# Wild Potato Collecting Expedition in Southern Peru (Departments of Apurímac, Arequipa, Cusco, Moquegua Puno, Tacna) in 1998: Taxonomy and New Genetic Resources

David M. Spooner*[1], Alberto Salas López[2], Zósimo Huamán[2], and Robert J. Hijmans[2]

[1]United States Department of Agriculture, Agricultural Research Service, Department of Horticulture, University of Wisconsin, 1575 Linden Drive, Madison, WI, 53706-1590. Tel: 608-262-0159; FAX: 608-262-4743; email: dspooner@facstaff.wisc.edu)
[2]International Potato Center (CIP), Apartado 1558, La Molina, Lima 12, Peru.

## ABSTRACT

**Peru has 103 taxa of wild potatoes (species, subspecies, varieties, and forms) according to Hawkes (1990; modified by us by a reduction of species in the *Solanum brevicaule* complex) and including taxa described by C. Ochoa since 1989. Sixty-nine of these 103 taxa (67%) were unavailable from any of the world's genebanks and 85 of them (83%) had less than three germplasm accessions. We conducted a collaborative Peru (INIA), United States (NRSP-6), and International Potato Center (CIP) wild potato (*Solanum* sect. *Petota*) collecting expedition in Peru to collect germplasm and gather taxonomic data. This is the first of a series of planned expeditions from 1998-2002. We collected from February 18 to April 18, 1998, in the southern departments of Apurímac, Arequipa, Cusco, Moquegua, Puno, and Tacna. We made 57 germplasm collections, including 14 taxa that are the first available as germplasm for any country (*Solanum aymaraesense*, *S. chillonanum*, *S. incasicum*, *S. megistacrolobum* subsp. *megistacrolobum f. purpureum*, *S. longiusculus*, *S. multiflorum*, *S. pillahuatense*, *S. sawyeri*, *S. sandemanii*, *S. tacnaense*, *S. tarapatanum*, *S. urubambae*, *S. velardei*, *S. villuspetalum*), and two additional taxa that are the first available for Peru but with germplasm from Bolivia (*S. megistacrolobum* subsp. *toralapanum*, *S. yungasense*). Collections also were made for the rare taxa *S. açroscopicum*, *S. buesii*, *S. limbaniense*, and *S. santolallae*. Our collections suggest the following minimum synonymy may be needed for Peruvian potatoes: *S. sawyeri* as a synonym of *S. tuberosum*; *S. hawkesii* and *S. incasicum* as synonyms of *S. raphanifolium*; *S. multiflorum* and *S. villuspetalum* as synonyms of *S. urubambae*.**

Accepted for publication September 28, 1998.
ADDITIONAL KEY WORDS: *Solanum* sect. *Petota*.

## INTRODUCTION

Wild and cultivated tuber-bearing potatoes (*Solanum* sect. *Petota*) are distributed from the southwestern United States to south-central Chile. The latest comprehensive taxonomic treatment of potatoes (Hawkes, 1990) recognized 216 tuber-bearing species, with 101 taxa (here to include species, subspecies, varieties and forms) from Peru. Ochoa (1989, 1992b, 1994a,b) described ten additional Peruvian taxa raising the total to 111. We lower this number to 103 with a modification of species in the *Solanum brevicaule* complex. Sixty-nine of these 103 species (67%) were unavailable from any of the world's genebanks and 85 of them (83%) had less than three germplasm accessions. Despite the efforts by CIP to collect and conserve a representative sample of this gene pool, intensive exploration was prevented by terrorist activities in the past 15 years. Wild potato collecting in Peru was therefore considered of first priority by the National Institute of Agrarian Research (Instituto Nacional de Investigacion Agraria, INIA), Peruvian Ministry of Agriculture; the National Research Support Program-6, United States (NRSP-6); the

**EXPLANATION OF ABBREVIATIONS**

APIC, Association of Potato Intergenebank Collaboration
CIP, International Potato Center (Centro Internacional de la Papa), and a herbarium code used by this organization for their herbarium in La Molina, Peru
CPRO-DLO/CGN, Centre for Plant Breeding and Reproduction Research, Centre for Genetic Resources, The Netherlands
INIA, Instituto Nacional de Investigacion Agraria (National Institute for Agrarian Research), Peruvian Ministry of Agriculture
IPK, German Potato Genebank at the Institute of Plant Genetics and Crop Plant Research, Gatersleben, Gross Lusewitz, Germany
MOL, Herbario Weberbauer, Departmento de Biología, Sección Botánica, Universidad Nacional Agraria, La Molina, Peru
NRSP-6, National Research Support Program-6, Sturgeon Bay, Wisconsin, USA (formerly called the Inter-Regional Potato Introduction Project, IR-1)
OCH, Herbarium code used by Carlos Ochoa for his private herbarium
PTIS, Herbarium of NRSP-6
WAG, Herbarium of the Department of Plant Taxonomy, Wageningen Agricultural University, Wageningen, The Netherlands.

International Potato Center (CIP); the Centre for Genetic Resources The Netherlands (CGN) at the Centre for Plant Breeding and Reproduction Research (CPRO-DLO), Wageningen, The Netherlands; and the German Potato Genebank at the Institute of Plant Genetics and Crop Plant Research (IPK), Gatersleben, Gross Lusewitz, Germany. This report details the results of a collaborative germplasm collecting expedition in Peru by INIA, CIP, and NRSP-6 from February 18 to April 18, 1998; the other genebanks plan to collect with us in future years. The goals of the expedition were to collect wild species germplasm and to increase them quickly and make them freely available internationally. CIP will distribute these genetic materials according to the in-trust agreement between the International Potato Center and FAO, and NRSP-6 according to established policy of the United States Plant Germplasm System.

## MATERIALS AND METHODS

### *Permission to Collect*

INIA is the Peruvian institution in charge of granting the permit for collecting activities of agricultural biodiversity in Peru. NRSP-6 and CIP obtained a general permit to collect in collaboration with INIA for a series of expeditions from 1998-2002. Because of the large size of Peru and logistical problems in Peru, and because of the many species in need of germplasm collection, we proposed a series of five expeditions. Collecting in specific areas required addenda to this general permit. Addenda for collections in 1998 allowed collections in the six southern Peruvian departments of Apurímac, Arequipa, Cusco, Moquegua, Puno, and Tacna. Only the 1998 expedition was funded and further expeditions await peer review of competitive grants to the USDA. These would continue to take two months each, from 1999-2002. CPRO-DLO/CGN and IPK will participate in some of these.

### *Locality, Geographic, and Herbarium Data*

Prior to the expedition, we compiled locality data from: 1) Correll (1962), 2) Ochoa (1962), 3) a database of herbarium records distributed by J.G. Hawkes, Birmingham University (Hawkes, 1997), 4) individual species descriptions for all type localities in Peru (the locality of the specimen upon which a species, subspecies, variety, or form is based), available from an unpublished database maintained by Ronald van den Berg (Wageningen Agricultural University) and David M. Spooner. Since the publication of Correll (1962), and Ochoa (1962), CIP (mainly through Carlos Ochoa and Alberto Salas) has collected extensively throughout Peru, Colombia, Venezuela, and Ecuador. Other than selected isotype specimens (duplicates of the holotype specimen, the one specimen upon which a species name is based), the majority of these specimens have been deposited in the herbaria of CIP and OCH (Ochoa's private herbarium). Our expedition lacked these latter herbarium data that will be available with the publication of Ochoa's book on the wild potatoes of Peru (in press).

We compared these literature records to germplasm holdings in an intergenebank database (Huamán, 1998; Huamán *et al.*, 1996) that summarizes holdings from NRSP-6, CPRO-DLO/CGN, IPK, CIP, the Commonwealth Potato Collection (CPC, Scotland), the Balcarce Potato Collection (INTA, Argentina), and the N.I. Vavilov Institute (VIR, Russia). Because NRSP-6 has most of the rarer Peruvian species held by other genebanks, we used these collections for planning, and concentrated on taxa with no or few germplasm collections.

In Peru as in much of Latin America, much of the countryside is given very specific local names that do not appear in gazetteers or maps. Many of these names are in native languages with sounds not common to Spanish or English and are often transcribed by collectors in different ways. These names can be extremely useful to collectors by guiding them to very specific places once near the area, but are most helpful when accompanied by other published names of localities to lead collectors to these places. We determined the location of ambiguous localities in the field with the help of local guides who also led us to many wild potato populations.

We assembled locality data with the aid of 1) National Imagery and Mapping Agency (1995); 2) Instituto Geográfico Nacional, 1:250,000-scale topographic maps (95 maps cover Peru, currently only the maps for southern and coastal Peru are available but the others are to be made available in the next couple of years), 1:100,000-scale topographic maps (504 maps cover Peru, most are available), 3) physical and political road and topographic maps for all 24 Departments, scales vary from 1:200,000 (Department of Tumbes), to 1:850,000 (Department of Ucayali), 4) Instituto Geográfico Nacional (1989). All available 1:250,000-scale maps (southern and coastal Peru) and all 1:100,000-scale maps for southern Peru were bought by NRSP-6 and incorporated in the NRSP-6 library.

We made an altitude map with the GTOPO30 database. GTOPO30 is a global digital elevation model, provided by the U.S. Geological Survey (http://edcwww.cr.usgs.gov/landdaac/gtopo30/gtopo30.html). The resolution of GTOPO30 is 30-arc seconds (approximately 1 $km^2$). We obtained the coordinates for type localities with the National Imagery and Mapping Agency's database of foreign geographic feature names (http://164.214.2.59/gns/html/index.html) and from the 1:100,000 and 1:250,000 maps. We determined ecoregions for each type locality by "overlaying" (simultaneously querying) the type locality map and the ecoregion map, using a geographic information system.

A jeep was used for the entire expedition, needed for the many unpaved roads in Peru. Collecting was done mainly on foot and occasionally on horseback. Local residents led us to many populations. Longitude and latitude data were obtained by a global positioning system (GPS) receiver, and altitudes with an altimeter. GPS readings were taken as decimal fractions of minutes rather than as seconds. We dried herbarium vouchers in the field, and deposited herbarium vouchers at CIP, MOL, PTIS, and WAG (herbarium acronyms follow Holmgren *et al.*, 1990; except PTIS, to appear in the next edition (Bamberg and Spooner, 1994), and CIP, planned for submission for inclusion).

### *Germplasm Collection, Increase, and Distribution*

True seeds were the preferred germplasm collection. Some sites were visited a second time if true seeds were not available on the first visit. To ensure a first increase and maximize efficiency, all parties agreed to divide the true seeds between CIP and NRSP-6 when more than 50 true seeds were available. If true seeds were not available we collected vegetative material (tubers, plants placed in pots in the field, stem cuttings). The vegetative collections were transported and transplanted at the CIP Station in Huancayo every two weeks to ensure their survival. They will be used for true seed increases (preferred) or in-vitro increases if true seed cannot be produced. Germplasm of this first increase will be distributed among INIA and cooperating Association of Potato Intergenebank Collaboration (APIC) genebanks for a subsequent increase and later distribution internationally.

## RESULTS AND DISCUSSION

### *Geographic Analysis*

Peru covers 1,299,836 km$^2$. It is divided into 24 departments (Fig. 1). The Andes mountains cover nearly half of its territory, with 39% of the country above 1000 m and 24% above 3000 m (Fig. 2). It is ecologically very diverse (Tosi, 1960). This ecological diversity originates from the influence of the Andes on the climate. Climate changes with altitude and slope exposure, and there are dramatically different climates at each side of the Andes due to the influence of the cold waters of the Pacific Ocean and the humidity from the Amazon basin.

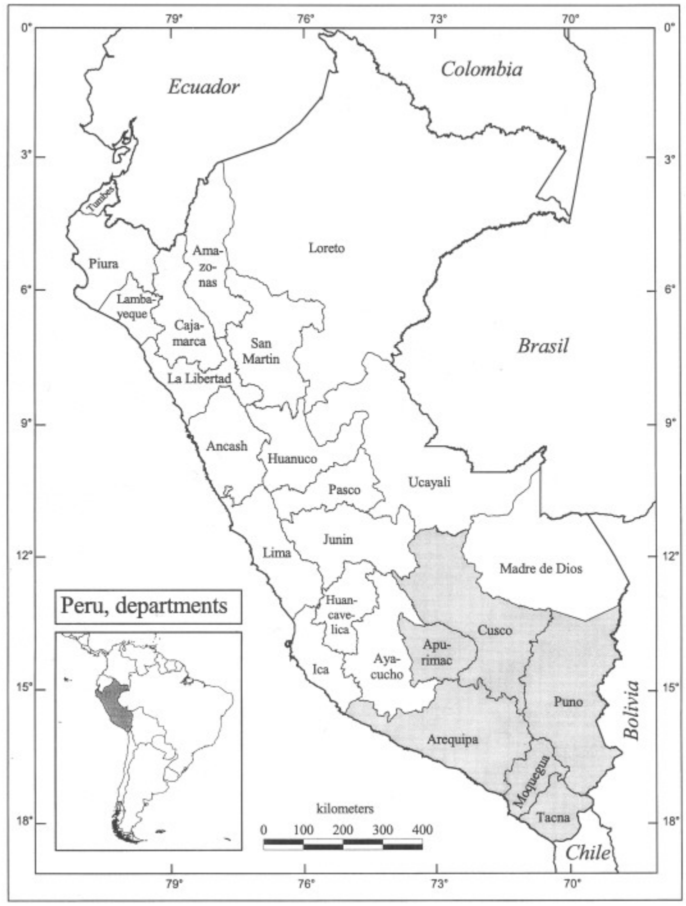


**FIGURE 1.**
**The 24 Departments of Peru with the six southern Departments shaded where collections were made in 1998.**

There have been several attempts to classify the ecological diversity of Peru (e.g., Tosi, 1960; Hueck, 1972; Instituto Geográfico Nacional, 1989; Pulgar Vidal, 1996). The simplest classification divides Peru into three zones: Coast, Sierra, and Jungle. However, this division ignores major differences within the Sierra. Figure 3 shows the ecoregions of Peru. It is our slightly modified version of the ecoregions map of the Instituto Geográfico Nacional (1989), produced by excluding minor categories in peripheral areas in the north and south. This classification suits our goal of exploring generalized habitats of wild potatoes. Figure 3 delineates the following zones: "Dry Forest", on the north coast, with a savanna-like vegetation; "Desert Coast", that has hardly any vegetation, with the exception of riverine gallery forests and lomas (see below); "Mountain Steppe", on the western side of the Andes,

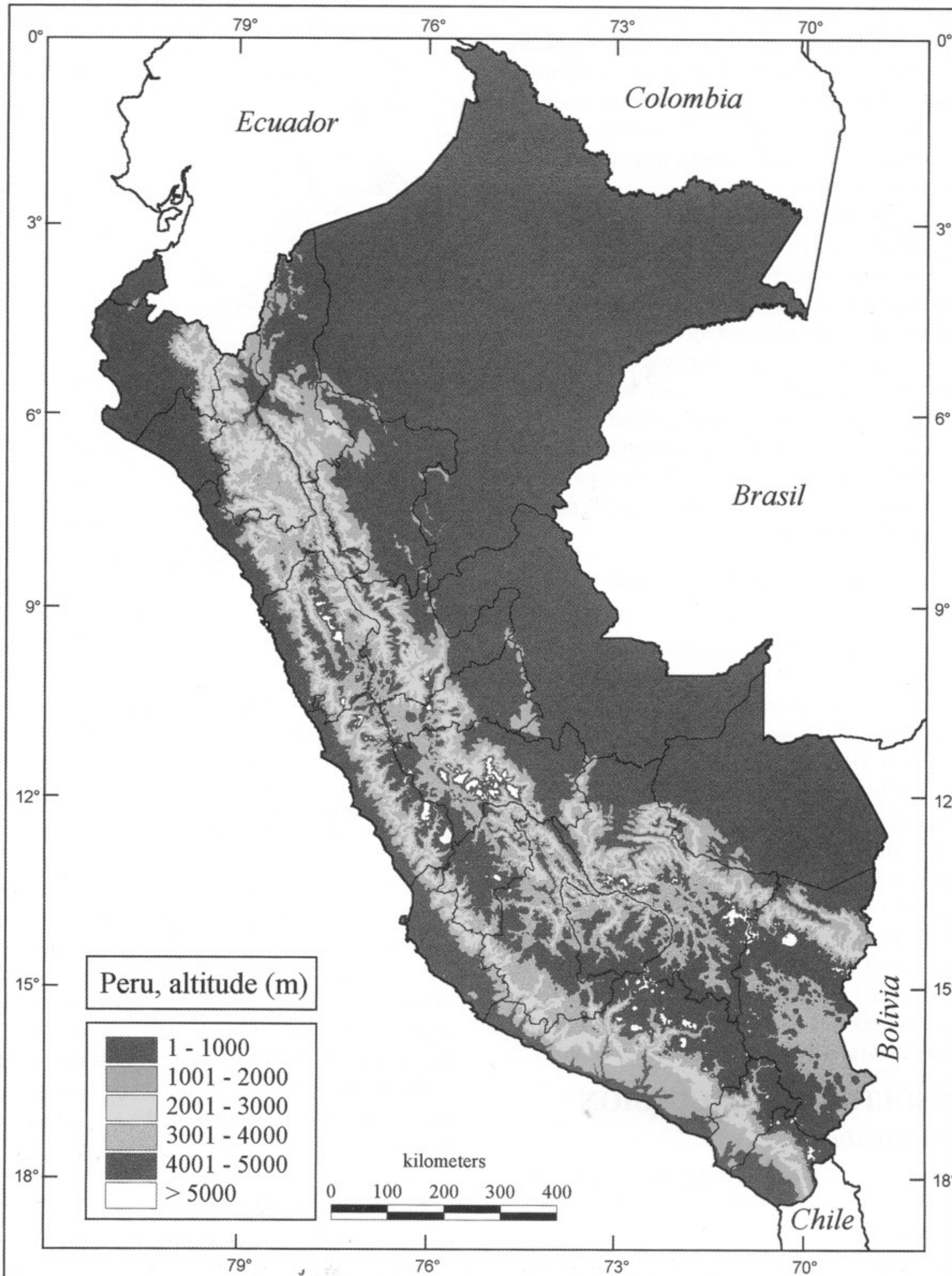


**FIGURE 2.**
**Altitudes in Peru.**

with a mostly xerophytic vegetation; "Puna", a high and cold zone above the tree line, dominated by bunch grasses (e.g., *Stipa ichu*); and at the eastern side of the Andes "High Jungle" and "Low Jungle", both generally wet and with a natural vegetation of evergreen forest. The ecoregion with most type localities is the High Jungle, while the Low Jungle does not have any (Table 1). Potatoes are absent or rare in the warmest zones (Low Jungle and Dry Forest). All ecogeographic interpretations of the diversity in Peru show major relationships of ecoregions with altitude (Figs. 2, 3).

The annual average temperature in the Low Jungle is about 25 C. In the Andes, temperature is mainly a function of altitude. It changes about 0.6 C per 100 meters (Frère *et al.*, 1975). The lower limit of the glaciers is between about 4600 to 5200 m (Pulgar Vidal, 1996). Because Peru is in the tropics, temperature changes over the year are small. Contrary to areas at higher latitudes, diurnal fluctuations are much larger than seasonal fluctuations and may amount up to 20 C (Troll, 1968).

Precipitation in Peru is largely determined by the effect of the Andes on the airflow (Frère *et al.*, 1975). The Low Jungle is very humid with a total annual precipitation above 1500 mm. It rains every month of the year. The lower parts of the High Jungle are also very humid with 1000-1500 mm rainfall per year. Going westwards, precipitation declines to 400 and 800 mm/year as the air loses its moisture and passes into the inter-Andean valleys. Precipitation increases again going up the subsequent mountain chains of the Puna zone, but total rainfall in the west is less than that of the east at comparable altitudes (Brush, 1982). The western flanks of the Andes are dry. Rainfall in the Mountain Steppe decreases with altitude to about 200 mm/year or less on its lower slopes and on the Desert Coast. The rainy season in the Andes is from September to May, with most rain falling from December to March. During the Peruvian winter, from June to September, there often is a thick cloud cover over the Coastal Desert. In some areas this leads to the formation of "Lomas". These are areas that due to their altitude and geomorphology are covered in a heavy fog most of the winter. This generates enough rain to allow herbaceous vegetation during these months.

### *Taxonomy Overview*

Wild and cultivated potatoes, *Solanum* L. sect. *Petota* Dumort., are distributed from the southwestern United States to southern Chile. They range in ploidy levels from diploid ($2n = 2x = 24$) to tetraploid ($2n = 4x = 48$) to hexaploid ($2n = 6x = 72$), with a few triploid or pentaploid species. They have been a difficult group to divide into species and higher taxa (series) and lower taxa (subspecies, varieties and forms). The taxonomic treatments of wild potatoes have differed greatly among taxonomists regarding number of species, their division into series, different use of subspecies or varieties for the same entity, and hypotheses of hybridization to account for putative interspecific intermediates (Spooner and van den Berg, 1992). Indeed, the taxonomic treatments of potatoes have been so variable that they were used by Harlan and de Wet (1971) to illustrate the difficulty of most taxonomic treatments of crops to serve breeders. The latest comprehensive taxonomic treatment of potatoes by Hawkes (1990) recognized seven cultivated and 225 wild species. However nine of these species lack tubers, are members of separate clades, and are best treated in sect. *Etuberosum* (Bukasov & Kameraz) A. Child, sect. *Lycopersicum* (Mill.) Wettst., and sect. *Juglandifolium* (Rydb.) A. Child (Child, 1990; Spooner *et al.*, 1993). This lowers the number of species of sect. *Petota* to 216.

TABLE 1.—*Locations of Peruvian type localities by ecoregion (Fig. 3).*

| Ecoregion | Number of type localities |
|---|---|
| Desert Coast | 19 |
| Dry Forest | 2 |
| Mountain Steppe | 22 |
| Puna | 28 |
| High Jungle (Yunga) | 57 |
| Low Jungle | 0 |

Despite a purported great variability in wild potatoes (Hawkes, 1990), many of the species have a general appearance to the cultivated potato, *Solanum tuberosum* (Spooner and van den Berg, 1992). A typical wild potato has leaves pinnately dissected (a few species have entire leaves), corollas various shades of purple (colors vary from white to pink), corollas pentagonal to rotate (some are stellate), and fruits spherical to ovoid (some are conical). The dominant taxonomic data have been provided by morphology, with intuitive judgments of often minute differences used to separate species. Computer-assisted multivariate studies of morphological data from germplasm collections planted in similar environments have suggested there are many fewer species than 216 (e.g., Castillo and Spooner, 1997; van den Berg *et al.*, 1998).

Peru has approximately one-half of the total number of potato species (Table 2). Their taxonomy including keys, descriptions, and specimens cited was provided by Correll

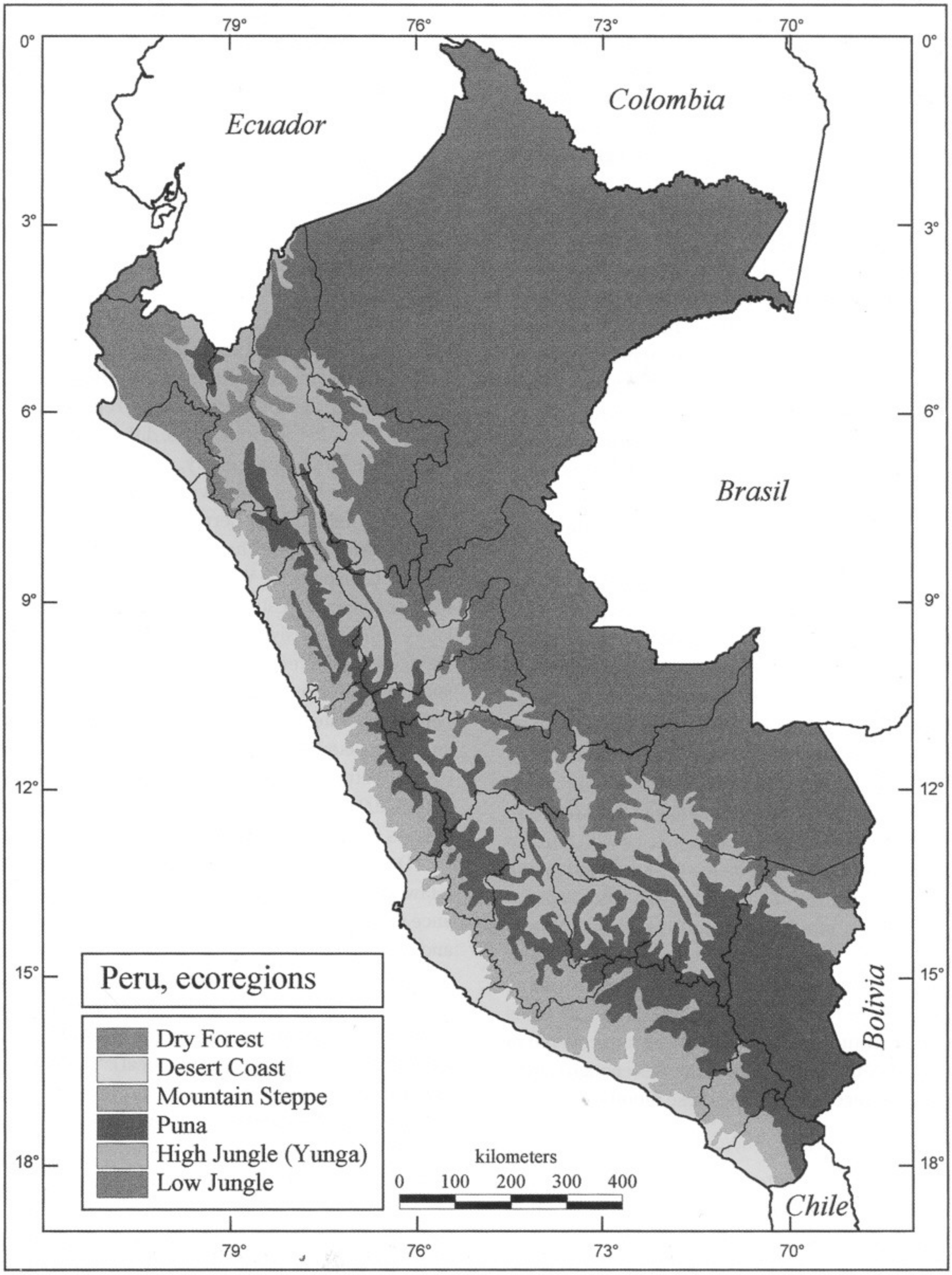


**FIGURE 3.**
**Ecoregions of Peru.**

TABLE 2.—*Wild potato taxa accepted for Peru (in bold type) and synonyms according to Hawkes (1990), except for* S. brevicaule, *see text. Taxa described at or after 1989 and not appearing in Hawkes (1990) are followed by their date of publication. Author abbreviations follow Brummitt and Powell (1992). The widespread taxa* S. acaule *subsp.* acaule, S. acaule *subsp.* punae, S. albicans, *and* S. brevicaule *are not mapped. All names, including synonyms, are placed in the department containing the type. Synonyms are listed under the accepted name.*

| Department (UNK = Unknown) | [1]Taxon | [2]Prior germplasm collections from Peru at NRSP-6 | Map Locality as shown on Fig. 4 |
|---|---|---|---|
| Amazonas (AMA) | ***Solanum burkartii* Ochoa** | 0 | 9 |
| | ***S. chiquidenum* f. *amazonense* Ochoa, 1994b** | 0 | 9 |
| | ***S. humectophilum* Ochoa** | 0 | 5 |
| Ancash (ANC) | ***S. anamatophilum* Ochoa** | 0 | 34 |
| | ***S. augustii* Ochoa** | 0 | 31 |
| | ***S. chavinense* Correll** | 0 | 29 |
| | ***S. chomatophilum* Bitter** | 18 (AMA, ANC, CAJ, LIM, LL, PAS, UNK) | 21 |
| | ***S. chomatophilum* var. *subnivale* Ochoa, 1994b** | 0 | 23 |
| | ***S. dolichocremastrum* Bitter** | 4 (ANC) | 24 |
| | ***S. moniliforme* Correll** | 0 | 32 |
| | ***S. multiinterruptum* f. *longipilosum* Correll** | 0 | 33 |
| | ***S. orophilum* Correll** | 1 (ANC) | 27 |
| | ***S. rhomboideillanceolatum* Ochoa** | see Junin | 23 |
| | *S. rhomboideillanceolatum* var. *ancophilum* Correll | | |
| | ***S. peloquinianum* Ochoa** | 0 | 22 |
| Apurímac (APU) | ***S. abancayense* Ochoa** | 3 (APU) | 58 |
| | ***S. aymaraesense* Ochoa** | 0 | 63 |
| | ***S. chillonanum* Ochoa** (=*S. tenellum* Ochoa) | 0 | 62 |
| | ***S. longiusculus* Ochoa** | 0 | 64 |
| | ***S. marinasense Vargas*** | 0 | 61 |
| | ***S. velardei* Ochoa** | 0 | 58 |
| Arequipa (ARE) | ***S. medians* Bitter** | See Lima | |
| | *S. medians* var. *majorifrons* Bitter | | 74 |
| | *S. medians* var. *majorifrons* subvar. *protohypoleucum* Bitter | | 74 |
| | ***S. megistacrolobum* f. *purpureum* Ochoa, 1994b** | 0 | 71 |
| | ***S. sandemanii* Hawkes** | 0 | 72 |
| | ***S. weberbaueri* Bitter** | 2 (UNK) | 74 |
| | *S. weberbaueri* var. *poscoanum* Cárd. & Hawkes | | 74 |
| Ayacucho (AYA) | ***S. acaule* var. *incuyo* Ochoa, 1994b** | 0 | 68 |
| | ***S. ayacuchense* Ochoa** | 0 | 52 |
| | ***S. sarasarae* Ochoa** | 0 | 69 |
| Cajamarca (CAJ) | ***S. albicans (*Ochoa*)* Ochoa** | 19 (ANC, APU, CAJ, HUO, LIM, LL, UNK) | Not mapped |
| | ***S. blanco-galdosii* Ochoa** | 4 (ANC, CAJ, UNK) | 12 |
| | ***S. cajamarquense* Ochoa** | 2 (CAJ) | 13 |
| | ***S. chiquidenum* Ochoa** | 5 (CAJ, UNK) | 13 |
| | *S. chiquidenum* var. *porconense* Ochoa | | 12 |
| | ***S. chiquidenum* var. *gracile* Ochoa, 1994b** | 0 | 7 |
| | ***S. chiquidenum* var. *robustum* Ochoa, 1994b** | 0 | 14 |
| | ***S. contumazaense* Ochoa** | 1 (UNK) | 14 |
| | ***S. guzmanguense* Whalen & Sagást.** | 0 | 14 |
| | ***S. mochiquense* Ochoa** | See La Libertad | |
| | *S. earl-smithii* Correll | | 12 |
| | ***S. irosinum* Ochoa** | 2 (CAJ) | 11 |
| | ***S. jaenense* Ochoa** | 0 | 3 |
| | ***S. jalcae* Ochoa** | See La Libertad | |
| | *S. jalcae* var. *pubescens* Correll | | 12 |
| | ***S. lopez-camarenae* Ochoa** | 0 | 7 |
| | ***S. nemorosum* Ochoa** | 0 | 3 |
| | ***S. trinitense* Ochoa** | 0 | 14 |
| Cusco (CUZ) | ***S. acaule* Bitter** | 73 (ANC, APU, ARE, AYA, CUZ, HUO, HUV, JUN, LIM, PAS, PUN, SM, UNK) Germplasm here includes accessions undesignated to subspecies. | Not mapped |
| | *S. acaule* var. *checcae* Hawkes | | |

| | | | |
|---|---|---|---|
| | ***S. brevicaule* Bitter**[1] | 168 (ANC, APU, ARE, AYA, CUZ, HUV, HUO, JUN, LL, LIM, PAS, PUN, UNK) | Not mapped |
| | *S. abbottianum* Juz. | | |
| | *S. amabile* Vargas | | |
| | *S. ambosinum* Ochoa | | |
| | *S. bukasovii* Rybin | | |
| | *S. calcense* Hawkes | | |
| | *S. calcense* var. *urubamba* Vargas | | |
| | *S. canasense* Hawkes | | |
| | *S. canasense* var. *alba* Vargas | | |
| | *S. canasense* var. *calcense* Vargas | | |
| | *S. canasense* var. *intihuatanense* Vargas | | |
| | *S. calcense* Hawkes | | |
| | *S. catathrum* Juz. | | |
| | *S. coelestipetalum* Vargas | | |
| | *S. espinarense* Vargas | | |
| | *S. fragariifructum* Hawkes | | |
| | *S. lechnoviczii* Hawkes | | |
| | *S. lechnoviczii* var. *latifolium* Vargas | | |
| | *S. lechnoviczii* var. *xerophylum* Vargas | | |
| | *S. longimucronatum*Vargas | | |
| | *S. membranaceum* Vargas | | |
| | *S. multidissectum* Hawkes | | |
| | *S. neohawkesii* Ochoa | | |
| | *S. ochoae* Vargas | | |
| | *S. pampasense* Hawkes | | |
| | *S. punoense* Hawkes | | |
| | *S. sicuanum* Hawkes [= *S. pumilum* Hawkes, *not S. pumilum* Juz.] | | |
| | *S. soukupii* Hawkes | | |
| | ***S. buesii* Vargas** | 1 (CUZ) | 54 |
| | ***S. hawkesii* Cárd. & Hawkes** | 0 | 54 |
| | ***S. incasicum* Ochoa** | 0 | 54 |
| | ***S. laxissimum* Bitter** | see Junin | |
| | *S. rockefelleri* Vargas | | 54 |
| | ***S. lignicaule* Vargas** | 4 (CUZ) | 60 |
| | *S. lignicaule* var. *longistylum* Vargas | | 56 |
| | *S. vargasii* Hawkes | | 60 |
| | ***S. marinasense* Vargas** | See Apurímac | |
| | *S. cuzcoense* Ochoa | | 57 |
| | *S. marinasense* var. *dentifolium* Vargas | | 59 |
| | *S. pampasense* f. *glabrescens* Correll | | 55 |
| | ***S. multiflorum* Vargas** | 0 | 57 |
| | ***S. pillahuatense* Vargas** | 0 | 55 |
| | ***S. raphanifolium* Cárd. & Hawkes** | 35 (APU, CUZ, PUN, UNK) | 54 |
| | ***S. santolallae* Vargas** | 2 (CUZ) | 54 |
| | *S. santolallae* var. *acutifolium* Vargas | | 54 |
| | *S. santolallae* f. *velutinum* Correll | | 54 |
| | ***S. sawyeri* Ochoa** | 0 | 54 |
| | ***S tarapatanum* Ochoa** | 0 | 56 |
| | ***S. urubambae* Juz.** | 1 | 54 |
| | ***S. villuspetalum* Vargas** | 0 | 54 |
| Huancavelica (HUV) | ***S. amayanum* Ochoa** | 0 | 48 |
| | ***S. bill-hookeri* Ochoa** | 0 | 48 |
| | ***S. gracilifrons* Bitter** | 0 | 51 |
| Huánuco (HUO) | ***S. ariduphilum* Ochoa** | 0 | 26 |
| | ***S. chomatophilum* f. *sausianense* Ochoa, 1994b** | 0 | 25 |
| | ***S. huanucense* Ochoa** | 0 | 26 |
| | ***S. nubicola* Ochoa** | 0 | 25 |
| | ***S. salasianum* Ochoa** | 0 | 30 |
| | ***S. scabrifolium* Ochoa** | 1(HUO) | 25 |
| | ***S. santolallae* Vargas** | See Cusco | |
| | *S. claviforme* Correll | | 28 |
| Junín (JUN) | ***S. acroglossum* Juz.** | 2 (PAS) | 35 |
| | ***S. antacochense* Ochoa** | 0 | 44 |
| | ***S. laxissimum* Bitter** | 1 (UNK) | 41 |

| | | | |
|---|---|---|---|
| | ***S. neovargasii*** **Ochoa** | 0 | 38 |
| | ***S. rhomboideilanceolatum*** **Ochoa** | 0 | 45 |
| La Libertad (LL) | ***S. chiquidenum*** **Ochoa** | See Cajamarca | 18 |
| | *S. chiquidenum* var. *cachicadense* Ochoa | | |
| | ***S. hastiforme*** **Correll** | 1 (UNK) | 15 |
| | ***S. jalcae*** **Ochoa** | 0 | 17 |
| | ***S. mochiquense*** **Ochoa** | 4 (LL, PIU) | 19 |
| | ***S. multiinterruptum*** **var.** ***machaytambinum*** **Ochoa** | 0 | 17 |
| | ***S. sogarandinum*** **Ochoa** | 2 (ANC, LL) | 18 |
| | ***S. taulisense*** **Ochoa** | 0 | 20 |
| | ***S. yabomambense*** **Ochoa** | 0 | 16 |
| Lambayaque (LAM) | ***S. incahuasinum*** **Ochoa** | 0 | 8 |
| | ***S. olmosense*** **Ochoa** | 0 | 6 |
| Lima (LIM) | ***S. arahuayum*** **Ochoa, 1994a** | 0 | 39 |
| | ***S. cantense*** **Ochoa** | 0 | 39 |
| | ***S. chancayense*** **Ochoa** | 2 (LIM) | 40 |
| | ***S. chrysoflorum*** **Ochoa** | 0 | 39 |
| | ***S. hapalosum*** **Ochoa** | 0 | 49 |
| | ***S. huarochiriense*** **Ochoa** | 0 | 47 |
| | ***S. hypacrarthrum*** **Bitter** | 0 | 46 |
| | *S. tuberosum* var. *puberulum* Hook. f. | | 46 |
| | ***S. immite*** **Dunal** | 4 (ANC, LIM, LL) | 42 |
| | *S. immite* var. *vernale* Correll | | 50 |
| | *S. mathewsii* Bitter | | 46 |
| | *S. tuberosum* var. *multijugum* Hook. f. | | 46 |
| | ***S. chacoense*** **Bitter** | 0 (not mapped) | |
| | *S. limense* Correll | | 46 |
| | ***S. medians*** **Bitter** | 9 (HUO, JUN, LIM, UNK) | 46 |
| | *S. medians* var. *angustifoliolum* Ochoa | | 36 |
| | *S. medians* var. *autumnale* Correll | | 43 |
| | ***S. multiinterruptum*** **Bitter** | 9 (ANC, CUZ, LIM, UNK) | 39 |
| | ***S. neoweberbaueri*** **Wittm.** | 0 | 46 |
| | ***S. simplicissimum*** **Ochoa, 1989** | 0 | 53 |
| | ***S. wittmackii*** **Bitter** | 0 | 46 |
| | *S. tuberosum* var. *macranthum* Hook. f. | | 46 |
| | *S. vavilovii* Juz. & Bukasov | | 46 |
| | *S. wittmackii* var. *glaciviride* Bitter | | 46 |
| Pasco (PAS) | ***S. acaule*** **Bitter subsp.** ***punae*** **(Juz.) Hawkes & Hjert.** | 18 (ANC, APU, AYA, CUZ, HUO, HUV, JUN, PAS, UNK) | Not mapped |
| | ***S. pascoense*** **Ochoa** | 1 (JUN) | 37 |
| Piura (PIU) | ***S. piurae*** **Bitter** | 3 (PIU, UNK) | 2 |
| | *S. chomatophilum* f. *pilosum* Correll | | 2 |
| | ***S. huancabambense*** **Ochoa** | 5 (PIU, UNK) | 2 |
| | ***S. ingaefolium*** **Ochoa** | 0 | 1 |
| | ***S. paucissectum*** **Ochoa** | 3 (PIU) | 2 |
| | ***S. raquialatum*** **Ochoa** | 0 | 4 |
| Puno (PUN) | ***S. limbaniense*** **Ochoa** | 1 (UNK) | 66 |
| | ***S. megistacrolobum*** **subsp.** ***toralapanum*** **R.B. Giannattasio & D.M. Spooner** | 0 | 70 |
| | ***S. saxatilis*** **Ochoa, 1992b** | 0 | 67 |
| | ***S. tapojense*** **Ochoa** | 0 | 73 |
| | ***S. yungasense*** **Hawkes** | 0 | 65 |
| San Martin (SM) | ***S. phureja*** **subsp.** ***hygrothermicum*** **(Ochoa) Hawkes** | 0 | 10 |
| Tacna (TAC) | ***S. acroscopicum*** **Ochoa** | 3 (ARE, TAC) | 76 |
| | ***S. tacnaense*** **Ochoa** | 0 | 75 |
| | ***S. weberbaueri*** **Bitter** | See Arequipa | |
| | *S. weberbaueri* var. *deccurrentialatum* Ochoa | | 76 |

[1]See text for provisional synonymy regarding *S. brevicaule*. In addition to the Peruvian types cited above, our provisional synonymy also includes *S. leptophyes* Bitter and *S. sparsipilum* Bitter, cited by various authors for Peru but with their types in Bolivia.

[2]This list does not include the Peruvian germplasm (or synonyms in Hawkes, 1990) for the cultivated species *S. curtilobum* Juz. & Bukasov (1 accession), *S. phureja* Juz. and Bukasov subsp. *phureja* (3), *S. stenotomum* Juz. & Bukasov subsp. *stenotomum* (8), *S. stenotomum* subsp. *goniocalyx* (Juz. & Bukasov) Hawkes (1), *S. tuberosum* L. subsp. *andigena* Hawkes (229), *S. tuberosum* subsp. *tuberosum* (20); or for unidentified accessions (12). It also does not include *S. aracc-papa* Rybin, shown by Hawkes (1990) to likely represent a mixed collection of *S. raphanifolium* Cárd. & Hawkes x *sparsipilum* (Bitter) Juz. & Bukasov or *S. multidissectum* Hawkes.

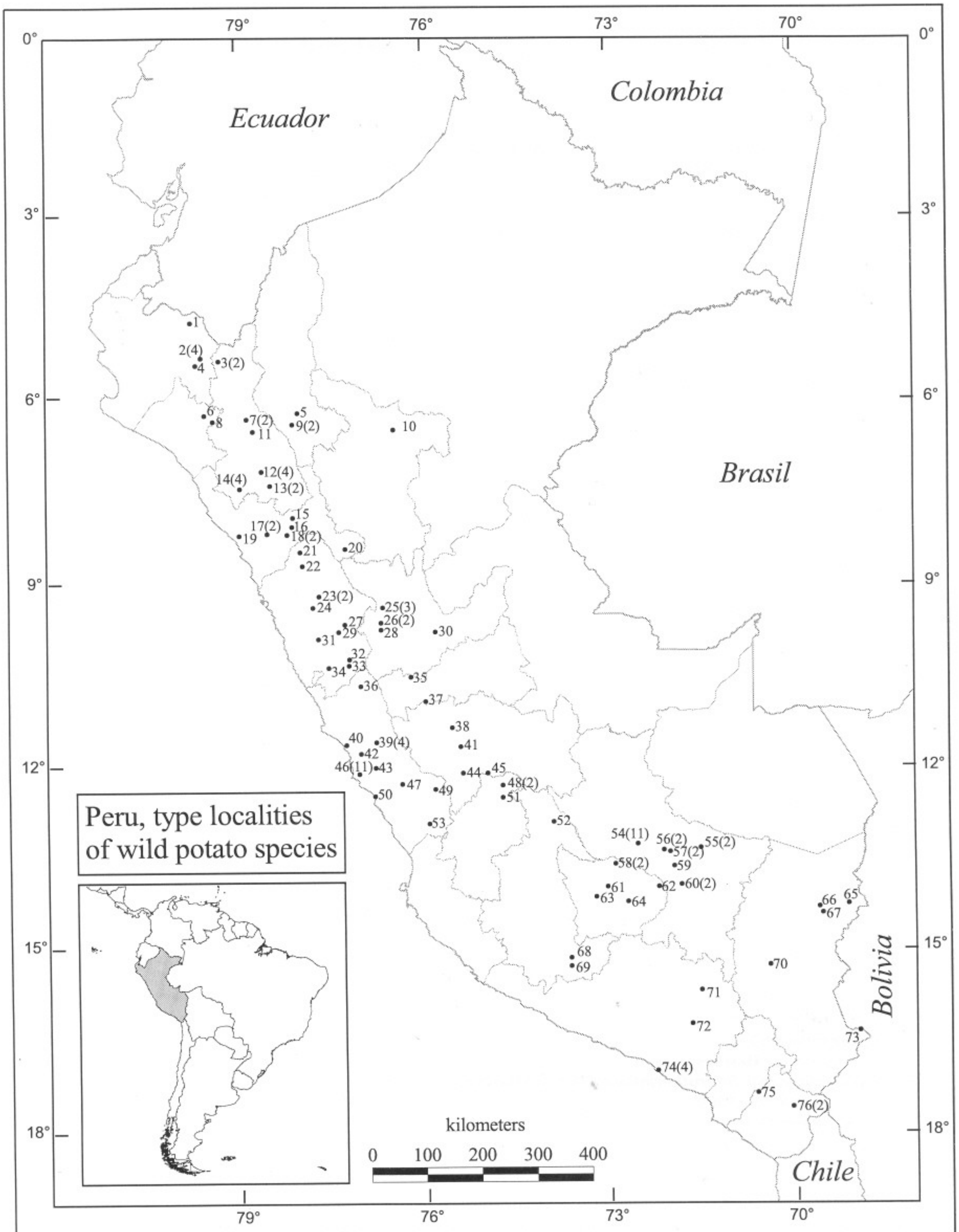


**FIGURE 4.**

**Location of type localities of Peruvian wild potatoes. Numbers correspond to Table 2. Number in parentheses corresponds to the number of type localities at that location. Some locations were generalized when they were too close to each other to map separately.**

(1962) and Ochoa (1962). Correll (1967) provided keys and descriptions. D'Arcy (1993) provided a list of the species. A revision of the Peruvian species is in press by Ochoa. The majority of new species descriptions for Peru since 1962 are from Ochoa (Table 2). According to Hawkes (1990), and adding taxa described since 1989 (Ochoa, 1989, 1992b, 1994a,b) there are 103 taxa of wild potatoes in Peru, using our reduction of species in the *Solanum brevicaule* complex.

Our collections from the 1998 expedition were obtained along the route shown in Fig. 5 and listed in Table 3. Some of the species appeared to us to be phenetically distinct and to be valid species (e.g., *S. acaule, S. aymaraesense, S. buesii,* S. *lignicaule, S. longuisculus, S. pillahuatense, S. velardei, S. yungasense*), while we question the species status of others. Below we provide our field observations on the taxonomy of many of our collections in southern Peru to guide future workers to potential research problems.

### *The Solanum Brevicaule Complex*

The *Solanum brevicaule* complex (Ugent 1970a; Grun, 1990) grows from Peru to Argentina. It is named for the earliest described member of about thirty wild species in ser. *Tuberosa* that look most similar to cultivated potatoes, and are their putative progenitors. The complex has perplexed workers and led to taxonomic treatments that recognized over 30 taxa (e.g., Hawkes, 1990), or combined many of these species into two (Ugent, 1966). Hawkes (1990) recognized the Peruvian species of this complex *Solanum amabile, S. ambosinum, S. bukasovii, S. canasense, S. coelestipetalum, S. leptophyes, S. multidissectum, S. pampasense,* and *S. sparsipilum.* Ochoa (1962, 1990, 1992a) recognized *S. ambosinum, S. brevicaule, S. bukasovii,* S. *coelestipetalum,* S. *leptophyes, S. sparsipilum,* synonymized *S. amabile, S. canasense* and *S. pampasense* with *S. bukasovii,* and reduced *S. multidissectum* to a variety of *S. bukasovii.*

As shown by van den Berg *et al.* (1998) with morphological data, and Miller and Spooner (in press) with single- to low-copy nuclear RFLP and RAPD data, the over 30 taxa of the *Solanum brevicaule* complex can be divided with great difficulty into only three groups, one from Peru and adjacent northwestern Bolivia, one from Bolivia and Argentina, and *S. oplocense* (that grows in Bolivia and Argentina). Our formal taxonomic decisions on the *S. brevicaule* complex awaits our replication of the morphological study of van den Berg *et al.* (1998) in Peru.

Because of these taxonomic ambiguities, we grouped all of these Peruvian species and synonyms of *S. brevicaule* for convenience, without yet implying a formal taxonomy (Table 2). Because they are the more common and weedy members of sect. *Petota* they represent the major holdings of the world's genebanks (Table 2) and therefore were not part of our collecting goals.

### *Cultigens and Relationship to the Wild Species*

The similarity of the *S. brevicaule* complex to the cultivated species often makes the distinction between wild and cultivated potatoes vague. This is especially true in Peru and Bolivia where the cultivated species are hypothesized to be either recent derivatives or products of ongoing hybridization with members of the *S. brevicaule* complex (Grun, 1990; Hawkes, 1990).

We encountered two Quechua (a Peruvian indigenous people) terms for potatoes that illustrate very well the difficulty of distinguishing wild from cultivated species. Apparent cultivars with large tubers that are weedy and persistent in cultivated fields and are referred to by the name "arakka". Arakka potatoes are common throughout much of Bolivia and Peru. This is contrasted with "siwa" or "sihua" potatoes, Quechua names of apparent cultigens that have escaped and persist naturally outside cultivated fields. Yet a third Quechua name is "kita papa" for wild potatoes, not cultigens. Often, the only feature useful to distinguish cultivated from wild potatoes are large tubers, short stolons, and the fact that they are cultivated.

Tuber sizes vary greatly among both wild and cultivated species, however, and some putatively "wild" species have tubers matching or exceeding some cultivated ones (e.g., the Ecuadorian species *S. burtonii* Ochoa or the Bolivian species *S. candolleanum* P. Berthault). Further complicating the distinction between cultivated and wild species is the great variability among the cultivated species mirroring that of similar (or indistinguishable) putative progenitors in the *S. brevicaule* complex. Van den Berg *et al.* (1998) documented that vegetative morphology, exclusive of tuber morphology, was unable to distinguish the cultivated species *S. tuberosum* and *S. stenotomum* from many members of the *S. brevicaule* complex. These results were concordant with molecular data of the same accessions (Miller and Spooner, in press).

The lack of agreement among taxonomists in the *S. brevicaule* complex is mirrored in lack of agreement regarding treatment of the cultivated species. At one end of the extreme, Dodds (1962) recognized only three cultivated species, with five informal "groups" within one of them, *S.*

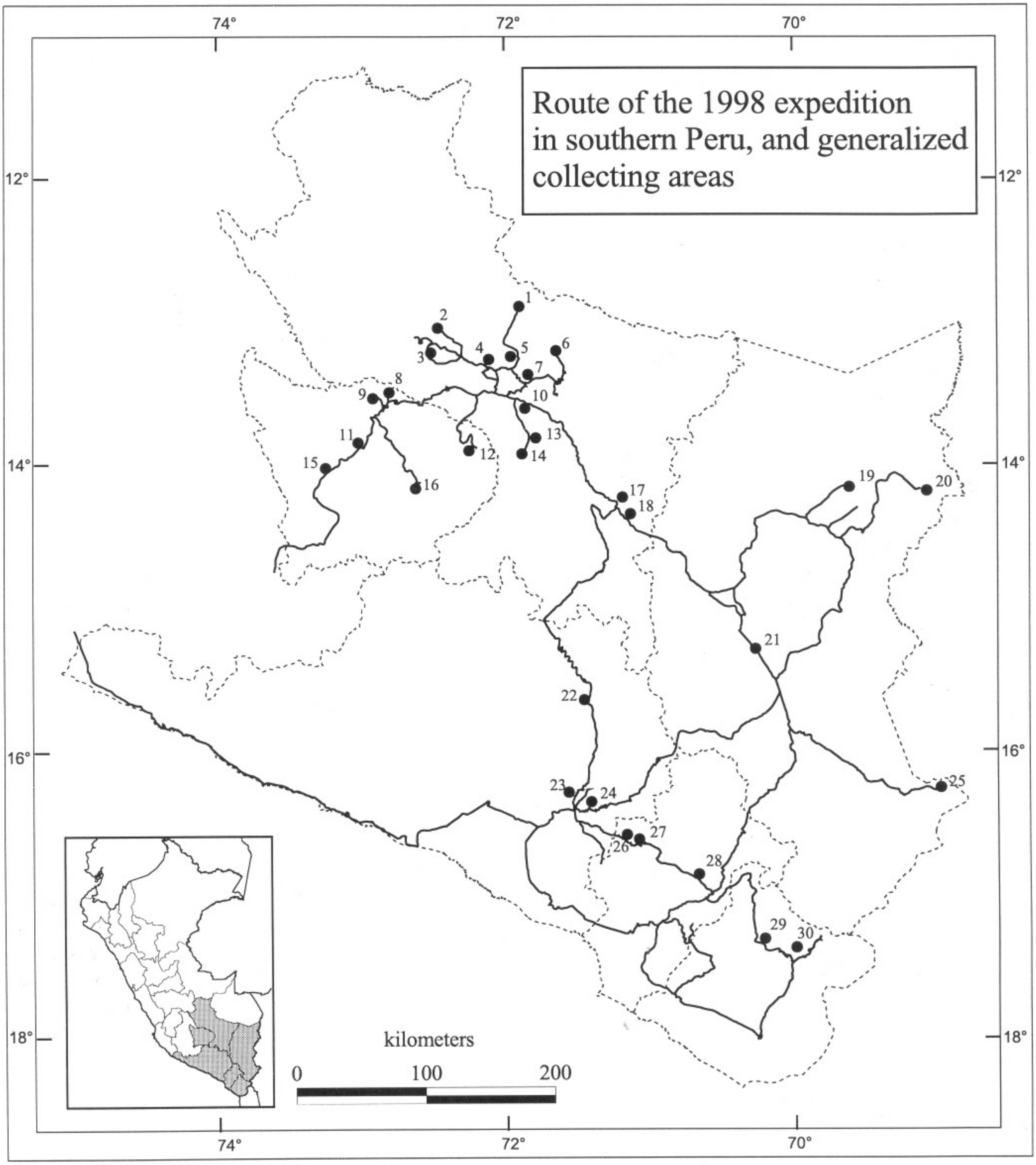


**FIGURE 5.**
**Route of the 1998 expedition in southern Peru, and generalized collecting areas corresponding to Table 3.**

TABLE 3.—*Summary of wild potato* (Solanum *sect.* Petota) *and outgroup species* S. suaveolens (Solanum *sect.* Basarthrum *[Bitter] Bitter) and* S. lycopersicoides (Solanum *sect.* Lycopersicum *[Mill.] Wettst.) germplasm collections made on the 1998 potato collecting expedition to Peru, and generalized map localities as illustrated on Fig. 5.*

| Coll. no. | Map locality (Fig. 5) | Species | Germplasm: No. fruits mature/ possibly immature | No. tubers new/no. mother tubers | No. stem cuttings for later planting | No. young plants placed in pots in field |
|---|---|---|---|---|---|---|
| *7201* | 25 | *Solanum tuberosum* | 0 | 20 | 0 | 0 |
| *7202* | 25 | *S. acaule* | 2/2 | 0 | 0 | 1 |
| *7203* | 20 | *S. suaveolens* | 9 | 0 | 0 | 0 |
| *7204* | 20 | *S. yungasense* | 0 | 35/0 | 10 | 3 |
| *7205* | 19 | *S. limbaniense* | 2/2 | 0 | 14 | 0 |
| *7206* | 21 | *S. megistacrolobum subsp. toralapanum* | 15 | 0 | 0 | 0 |
| *7207* | 18 | *S. raphanifolium* | 25 | 0 | 0 | 0 |
| *7208* | 17 | *S. raphanifolium* | 0 | 6/0 | 5 | 3 |
| *7209* | 10 | *S. marinasense* | 15/15 | 0 | 0 | 0 |
| *7210* | 10 | *S. raphanifolium* | 0 | 0 | 0 | 0 |
| *7211* | 7 | *S. lignicaule* | 1/9 | 0/3 | 10 | 0 |
| *7212* | 7 | *S. brevicaule* | 6/10 | 0 | 0 | 0 |
| *7213* | 4 | *S. brevicaule* | 0 | 10 | 0 | 1 |
| *7214* | 4 | *S. tarapatanum* | 0 | 4 | 0 | 2 |
| *7215* | 4 | *S. lignicaule* | 0 | 6/6 | 0 | 1 |
| *7216* | 4 | *S. tarapatanum* | 0 | 4 | 10 | 0 |
| *7217* | 3 | *S. urubambae* | 0 | 0 | 20 | 0 |
| *7218* | 3 | *S. laxissimum* | 0 | 0 | 20 | 0 |
| *7219* | 5 | *S. brevicaule* | 1/5 | 0 | 0 | 1 |
| *7220* | 6 | *S. pillahuatense* | 0 | 4 | 15 | 5 |
| *7221* | 13 | *S. brevicaule* | 3 | 0 | 0 | 0 |
| *7222* | 13 | *S. lignicaule* | 6 | 2 | 0 | 0 |
| *7223* | 13 | *S. tuberosum* subsp. *andigena* | 6 | 16 | 0 | 0 |
| *7224* | 13 | *S. lignicuale* | 0 | 4 | 20 | 0 |
| *7225* | 1 | *S. multiflorum* | 0/3 | 0 | 20 | 0 |
| *7226* | 1 | *S. multiflorum* | 0 | 0 | 5 | 0 |
| *7227* | 3 | *S. santolallae* | 6 | 0 | 0 | 0 |
| *7228* | 3 | *S. santolallae* | 15 | 0 | 0 | 0 |
| *7229* | 3 | *S. buesii* | 13/5 | 0 | 0 | 0 |
| *7230* | 3 | *S. buesii* | 3 | 0 | 5 | 0 |
| *7231* | 3 | *S. villuspetalum* | 0 | 0 | 5 | 0 |
| *7232* | 3 | *S. buesii* | 5 | 0 | 0 | 0 |
| *7233* | 3 | *S. buesii* | 7/6 | 0 | 0 | 0 |
| *7234* | 3 | *S. raphanifolium (S. incasicum)* | 30 | 0 | 0 | 0 |
| *7235* | 3 | *S. buesii* | 65 | 0 | 0 | 0 |
| *7236* | 2 | *S. sawyeri* | 0 | 40 | 0 | 0 |
| *7237* | 2 | *S. santolallae* | 0 | 20 | 0 | 0 |
| *7238* | 2 | *S. sawyeri* | 0 | 8 | 3 | 0 |
| *7239* | 12 | *S. chillonanum* | 15 | 0 | 0 | 0 |
| *7240* | 8 | *S. velardei* | 2 | 0 | 10 | 0 |
| *7241* | 9 | *S. abancayense* | 0 | 0 | 6 | 0 |
| *7242* | 11 | *S. marinasense* | 0 | 20 | 0 | 0 |
| *7243* | 30 | *S. acroscopicium* | 14/16 | 0 | 0 | 0 |
| *7244* | 29 | *S. lycopersicoides* | 100 | 0 | 0 | 0 |
| *7245* | 28 | *S. acaule* | 15/20 | 0 | 0 | 0 |
| *7246* | 28 | *S. tacnaense* | 0/6 | 0 | 10 | 0 |
| *7247* | 28 | *S.* sp. | 12/10 | 0 | 0 | 0 |
| *7248* | 27 | *S.* sp. | 45/99 | 15 | 0 | 0 |
| *7249* | 26 | *S.* sp.` | 10/35 | 1 | 0 | 0 |
| *7250* | 24 | *S. sandemanii* | 40 | 30 | 0 | 0 |
| *7251* | 24 | *S. sandemanii* | 0 | 30 | 0 | 0 |
| *7252* | 23 | *S. sandemanii* | 45/50 | 88 | 0 | 0 |
| *7253* | 22 | *S. acaule* | 152 | 0 | 0 | 0 |
| *7254* | 22 | *S. megistacrolobum* subsp. *megistacrolobum* f. *purpureum* | 2 | 30 | 5 | 0 |
| *7255* | 16 | *S. longiusculus* | 2 | 0 | 5 | 0 |
| *7256* | 16 | *S.* sp. | 2 | 10 | 0 | 0 |
| *7257* | 15 | *S. aymaraesense* | 4 | 1 | 0 | 0 |

*tuberosum*. At the other end, Ochoa (1990) formally recognized seven cultivated species and 141 infraspecific taxa (subspecies, varieties and forms, including his unlisted autonyms) for Bolivia alone. Hawkes (1990) recognized seven cultivated species and seven infraspecific taxa (including his unlisted autonyms) for all of sect. *Petota*.

This shows a persistent problem in identifying cultigens. For example, Ochoa (1992a) identified the Venezuelan "wild" species *S. paramonese* Bitter to be *S. tuberosum* subsp. *andigena* Hawkes. Likewise, Hawkes (1990) recognized the Colombian "wild" species *S. estradae* L. López as a variety of the cultivated species *S. phureja*, and the Peruvian "wild" species *S. apurimacense* as a synonym of *S. tuberosum* subsp. *andigena*. Likewise, our field work showed the southern Peruvian "wild" species *S. acroscopicum* (*7243*) and *S. sawyeri* (*7236*, *7238*) to be vegetatively similar to many cultigens. The former grows in weedy situations near cultivated fields, while the latter grows among coffee and fruit plantations. If they were collected in cultivated fields they possibly would be identified as one of the cultivated species.

These taxonomic problems provided difficulties in the identification of many of our collections. We identified our collections as *S. acroscopicum* (*7243*) and *S. sawyeri* (*7236*, *7238*) because they were found at the type localities or where they were listed by Correll (1962). We identified our collections *7212*, *7213*, *7219*, *7221* as *S. brevicaule* because they were generally smaller plants usually found away from cultivated fields. We identified our collections *7201* and *7223* as *S. tuberosum* because they were found in cultivated fields and had colored tubers similar to some cultivated species. Our collections *7247*, *7248*, *7249* were robust plants collected at the margins of cultivated fields; we do not know if they are cultivated or wild, and we did not identify them to species. Many populations are ambiguously identified as members of the *S. brevicaule* complex or cultivated species and were commonly encountered on our expedition. They illustrate the difficulty of distinguishing wild from cultivated species.

The lack of clear distinctions among wild and cultivated species, and possible ongoing hybridization between them (Ugent, 1970a; Johns *et al.*, 1987; Grun, 1990; Hawkes, 1990) makes the search for a species-specific progenitor of cultivated potatoes likely an impossible task (Miller and Spooner, 1998; Van den Berg *et al.*, 1998). Additionally, it makes the direction of derivation difficult or impossible to discover, as some "wild" species "progenitors" may equally likely be recent escapes from cultivation. We suggest that current taxonomies in sect. *Petota* recognize too many species, and that future interpretations will recognize far fewer species than the 232 recognized by Hawkes (1990).

## *Solanum ser. Conicibaccata*

*Solanum* series *Conicibaccata* Bitter contains 40 of the 225 tuber-bearing species recognized by Hawkes (1990), and is the second largest series in sect. *Petota* in Peru after series *Tuberosa*. Species are distinguished largely by conical fruits, although conical fruits also are present in species in series *Circaeifolia* Hawkes, *Demissa* Bukasov, and *Pinnatisecta* (Rydb.) Hawkes. Members of series *Conicibaccata* are distributed from southern Mexico to northern Bolivia, and include diploids, tetraploids, and hexaploids. Peru contains one-half of these species, with those nine in brackets from our collection area in southern Peru (*S. ayacuchense*, [*S. buesii*], *S. burkartii*, *S. chomatophilum*, *S. contumazaense*, *S. irosinum*, *S. jaenense*, [*S. laxissimum*], [*S. limbaniense*], [*S. multiflorum*], *S. nemorosum*, *S. neovargasii*, *S. nubicola*, [*S. pillahuatense*], *S. salasianum*, [*S. santolallae*], *S. trinitense*, [*S. urubambae*], [*S. villuspetalum*], [*S. violaceimarmoratum*]). All Peruvian species with known chromosome numbers are diploid except *S. nemorosum* (hexaploid), and *S. nubicola* (tetraploid).

Morphological and chloroplast DNA (cpDNA) studies of Castillo and Spooner (1997) showed: 1) there likely are many fewer than 40 species in the group, 2) the tetraploids and hexaploids form a distinct clade by cpDNA data and a distinct phenetic group by morphological data from the diploids, 3) some species (*S. chomatophilum*, *S. contumazaense*, *S. irosinum*) are likely members of series *Piruana*, not ser. *Conicibaccata*. However, this study was hindered by big gaps of germplasm representation from Peru, with the Peruvian species *S. ayacuchense*, *S. burkartii*, *S. jaenense*, *S. multiflorum*, S. *nemorosum*, *S. neovargasii*, *S. nubicola*, *S. salasianum*, *S. trinitense*, and *S. villuspetalum* unavailable as germplasm.

We collected germplasm at the type localities of *S. buesii*, *S. limbaniense*, *S. multiflorum*, *S. pillahuatense*, *S. urubambae*, and *S. villuspetalum*, and collected plants that could be identified as *S. santolallae* or *S. violaceimarmoratum* (Table 3). *Solanum buesii* and *S. pillahuatense* are distinct from the others. All the remaining species, however, are difficult to distinguish one from the other (Correll, 1962). Most similar, and possibly conspecific, are *S. laxissimum* and *S. santolallae*; separately *S. multiflorum*, *S. urubambae*, and *S. villuspetalum*.

## *Solanum Series Megistacroloba*

*Solanum hawkesii* and *S. raphanifolium* were placed in series *Megistacroloba* Cárd. and Hawkes by Correll (1962) and Hawkes (1990), and *S. raphanifolium* in series *Megistacroloba* by Ochoa (1962). *Solanum incasicum* was not described until 1981, and was placed by both Ochoa (1981) and Hawkes (1990) in ser. *Tuberosa*. Our collections at the type locality of *S. incasicum* (*7235*) lead us to suspect it is a synonym of *S. raphanifolium*. It is an abundant species there. It matches the habitat of *S. raphanifolium* (growing in high-elevation grasslands and among shrubs), leaf morphology (many, but not all of the lateral leaflets are highly decurrent), corolla morphology and color (pentagonal, purple), and fruit morphology (spherical to oval). Similarly, collection *7235* is especially similar to the published description and photo of *S. incasicum* by the dense pilose leaves with sinuate-crenate margins, large purple corollas, and spherical fruits. The lateral leaflets of *7235* (four sheets collected) vary in shape from ovate to elliptic-lanceolate, with the latter fitting the description of *S. incasicum*. Ochoa (1962) recognized the great variability of *S. raphanifolium* and used eight photographs to illustrate it. We think *S. incasicum* is yet another variation of *S. raphanifolium*. Our final determination of synonymy will depend on inspecting the type of *S. incasicum*, that unfortunately has not been placed in a public institution and is not yet available publicly. However one of our four collections (at PTIS) is a close match of a photo of the type (Ochoa, 1981) leading us to suspect that this synonymy is inevitable.

Similarly, in agreement with Ochoa (1992a), we believe *S. hawkesii* to be a synonym of *S. raphanifolium*. Its type matches variability in *S. raphanifolium* (compare the type of *S. hawkesii*, Fig. 118 of Correll [1962] to Fig. 38 of Ochoa [1962]). We searched unsuccessfully for *S. hawkesii* at its type locality in Cusco Department, below Machu Pichu, at 2000 m (area 54, Fig. 5). The type was collected much lower than is typical for this species (2800-3800 m; Correll, 1962; Ochoa 1962; Hawkes, 1990). It is possible that the type specimen has a labeling error.

We collected the first available germplasm collection of *S. megistacrolobum* subsp. *megistacrolobum* f. *purpureum* (*7254*) and the first available germplasm collection of *S. megistacrolobum* subsp. *toralapanum* (*7206*) from Peru. The latter is here documented for the first time in Peru. The identity of *S. megistacrolobum* in Peru has been confused in the literature. It was first reported to occur in Peru by Correll (1962), but as shown by Ochoa (1962) these likely were misidentifications of *S. megistacrolobum*-like morphotypes of *S. raphanifolium*. It was later reported for southern Peru by Ugent (1970b), in the Department of Cusco, that similarly were likely misidentifications of *S. raphanifolium*. The only other report of *S. megistacrolobum* from Peru was by Ochoa (1994b) who described the new taxon *S. megistacrolobum* f. *purpureum* from the adjacent department of Arequipa. Ugent (1970b) proposed Peruvian populations of "*S. megistacrolobum*" (likely *S. raphanifolium*) to hybridize with *S. canasense* to form *S. x raphanifolium*. This hybridization hypothesis was discounted by Spooner *et al.* (1991) with chloroplast and nuclear ribosomal DNA restriction site data and Giannattasio and Spooner (1994) with single- to low-copy nuclear DNA restriction site data. However, both of these later two studies used *S. megistacrolobum* from adjacent Bolivia because germplasm of *S. megistacrolobum* was not available from Peru.

### *Solanum Yungasense*

Hawkes (1954) first reported the chromosome number of *S. yungasense* as ($2n = 24$). This species was first reported for Peru by Ochoa (1984) who reported a triploid chromosome number of the species of $2n = 36$. Ochoa (1990) later reported chromosome numbers of *S. yungasense* as $2n = 24, 36$. He cited no vouchers and it is unknown if these are from Bolivia or Peru. The only other reports of *S. yungasense* were from adjacent Bolivia in the Province of La Paz (Hawkes, 1954; Hawkes and Hjerting, 1989; Ochoa, 1990; Spooner *et al.*, 1994). The first available germplasm collections of *S. yungasense* were made by Spooner *et al.* in La Paz Province in Bolivia in 1993 and 1994 (Spooner *et al.*, 1994). They reported variation in ploidy from $2n = 24$ (from plants with tubers with tan-colored skin) and $2n = 36$ (from plants with purple skin). Our first available Peruvian germplasm collections of this species (*7204*, with tan skin) will allow similar comparisons of tuber color and ploidy.

### *Plans for Future Collecting*

The many uncollected or under collected wild potatoes from Peru are distributed throughout much of the Andes mountains (Table 2, Fig. 4). Our collecting goals in southern Peru were largely met on the 1998 expedition. *Solanum saxatilis* occurs in one location in the department of Puno. We searched for this species at its exact location (originally collected by Salas) at the beginning and at the end of the expedition but it did not grow there. We similarly could not locate *S. tapojense* at its type locality in Puno Department. We were not able to collect all documented populations of *S. tacnaense* because of a drought in the department of Tacna. These will be sought again on later expeditions. Our next plans are to collect in the species-rich departments of Ancash, Huancavelica, La Libertad, and Lima.

## ACKNOWLEDGMENTS

We thank Ned Garvey and Karen Williams of the USDA, Agricultural Research Service, National Germplasm Resources Laboratory, Henry Shands, USDA, Agricultural Research Service, Deputy Administrator for Germplasm, and CIP, for collecting funds; and Stephen Eberhardt of the USDA, Agricultural Research Service, National Seed Storage Laboratory, for funds to increase germplasm at CIP for the germplasm collected as vegetative material.

We thank Manuel Arca Bielick and Mario Rodríguez of INIA for obtaining the permission to collect in Peru; Wanda Collins, Fernando Ezeta, Hubert Zandstra (CIP), Richard Lower (NRSP-6 Administrative Advisor), and Henry Shands for advice on drafting the collecting proposal; Jorge de la Cruz (CIP) for assistance in map production; Alan Stoner of the USDA, Agricultural Research Service, National Germplasm Resources Laboratory for importing herbarium and germplasm collections into the United States; John Bamberg, USDA, Agricultural Research Service, NRSP-6, for increasing germplasm after passage through United States quarantine; and Celeste Raker, Roel Hoekstra, K. Schüler, and Ronald van den Berg for comments on an earlier draft of this paper.

### *Postscript:*

CIP recently obtained taxonomic identifications for some of their accessions that previously were listed as undetermined. Two of these species are *S. urubambae* and *S. velardei*. All other accessions we list as new germplasm collections were here collected as germplasm for the first time.

## LITERATURE CITED

Bamberg, J.B., M.W. Martin, J.J. Schartner, and D.M. Spooner. 1996. Catalog of potato germplasm - 1996. Potato Introduction Station, NRSP-6. Sturgeon Bay, Wisconsin.

Bamberg, J.B. and D.M. Spooner. 1994. The United States Potato Introduction Station Herbarium. Taxon 43:489-496.

Brummitt, R.K. and C.E. Powell. 1992. Authors of plant names. Royal Botanic Gardens, Kew, England.

Brush, S.B. 1982. The natural and human environment of the Central Andes. Mountain Res Develop 2:19-38.

Castillo, R.O. and D.M. Spooner. 1997. Phylogenetic relationships of wild potatoes, *Solanum* series *Conicibaccata* (sect. *Petota*). Syst Bot 22:45-83.

Child, A. 1990. A synopsis of *Solanum* subgenus *Potatoe* (G. Don) (D'Arcy) (*Tuberarium* (Dun.) Bitter (s.l.)). Feddes Repert Spec Nov Regni Veg 101:209-235.

Correll, D.S. 1962. The potato and its wild relatives. Contrib Texas Res Found, Bot Stud 4:1-606.

Correll, D.S. 1967. Flora of Peru: Solanaceae, section *Neolycopersicon* and section *Tuberarium*. Field Mus Nat Hist, Publ Bot Ser 13:271-458.

Dodds, K.S. 1962. Classification of cultivated potatoes. *In*: Correll, D.S., The potato and its wild relatives. Contrib Texas Res Found, Bot Stud 4:517-539.

D'Arcy, W.G. 1993. Solanaceae. *In*: Brako, L. and J.L. Zarucchi (eds.). Catalogue of the flowering plants and gymnosperms of Peru. Monogr Syst Bot Missouri Bot Gard 45:1098-1137.

Frère, M., J.Q. Rijks, and J. Rea. 1975. Estudio agroclimatológico de la zona Andina. FAO, Rome, 375 p.

Giannattasio, R.B. and D.M. Spooner. 1994. A reexamination of species boundaries and hypotheses of hybridization concerning *Solanum megistacrolobum* and *S. toralapanum* (*Solanum* sect. *Petota*, series *Megistacroloba*): molecular data. Syst Bot 19:106-115.

Grun, P. 1990. The evolution of cultivated potatoes. *In*: Bretting, P.K. (ed.). New perspectives on the origin and evolution of New World domesticated plants. Econ Bot (3 suppl) 44:39-55.

Harlan, J.R. and J.M.J. de Wet. 1971. Toward a rational classification of cultivated plants. Taxon 20:509-517.

Hawkes, J.G. 1954. New *Solanum* species in sub-section *Hyperbasarthrum* Bitt. Ann Mag Nat Hist ser 12, 7:689-710.

Hawkes, J.G. 1990. The potato: evolution, biodiversity and genetic resources. Belhaven Press, Oxford.

Hawkes, J.G. 1997. A database for wild and cultivated potatoes. Euphytica 93:155-161.

Hawkes, J.G. and J.P. Hjerting. 1989. The potatoes of Bolivia: their breeding value and evolutionary relationships. Oxford Univ Press, Oxford.

Holmgren, P.K., N.H. Holmgren, and L.C. Barnett. 1990. Index herbariorum, part I: the herbaria of the world. Ed. 8. New York Botanical Garden, Bronx, New York.

Huamán, Z. 1998. Collection, maintenance and evaluation of potato genetic resources. Plant Var Seeds 11:29-38.

Huamán, Z., R. Hoekstra, and J.B. Bamberg. 1996. The Intergenebank Potato Database. *In*: Abstracts of Conference Papers, Posters and Demonstrations of the 13th Triennial Conference of the EAPR. Veldhoven, The Netherlands, 14-19 July 1996.

Hueck, K. 1972. Mapa de la vegetacion de America del Sur. Gustav Fischer Verlag, Stuttgart.

Instituto Geográfico Nacional. 1989. Atlas del Perú. Instituto Geográfico Nacional, Lima.

Johns, T., Z. Huamán, C.M. Ochoa, and P.E. Schmiediche. 1987. Relationships among wild, weed, and cultivated potatoes in the *Solanum* x *ajanhuiri* complex. Syst Bot 12:541-522.

Miller, J.T. and D.M. Spooner. In press. Collapse of species boundaries in the wild potato *Solanum brevicaule* complex (Solanaceae, *S.* sect. *Petota*): molecular data. Plant Syst Evol.

National Imagery and Mapping Agency. 1995. Database of foreign geographic feature names. Internet: http://164.214.2.59/gns/html/index.html.

Ochoa, C.M. 1962. Los *Solanum* tuberíferos silvestres del Perú (Secc. *Tuberarium*, Sub-secc. *Hyperbasarthrum*). Privately Published, Lima, Peru.

Ochoa, C.M. 1981. Two new tuber-bearing *Solanum* from South America. Phytologia 48:229-232.

Ochoa, C.M. 1984. Karyotaxonomic studies on wild Bolivian tuber-bearing *Solanum*, sect. *Petota*. I. Phytologia 55:17-40.

Ochoa, C.M. 1989. *Solanum* ser. *Simplicissima*, nueva serie *Tuberifera* de la sect. *Petota* (Solanaceae). Rev Acad Colomb Ci Exact 17:321-323.

Ochoa, C.M. 1990. The potatoes of South America: Bolivia. Cambridge Univ Press, Cambridge.

Ochoa, C.M. 1992a. New synonyms in the tuber-bearing *Solanum*. Phytologia 73:166-168.

Ochoa, C.M. 1992b. *Solanum saxatilis*, a new wild potato species from Peru. Phytologia 73:378-380.

Ochoa, C.M. 1994a. *Solanum arahuayum* (sect. *Petota*), nova specie Peruana. Phytologia 77:96-98.

Ochoa, C.M. 1994b. New taxa in section *Petota* of *Solanum*. Phytologia 77:390-392.

Pulgar Vidal, J. 1996. Geografía del Perú. Las ocho regiones naturales. 10th edition. PEISA, Lima.

Spooner, D.M., G.J. Anderson, and R.K. Jansen. 1993. Chloroplast DNA evidence for the interrelationships of tomatoes, potatoes, and pepinos (Solanaceae). Amer J Bot 80:676-688.

Spooner, D.M., K.J. Sytsma, and J.F. Smith. 1991. A molecular reexamination of diploid hybrid speciation of *Solanum raphanifolium*. Evolution 45:757-764.

Spooner, D.M. and R.G. van den Berg. 1992. An analysis of recent taxonomic concepts in wild potatoes (*Solanum* sect. *Petota*). Genet Res Crop Evol 39:23-37.

Spooner, D.M., R.G. van den Berg, W. García, and M.L. Ugarte. 1994. Bolivia potato germplasm collecting expeditions 1993, 1994: taxonomy and new germplasm resources. Euphytica 79:137-148.

Tosi Jr., J.A. 1960. Zonas de vida natural en el Perú: Memoria explicativa sobre el mapa ecológico del Perú. Boletin Técnico 5. IICA, Lima. 271 p.

Troll, C. 1968. The cordilleras of the tropical Americas. Aspects of climatic, phytogeographical and agrarian ecology. *In*: Troll, C. (ed.) Geo-ecology of the mountainous regions of the tropical Americas. Ferd Dummlers Verlag, Bonn. p.15-56.

Ugent, D. 1966. Hybrid weed complexes in *Solanum*, section *Tuberarium*. Ph.D. Diss, Univ Wisconsin, Madison. Madison, WI.

Ugent, D. 1970a. The potato, what is the origin of this important crop plant, and how did it first become domesticated? Science 170:1161-1166.

Ugent, D. 1970b. *Solanum raphanifolium*, a Peruvian wild potato species of hybrid origin. Bot Gaz (Crawfordsville) 131:225-233.

Van den Berg, R.G., J.T. Miller, M.L. Ugarte, J.P. Kardolus, J. Villand, and D.M. Spooner. 1998. Collapse of morphological species in the wild potato *Solanum brevicaule* complex (Solanaceae: sect. *Petota*). Am J Bot 85:92-109.