Table 2. Some characteristics of natural distribution areas of wild P. lunatus forms in Meso-America

Country	Habitat	Elevation (masl)	Annual mean temp. (°C)	Annual mean rainfall (mm)	Length of dry season (months)
Mexico	Pacific and Atlantic slopes, warm valleys, at the border or inside dense semi-deciduous or deciduous forest, clearing of evergreen or semi-evergreen forests	0-1,500	16-27	750-1,500	5-7
Guatemala	Pacific and Atlantic slopes, warm valleys, clearing of warm and humid subtropical forests	50-1,800	20-26	500-3,000	1-6
Salvador	Dry forests, but forests almost completely destroyed and replaced by cropping systems	10-1,000	22-28	1,700	4-6 (severe)
Nicaragua	Semi-arid deciduous forests and montane sub-humid forests (with pines and oaks)		25	1,000-1,500	4-6
Honduras	Mountains with woodlands made of pines and oaks	50-1,000	22-28	1,000-2,000	2-5
Costa Rica	Pacific slopes, clearing of dense evergreen and deciduous forests	100-1,800	22-27	1,400-3,000	1-5

eastern part of South America. Although Piper (1926) reported the species in Brazil, he did not provide geographical data. Wild populations are also not found in Chile (probably due to excessive dryness in northern Chile) and in Bolivia, despite a similar climate in nearby Peru and Argentina.

Landraces

Small-seeded landraces are grown in the semi-arid subtropical region of the south-western USA, mainly in Arizona, home of the Hopi Amerindians (Kuhnlein, Appalachian Mountains when the first bush type appeared in eastern USA at the end of the 19th century, showing adaptation to subtropical climate. Landraces in Meso-America are also characterized by small seeds and are distributed from Mexico to southern Panama, an important part of the "milpa" subsistence agricultural system (S.A.R.H. *et al.*, 1984; Maquet and Baudoin, 1997). A similar situation exists through the Caribbean Islands, where Lima beans are present at low and mid-altitudes in the traditional homegardens known as "conucos" in Cuba (Esquivel and Hammer,

Table 3. Some characteristics of natural distribution areas of wild P. lunatus forms in the Andes

Country	Habitat	Elevations (masl)	Annual mean temp. °C	Annual mean rainfall (mm)	Length of dry season (months)
Colombia	Atlantic coast	50-600	25	1,000	1-2
	East slope of the eastern Andean Belt	1,600	20		
Ecuador	Dry forests of lower mountain; very humid forests of low mountain; thorn sub-desert of low mountain; damaged vegetation, valleys	300-1,900	14-20	500-1,500	1-4
Peru	Eastern slope of the Southern Andean belt;	1,000-1,400	24	1,300-2,000	1-4
	In the North (Cajamarca), thorn dry forest with Cereus and graminaceae	1,100-1,800	14	700	3
Argentina	Province of Salta	650	17-23	700-1,300	1-6

Indians at the frontier between Costa Rica and Panama show a very good drought tolerance.

Small-seeded landraces are also distributed throughout South America (Maquet and Baudoin, 1997). In the eastern part, they are particularly common in north-eastern Brazil. The frequency of large-seeded landraces increases in central and southern Brazil (Erickson, 1982). Consequently a hybrid zone has developed, with landraces having intermediate seed sizes. Landraces are cultivated in the Andean region from Venezuela to Argentina, with small-seeded landraces found at lower altitudes (700 masl on average) than large-seeded landraces (1,880 masl) (Maquet, 1995). It is also essential to mention the occurrence of large-seeded landraces in valleys of the arid coastal region in Peru. According to Mackie (1943), these genotypes are the final products of an evolutive branch, i.e., the Inca Branch, following trade routes of pre-Colombian residents and giving rise to the cv-gr Big Lima bean. In these coastal valleys of Peru, annual rainfall averages only 2.2 mm; temperatures average 13°-19°C due to the cooling effects of cloudy skies and ocean currents; dense fog also provides additional moisture for growth (Baudoin, 1991).

There is scarce information from Chile, but large-seeded landraces have been collected in the dry north (Maquet, 1995).

Weedy types resulting from gene flow between wild and cultivated forms have been observed where these grow

sympatrically (Maquet, 1995). For example, hybridization between the small-seeded wild form and the cultigen is known from Mexico, Guatemala, Costa Rica, the Bahamas, Cuba, Puerto Rico, and Jamaica (Correll and Correll, 1982; Liogier, Martorell, 1982; Maquet, 1991: Esquivel *et al.*, 1993). The weedy type is also present in the Andean region and particularly in Ecuador and Peru (Debouck, 1990). It is distributed from 1,800 to 2,000 masl in Peru and even up to 2,400 masl in Ecuador.

Discussions

The wild Andean form has a very limited distribution from north of Ecuador to north of Peru, which reflect a reduced adaptability to low and highland environment. On the contrary, the wild Meso-American form is geographically widely distributed from Mexico to the north of Argentina, extending on the eastern slopes of the Andes and in the Carribean Islands. This wild form is found in a wider array of elevations, from 3 to 1,820 masl, and therefore appears much more flexible than the wild Andean form.

The geographic distribution of the wild forms corresponds generally to the deciduous and semi-deciduous forests, the transition between very rainy and drier regions. In these regions, the annual rainfall varies between 800 and 1,500 mm, with a marked dry season extending to 3 to 5 months. Temperature is a very important factor and too low values limit the extension of the species in altitudes and latitudes. In particular, in Mexico, the Meso-American form is more frequent in lower elevations, forests are converted into grassland due to shortage of precipitation. This situation might explain a better drought tolerance of the Andean form. This should be, however, checked because average annual rainfall is not the most critical factor in the vegetation distribution. Average annual temperatures are much more important in the altitudinal distribution: the Andean wild form, more adapted to higher elevations, tolerates lower values than the wild Meso-American form.

Some natural populations have been reported in the evergreen forest, on relatively well drained soils (calcareous or sandy) and under sunny conditions. In this environment, a constant humidity facilitates the spread of fungal diseases, such as *Alternaria* and *Phoma* (Maquet and Baudoin, 1997). Only some rustic populations can survive such unfavorable conditions. On the other hand, some populations are reported to be xerophytic. In this case, a nearby river, fog or the presence of a water table in the soil provide the minimum of humidity required for the development of these ecotypes.

In view of *in situ* conservation of wild forms, it is important to point out the instability of the deciduous forests, which are often mismanaged or even destroyed in large parts of the American continent (Schnell, 1987). Nevertheless, some wild *Phaseolus* species and, in particular, the wild forms of *P. lunatus* are well adapted to the secondary anthropic vegetation (Debouck, 1987). Unfortunately, these deciduous forests do not evolve, after deforestation, to the canopy restoration and

exposed to annual fire, preventing the establishment of wild forms. Considering the small population size (on average 10 plants per population), this practice has a very detrimental effect on the survival of wild Lima beans.

The extended geographic distribution of *P. lunatus* is mainly due to the adaptation of Meso-American and Andean landraces to extremely diverse ecological conditions, such as coastal deserts, lowland humid and subhumid tropics and highland areas. The cultivated form has also been adapted to warm temperate regions (such as California) and some early cultivars have been bred to thrive well in the southern part of Canada.

In spite of this adaptation to new ecological situations, it is urgent to preserve the local *P. lunatus* landraces before their extinction. Indeed, in the whole of Latin America and in Arizona, drastic changes in traditional agriculture contribute to the replacement of local landraces by modern cultivars being more productive and resistant or tolerant to abiotic and biotic conditions. In particular, *P. lunatus* is being replaced by other food legume species, for which more breeding efforts have been made, such as cowpea and pigeon pea. Varieties of these two species have been improved for higher drought tolerance, better earliness and yield stability.

A case study: Phytogeography in the Central Valley of Costa Rica

The ecology of the Central Valley of Costa Rica: The Central Valley is an intermontane valley located in the geographic center of Costa Rica. It is delimited by two major mountain ranges: The Cordillera Central to the north, and the Cordillera de Talamanca to the south (Flores, 1991; Bergoeing, 1998). The valley encloses a maximum area of 3,246 km^2, within the altitude range 800-1,800 masl. The maximum length of the area is some 70 km, running from east to west, and the width is about 30 km, running from north to south.

The Central Valley is divided into two smaller valleys: the western valley, or Valle de San José, the larger, including about two-thirds of the total area, and the eastern valley, or Valle de Cartago, located between the Cordillera Central to the north and the Cordillera de Talamanca to the south. Both valleys have access to the coastal lowlands, the former descending slowly along the basin of the Grande de Tárcoles River, and the latter along the basin of the Reventazón River. The eastern valley drains into the Caribbean Sea, while the western valley drains into the Pacific Ocean.

The most striking change in land use in the Central Valley began with the introduction of coffee to Costa Rica in 1808, when the Governor Tomás de Acosta attempted to strengthen the economy of the poverty-stricken colony, and considered that this crop could provide a much-needed commodity to trade with Europe. Although the cultivation of coffee evolved slowly and little progress was made before 1920, these actions resulted in the establishment of most of the Costa Rican population in the Central Valley. The landscape changed dramatically, as the forest was almost totally replaced with agricultural fields. Coffee and sugarcane, with smaller areas of other crops and pastures, dominate the landscape to this day, and the majority of the Costa Ricans still inhabit the Central Valley