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# The Search for Wild Relatives of Cool Season Legumes

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# Preface

The origin and domestication of legumes described in this book began to be seriously studied when it became apparent that, while this kind of information had been quite extensively researched with regard to cereals, there was little knowledge available on pulses. At the end of the 1960s, a study on the wild relatives of chickpea was initiated by the senior author, and this was followed by similar studies on broad bean, fenugreek, common vetch, bitter vetch, and lentil, with a moderate emphasis on the pea. The junior author joined the project as a PhD student in the late 1980s to study the genetics of interspecific hybrid embryo abortion in lentil, and later developed his own research programs on chickpea domestication and its evolution under domestication, and on wild peas. While this book describes mainly the findings of our research, pertinent results obtained by others are mentioned and evaluated.

Studies of the wild relatives of each of the abovementioned legumes included evaluation of their taxonomic status, morphological variations, ecological requirements, exploration of their distribution, and seed collection in their natural habitats. Protein profiles of the seeds were examined to obtain preliminary hints of their affinity with the cultigens. Plants grown from these seeds were used to establish their karyotypes, produce intra- and interspecific hybrids, and analyze their chromosome pairing at meiosis and fertility. The aim of these investigations was to identify the potential wild gene pool of the domesticated forms. Genetic variations among accessions, particularly in the genus *Lens*, were assessed by the studies of isozymes and chloroplast DNA. The main findings of such research were discovery of the chickpea wild progenitor *Cicer reticulatum* and the arrangement of annual wild chickpea species in three crossability groups, one of which includes the domesticated form and its wild progenitor, as well as *C. echinospermum*, which can be used to improve chickpea cultivars. Chickpea domestication appears to be a remarkable achievement of prehistoric farmers. It became a crop only after the seed dormancy of the wild progenitor was overcome and a vernalization-insensitive type was selected. This enabled spring sowing, thereby minimizing damage by ascochyta blight.

The wild species of lentil were found to form three crossability groups. One contains the domesticated form, its wild progenitor, and the wild *Lens odemensis*. From this group, *L. tomentosus* was isolated by hybrid embryo abortion and hybrid sterility. Both *L. odemensis* and *L. tomentosus* were delimited as new species during the course of that study. While the idea that *L. culinaris* ssp. *orientalis* is the wild progenitor of lentil had already been put forward by Barulina in the 1930s, we were able, with the aid of characteristics that are monomorphic in the cultigens but variable in the wild form, to identify the wild genetic stock that gave rise to the domesticated form. All of the wild lentil species exhibit strong seed dormancy, making their sowing unprofitable. It seems that selection of dormancy-free types by prehistoric humans was done in wild stands.

Our efforts with wild peas have been only modest, and have proceeded along with two lines: study of amphicarpy in *Pisum fulvum*, and assessment of the seed yield of different wild pea species under natural conditions and under cultivation.

Faba bean and fenugreek are two legumes whose wild progenitors and any other genetically related species have not yet been identified. The suggestion that the faba bean originated from the *Vicia narbonensis* group of species was refuted on the basis of differences in chromosome numbers and shape, seed protein profile, and cross-incompatibility. Fenugreek is a minor crop with no known genetically related wild species. The wild *Trigonella berythea* is the only species known to be cross-compatible with the cultigens, but the resulting hybrid seeds either do not germinate or they give rise to the albino seedlings that soon die.

Common vetch and bitter vetch are fodder plants. The common vetch and its related form are traditionally divided into a number of species, but are treated here as an aggregate under the epithet *Vicia sativa*. Morphologically and karyotypically this aggregate is remarkably variable, but generally there is no direct relationship between a given karyotype and a specific morphological species. The *V. sativa* aggregate is in a stage of incipient speciation, although interkaryotypic hybrids still can be obtained, most of which are partially fertile. This indicates that gene flow between members of different karyotypes is still possible.

Bitter vetch is a minor crop that is utilized to feed ruminants but is poisonous to monogastric animals. Its wild progenitor is found mainly in Turkey, and relationships between the wild and the domesticated form were established by breeding experiments during the course of this study. Because the wild bitter vetch grows in nature in small populations and sparse stands, it is not a classical forage plant. Why and how it has been adopted as such remains a mystery.

# Contents

# Chapter 1
# The *Lens* Genus

The genus *Lens* owes its economic importance to the domesticated lentil, *Lens culinaris* Medik. Lentil has been a traditional crop for millenia in the Middle East, Mediterranean countries, the Indian subcontinent, and the Ethiopian Highlands. In modern times the crop has also been grown in Australia and in North and South America. *Lens* is a small genus comprising the domesticated form and six wild taxa: the lentil wild progenitor *L. culinaris* ssp. *orientalis* (Boiss.) Ponert; *L. tomentosus* Ladizinsky; *L. odemensis* Ladizinsky; *L. ervoides* (Brign.) Grande; *L. lamottei* Czefr., and *L. nigricans* (M. Bieb) Godr.

Growing worldwide interest in the wild genetic resources of crops led us, during the 1970s, to initiate a series of studies on wild relatives of pulses and fodder legumes that had been domesticated in the Middle East. One of these crops was lentil. At that time there was only limited information on the botany of this genus or on the distribution of its various species and their ecological requirements. Furthermore, seeds of wild lentil species were practically nonexistent in gene banks. After the initial stage of becoming acquainted with the morphology of each *Lens* species a number of visits were undertaken to areas where wild lentils were reported, with the object of collecting seed and examining the ranges of the ecological requirements of each of these species. Plants grown from the collected seeds were used for intra- and interspecific hybridization experiments to assess the cytogenetic structure of each species and the cytogenetic relationships among them. The collected material was later used in a number of molecular studies, with the twofold purpose of assessing the validity of each species as a taxonomic entity and identifying the potential of the various wild species as genetic resources for improvement of the domesticated lentil.

As in other publications (Ladizinsky 1998a, 2012), here too, we have adopted the biological species concept instead of the morphological species concept for delimiting natural groups. Accordingly, the species is considered here as a group of individuals which, actually or potentially, freely interbreeds and forms a coherent gene pool that is kept isolated from other biological species by means of various reproductive barriers. At the same time, however, the biological species is usually



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