CWR only, 108 (108) WHP only, and 1,821 (1,710) CWR and WHP at the same time. Taxa and species resulted distributed as follows: 7,916 (6,641), 2,745 (2,600), and 2,952 (2,738) for the Italian Peninsula, Sardinia, and Sicily, respectively.

Priority taxa identified through the above-described qualitative process - whose number is here reported followed by number of species (in brackets) - were 102 (82) for the "A" category and 57 (50) for the "B" category, while the remaining 735 taxa (648) were designated to category "C", thus considered as not deserving any immediate specific protection or monitoring measures. The identified taxa to be protected with the highest priority in Italy ("A" category) belong to 36 different genera. Among them, *Allium* L., *Asparagus* L., *Avena* L., *Brassica* L., *Cichorium* L., *Citrullus* Schrad., *Daucus* L., *Diplotaxis* DC., *Festuca* L., *Lactuca* L., *Lathyrus* L., *Malus* Mill., *Prunus* L., *Trifolium* L., and *Vicia* L. have already been reported to be of highest conservation priority, both for Italy (Landucci & al. 2014) and globally (Castañeda-Álvarez & al. 2016).

The new produced inventory provided a list of those CWR and/or WHP taxa deserving priority conservation actions in Italy. The available results can be useful not only for further scientific insights to the issue but also for shedding light on the importance of Plant Genetic Resources for Food and Agriculture conservation according to their relevance and threat status. However, in developing this inventory we had to deal with several aspects and problems which deserved special attention. We are referring to the evaluation methodology for the priority level assessment for each taxon. In fact, when we tried to compare our results to others coming out from other geographic contexts it emerged the difficulty related to the different approaches and methodologies adopted from time to time. Sometimes a quantitative approach is adopted (evaluation in parallel with scores for each criterion) and other times a qualitative one (evaluation based on serial systems where the scores are given in sequence, one criterion at a time). As a result, most of the time, different methodologies make the results difficult to compare.

During the prioritization process, one of the main criteria applied is the social-economic importance of the related crop. Socio-economic importance can be estimated using data regarding trading values and country's food supply which can be extracted from FAOSTAT, a food and agriculture free database for over 245 countries and territories administered by FAO Statistics Division (FAO 2021). The main issue here is that only major crops or crop groups are usually listed in this database, and some may be missing or grouped

with others according to the FAO commodity list codes. Furthermore, crop groupings in FAO food supply statistics differ from those in production statistics (Kell & al. 2015). This makes problematic the scoring process of those combined crop groups because it is not possible to obtain a crop-specific economic value. Possible solutions are to use the value as it is for every crop of that commodity group or use additional data and sources as indicators to estimate it. The disadvantage here is that it could bring bias in the evaluation and different approaches to solve this issue. Furthermore, Annex 1 of the FAO International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) (FAO 2001) has often been used as a list of socio-economic important plants globally. However, it has been recently pointed out that this list is not comprehensive enough, so it needs to be integrated with other data at national (i.e., national agricultural statistic services) and global scale (i.e., FAOSTAT). Sometimes it may be considered sufficient to pair the ITPGRFA Annex I with a national trading value statistic, whereas in other cases it has emerged the need to also use food supply data expressed in Kcal/capita/day to have a more comprehensive point of view on the crop importance for the local population (FAO 1997).

Socio-economic importance is one of the necessary criteria for a taxon to be included in the highest priority category ("A") used in our paper (Ciancaleoni & al. 2021). Here we decided to estimate the social-economic importance by using the crops listed in Annex I of the ITPGRFA (FAO 2001) and/or by the Italian Institute of Statistics for cultivated areas and yield in the last 5 years (ISTAT 2019). The two groups together include the most socioeconomically important crops for food and agriculture for Italy and the rest of the World. Consequently, because all the food crop genera resulted already included in our inventory by the combination of the two above mentioned sources, we evaluated as not necessary to include data from the FAOSTAT and this with the aim also of allowing an easier comparison with the previous work from Landucci & al. (2014). In our database, more than 1,200 taxa resulted mentioned in at least one of the two sources used. In other regions, according also to the available information and the different level of development, the approaches registered have been different like in Tunisia (El Mokni & al. 2022) and China (Kell & al. 2015).

Also, the choice of considering only taxa native to Italy is questionable, taxa like *Juglans regia* L., widely cultivated and reported as established in the wild in several regions as a cryptogenic in Lombardia, Veneto and Sardinia, and as casual or naturalized from many Italian regions could have been considered; the same could be true for *Opuntia ficus-indica* (L.) Mill. due to their importance as crops. Another widely used criteria to prioritize CWR taxa is their threat status. The major problem with it is due to the lack of national Red Lists and assessments for many taxa. Alternatively, it is possible to use other indicators such as endemism or restricted distribution for those taxa not assessed yet. Furthermore, there are cases when a taxon is assessed at different geographical scales (i.e., regional, national), so that in a scoring process, this could be misleading. Again, this becomes time-consuming when the evaluation needs to be done on a wide checklist.

In Ciancaleoni & al. (2021) we considered the threatened taxa assessed in the most recent Italian and IUCN Red Lists (Rossi & al. 2016; Orsenigo & al. 2018, 2020; IUCN 2021). We decided to use the IUCN Red List for those alien species that occur outside of our target region and that were not assessed for Italy. We considered the following categories: Critically Endangered or Possibly Extinct, (CR(PE)), Critically Endangered (CR),

Endangered (EN), Vulnerable (VU), and Near Threatened (NT). Taxa characterized by a low-risk level (LC) or by inadequate information (DD) indicating a lack of knowledge about these species were not considered. Furthermore, when the assessment was referred to the species only, we transferred the assessment at least to the nominate subspecies. As mentioned above, one option to face the incompleteness of the Red Lists is to integrate them with other factors which could function as indicators of a potential threat. Because, in general, species with restricted distribution should be given higher priority, we decided to use endemicity as an additional indicator and we included it among the criteria of the "B" priority category. Other approaches used in the literature include the use of a neighbouring nation's red list as a proxy of the taxa threat status (Mponya & al. 2020), the collection and combination of all the taxa assessments available in the literature and online (El Mokni & al. 2022) or, lastly, the decision to avoid the use of this criterion due to the insufficient data available (Rahman & al. 2019). Finally, it should be noted that using the threatened taxa approach often results in excluding from the priority list CWR taxa that indeed are of importance for future breeding and for guaranteeing food safety and food risk management. For example, *Beta vulgaris* L. subsp. *maritima* (L.) Arcang., the direct CWR of *B. vulgaris* L., an important crop worldwide, is not a taxon under threat due to its wide distribution, should its populations be excluded a priori from a list aimed at protecting important genetic resources?

The degree of relatedness of a CWR to the crop is another among the most common factors used as criteria in the priority evaluation. It is well known that it is originally based on the gene pool concept by Harlan & de Wet (1971) which, in turn, is not available for all crops yet. Therefore, in 2006, Maxted & al. developed the taxon group concept that, being based on the taxonomical hierarchy, could help fill the gap when the gene pool information is missing because it can approximate the genetic distance. Nowadays there are two freely available databases with data regarding gene pool and taxon group for a wide range of CWR (Vincent & al.,2013; USDA 2021). Unfortunately, these data are not available for every taxon, bringing researchers to different approaches to compensate for the missing information (e.g., using the Taxon Group 4 for all the CWR taxa in the same genus of the related crop). When dealing with the degrees of relatedness, the evaluation of taxa related to more than one crop (e.g., brassicas) needs to be discussed. Should we consider the higher gene pool (or taxon group) value and evaluate it accordingly or consider the fact that this plant is related to more crops as an added value? Here again, there are different approaches and points of view.

In our evaluation, we decided to add this information to the database, but not to use it in the prioritization process. This is because otherwise we would have not been able to compare our results with the previous work from Landucci & al. (2014) and because it was not possible to obtain enough data regarding the degree of relatedness from the available databases (only 700 taxa got a gene pool or taxon group higher than TG4).

Conclusions

Despite possible methodological problems and the difficulty that is easily encountered when trying to compare results obtained in different countries and geographic contexts,

there is a consensus on the relevance of assessing CWR and WHP species and taxa for prioritized inventories. As recently highlighted by FAO (2019), Plant Genetic Resources for Food and Agriculture (PGRFA), part of the broader concept of Biodiversity for Food and Agriculture (BFA), are in constant decline and crop diversity is following the same trend (FAO 2010). Furthermore, lack of funding, human resources, knowledge, and coordination are some of the weak points in the global strategy for the protection of these important resources. Among the priority actions to counteract this situation, addressing the knowledge and data gaps and establishing monitoring plans are considered essential. Specifically, the need to preserve CWR and WHP should pass through efficient conservation planning actions based on the selection of those taxa more in need of protection through the help of comprehensive prioritised inventories like the one for Italy discussed here. As highlighted also in other contexts, the need to better coordinate the protection efforts both at research level, with similar methodologies, and policy level remains essential and needs to be better developed to preserve this part of biodiversity and its contributions to food, agriculture, and ecosystems, especially considering climate change and growing anthropic pressure on the environment.

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