T R I P   R E P O R T

Phaseolus Germplasm Collection in Central and Southern Mexico

October 20 - November 24, 1987

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Resumen

Después de un viaje de recolección en la zona central de México se discuten las perspectivas de conservación en bancos de germoplasma e *in situ* para los 18 taxa de *Phaseolus* encontrados, en base a la biología, la ecología y la distribución geográfica de cada especie. Frente a los resultados de la actividad humana sobre la vegetación natural, dos grupos de especies de *Phaseolus* con reacción diferente vienen definidos.

Summary

After a collection trip in central Mexico, the ways of conserving germplasm in germplasm banks and through *in situ* conservation are discussed for the 18 *Phaseolus* taxa found during it, taking into account the biology, ecology and geographical distribution of each species. In relation to the results of human activities on vegetation, two groups of *Phaseolus* species with different reaction are tentatively defined.

Correct citation: D. G. Debouck (1988) "*Phaseolus* germplasm collection in Central and Southern Mexico", The World Conservation Union (IUCN), Gland, Switzerland, Mimeographed, 48p.

C O N T E N T S

Objectives

This work is the direct continuity of previous explorations carried out in Mexico with the Unidad de Recursos Geneticos del Instituto Nacional de Investigaciones Forestales, Agricolas y Pecuarias de Mexico (INIFAP), formerly Instituto Nacional de Investigaciones Agricolas (INIA), aiming at the following:

-- to fill gaps in the genetic variability already present in germplasm banks,

-- to generate knowledge from the field studies about the genetic variability present in Phaseolus and make it available to users of bean germplasm,

-- to initiate a study about the feasibility of in situ conservation.

Let us comment these points a bit.

Up to recent years, bean germplasm in seed banks was made of cultivated materials chiefly P. vulgaris (Lyman, 1984). According to this author, wild germplasm in seed banks in those times was about 1%, and made essentially of wild ancestors. Alien germplasm has been used extensively in improving crops such as wheat, rice, oat, potato, tomato and tobacco (Goodman et al., 1987). It seems reasonable to think that such gene transfers from wild materials will also be used practically in pulse crops (e.g. peanut: Moss, 1980; soybean: Newell & Hymowitz, 1982) in the near future. In the case of beans, there would be an increasing demand for alien Phaseolus germplasm and germplasm banks should already take it into account. There are also other reasons to broaden the genetic base of the bean crops, namely the potential vulnerability of our present bean cultivars and the founder effect of domestication which we will comment upon when dealing with P. vulgaris.

Several steps down in the process of using bean germplasm are heavily dependent upon the information generated during the field studies at the collection site. Let us illustrate it with a few examples. An interesting trait in common bean is the presence of certain types of arcelin - a seed protein - which are lacking in cultivated, but are present in wild forms, since it confers resistance to bruchids (Osborn et al., 1986; Cardona & Posso, 1987). This interesting trait can be lost at the collection site if sampling is not properly done, because these arcelin types are in low frequencies in natural populations, or it can be lost during the seed increase process if the material are multiplied in unappropriate temperature conditions(genetical drift during germplasm handling). Any future work on gene mapping will rely on accurate data about collection sites and sampling methods. On the other hand, the information provided by the farmer only that a certain cultivated bean can "pop", changes the fate on this material in its subsequent process and use by agronomists. Popped beans (nuñas) may be an excellent food at higher altitudes where boiling is a problem (Vietmeyer, 1986), since it may be cooked in a few minutes on any hot surface. In this case, it is the information at the collection site which gives the material a particular cultural significance, which otherwise will be lost even if the seeds can be secured.

Conservation of crop genetic resources are and will be of great concern. It can be addressed in two ways: either by conserving the material in germplasm banks or by maintaining it in situ. In fact, the best solution would be the in situ conservation with traditional farming systems keeping in the field their wealth of numerous and varied genotypes, and with intact natural ecosystems maintaining all wild plants. But those times are gone, and gene banks are likely to be the deposit of most of the world crops and their wild relatives (Plucknett et al., 1987), with this definitive advantage: the genetic resources of a crop can practically be studied as a whole in a few places. However, there are some imperatives why for Phaseolus beans an in situ conservation should be maintained and developed:

-- once taken out of its original habitat, the genetic diversity begins to be somewhat fossil, and germplasm collections even when they are as large as possible are not a formal guarantee against future mutations of some pathogens (e.g. rust). The coevolution between the crop as a host and its abiotic and biotic (mainly disease and pests) environment should be kept taking place year after year. For practical and socio-economic reasons, it is not always easy to maintain in situ the whole genetic diversity present in landraces over long periods of time, but it can be applied to the other part of the primary gene pools: the wild ancestors. In the case their original ecological niches are maintained, they will continue to evolve and when necessary genes can be picked up and incorporated into breeding lines.

-- the plant populations, either crops especially when native or wild materials, in their natural habitats often display a not random, not uniform genetic structure. Again this is key information for proper conservation, if gene diversity is the target. For any Phaseolus bean, we currently do not have a gene map, i.e. how many genes do we have? how many alleles? how are they geographically distributed? In a related field of knowledge, for only one species P. vulgaris, there is evidence that we are dealing with different gene pools (Gepts et al., 1986). Perhaps the best source of information about the genetic structure of bean populations is the wild materials.

-- There is perhaps a third aspect in in situ conservation: information resulting from germplasm studies is somewhat unforeseeable. Let us turn back to the bruchid resistance story. Germplasm of wild P. vulgaris has been collected and is available in seed banks. For reasons unknown so far, the sources of resistance - certain types of arcelin - are geographically concentrated mainly in western Mexico (Jalisco, Michoacan, Guerrero). The previous sampling is perhaps inadequate (see under results per species P. vulgaris), in order to understand this peculiar concentration, and more field work would be necessary. There would thus be some interest in having always the possibility of turning back to the original, since one could hardly collect everything. As stated by Hernandez (1970), germplasm collection is a kind of dialectical process.

In a previous report (Debouck, 1987a), the status of collection, evaluation, crossability, was revised for each known true Phaseolus species. Gaps in terms of representation of species or in terms of covering up the variability were defined. Accordingly, it was decided to continue the surveys in central and southern Mexico (see also results per species).

Timing and Routes

October 19: Trip Cali-Mexico

October 20: Meetings in Mexico City; Instituto Nacional de Estadística, Geografía e Informática, Secretaría de Programación y Presupuesto.

October 21: Meetings in Chapingo with Dr. Francisco Cárdenas Ramos and Ing. J.S. Muruaga M.; discussions about materials and routes.

October 22: Trip to Puebla. Collections in the municipios of Ixtapaluca, Tlalhuapan, Tlalancaleca (# 2320 to 2322).

October 23: Trip to Izucar de Matamoros. Collections in Cholula, Izucar, Tehuitzingo, Acatlán (# 2323 to 2328).

October 24: Trip to Tlacolula. Collections in Teposcolula, Nochixtlán, San Andrés Ixtlahuaca (# 2329 to 2332).

October 25: Trip to Oaxaca. Collections in Diaz Ordaz,

	Teotitlán del Valle (# 2333 to 2339).
October 26:	Collections in Coatecas, Cerro El Labrador (# 2340 to 2342).
October 27:	Trip to Pochutla. Collections in Miahuatlán, Pochutla (# 2343 to 2349).
October 28:	Collections in Juquila, San Gabriel Mixtepec (# 2350 to 2351).
October 29:	Trip to Chilpancingo. Collections in Jamiltepec, Jamiltepec (# 2352).
October 30:	Collections in Xaltianguis, Mazatlán (# 2353 to 2354).
October 31:	Trip to Tixtla and Iguala. Collections in Tixtla, Zumpango and Tuxpan (# 2355 to 2361).
November 1:	Trip to Taxco and Texcoco. Collections in Taxco, Coatepec, Temascaltepec (# 2362 to 2369).
November 2 and 3:	Classification of collections in Campo Experimental CAEVAMEX-INIFAP, Chapingo.
November 4:	Trip to Chalma. Collections in Coatepec, Ocuilan (# 2370 to 2373).
November 5:	Trip to Calpulalpán. Collection in Nanacamilpa (# 2374).
November 6:	Trip to Villa del Carbón. Collection in Ciudad Alfonso López, Villa del Carbón (# 2375 to 2378).
November 7:	Trip to Tulancingo. Collections in Tulancingo, Acaxotchitlán (# 2379 to 2381).
November 8:	Classification of collections in Texcoco.
November 9:	Trip to Tehuacán.
November 10:	Collections in Esperanza, Maltrata (# 2382 to 2386).
November 11:	Trip to Apizaco. Collections in Acajete (# 2387 to 2389).
November 12:	Trip to Pachuca. Collections in Chignahuapán, Pachuquilla (2390 to 2391).
November 13:	Trip to San Juan del Río. Collection in

	Timilpán (# 2392).
November 14:	Trip to Dolores Hidalgo. Collection in San José Iturbide (# 2393).
November 15:	Trip to Guanajuato. Collections in Dolores Hidalgo (# 2394 to 2398).
November 16:	Trip to Acambaro. Collections in Valle de Santiago (# 2399 to 2402).
November 17:	Trip to Tlapujahua. Collections in Senguio, Tlapujahua.
November 18:	Trip to Temascaltepec. Collections in Temascaltepec (# 2369).
November 19 to 20:	Classification of collections in CAEVAMEX, Chapingo. Discussions with Dr. Francisco Cárdenas R.
November 23:	Conference presented at Chapingo: "Problemática reciente de la Domesticación del Frijol"; discussion with Dr. A. Delgado S., Herbario Nacional, Universidad Nacional Autónoma de México.
November 24:	Trip Mexico-Cali.

Results

General

During this exploration, 87 Phaseolus populations were found distributed among 18 taxa as follows:

Species	No. of samples
P. acutifolius var *tenuifolius*	2
P. chiapasanus	1
*P. coccineus**	22
P. esperanzae	9
P. hintonii	1
P. leptostachyus	15
P. maculatus	2
P. marechalii	2
P. microcarpus	10
P. nelsonii	5
P. oaxacanus	2
P. ovatifolius	1
P. pedicellatus	4
P. pluriflorus	1
P. polymorphus	2
P. sp.	1
*P. vulgaris**	6
P. xolocotzii	1

* more infraspecific divisions could be recognized: see under "Per species!"

The distribution among the Mexican States is as follows:

State	No. of Samples
Guanajuato	10
Guerrero	11
Hidalgo	4
Mexico	16
Michoacán	4
Oaxaca	24
Puebla	16
Veracruz	2
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Total: 8	Total: 87

As in previous works, a total of 428 herbarium specimens were also collected for both didactical and scientific purposes, of which 201 were left in Mexico. Each specimen was identified with a label like the one found in the annex (see Annex 1).

Note: The number of the samples for the 1987 exploration (supported by IUCN) range from 2320 to 2406; lower series (20..; 15..; etc.) refer to previous explorations carried out in Mexico with the support of IBPGR.

Per species and Comments

Phaseolus acutifolius Asa Gray var tenuifolius

When looking for P. leptophyllus at the type locality (Finca Mazatlán, Chilpancingo, Guerrero), we found P. acutifolius var tenuifolius(# 2354) and we found it again in the surroundings of Tixtla (# 2356). This is the narrow leaflet variant of P. acutifolius, the distribution of which extends from New Mexico (where the type locality) and Arizona in the US up to eastern Jalapa in Guatemala (the recent explorations by the writer).

Although its distribution is well documented by herbarium specimens in both the US and northwestern Mexico (see Delgado, 1985), the collection of germplasm is far less advanced especially in central an southern Mexico (see map 1).

In these parts of that country, the presence of this wild tepary is linked to the "bosque tropical caducifolio" and the driest parts of the "bosque de Quercus" according to the phytogeographic classification by Rzedowski (1978). This is an annual somewhat delicate vine climbing 2 m high on thorny thickets. Germination is epigeal, and branching uses to be limited to the lower part of the stem with 1-2 guides climbing like the main stem. Juvenile period is rather short and it starts blooming at about 25 days from germination at trifoliate leaf 4 node on main stem. As pointed out by Nabhan (1979), it is frequent on sunny slopes between igneous rocks and basalts where cattle has more difficult access. In the valley of Mazatlán, poor milpas and pastures (drought!) spread over, but between rocks on the slopes, it is still possible to find a few tenuifolius (Figure 1). It is an early desert ephemeral, blooming in July and dispersing seeds in September-October, but because as in any wild plant species they are late plants and because of the extension of the pod setting period, we were still able to pick some seeds. These dates are when the rainfalls (about 400-500 mm/year) are not too erratic, as common in dry areas. It is probably an opportunistic desert ephemeral, seed dormancy being lost once the water field capacity has been attained.

Figure 1. Finca Mazatlán, Chilpancingo, Guerrero, the type locality for P. leptophyllus, an endemic pluriannual desert vine. Because of agriculture extending in the valley and overgrazing on the hills, no material was found. Instead, on the rocky slopes, on the right corner, a few seeds of P. acutifolius var tenuifolius, a widespread annual desert ephemeral, were recovered.

Because of this biology and because it can be used for the genetic improvement of the tepary itself or in wide crossing (e.g. Thomas & Waines, 1984), two strategies of conservation can be defined: germplasm collection and in situ conservation. Germplasm collection, since it allows to study and use the germplasm, should be targeted at all areas where tenuifolius has been reported and not collected already. Beside this, it is more an opportunistic collection, since this taxon matures earlier. In this way, seeds can be picked up when preparing routes at flowering for other species such as P. vulgaris, since there is some interest for bean drought-tolerant germplasm (Laing et al., 1984), the seeds of which will be collected in the fall of the year. However, one should keep in mind that there are also early species in the genus: e.g. P. leptophyllus, P. sonorensis, and several poorly known materials. All these early species, some of them interesting for their drought tolerance, are so far absent in germplasm banks, simply because plant collectors go to collect seeds in Mexico in November-December.

In regard to *in situ* conservation for this taxon, the main aspect is in the conservation of important populations, There would always be throughout the range of distribution some rocky slope or cliff in order to a allow the survival of a few plants, since it produces a lot of seeds (150/plant) and it is not a showy plant. The information we need now for a proper *in situ* conservation is:

-- how structured is the genetic variability within an intact wild *tenuifolius* population?

-- is this genetic structure uniform throughout the range of its distribution from New Mexico to Jalapa?

Obviously this is an important point to take into account before advising on the best locations for *in situ* conservation. Giving the low and unequal representation of this taxon in germplasm banks (see map 1) and also in order to perform this study on genetic structure, it would be advisable to continue with some field collection.

Phaseolus chiapasanus Piper

This species described by Piper in 1921 was known to be present in Veracruz, Chiapas and recently in Oaxaca thanks to a few herbarium specimens. On the basis of pollen morphology, Delgado *et al*. (1982) concluded that this species is somewhat intermediate between *Phaseolus* and the American *Vigna*. In his taxonomical treatment of *Phaseolus*, Delgado (1985) created a new section just for this species. These elements incited us to try and collect germplasm of this species, so far then not present in seed banks.

During this exploration we were able to find one population in Oaxaca not very far from the place where Sousa and co-workers reported its presence. The compilation of present data would give the following: pluriannual vine with hypogeal germination, 4-8 m high, climbing on trees, in the underwood of the "selva baja subperennifolia" (Anon., 1980), 3000-3500 mm rainfall/year with 1-2 months of dry season, 1000-1500 m.a.s.l., at low densities of 20-50 plants/Ha in shaded or semi-shaded habitats. On yellow clays derived from acidic metamorphic schists (at least for # 2349). Apparently, it is not a pioneering plant, but growing in undisturbed well established habitats. As these tropical rain forests (in fact a drier variant of it) are cut down for coffee plantations (a crop expanding now on both coastal mountainous ranges of Mexico), the number of natural sites where this species grows is decreasing rapidly.

With a single germplasm accession available worldwide and these few data, it would appear overweening to give indications about conservation strategies. More field collections are definitively necessary in order to assess its geographic distribution (e.g. is it present in Jalisco, in Guatemala?), its ecological reaction to fire, to grazing (one could guess it as susceptible, but one cannot now answer this question: can it sprout again after such a damage?), its biological cycle (does it bloom the first year? does is set pods every year?), etc. The first indications we have would be to press strongly for conservation and recommend total protection of whole ecosystems, as it appears as ecologically fragile as P. macrolepis or ancestral P. polyanthus in Guatemala. A future question will be about the size of the plots under conservation. In regard to this point, it is not sure that larger areas would ensure better conservation, as explained by Spellerberg (1981), especially when land is under high demand for planting coffee. What we need is to know the minimum acreage(s) in order to maintain for instance 90% of the alleles present in the population(s).

Phaseolus coccineus L.

Instead of one single species, with wild and cultivated forms, the later being derived from the former, one could consider for Mexico that we are dealing with a complex of many forms. This complex like the group of P. pedicellatus can be seen as in expansion now in Mexico and Central America, in a kind of active speciation process. At this time in the course of evolution, the different materials cannot be already recognized as fully separated species or even subspecies in all cases, partly because some gene flow between forms still exists resulting in a lot of intermediate materials beside the natural variants within each form. But geographic isolation due to xeric - pluvial alternations during the late Ice Age confining the populations on the mountainous ranges like islands, as well as biological isolation (variation in pollen morphology between forms, Maréchal et al., 1978) are taking place. Three major trends could be recognized within the complex:

1. some material with scarlet flowers are already sufficiently distinct either geographically or morphologically or both, so that they deserve a separate taxonomical treatment. Here two taxons separated by Delgado (1985) can be listed:

-- subspecies glabellus: distributed on the eastern flank of the Sierra Madre Oriental, this fully glabrous plant showed very little introgression in its natural habitat with others (Debouck, 1987b). This is being confirmed experimentally (R. Maréchal, personal communication).

-- subspecies griseus: distributed on the western flank of the Sierra Madre Occidental, also in the central part of Mexico, this plant with short greyish pubescence is still poorly understood since germplasm was never collected so far.

2. several material with scarlet flowers are a step behind in the evolutionary process. Some trends in geographic distribution/morphology can well be observed (e.g. condensed racemes in the Huasteca, strigillose and stout racemes in Central Mexico, spicate racemes in Michoacan, silky leaflets in El Progreso in Guatemala, etc.), but natural introgression still occurs at the margins of the populations (and can be done experimentally), i.e. there are not yet strong sterility barriers. This situation is further complicated by the presence of the wild ancestor of _P. coccineus_ (and its derived cultigen) in the central highlands from Durango to Panama. This distribution can be seen as superimposed on the distribution of all other forms, and cases of natural introgression can be observed between wild ancestors and other wild forms on the one hand, and between wild ancestors and their cultivated derivatives on the other hand. By now, we do not know about cases of natural introgression between cultivated materials and non ancestral wild forms.

3. a similar situation exists with the purple-flowered populations, apparetnly restricted to higher altitudes in central Mexico. This is the _striatus_ group of "species". We do not know if they are infertile, since germplasm is not available for most of these taxa; but natural introgression can be observed between some of these "species" and the wild _P. coccineus_ with scarlet flowers, thus resulting in fuchsia-flowered materials.

Are these trends reflected by our collections?

No seed collections of subsp. _glabellus_ or subsp. _griseus_ this year because we did not enter into areas of distribution. However, we did find one population of subsp. _glabellus_ blooming on the western side of Orizaba, Veracruz, but this population will have mature seeds only in January. Interestingly enough the closest population of wild _P. coccineus_ (# 2383) did not show traits of _glabellus_ and can thus be considered as wild _P. coccineus_. Wild _P. coccinues_ with scarlet flowers were found on several occasions in the highlands, generally in open (and disturbed!) habitats:

in Guanajuato: # 2397
in Hidalgo: # 2391
in Mexico: # 2320, 2365, 2367, 2372, 2375, 2392
in Michoacan: # 2404, 2405
in Oaxaca: # 2336, 2343, 2345
in Puebla: # 2374, 2385, 2388
in Veracruz: # 2383

The following collections could be seen as peculiar wild forms already morphologically distinct from the typical wild "ayocote" (the nahuatl derived name for the cultigen in central Mexico), although they all had scarlet flowers:

 # 2333: from NW Oaxaca, a sprawling delicate vine with small lobed and variegated leaflets, few flowered racemes, and a strong taproot forked some 20 cm below surface.

 # 2338: from central Oaxaca, very similar to # 2333, leaflets can be similar or even hastate as in P. oligospermus.

 # 2359: from N Guerrero, a climbing vine with multiflowered racemes, small apiculate primary bracts, multiseeded falcate pods.

Two materials have shown indication of introgression with the P. striatus group because of their fuchsia red flowers.

 # 2321: from W Puebla, perhaps introgressed with purpurascens, a climbing vine, in woody areas where there is incidence of early frosts.

 # 2323: from W Puebla, perhaps introgressed with striatus, a climbing vine, stronger than # 2321.

The above mentioned trends are thus reflected in the materials and prevent to consider all the wild P. coccineus as a single kind of non cultivated material. We cannot therefore plot them equally on a map. This way of grouping the materials within P. coccineus is not merely academic, but would have practical consequences in breeding because these materials are the reservoir of genes for P. vulgaris, only second after the wild ancestors of the common bean (Smartt, 1984).

Because of this use of the P. coccineus germplasm, both approaches in conservation, in germplasm banks and in situ, should be considered. Because we are dealing with numerous subspecies or, as we have seen, subspecies-to-be, extending over large areas in a wide range of habitats, it is very difficult to give guide-lines valid for all taxa. The following information is just indicative. Short-lived perennials sprouting annually from tuberous taproots. Probably not producing seeds during the first (even second?) year. Vigorous growth, stems climbing or sprawling 1-8 m long. Strictly or preferentially allogamous, brightly colored blossoms, nectariferous flowers. Primarily in sunny underwoods on deep volcanic soils in pine-oak grasslands at 1800-3000 m.a.s.l. Because of these altitudes, the materials can stand cooler weather, higher moisture, mists, etc., and can be interesting for their reaction to foliar fungi diseases. Because of human and cattle pressures, were progressively restricted to pine-oak forests and derived secondary matorrals at higher altitudes on poorer and stony soils. Those which were unable to adapt disappeared or are disappearing (for instance P. striatus in the valley of Mexico).

The allogamy makes this germplasm very difficult (and thus expensive) to maintain, and perhaps among the species of the genus, most suggest an in situ conservation. However, three reasons would incite to collect more (or more selectively) germplasm of the P. coccineus complex:

-- a lot of very interesting traits (male sterility, fertility restorers, extrorse stigma, low temperatures tolerance, etc.) can be found in the complex.

-- the genetic relationships towards the common bean are still poorly understood, because of the lack of available germplasm for almost all infraspecific taxa with the exception of wild P. coccineus.

-- a lot of potentially very promising materials are distributed in the central highlands of Mexico (Mexico, Puebla, Oaxaca) where pressure of natural vegetations is the highest.

For both strategies of conservation, either in germplasm banks or in situ, we need information on the genetic structure of the natural populations, and when it occurs, on the genetic flow between P. coccineus populations. According to some results presented by Oka (1975) for rice species, one could lower the number of plants to be collected (or maintained) for a given level of variability when one deals with perennial and allogamous forms. However, the presence of a gene flow (is it important? is it useful?) could perhaps increase the number of plants to be collected and/or to be maintained in situ, and prevent to consider conservation solely in scattered habitats.

Phaseolus esperanzae Seaton

This species described by Seaton (1893) on the basis of the material he collected in "wooded hills near Esperanza, 8000 feet" was considered as a true species by Piper (1926) within the group of P. pedicellatus. It was recently put in synonymy of P. pedicellatus by Delgado (1985). Because of that situation, and because the type is somewhat out of the range of typical P. pedicellatus (limited to the southern part of the Sierra Madre Oriental), we included this species in the list of materials to be looked for.

During this exploration, we were able to find 9 populations apparently belonging to this species, distributed from nearly Veracruz up to Michoacan (see map

2). It was observed entering Veracruz down from San Jose (Municipio de Esperanza, Puebla) at 2100 m. It is present in Puebla, Hidalgo, and Mexico. Our collections include the type (# 2386) or what would be considered as the type, since the original location was poorly described and on the other hand the immediate surroundings of Esperanza are now heavily deforested.

We considered P. esperanzae as a distinct species from P. pedicellatus to the contrary of the synonymy proposed recently by Delgado (1985). P. esperanzae is a pluriannual vine sprouting from a turnip-like tuberous root with stout stems sprawling on the ground with little climbing aptitude in terminal parts of the guides. The leaves with rounded lobes are somewaht more coriaceaous than in P. pedicellatus. Big differences can be observed in pod and seed characters. The pods are 3-4 seeded, heavily pubescent and marginate. The seeds are spherical, pea-like, 6-8 mm diameter, generally uniformly black and dull. Grey spotted brown seeds also exist (# 2378).

This species belongs to the underwood of the pine(-oak) forest in the flat highlands (2200-2600 m.a.s.l.) of central Mexico between 19 and 20^{o} latitude N, on igneous rocks derived soils. Other parameters are: 600-1000 mm rainfall/ year, annual mean temprature 14^{o}C, rainfalls from May to October, frosts from November to April. Its habitats use to be shaded, sometimes misty (# 2382) although it can stand open sunlight (# 2027; figure 2). Its distribution overlaps with wild P. coccineus in pine matorrals at higher altitudes (the sites of # 2027, 2337, 2376) and with P marechalii on steep slopes in pine(-oak) forests (the sites of # 2378, 2387). As the latter, it requires deep soils.

Plots with flat, deep, volcanic soils were very early prized by the Mexican Indians for milpa agriculture, and therefore one will hardly find a piece of intact pine forest in central Puebla, where one could guess was the core of the distribution of this species. In the same zone, under 500-600 mm rainfal/year, the pine forest is replaced by a grassland (or pastizal, Rzedowski, 1978), and P. esperanzae is replaced by P. maculatus at those latitudes. The latter was looked for, but in vain in Puebla and Tlaxcala.

Thanks to this exploration, germplasm is now available and from a wide arc of distribution. Evaluation and crossability studies can thus begin (the genetic relationships between this species and all the others are still unknown). Because this species is disappearing together with the original pine forest, and that it cannot bear grazing, as safety measure, germplasm collection should continue especially in Mexico, Tlaxcala and Puebla, where some populations still need to be secured. In situ conservation also should be considered, for instance, in those places where germplasm was already collected (see annex 2), especially in Ciudad Adolfo Lopez Mateos (# 2376)

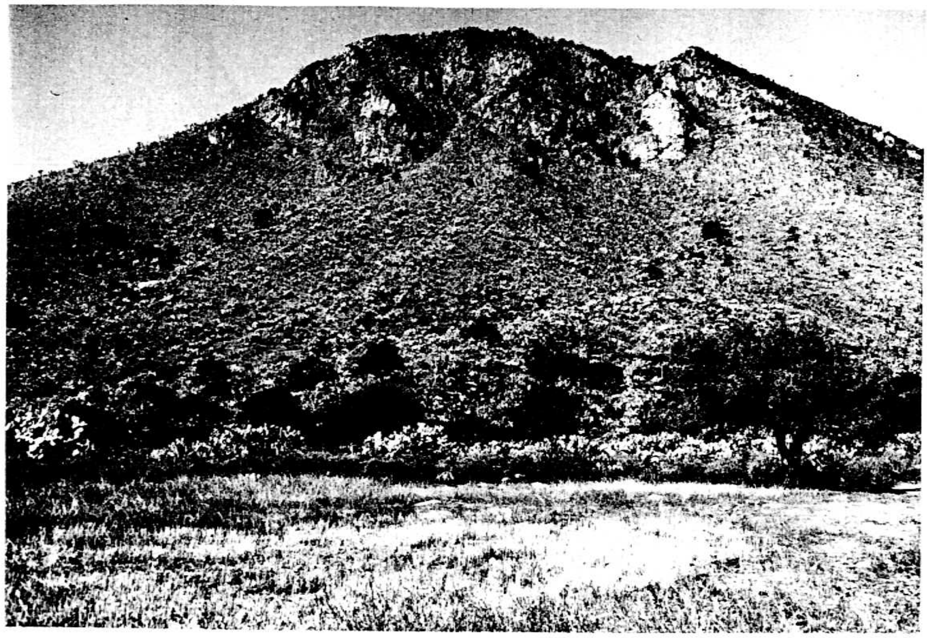


Figure 2. Site of P. esperanzae # 2027 near Tepeapulco, Hidalgo. In the foreground, on the flat land - the natural niche for that species - wheat has just been harvested. Nowadays, it can just be found above the Opuntia-Yucca matorral (secondary, because of fires), below the remaining pine-trees near the top and the cliffs.

or in Acajete (# 2387). This should be through the conservation of natural vegetations as they are without grazing and fire. Anti-erosive devices like Pine strips between terraces on the Malinche slopes in Tlaxcala would be sufficient for wild P. coccineus if wide enough, but unadequate for P. esperanzae since it is not a colonizer. Further studies should focus on minimal plot size.

Phaseolus hintonii Delgado

When collecting on the Cerro Tuxpan, Guerrero, we found a small population, already dried and in seed dispersal phase, of what could well be P. hintonii, as judging on the seed and pod characters. This species recently named by Delgado (1985) is known by a very few herbarium specimens and its distribution is apparently restricted to western Mexico (Navarit, Jalisco, Mexico). Our collection # 2361 would be the first seed record from Guerrero, and perhaps the only seed record available so far.

This species, in the case it is confirmed, belongs to the Xanthotricha section, together with P. xanthotrichus (present in southern Mexico, Guatemala and Costa Rica), and P. zimapanensis present in the Huasteca, and perhaps 1-2 more species. All of them have an additional coil in their keel, a floral morphology not present in other Phaseolus species. Beside P. zimapanensis for which some germplasm is now available (Debouck, 1987b), there is a second priority interest to collect more germplasm of all these taxa in order to know more about:

-- their biology (autogamous only?; short-lived perennials only?).

-- their respective distribution

-- their identification (how to name the closely related materials found in Durango?)

-- their crossability towards other Phaseolus species

-- the threats, if any, on their habitats (e.g. how far can they stand fire and grazing?)

More basic information is needed in the Xanthotricha (the same can be said for the Minkelersia), prior to discussing about conservation strategies, also because both groups of species could already be much more distant from the cultivated species.

Phaseolus leptostachyus Bentham

Phaseolus species currently have 2n = 22 chromosomes (Maréchal, 1970; Delgado, 1985). However, there is a small group of species with 2n = 20:

= P. leptostachyus. from northern Mexico to Costa Rica,
= P. micranthus, coastal piedmonts of Nayarit, Jalisco and Michoacan,
= P. opacus, coastal piedmonts of Veracruz.

P. leptostachyus is perhaps the bean species with the widest distribution (nearly continuous from Chihuahua up to Costa Rica) and range in altitudes from 600 m.a.s.l. (# 480 in Jalisco) up to 2300 m.a.s.l. (# 410 in Durango). It is thus not surprising to find several variants in it, without need for further taxonomic subdivision: variants with white flowers, with incised (# 369) or hastate leaves (# 2395, type of P. intonsus), with cylindrical tuberous taproot or with herbaceous fibrous roots.

During this exploration we were able to add 15 more records from central Mexico and Oaxaca to the known distribution, and the accessions now present in gene banks give the following picture (see map 3). As it appears on it, the representation of P. leptostachyus in terms of available accessions begins to be good for several parts of Mexico, with still some gaps in the southeast. As evidenced by herbarium records (Delgado, 1985), we know it is present there. Its distribution is in fact closely linked to the one of the pine(-oak) forests and some of their tropical variants at lower altitudes, where it is an underwood prostrate vine. Straight, often determinate stems sprout from a tuberous taproot which allows the plant to survive for several years. Roots can also be produced at lower nodes on the stems; because of this trait, this species can be useful to stabilize soils when eroded (see Figure 3). Although it is usually found in semi-shaded habitats, it can stand in open and sunny places (see figure 3) and because of the two last traits, it is also a pioneering plant on cliffs, eroded slopes, lava beds, etc. Seed production in intact plants can be important (> 500 seeds/plant), but with very small seeds (1-2 g/100 seeds). Since it is coming in a wide range of habitats and consequently under a wide variation in rainfall (800-1600 mm/year), I suspect a high variation in yield depending on the amount of rainfall, and also more variation in the peak yield period.

Figure 3. P. leptostachyus # 2062, at noon in Los Altares, Iturbide, Nuevo Leon, was found colonizing stony landslides on the borders of a brook. Note the reflexed leaflets in order to limit the insolation effects.

The biology and the relatively good survival of *P. leptostachyus* in disturbed habitats (with temporary grazing, felling) would suggest to rely on *in situ* conservation for a lot of places where this species is distributed. Some additional germplasm collections could be done where there are specific gaps (e.g. Chiapas) or where specific threats (e.g. Valley of Mexico, Bajio, surroundings of Guadalajara, Guanajuato, and other quickly expanding cities within the range) exist. Germplasm can be collected when looking for other species. *P. leptostachyus* can be maintained *in situ* in undisturbed pine(-oak) forests, the same exploited for timber production, within agroforestry systems, in woody strips separating terraces, on slopes bordering roads, in many places of abandoned land where grazing and felling are limited. In order to save a broader genetic diversity, ruderal habitats should be in contact at least at the beginning with plots of undisturbed pine(-oak) forests. Fire practicing and grazing by goats (see figure 5) should be avoided as far as possible, especially when aiming to conserve populations.

Very little is known about *P. micranthus*, and probably just a single seed accession exists worldwide collected by Buhrow on coastal Jalisco (El Tuito). More material is definitively needed to assess conservation problems and incognita about its biology. Field studies will also document on its range (does it enter Sinaloa, Guerrero, Oaxaca?), on its ecological reaction particularly to soil texture (are we dealing with the same material on the coastal sands and on the metamorphic shists as suggested by Delgado, 1985?). The recent development of several seaside resorts in that area could indirectly help to maintain some natural parks, given its biological diversity and rich flora (Rzedowski & McVaugh, 1986), but would incite to speed up the field surveys.

Phaseolus maculatus Scheele

This species was known previously as *P. mecalfei* after J.K. Metcalfe who tried to introduce it in southwestern USA as a forage crop (Wooton & Standley, 1915). After our personal observations in the Valle del Guadiana, Durango in 1978, a single plant could cover 25-30 m^2 at 1930 m.a.s.l. after three months and under 475 mm/year; the species should thus deserve more attention as potential forage crop for dry areas. It has been reported as tolerant to waterlogging (Buhrow, 1981) and frost (Buhrow, 1980). It has been crossed successfully with *P. lunatus* (Le Marchand *et al.*, 1976; Baudoin *et al.*, 1985). As noted by Gentry (1957), this species is part of the "pastizal" flora . This vegetation, according to Rzedowski (1978), extends in the flat highlands of Mexico along the Sierra Madre Occidental, from central Chihuahua up to Guanajuato. There are still a few areas with the same climax vegetation in Mexico, Puebla, and Oaxaca. These areas, especially southwards, because of their convenient topography and potentially good soil fertility were exploited early in history for raising cattle and irrigation agriculture. These elements incited us to list this species in the materials to be looked for in central Mexico.

During this exploration we were able to collect 2 populations in Guanajuato, after looking for it, but in vain in northwest Mexico, eastern Hidalgo and central Puebla. Since the confusion with a closely related species P. ritensis, has been solved (Nabhan et al., 1980), the distribution of P. maculatus is now well established and documented, thanks to numerous herbarium specimens, especially in the northern part of its range. Representation in germplasm banks still suffers some gaps (see map 4). Because this species is growing in a natural habitat now under permanent threat, both approaches for conservation, in gene banks **and** in situ, are to be considered.

Let us consider some biological data as a basis for an adequate in situ conservation. More information can also be found in Nabhan et al. (1980).

It is a pluriannual vine with hypogeal germination, stout stems 1-6 m long, with almost no climbing aptitude, sprawling on the ground. Blooming in July after the rainfalls (400-700 mm/year, somewhat erratic) and seed dispersal in September. With a tuberous taproot up to 1 m long, 15 cm in diameter (see figure 4). Part of the "pastizal" (grassland with Graminae, "Zacate", Bouteloua and Compositae, Bidens) between 1700 (# 299) and 2800 m.a.s.l. (# 332), on deep silty soils. According to Nabhan et al. (1980), very high densities (50,000 plants/Ha) can be found. In Durango, we found populations of about 200-500 plants/Ha. It may not enter into reproductive phase during the first year. Yield is probably heavily dependent on the amount of rainfall; according to these authors, it could be low (5-10 kg/Ha). These indications together with the fact that it is palatable to cattle, strongly suggest total protection of pieces of grassland throughout its range, the size and the number of which can be defined once the studies on the genetic structure will be completed. It should be mentioned that in many parts of Durango this species can be found together with P. acutifolius and P. vulgaris, both as wild ancestors. In this case, the later will be climbing on thorny thickets on rocky basaltic slopes, while P. maculatus will grow in pieces of flat land between lava beds. For instance, one location worth conserving could be the Volcan El Jaguey area, 10-12 km north of Castillo Najera, Durango, Durango, Mexico.

Figure 4. P. maculatus # 299, Arroyo Las Minas, Peñon Blanco, Durango, Mexico. On October 5, 1978. One plant on the left is to be carried out by the stream. Note the vigorous taproot of this young plant; it allows this species to compete successfully among the "desert ephemerals" (Graminae, Compositae) of the pastizal.

Phaseolus marechalii Delgado

This species still to be formerly published was defined in order to name several populations, sharing with P. polystachyus from the southeasterm USA (from N Florida to New York) an outstanding character: the development of the axis of the secondary racemes, and consequently the presence of additional flowers at that level. Indeed we are dealing with a difficult group of materials still poorly understood and reported from several and distant places in Mexico: a group from Morelos called P. glaucocarpus by Norvell; a group from Nuevo Leon called P. polystachyus by Delgado. One of these forms (N.I. 402 from Morelos) has been found interesting for its protein quality (Otoul, 1976) and its reaction to the Golden Mosaic Virus (Baudoin, 1981); it can be crossed successfully with P. lunatus (Baudoin, 1981). These elements incited us to enlist that species in the materials to be looked for during this exploration.

During it, we were able to sample 2 populations of this species, kindly identified by Dr. A. Delgado S., one in western Mexico (# 2377), the other in central Puebla (# 2389). Both were found at low densities (10-20 plants/Ha) in pine-oak forests (principally pine) in the less disturbed parts, on steep slopes, at 2400-2600 m.a.s.l. In both places, they were found together with P. esperanzae, although the later was much more abundant. On the basis of these two records, one could suggest the following about the biology of P. marechalii. Pluriannual vine with hypogeal (?) germination, with sprawling stems 1-4 m long, with some climbing aptitude in their terminal parts, sprouting from a fusiform taproot (9 cm long, 2 cm in diameter) with the summer rainfalls (700-900 mm/year). May not produce any seed during the first (even second?) year; low productivity even when established (20-60 seeds/plant). In (semi-) shaded habitats, on deep volcanic ashes derived soils; apparently cannot afford grazing and fire use in the underwood. May suffer from early frosts in open habitats and from bean pod weevil Apion attacks (as evidenced by # 2389). As a concluding remark, it appears to be a component of the underwood in undisturbed pine-forests along parts of the Eje Volcanico and in the Central highlands.

These elements would again stress on the interest of both approaches in conservation. The fact that there are worldwide less than 5 seed accessions would stress on the importance of continuing some field collection, since this species could be distributed from Jalisco up to Puebla. Also in order to know more about the material (how many taxa are we dealing with?), its biology (why is it restricted to undisturbed woodlands?), the genetic structure of the populations (would it be more adequate to maintain in situ the populations of Morelos, Mexico or Puebla, all of them or which of them?). The last question is not neutral when one knows the price of land around quickly expanding cities in that part of Mexico.

Phaseolus microcarpus Mart.

One of the few annual species of the genus mainly distributed in the tropical deciduous forests, some dry oak forests and other variants, from Durango up to Chiapas under a wide range of elevations (0-2000 m.a.s.l. as evidenced by the collections # 424 and 389, respectively). During this exploration we were able to collect seed for 10 more populations from Guerrero, Oaxaca and Puebla. This would give for the present accessions available worldwide the following picture (see map 5).

It is a monocarpic annual vine with strong climbing ability, "killing" itself in seed production. Its survival strategy is based on:

-- a high number of seeds, perhaps more than 200 seeds/plant.

-- earliness and a very long period of flowering/fruiting. The lower part of the vine could be already completely defoliated while it is still blooming in the upper parts.

-- absence of juvenility: perhaps the only Phaseolus species to present inflorescences already at the node of primary leaves. Racemes use to appear from node 5-6 upwards in other species.

The single-seeded pods use to dry out without the explosive dehiscence commonly found in all other wild species; this trait could explain the large densities when left intact by cattle. On the contrary, under high grazing pressure, it could be negative to the survival of the population. One should also remember that since the epigeal germination all buds are above ground level, and thus susceptible to grazing.

This species has been little used in wide crossing so far perhaps because of the minute size of its flower; consequently its position in the genus is poorly understood; its agronomical attributes are unknown. The limits of its range are still to be documented: it is not clear whether it goes north of Durango (Nabhan et al., 1986) and east of Chiapas. Germplasm collection for conservation in seed banks faces this difficulty that this species can bloom nearly the whole year round since it is definitively thermophilous. Perhaps there is no seed dormancy or it is quickly broken by any significant rainfall. Consequently germplasm collection for this species gains much in being opportunistic when looking for other species. For in situ conservation, it is not clear whether a few plants which will always(?) survive among metamorphic rocks, can fully represent the variability found in larger populations. This aspect is of key importance since this species very frequently in its range suffers from grazing by goats (see figure 5). An alternative could be to ban grazing by goats and sheep from selected areas where P. microcarpus has already been reported.

Phaseolus nelsonii M.M.S.

It is probably the first time germplasm is collected for that Minkelersia species. Four collections are from Oaxaca (# 2329, 2332, 2337, 2344) and one is from Mexico (# 2366), all from pine forests between 2100 and 2500 m.a.s.l. It is a small, inconspicous herb with one or two delicate climbing stems up to 60 cm high sprouting out of a spherical tuberous root (diameter 1 cm). It does not seem to flower the first year, but after the root has been established. It grows in the shade in undisturbed old pine forests, often on humid but well-drained slopes.

Like for many other Minkelersia, the second section within Phaseolus (Lackey, 1983), very little is known about crossability and agronomic attributes. So there is no evidence to make recommendations to include this species in conservation programs or to not include it. Furthermore, because it is so inconspicous and the aerial part is ephemeral, most plant collectors will not see it or not collect it. Given that situation, germplasm collection can just be opportunistic when looking for other species in the range (e.g., wild P. coccineus) in order for instance to know more about the geographic distribution of P. nelsonii. On the other hand, one should mention that there are good opportunities of in situ conservation for that species provided that the pine forests are maintained as such. In many parts of Oaxaca, on the long term, pine forestry for timber production is probably the best way to limit soil erosion and to make money on poor soils. In such forests, even in intensive timber production and provided that grazing is controlled, there are still possibilities to maintain enough populations of P. nelsonii and even P. oaxacanus.

Phaseolus oaxacanus Rose

This species has been considered as a variety of P. pedicellatus by Delgado (1985). No doubt that it belongs to the Pedicellatus section as stated by Piper (1926). Pending on some hybridological work, we will however, maintain it as a separate taxon within the same section. During this exploration, we were able to sample 2 populations of this (sub-) species in Oaxaca, one (# 2335) north of Tlacolula and the other (# 2342) in Cerro El Labrador (see figure 5). Our preliminary observations would indicate that it is a pluriannual vine with hypogeal germination, somewhat of less vigour in comparison to P. pedicellatus. It grows in oak-pine forests (with Quercus dominant) in shaded places. It is not sure that it blooms before the tuberous taproot has been established. Seed production seems quite variable between plants within a population (problems of flower fertilization?): many plants are found just vegetative, while others bear a few pods (up to 10 per plant); high pod production (more than 50 pods per plant), is possible, but rare. Contrary to what happens in most Phaseolus species, the late flowers are most likely to transform into pods (because of the lowering temperatures?). In both cases found on reddish, clayish, igneous rocks derived soils, between 1900 and 2600 m.a.s.l., under 800-1100 mm rainfall/year.

Figure 5. Southern slopes of Cerro El Labrador, Ejutla, Oaxaca. Because of excessive grazing by goats, the natural oak-pine forest has been replaced by a poor scrub where between rocks it is still possible to find a few P. leptostachyus (# 2340). Near the top at 1900 m.a.s.l. (left upper corner), below the pine trees, in most protected areas, a few P. oaxacanus (# 2342) and P. microcarpus (# 2341) are left.

Worldwide there are perhaps only these two germplasm accessions, for a species reported so far mainly from the forests surrounding Oaxaca (Delgado, 1985). Because of this low number and the general vegetation degradation in Oaxaca, it would be safer to enlist this species in the endangered Phaseolus to be looked for specially in future germplasm explorations. In situ conservation for this species is obligatory through total protection of pine-oak forests, also in forests exploited for timber production provided that fire practices and grazing are strictly banned. In order to see this species present again in many parts of Oaxaca, one should now protect areas around the place where it was mentioned, starting with planting Quercus and Pinus trees. In Central Oaxaca, it is not only the matter of maintaining a wild bean, but saving entire sets of the Mexican flora, some of them of future economic importance (medicinal herbs, nectariferous plants, etc.).

Phaseolus ovatifolius Piper

One of our materials (# 2331) was tentatively identified as P. ovatifolius, because it could fit better here than anywhere else. Since we did not have the opportunity to see the type, this identification needs confirmation. We did not find this species in any other place but just in a single pine-oak forest in northwestern Oaxaca, even in a single undisturbed gully. Apparently we are dealing with a species requesting shaded habitats in pine-oak (with Quercus dominant) forests. Curiously, it was found alone with no P. esperanzae nor P. marechalii nor P. oaxacanus in the surroundings. Collecting more in the Mixteca area - where intensive erosion is now taking place - will tell us more on the subject: which species are we dealing with? how far is it distributed in Oaxaca, in other Mexican states? which are its attributes? how to conserve it?

Phaseolus pedicellatus Bentham

During this exploration we added 4 more records to the known germplasm distribution of P. pedicellatus (see map 6). Of particular interest were # 2368 and 2370 from Mexico on the western side of Morelos, since they are already on the edge of its distribution. The species is otherwise widespread in the southern part of the Sierra Madre Oriental, in the Huasteca, somewhat in the Sierra Gorda, in the following montainous ranges: Ajusco, Tlaloc, Pico de Orizaba, between 1500 and 2800 m.a.s.l.

This pluriannual vine with climbing stems 2-3 m high sprouting from a tuberous fusiform taproot is commonly found in pine- and pine-oak forests. Grows well as an understory climber in shaded habitats on organic, igneous rocks derived soils, under 900 - 1500 mm rainfall/year. Sometimes locally abundant (> 2000 plants/Ha). With hypogeal germination and thus there is the cotyledonary node below soil surface from which sprout a few stems every year depending on the rainfall. May not enter into flowering the first year in its natural habitat. As, in P. oaxacanus, late flowering is better converted into pod setting, even though many racemes will eventually not bear anything. Seed production somewhat highly variable within populations (0-150 seeds/plant). Disappearing in non woodland habitats a few years after felling, even though the populations could increase a bit immediately after the pine trees have been cut down (as evidenced by populations # 2370 and 2380). From field observations, it cannot afford grazing and fire practices in the underwood.

Conservation strategies should be aimed as for P. oaxacanus at:

-- germplasm collecting in underexplored parts of its range (Veracruz, Guerrero, Sinaloa, and Durango). Some of these places are mentioned by Delgado (1985), but could be doubtful in the case for instance P. foliaceus Piper is recognized as a valid species.

-- maintaining woodlands as such and thus banning there fire practices and grazing. Since it grows frequently on steep slopes, extensive forestry is probably the best way to protect soils and water resources.

-- determining on the basis of present accessions how the genetic diversity is distributed in order to define the best balance between ex situ/in situ conservations, and the places to maintain under protection.

Phaseolus plufiflorus M.M.S.

During this explorationn, we found one population of P. pluriflorus (# 2403) in one area where it was apparently not reported before: the municipio of Senguio in the upper right corner of Michoacan. We saw another population in Western Puebla near Nanacamilpa, but it was too late to pick up seeds. Another Minkelersia distributed principally in the Eje Volcanico of Mexico and surrounding highlands above 2000 m.a.s.l. Usually found in pine-oak forests in shaded habitats, but also in subsequent disturbed scrubs and thickets. On igneous rocks derived soils, under 800-1100 mm rainfall/year. A somewhat inconspicuous vine sprouting out of a radish-like tuberous root, with climbing delicate stems 1-2 m high. Early and good yielding (> 150 seeds/plant). May not bloom the first year. Aerial part may be killed by early frosts in the upper part of its range (2800 m.a.s.l.).

No information about crossability and agronomical attributes, but could perhaps be more distant from the Phaseolus section. On the other hand, its earliness (maturing by September-October) and inconspicuous aspect could do plant collectors to not pay attention to it. These elements together with its ability to survive in marginal thickets and oak scrubs close to Mexico City (# 2083) would suggest a second priority in collecting activities. Collection can be more opportunistic, when looking for other species in the range and at bloom in September. In situ conservation would be through the protection of woodlands and resort parks around expanding cities in central Mexico. One can reasonably think that populations of this species could also survive well in forests for timber production.

<u>Phaseolus polymorphus</u> S.Watson

This species has been considered as a variety of <u>P. pedicellatus</u> by Delgado (1985). Its known distribution was so far restricted to the surroundings of San Luis Potosi, SLP, Mexico. As for <u>P. oaxacanus</u>, pending on some hybridological work, we will maintain it separate, although it could well be an allied species of <u>P. pedicellatus</u> as claimed by Piper (1926).

Figure 6. Site of <u>P. polymorphus</u> # 2393 in Guanajuato, San Jose Iturbide, 8 km E of Carbajal, at 1970 m.a.s.l. Because of grazing there is no vegetation cover left on lower slopes. But <u>P. polymorphus</u> is still relatively abundant below the pine trees in the most protected parts (top).

During this exploration we found two populations (# 2393 and 2398) in eastern Guanajuato where apparently it was not reported before. Its distribution is linked to the one of the pine-oak forest with small thickets (<u>Quercus</u>, <u>Crataegus</u>, <u>Arctostaphylos</u>), in very sunny climates, between 1900 and 2500 m.a.s.l. and under 600-1000 mm rainfall/year (Figure 6). It is a pluriannual vine with stems 2-3 m long sprouting out of a sugar beet-like taproot. It grows on schists derived soils on dry slopes below thickets on which the terminal parts of the stems otherwise straight and sprawling can climb. Can be relatively abundant in protected areas (1000-2000 plants/Ha), but rare where grazing and subsequent erosion have taken place (see Figure 6). Seed production in most cases is very low (0-10 seeds/plant) because of drought stresses, early frosts (?). Some plants may not bloom every year and the available carbohydrates may be stored in the taproot instead.

Conservation strategies are very similar to those defined for the woodland species such as: *P. marechalii*, *P. oaxacanus*, *P. pedicellatus*. One should further take into account that we are dealing with dry areas where water availability is the limiting factor for forest growth and reproduction: we are at the ecological limit of the forest and there is virtually no alternative to it. Because of topography, rainfed agriculture "de temporal" cannot be done; because of soil texture, grassland will be very poor. Sheep and goat husbandry is possible but should be used in such an extensive way that rentability is questioned. In order to increase the sources of income with the pine-oak forest, especially during the first years, one can think advantageously in raising *Agave*, *Opuntia*, medicinal herbs, ets.

Phaseolus sp.

One collection # 2384 could not be identified and looks quite new to us. It was found on the eastern slope of the Pico de Orizaba, already in Veracruz, at 1940 m.a.s.l. Also in a particular vegetation: pine forest under high humidity (1600-2000 mm/year) and frequent mists. Pluriannual vine with a fusiform tuberous taproot (30 cm long, 5 cm diameter). Seen in just a single place and even at low density in it.

Several comments made about # 2331 (called here *P. ovatifolius*) are relevant here. We must know more about this taxon and its distribution, since beside *P. coccineus* subsp. *glabellus*, there is no (?) *Phaseolus* species entering misty climates. More field work is thus needed. Also because of the quick modification of the eastern slope of the Pico de Orizaba range because of coffee planting (also important for *P. opacus*, still absent in germplasm banks).

Phaseolus vulgaris L.

The wild forms of *P. vulgaris* in the Mesoamerican Center (Debouck, 1986) are distributed from southern Chihuahua (Nabhan, 1985) up to Costa Rica (Debouck *et al.*, in press). Some of these wild forms can be considered as ancestral, i.e. that they gave rise to the cultivated common bean varieties (Gepts *et al.*, 1986). Despite that apparently just a reduced part of the Mesoamerican range was included in the domestication process (Jalisco-western Guanajuato?, Gepts & Bliss, 1985), there is no evidence so far that there are problems of genetic incompatibility inside the Mesoamerican Center for P. vulgaris. Consequently, all the wild forms, either ancestral or untouched by domestication, can be considered as belonging to the primary gene pool of P. vulgaris. An evidence of such free gene transfer is the breeding program for bruchid resistance being developped at CIAT (Cardona & Posso, 1987). Some of the best sources of resistance come from Guerrero, perhaps outside the area of primary domestication; nevertheless the different arcelin types are now included in several breeding lines.

There are other kinds of evidence which stress the interest of the wild forms of P. vulgaris. The fact that resistance to bruchids was never found so far in any cultivated P. vulgaris (Schoonhoven et al., 1983), although this trait is not negative in the domestication efforts (F. Bliss, personal communication), gives additional support to the hypothesis of the founder effect of domestication (Ladizinsky, 1985), that is the domestication has begun with just a few populations taken from the wild. In the case it is formally proven for beans, this means that a lot of traits (some of them potentially interesting such as bruchid resistance) were not included into the domesticated gene stock, not because they are negative to those selected by man, but simply because many wild populations remained untouched by man. In this case, the largest reservoir of genes for P. vulgaris, principally in terms of different alleles and not in terms of allelic combinations, is in the wild forms and not in the cultivated stock. An additional point that further studies should demonstrate is the contribution of the gene flow between wild forms and early domesticated cultivars, i.e. as a contribution to enrich the initial gene stock.

Another interesting character of the wild forms of P. vulgaris is that they can be used as geographical markers. There is little probability that the wild forms can be distributed by animals, man, but by their own seed dispersal mechanisms. A wild bean population has thus been present in a particular location for thousands of years. Phaseolin because of certain characteristics (Gepts & Bliss, 1985) can link geographically wild forms and their cultivated derivates. More refinement is expected especially with the studies on "silent" DNA, i.e. the non translated bases sequences present in the nuclear or mitochondrial genomes. The possibility to trace back cultivars to a specific origin will be of great importance when one knows that more than 70% of the cultivated bean germplasm lack accurate passport data!

As concluding remarks, because we are dealing with the germplasm of an important cultivated crop, one can say:

1) the collection of germplasm for its subsequent conservation in germplasm banks should be as large and extensive as possible. One of the primary objectives is now to fill geographical gaps; the next step, as studies on genetic diversity progress, is to fill gaps in genetic diversity.

2) _in situ_ conservation should be as complete as possible, that is applied to the largest number of wild populations as possible, simply because one cannot predict where new strains of pests or pathogens are likely to appear.

This year we went to fill geographical gaps in central and southern Mexico, and found 6 populations including a regressive form (# 2348), resulting in the following picture for the wild common bean distribution (see map 7).

Wild _P._ _vulgaris_ is a typical mesophilous vine with stems 2-6 m high, climbing in open habitats on small trees and thickets. Most populations behave as strictly annual seed plants, although some perennialism has been reported in Nayarit, Jalisco and Michoacan (Gentry, 1969). This perennialism is however not at all comparable to that of true pluriannual species with tuberous taproots: in _P._ _vulgaris_, germination is epigeal and there is no secondary growth of the root cambium. It is more a kind of survival after the first seed production (because of a strong root growth?). It grows in such climates where rainfalls end up with pod production (600-1100 mm/year), between 800-2200 m.a.s.l. Found in oak-pine forests and several disturbed secondary but woody vegetations, on volcanic ashes, igneous rocks, or basalts derived soils, always well-drained soils. Can be locally abundant (up to 5000 plants/Ha) and if protected, can be yielding (up to 100 pods/plant, or 500-600 seeds/plant). 100 seeds-weight is about 5 g.

Conservations strategies should thus be aimed at:

-- more field collections especially in the southern part of its range Oaxaca and Chiapas where geographical gaps are still important. One should note that the intensity of sampling should be high, i.e. with several stops on short distances. Let us illustrate this with an example. Between Teloloapan and Arcelia, Guerrero, over 50 kms, H.S. Gentry in the 1960's collected 7 populations of wild _P._ _vulgaris_, of which only 3 were resistant to bruchids (_Zabrotes_)(C. Cardona, personal communication). In Mexico, it is calculated that the common bean extends over 220.000 km^2 from southern Chihuahua to Chiapas. In 1986, the CIAT collections by far the most complete, currently has 344 accessions of wild _P._ _vulgaris_ (including some weedy types) from Mexico, but after plotting them on a map, these only represent 63 different localities or original populations!

-- the definition of the genetic struture of the wild beans. This study is now overdue and urgently needed to orient further field collections and to define areas for conservation as well. A point to be cleared out is the significance of perennialism in wild P. vulgaris: are all the annual forms weedy forms and escaped?

-- the definition of areas to be protected, where fire practicing and grazing should be avoided. Wild P. vulgaris naturally comes in wood openings, river sides, cliffs, etc. It has been repeatedly observed in half disturbed habitats where grazing and fire practices did not take place. This means that wild P. vulgaris can grow well and even expand in habitats little disturbed by man and could perhaps disappear from them without this limited human intervention.

Phaseolus xolocotzii Delgado

This species still to be formerly published was represented only by one collection (# 2346) kindly identified by Dr. A. Delgado. It was found in Oaxaca when crossing the Sierra Madre Sur, in pine-oak forest at 1780 m.a.s.l. Found in just one place on a single opportunity; this is probably the first seed accession available worldwide. A pluriannual vine with stems 3-5 m high climbing on small trees and thickets, with a vigorous conical taproot (1 m long 15 cm diameter). Growing in semishaded habitats on volcanic ashes derived soils. Low densities (100 plants/Ha), but relatively good yielding (approximately 50 pods/plant). Disappearing with the primary climax forest.

Any conservation effort should now be focused on more germplasm collection in the upper Balsas river drainage basin and on the southern slopes of the Eje Volcanico. We need more information about its distribution, ecological reaction and biology, before reaching conclusions on the best conservation strategies.

Conclusions

A first question to be answered is what is to be conserved. It involved a thorough knowledge of the plant material itself and its reactions to all agents interfering with its survival. This would bring up the following conclusions.

1) we are still in the process of building up knowledge about the Phaseolus species, mainly about their geographical distribution, their reproduction biology,

their ecological reactions, the actual threats on them now and on the long term, etc. Each field work during the last years has come with new germplasm, i.e. species new to Science or seed germplasm first available worldwide or seed germplasm reported from a new area. In that sense, field work has paid off and will continue to do so for the years to come especially with regard to the huge gaps in the representativity for the wild ancestors of the cultivated beans (P. vulgaris, P. coccineus, P. polyanthus, P. acutifolius, and P. lunatus). Future field germplasm studies have much to gain in a "whole genus" vision. Because of practical and money saving reasons: in a particular ecosystem, several Phaseolus species could offer mature seeds at about the same time. On the long term, collecting one and not the others is conterproductive. Because of scientific reasons: for instance, for P. vulgaris, there are still some place where a biological continuum can be observed from the truly wild up to the fully cultivated material; there are still some places where natural hybrids can be observed between P. vulgaris and P. coccineus. In these cases, because of their increasing value for bean breeding, the safer and more logical approach is to collect them all.

2) once the distribution of each species will be known, the next step will be to define how the genetic diversity is geographically distributed, i.e. are the same alleles uniformly distributed throughout the range? or do we have some alleles only concentrated in a single locality? When viewing at in situ conservation, the following questions can be addressed: could be define a few places where the majority of alleles can be preserved? which will be the risk of losing certain alleles if some areas are definitively excluded from in situ conservation? They can be solved by a model study of the genetic structure of 1-2 Phaseolus species through its range. Enzyme variability is perhaps a good indicator of genetic diversity and since it has proven to be useful to separate white seeded bean cultivars (Weeden, 1984), it would be quite possible to characterize wild bean populations, where almost all morphological characters are dominant, that is to measure their biochemical variability.

A second question to be answered is how to conserve the different materials once enough information has been gathered about them. This lead us to the following conclusions.

3) During this collection trip, we came across two groups of Phaseolus species, perhaps two kinds of ecological reaction and reproductive biology. On the one hand,

the species which can grow in disturbed habitats where felling, grazing have taken place with some frequency. Most annual species with epigeal germination (P. acutifolius, P. filiformis, P. microcarpus, P. vulgaris) are found in this group. Most of them will also request sunny habitats. On the other hand, the species which need climax woodland habitats and disappear when the forest is cleared out (such a P. chiapasanus, P. marechalii, P. oaxacanus, P. xolocotzii). Most of them are pluriannual with tuberous taproots, grow well in shaded habitats, and could not be high yielding every year, but periodically. From these observations, two conservation strategies could be defined: for the first group, germplasm collection for ex situ conservation will be aimed at filling gaps (on a geographical basis first and then on a genetic diversity basis), while for the second group it will be seen as the safest way to save some germplasm in the case the woodlands cannot be fully maintained at such. About in situ conservation, while the first group will probably accept some human activities (periodical felling, very extensive grazing, timber exploitation, etc.), the second group will accept only extensive forestry or request total protection of woodlands. The first group would thus be easiest to maintain since a broader number of habitats could be considered, such as abandoned land, anti-erosion terraces, land for fuelwood, etc.

4) this last observation leads up to think about costs. In many cases, for Phaseolus, in situ conservation is not an alternative to conservation in germplasm banks, but a complementary approach rooted in other imperatives. The whole range of each of the 60 or so Phaseolus species could not be fully protected since it is already heavily modified in many places. At best, some places could be protected, the number of which will be critical, because the interest is not only to save a plant species, but its populations. A multiplicity of parks and forest reserves should thus be considered. Given that situation, the money-saving approach especially on the long term is a synthetic one, trying to save in a given acreage as many plant species as possible, especially if of some economic interest. The fact that all the collections made so far are registered in a computerized data base will be of tremendous help when combined with other computerized sources about vegetation, land use, etc., in order to define the areas to be protected or, if not possible, to be sampled.

Acknowledgements

This work has been made thanks to a grant of the International Union for Conservation of Nature (IUCN) which is fully acknowledged. My thanks are due to the Instituto National de Investigaciones Forestales, Agricolas y Pecuarias de Mexico (INIFAP) and especially to the CAEVAMEX Experimental Station at Chapingo for its total logistic support. The author is deeply grateful to Dr. F. Cardenas R. for constant support and helpful advice, and to Ing. J. S. Muruaga M. for hard work during the field exploration. It is a pleasure to thank here the following persons for their kind interest in this work: Drs. R. Claveran A., M. Holle, D. R. Laing, D. Pachico and D. Wood. My warmful thanks to H. Dierolf for the preparation of the manuscript.

Literature Cited

Anonymous. 1980. Carta de uso de suelo y vegetación, Escala 1:1.000.000. Secretaría de Programación y Presupuesto, Dirección General del Territorio Nacional, México, D.F., México, 8 hojas.

Baudoin, J.P. 1981. Observations sur quelques hybrides interspécifiques avec Phaseolus lunatus L. Bull. Rech. Agron. Gembloux 16(4):273-286.

Baudoin, J.P., Katanga, K., Maréchal, R. & Otoul, E. 1985. Interspecific hybridizations with Phaseolus lunatus L. and some related wild species. Ann. Rept. Bean Improv. Coop. 28:67-68.

Buhrow, R.A. 1980. Frost tolerance of the Phaseolinae of the southwestern United States. Ann. Rept. Bean Improv. Coop. 23:62-64.

Buhrow, R. A. 1981. Stress tolerance of southwestern Phaseolinae. Ann. Rept. Bean Improv. Coop. 24:94-95.

Cardona, C. & Posso. C.E. 1987. Bean varietal resistance to stored grain weevils: sources, mechanisms and factors of resistance. Bean Newsl. 9(2):1-4.

Debouck, D.G. 1986. Primary diversification of Phaseolus in America: three centers? Plant Genetic Resources Newsl. 67:2-8.

Debouck, D.G. 1987a. Final Report - Collaborative Project IBPGR-CIAT on Phaseolus germplasm collection. International Board for Plant Genetic Resources, Rome, Italy. AGPG/IBPGR:87/138. 37 p.

Debouck, D.G. 1987b. Phaseolus collection in the Huasteca and surrounding regions, Mexico. Trip Report. International Board for Plant Genetic Resources, Rome, Italy. AGPG/IBPGR:87/65. 26 p.

Debouck, D.G., Gonzalez, W.G., Araya, R. & Tohme, J. Presencia de formas silvestres de Phaseolus vulgaris L. en Costa Rica. Actas XXXIV Reunión Anual Programa Centroamericano para el Mejoramiento de Cultivos Alimenticios, PCCMCA, San José, Costa Rica, 21-25 marzo 1988. (In press)

Delgado Salinas, A. 1985. Systematics of the genus Phaseolus (Leguminosae) in north and central America. Ph.D. Thesis, University of Texas, Austin, Texas, USA. 363 p.

Delgado Salinas, A., Martinez Hernandez, E. & Fernandez Ortuño, P. 1982. Estudio del polen de Phaseolus chiapasanus Piper (Leguminosae-Phaseolinae). Bol. Soc. Bot. Mexico 43:25-34.

Gentry, H.S. 1957. Los Pastizales de Durango - Estudio ecológico, fisiográfico y florístico. Ediciones Inst. Mex. Rec. Nat. Renov. México, D.F., México. 361 pp. (Traducido del original inglés inédito por Efrain Hernandez Xolocotzi).

Gentry, H.S. 1969. Origin of the common bean, Phaseolus vulgaris. Econ. Bot. 23(1):55-69.

Gepts, P.L. & Bliss, F.A. 1985. Usefulness of phaseolin as an evolutionary marker. Ann. Rept. Bean Improv. Coop. 28:60-61.

Gepts, P.L., Osborn, T.C., Rashka, K. & Bliss, F.A. 1986. Phaseolin protein variability in wild forms and landraces of the common bean (Phaseolus vulgaris L.): evidence for multiple centers of domestication. Econ. Bot. 40(4):451-468.

Goodman, R.M., Haupli, H., Crossway, A. & Knauf, V.C. 1987. Gene transfer in Crop Improvement. Science 236:48-54.

Hernandez X., E. 1970. Apuntes sobre la exploración etnobotánica y su metodología. Colegio de Postgraduados, Escuela Nacional de Agricultura, SAG, Chapingo, México. 69 pp.

Lackey, J.A. 1983. A review of Generic Concepts in American Phaseolinae (Fabaceae, Faboideae). Iselya 2(2):21-64.

Ladizinsky, G. 1985. Founder effect in Crop-plant evolution. Econ. Bot. 39(2):191-199.

Laing, D.R., Jones, P.G. & Davis, J.H.C. 1984. Common bean (Phaseolus vulgaris L.). In: "The Physiology of Tropical field Crops". P.R. Goldsworthy & N.M. Fisher (eds.), John Wiley & Sons Ltd., Chichester, England, p. 305-351.

Le Marchand, G., Maréchal, R. & Baudet, J. C. 1976. Observations sur quelques hybrides dans le genre Phaseolus. (3). P. lunatus: nouveaux hybrides et considérations sur les affinités interspécifiques. Bull. Rech. Agron. Gembloux 11(1-2):183-200.

Lyman, J. M. 1984. Progress and planning for germplasm conservation of major food crops. Plant Genetic Resources Newsl. 60:3-21.

Maréchal, R. 1970. Données cytologiques sur les espèces de la sous-tribu des Papilionaceae-Phaseoleae-Phaseolinae. Deuxième série. Bull. Jard. Bot. Nat. Belg. 40:307-348.

Maréchal, R., Mascherpa, J.M. & Stainier, F. 1978. Etude taxonomique d'un groupe complexe d'espèces des genres Phaseolus et Vigna (Papilionaceae) sur la base de données morphologiques et polliniques, traitées par l'analyse informatique. Boissiera 28: 273 pp.

Moss, J.P. 1980. Wild species in the improvement of groundnuts. In: "Advances in legume science", Summerfield R. J. and Bunting A.H. (eds.), Royal Botanical Garden, Kew, England, pp. 525-535.

Nabhan, G.P. 1979. Tepary beans: the effects of domestication on adaptations to arid environments. Arid Lands Newslett. 10:11-16.

Nabhan, G.P. 1985. Native crop diversity in Aridoamerica: Conservation of Regional Gene Pools. Econ. Bot. 39(4):387-399.

Nabhan, G.P., Berry, J.W. & Weber, C.W. 1980. Wild beans of the greater Southwest - Phaseolus metcalfei and P. ritensis. Econ. Bot. 34(1):68-85.

Nabhan, G.P., Muruaga Martinez, J., Cardenas Ramos, F. & Burns, B.T. 1986. Wildbean exploration in northwest Mexico and Southwest USA. Plant Genetic Resources Newsl. 65:23-25.

Newell, C.A. & Hymowitz, R. 1982. Successful wide hybridization between the soybean and a wild perennial relative, G. tomentella Hayata. Crop Sci. 22:1062-1065.

Oka, H.I. 1975. Consideration on the population size necessary for conservation of crop germplasms. In: "Gene conservation-Exploration, Collection, Preservation and Utilization of Genetic Resources". T. Matsuo (ed.), JIBP Synthesis, Vol 5, p. 57-63, Tokyo, University of Tokyo Press, Japan.

Osborn, T.C., Blake, T., Gepts, P.L. & Bliss, F.A. 1986. Bean arcelin. (2) Genetic variation, inheritance and linkage relationships of a novel seed protein of Phaseolus vulgaris L. Theor. Appl. Genet. 71(6):847-855.

Otoul, E. 1976. Spectres des acides aminés chez Phaseolus lunatus L., chez quelques espèces apparentées et chez l'amphidiploide P. lunatus L. x P. polystachyus (L.) B.S.P. Bull. Rech. Agron. Gembloux 11(1-2):207-220.

Piper, C.V. 1926. Studies in American Phaseolinae. Contr. US Nat. Herb. 22(9):663-701.

Plucknett, D.L., Smith, N.J.H., Williams, J.T., & Anishetty, N.M. 1987. Gene banks and the world's food. Princeton University Press, Princeton, New Jersey, USA, 247 pp.

Rzedowski, J. 1978. Vegetación de México. Editorial Limusa, México, D.F., México. 432 pp.

Rzedowski, J. & McVaugh, R. 1966. La vegetación de Nueva Galicia. Contr. Univ. Mich. Herb. 9(1):1-123.

Schoonhoven, A.v., Cardona, C. & Valor, J. 1983. Resistance to the Bean Weevil and the Mexican Bean Weevil (Coleoptera:Bruchidae) in non cultivated common bean accessions. J. Econ. Entomol. 76(6):1255-1259.

Seaton, H. E. 1893. New and little known plants collected on Mt. Orizaba in the summer of 1891. Proceed. Amer. Acad. Arts & Sci., Boston, 29 (N.S. 20):116-123.

Smartt, J. 1984. Gene pools in Grain legumes. Econ. Bot. 38(1):24-35.

Spellerberg, I.F. 1981. Ecological evaluation for conservation. Studies in Biology NO. 133, Edward Arnold, London, 60 p.

Thomas, C.V. & Waines, J.G. 1984. Fertile backcross and allotetraploid plants from crosses between tepary beans and common beans (Phaseolus acutifolius, Phaseolus vulgaris). J. Hered. 75(2):93-98.

Vietmeyer, N.D. 1986. Lesser-known plants of potential use in agriculture and forestry. Science 232:1379-1384.

Weeden, N.F. 1984. Distinguishing among white seeded bean cultivars by means of allozyme genotypes. Euphytica 33:199-208.

Wooton, E.O. & Standley, P.C. 1915. Flora of New Mexico. Contr. US Nat. Herb. 19:1-714.

ANNEX 1

Trabajo de Recolección de Germoplasma de *Phaseolus*
patrocinado por la International Union for Conservation of Nature

Misión colaborativa entre el Centro Internacional de Agricultura Tropical (Cali, Colombia) y la Unidad de Recursos Fitogeneticos del Instituto Nacional de Investigaciones Forestales, Agricolas y Pecuarias de Mexico (SARH/Chapingo).

HERBARIO

Nombre científico: Phaseolus vulgaris L. Forma escapada
Determinavit: D.G. Debouck **Fecha:** 23/II/1988
Nombre vulgar: desconocido
País/Estado/Municipio/Localidad: MEXICO, OAXACA, Pochutla, Candelaria Loxicha, 40 Km S de San Jose Pacifico.

Longitud: 96 ° 31 ' W **Latitud:** 15 ° 59 ' N **Altitud:** 1700 m

Fecha de Recolección: 27/X/1987

Observaciones: flora de barranco con Compuestas, P. leptostachyus # 2347. Bosque de Quercus perturbado con Pinus. Soleado, abierto. Suelo pedregoso derivado esquistos metamorficos. Pocas plantas. En fin floracion (flor lila) - vainas verdes. Tallos trepadores 3-4 m alto.

Colectores: D.G. Debouck & Jose S. Muruaga Martinez
Nº: 2348 **Se colectaron semillas bajo el Nº:**

Trabajo de Recolección de Germoplasma de *Phaseolus*
patrocinado por la International Union for Conservation of Nature

Misión colaborativa entre el Centro Internacional de Agricultura Tropical (Cali, Colombia) y la Unidad de Recursos Fitogeneticos del Instituto Nacional de Investigaciones Forestales, Agricolas y Pecuarias de Mexico (SARH/Chapingo).

HERBARIO

Nombre científico: Phaseolus chiapasanus Piper
Determinavit: D.G. Debouck **Fecha:** 23/II/1988
Nombre vulgar: frijol de monte
País/Estado/Municipio/Localidad: MEXICO, OAXACA, Pochutla, Candelaria Loxicha, 2 Km NW de La Galera, 6 Km S de La Soledad.

Longitud: 96 ° 30 ' W **Latitud:** 15 ° 58 ' N **Altitud:** 1260 m

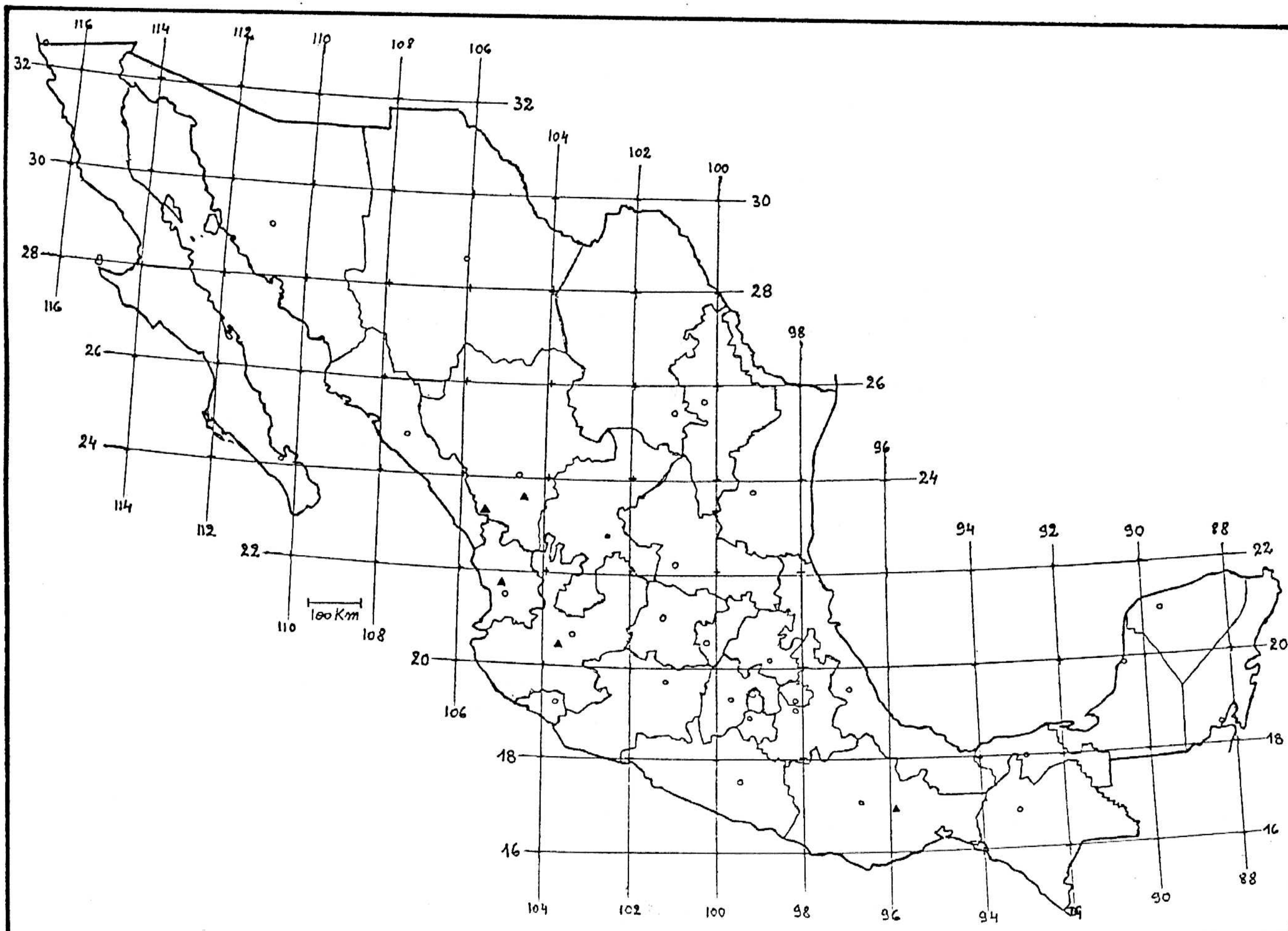
Fecha de Recolección: 27/X/1987

Observaciones: bosque alto tropical subperennifolio talado para instalar cafetales ; en partes intactas. Mi soleado. Suelo organico arcilloso amarillo derivado esquistos metamorficos. Con bejucos : Ipomoea, Cucurbita. Tallos trepadores 4-8 m alto. Fin floracion (flor lila) - vainas verdes. Abundancia localizada y escaso.
Colectores: D.G. Debouck & Jose S. Muruaga Martinez
Nº: 2349 **Se colectaron semillas bajo el Nº:** 2349

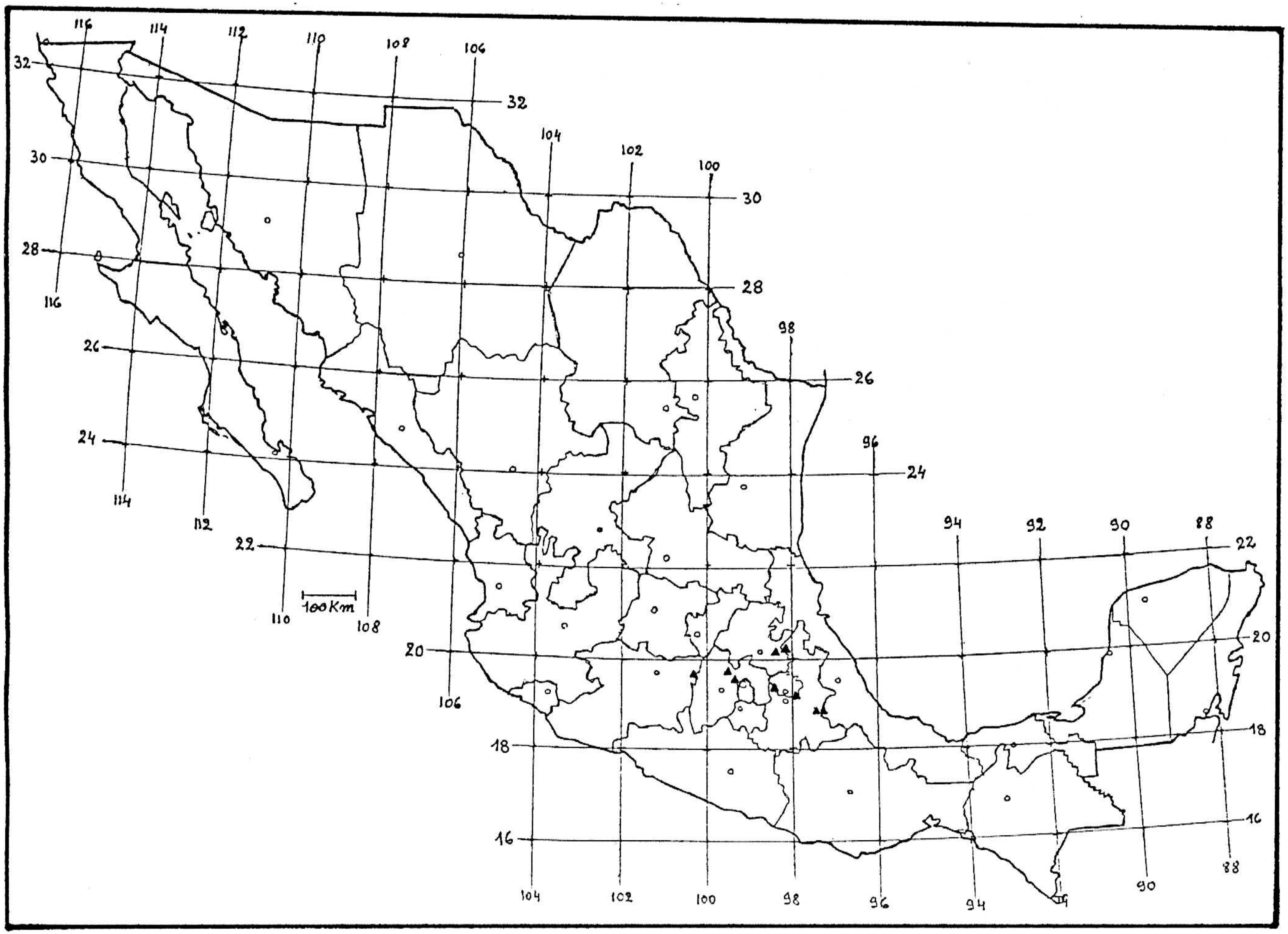
ANNEX 2. Sites for the materials collected in 1987.

Nr	Species/subspecies/form	Longitud	Latitud	Altm
2320	P.coccineus-coccineus	98.46W	19.20N	2630
2321	P.coccineus-hybrido	98.41W	19.19N	2730
2322	P.esperanzae	98.38W	19.18N	2450
2323	P.coccineus-hibrido	98.23W	18.58N	1880
2324	P.leptostachyus	98.23W	18.58N	1880
2325	P.vulgaris	98.23W	18.58N	1880
2326	P.microcarpus	98.23W	18.28N	1430
2327	P.microcarpus	98.18W	18.22N	1000
2328	P.microcarpus	98.10W	18.15N	1300
2329	P.nelsonii	97.24W	17.36N	2530
2330	P.leptostachyus	97.08W	17.20N	2030
2331	P.ovatifolius	97.05W	17.19N	2140
2332	P.nelsonii	97.02W	17.13N	2180
2333	P.coccineus	97.02W	17.13N	2230
2334	P.leptostachyus	96.58W	17.16N	2130
2335	P.oaxacanus	96.24W	17.04N	2550
2336	P.coccineus	96.24W	17.03N	2270
2337	P.nelsonii	96.24W	17.03N	2270
2338	P.coccineus	96.24W	17.04N	2570
2339	P.microcarpus	96.33W	17.01N	1570
2340	P.leptostachyus	96.35W	16.38N	1820
2341	P.microcarpus	96.35W	16.38N	1900
2342	P.oaxacanus	96.35W	16.38N	1900
2343	P.coccineus-coccineus	96.34W	16.19N	2060
2344	P.nelsonii	96.32W	16.15N	2160
2345	P.coccineus	96.30W	16.00N	2240
2346	P.xolocotzii	96.31W	15.59N	1780
2347	P.leptostachyus	96.31W	15.59N	1780
2348	P.vulgaris	96.31W	15.59N	1700
2349	P.chiapasanus	96.30W	15.58N	1260
2350	P.microcarpus	97.05W	15.58N	90
2351	P.leptostachyus	97.04W	16.07N	860
2352	P.microcarpus	97.48W	16.16N	190
2353	P.microcarpus	99.39W	17.08N	320
2354	P.acutifolius-tenuifolius	99.29W	17.26N	1270
2355	P.vulgaris	99.29W	17.34N	1620
2356	P.acutifolius-tenuifolius	99.29W	17.34N	1620
2357	P.leptostachyus	99.29W	17.34N	1620
2358	P.microcarpus	99.33W	17.42N	860
2359	P.coccineus	99.28W	18.13N	1630
2360	P.leptostachyus	99.28W	18.23N	1630
2361	P.hintonii	99.28W	18.23N	1620
2362	P.leptostachyus	99.35W	18.28N	1010
2363	P.leptostachyus	99.34W	18.34N	1630
2364	P.leptostachyus	99.46W	18.55N	1980
2365	P.coccineus-coccineus	99.46W	18.55N	1980
2366	P.nelsonii	99.47W	18.55N	2120
2367	P.coccineus	99.52W	18.55N	2470
2368	P.pedicellatus	99.52W	18.55N	2470
2369	P.vulgaris	100.03W	19.02N	1630
2370	P.pedicellatus	99.24W	19.05N	2410
2371	P.vulgaris	99.26W	18.57N	1890
2372	P.coccineus-coccineus	99.26W	18.57N	1890

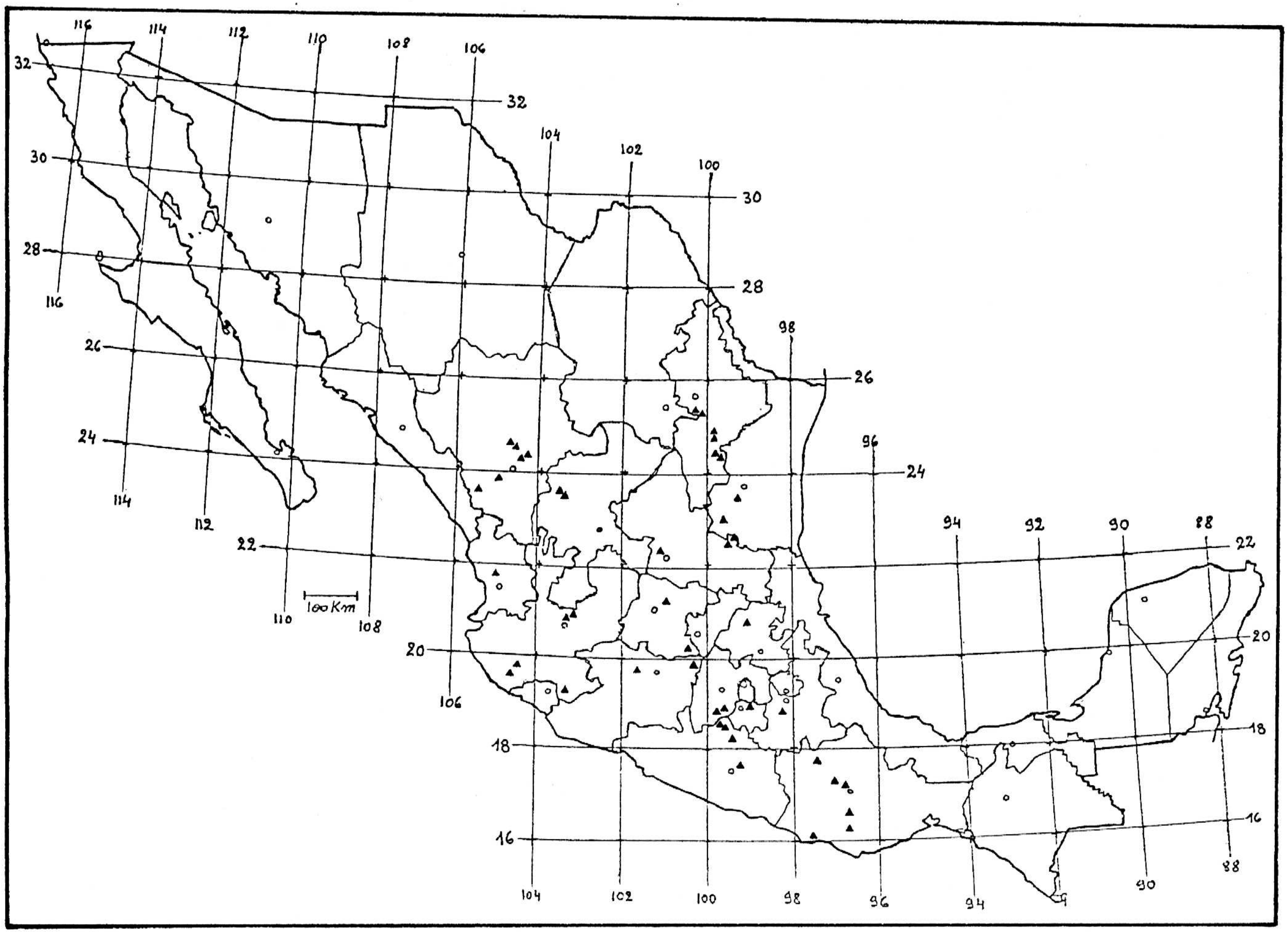
2373	P.leptostachyus	99.28W	18.55N	2370
2374	P.coccineus-coccineus	98.32W	19.26N	2560
2375	P.coccineus-coccineus	99.21W	19.32N	2530
2376	P.esperanzae	99.21W	19.32N	2520
2377	P.marechalii	99.25W	19.41N	2520
2378	P.esperanzae	99.25W	19.41N	2520
2379	P.esperanzae	98.19W	20.07N	2200
2380	P.pedicellatus	98.08W	20.09N	2180
2381	P.esperanzae	98.12W	20.08N	2190
2382	P.esperanzae	97.17W	18.51N	2400
2383	P.coccineus-coccineus	97.15W	18.50N	1940
2384	P.sp	97.15W	18.50N	1940
2385	P.coccineus-coccineus	97.19W	18.56N	2590
2386	P.esperanzae	97.19W	18.56N	2590
2387	P.esperanzae	97.54W	19.08N	2400
2388	P.coccineus-coccineus	97.54W	19.08N	2400
2389	P.marechalii	97.54W	19.08N	2400
2390	P.pedicellatus	97.59W	19.55N	1950
2391	P.coccineus-coccineus	98.38W	20.03N	2320
2392	P.coccineus-coccineus	99.41W	19.51N	2620
2393	P.polymorphus	100.11W	21.04N	1970
2394	P.maculatus	100.06W	21.07N	2040
2395	P.leptostachyus (intonsus)	100.06W	21.07N	2040
2396	P.maculatus	100.11W	21.04N	2520
2397	P.coccineus-coccineus	100.11W	21.04N	2520
2398	P.polymorphus	100.11W	21.04N	2520
2399	P.microcarpus	101.12W	20.19N	1850
2400	P.leptostachyus	101.12W	20.19N	1850
2401	P.vulgaris	101.12W	20.19N	1850
2402	P.leptostachyus	100.52W	20.02N	2080
2403	P.pluriflorus	100.17W	19.47N	2340
2404	P.coccineus-coccineus	100.17W	19.47N	2340
2405	P.coccineus-coccineus	100.10W	19.48N	2500
2406	P.esperanzae	100.10W	19.48N	2500



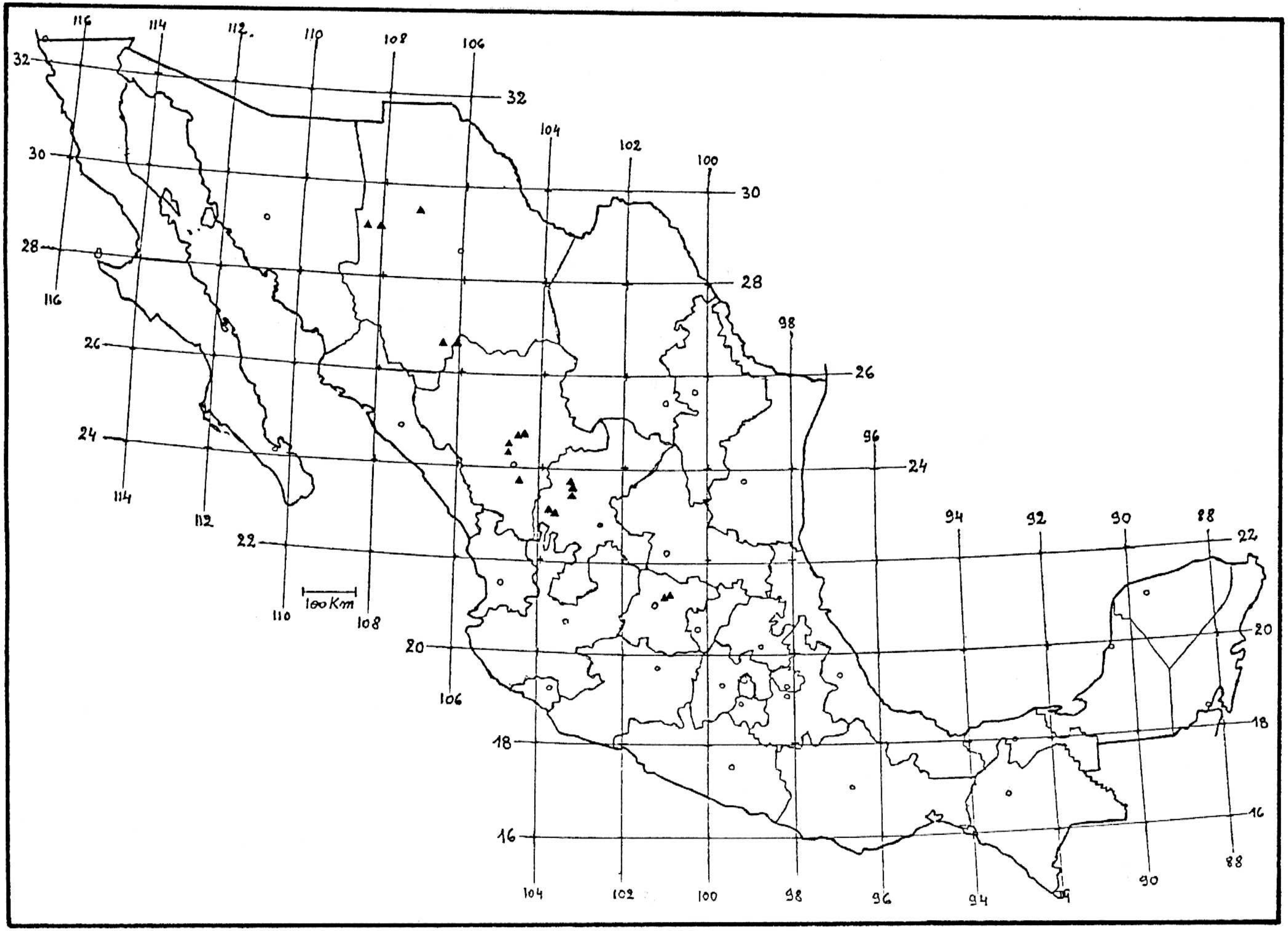
Map 1. Distribution of existing seed accessions of Phaseolus acutifolius Asa Gray var tenuifolius.



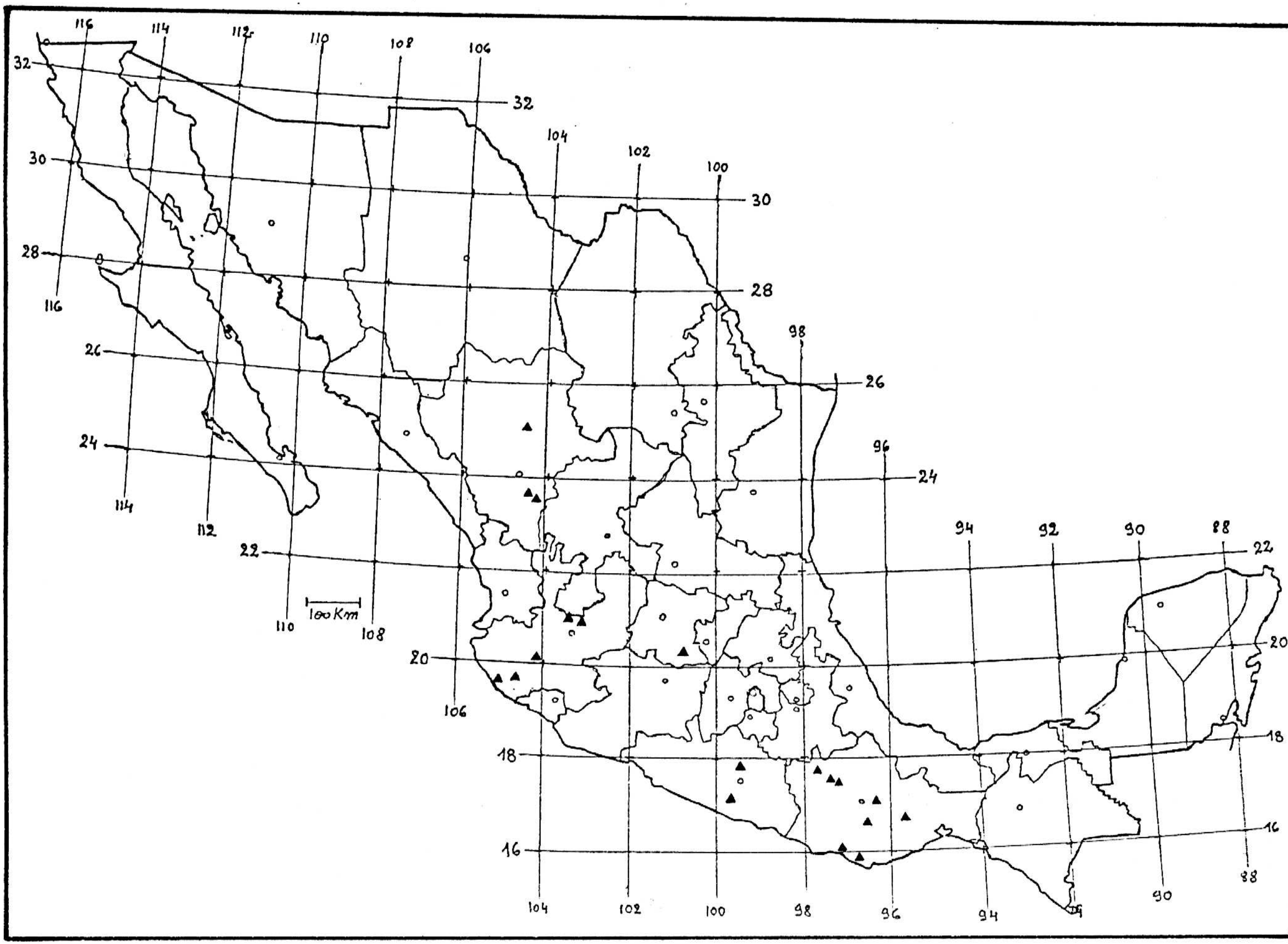
Map 2. Distribution of existing seed accessions of Phaseolus esperanzae Seaton.



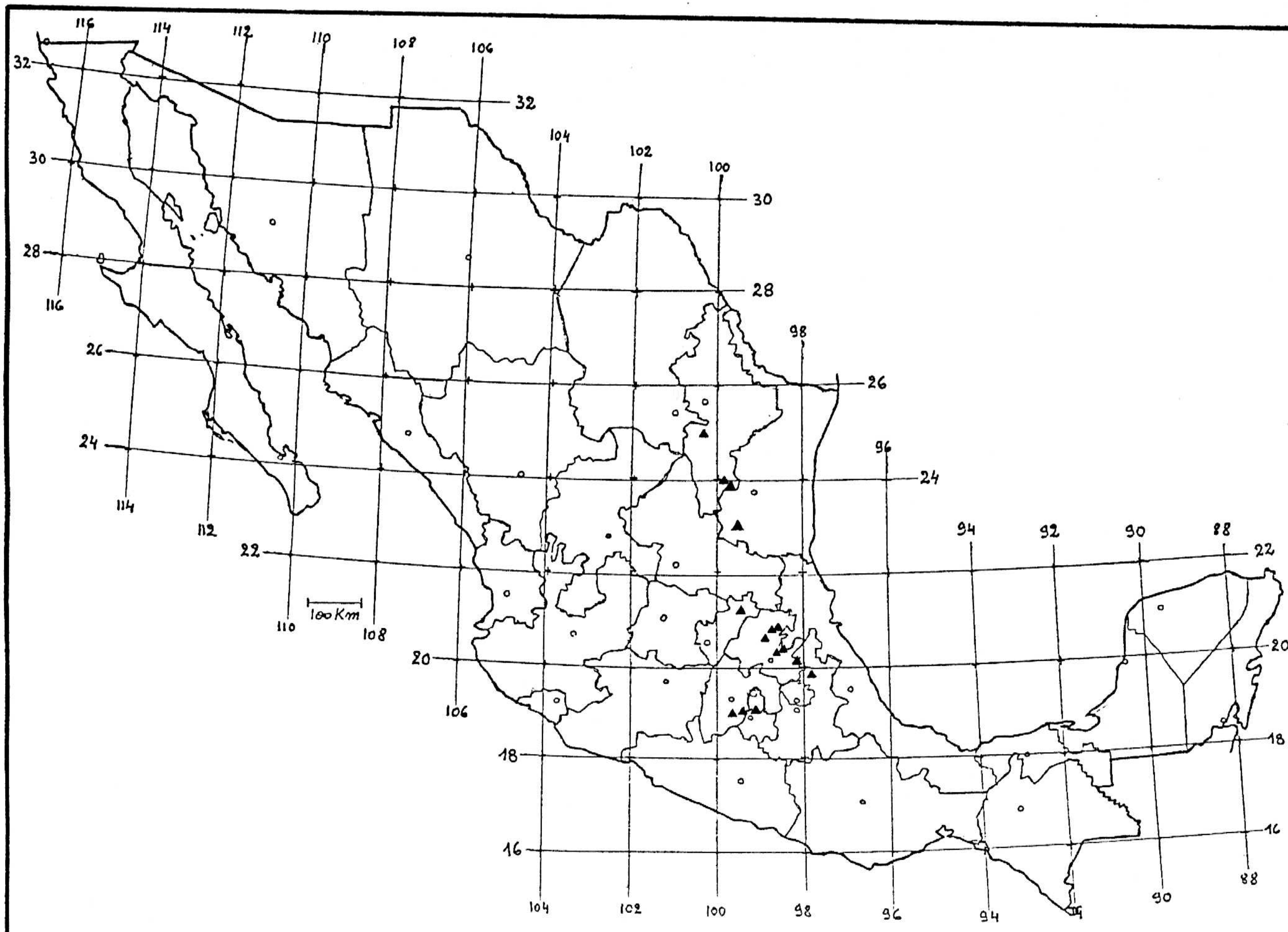
Map 3. Distribution of existing seed accessions of *Phaseolus leptostachyus* Bentham.



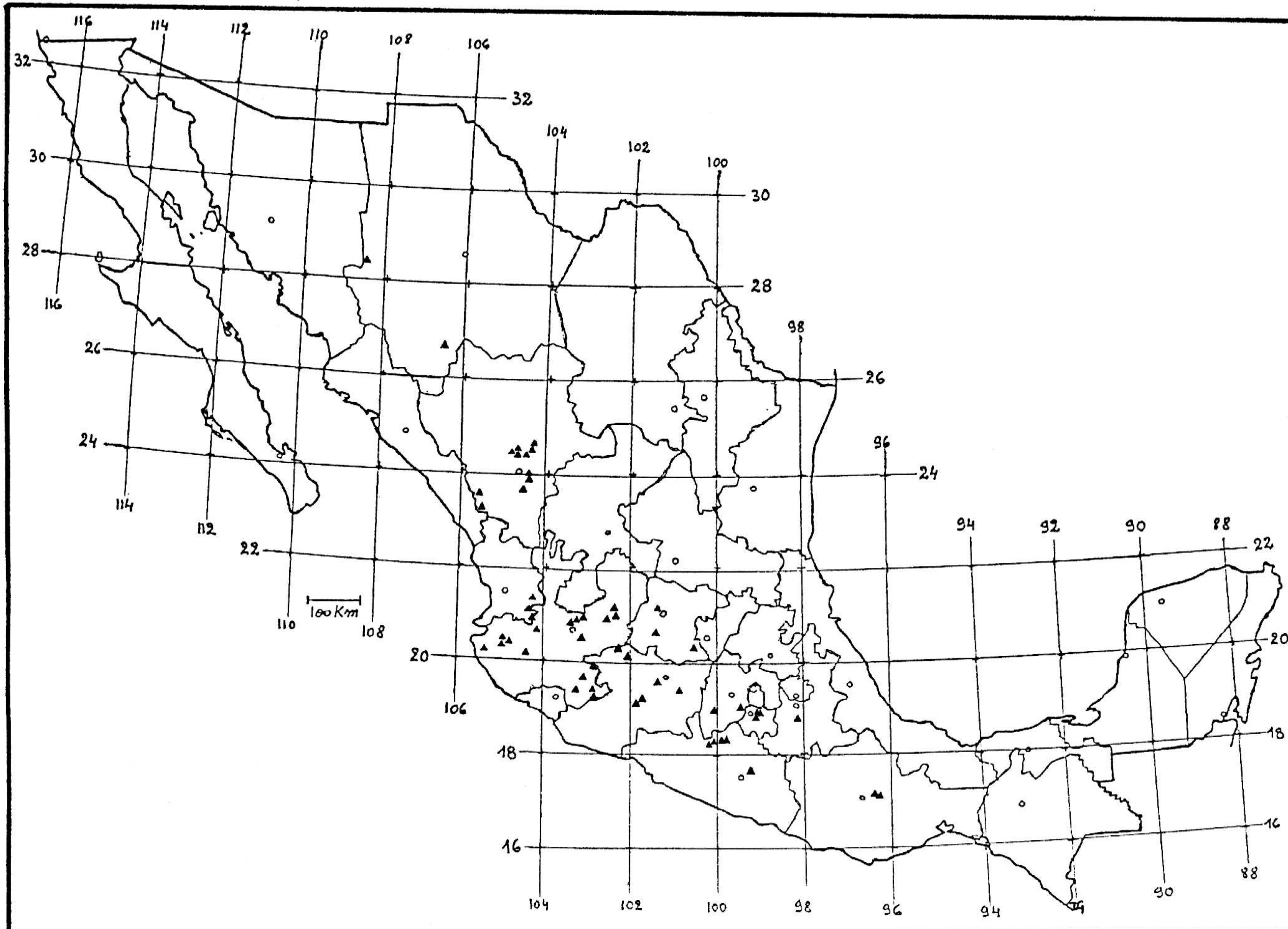
Map 4. Distribution of existing seed accessions of <u>Phaseolus</u> <u>maculatus</u> Scheele.



Map 5. Distribution of existing seed accessions of <u>Phaseolus</u> <u>microcarpus</u> Mart.



Map 6. Distribution of existing seed accessions of Phaseolus pedicellatus Bentham.



Map 7. Distribution of existing seed accessions of wild Phaseolus vulgaris L. Some dots may represent more than one population.