Solanum sect. Petota in Guatemala; Taxonomy and Genetic Resources

David M. Spooner¹, Roel Hoekstra², Ronald G. Van den Berg³, and Vincente Martínez⁴

¹USDA-ARS, Department of Horticulture, University of Wisconsin, 1575 Linden Drive, Madison, WI, 53706-1500, USA.
Tel: 608-262-0150; FAX: 608-262-4743; email: dspoone@facstaff.wisc.edu.
²Centre for Plant Breeding and Reproduction Research (CPRO-DLO/CGN), Centre for Genetic Resources The Netherlands (CGN), Drouwendaalsesteeg 1, P.O. Box 16, 6700 AA Wageningen, The Netherlands.
³Department of Plant Taxonomy, Wageningen Agricultural University, Generaal Postkwesweg 37, P.O. Box 8010, 6700 ED Wageningen, The Netherlands.
²Instituto de Ciencia y Tecnología Agrícolas (ICTA), km 21.6 Carretera hacia Amanatitlán, Bárbenas, Villa Nueva, Guatemala.
Current position: Facultad de Agronomía, Universidad de San Carlos, Zona 12, Guatemala City, Guatemala.

ABSTRACT

There are five wild potato species in Guatemala: Solanum agramonifolium, S. bulbocastanum, S. clarum, S. demissum, and S. morelliforme. We conducted a collecting expedition there from September 11 to November 5, 1995. The goals of the expedition were to gather field data for taxonomic studies of the five species of Guatemalan wild potatoes and to collect potato germplasm. Our 48 true seed collections nearly quadrupled the available wild potato germplasm for Guatemala, provide germplasm from most previously known localities, and add new ones. We provide a systematic treatment of Guatemalan wild potatoes, geographic and logistical data for collecting wild potatoes in Guatemala, statistics on human population growth and deforestation to help explain decline of wild potato populations, recommend areas for future collecting, and suggest two areas as in-situ reserves for wild potatoes.

INTRODUCTION

Solanum L. sect. Peitota Dumort., the potato and its relatives, occurs from the southwestern United States to southern Chile. It consists of seven cultivated and 225 wild species, according to the latest comprehensive taxonomic treatment of Hawkes (1990). However, nine of these species are alternatively treated in sect. Etuberosum (Bak. and Kameraz) A. Child, sect. Lycopersicum (Mill.) Wettst., and sect. Juglandifolium (Ryd.) A. Child (Spooner et al., 1993).

Most wild potato species are distributed in the Andes, but about 30 grow in Mexico and Central America, with five in Guatemala: Solanum agramonifolium Rydb., S. bulbocastanum Dunal, S. clarum Correll, S. demissum Lindl., and S. morelliforme.
morelliforme" Bitter and G. Muench (Correll, 1952, 1962; Gentry and Standley, 1974; Hawkes, 1990). These five species also grow in Mexico and reach their southern-most distribution in Guatemala, except for "S. agrimoniifolium" and "S. morelliforme," that also grow in adjacent Honduras (both in Morazán Department). The Mexican distributions of these species are: "S. agrimoniifolium," southern Mexico (States of Oaxaca and Chiapas); "S. bulbocastanum," central to southern Mexico; "S. clarum," southern Mexico (Chiapas); "S. demissum," northern to southern Mexico; "S. morelliforme," central to southern Mexico (Correll, 1952, 1962; Hawkes, 1966, 1990; Spooner et al., 1991).

Central America represented a relatively under-collected region for potato germplasm, and Guatemala became a collecting priority for the Instituto de Ciencia y Tecnología Agrícolas, Guatemala (ICTA); the Centre for Genetic Resources The Netherlands (CGN); and the National Research Support Program-6, United States (NRSP-6, the United States potato genebank), that formed a joint collecting expedition to Guatemala. The goals of the expedition were to collect wild species germplasm (the cultivated species are well represented at the International Potato Center [CIP, Peru] and other national genebanks), to increase them quickly and make them freely available internationally, and to gather field data for continuing taxonomic studies.

MATERIALS AND METHODS

We collected throughout Guatemala from September 11 to November 5, 1995. Our locality data came from: 1) database files backing up germplasm records from CGN (Hoekstra and Seidewitz, 1987) and NRSP-6 (Bamberg et al., 1996); 2) literature records from Correll (1962), who obtained these from herbarium material in F, G, GH, K, LL, MICH, MSC, NY, S, US, 2; 3) a database of herbarium records announced for distribution in Hawkes (1997); 4) our own inspection of herbarium specimens from AGUAT, BIGUA, BM, C, ENCB, F, GH, K, LL, MEXU, MICH, MO, MSC, NA, NY, PTIS, TEX, US, USCG, UVAL, WAG, WIS (herbarium codes follow Holm- gren et al., 1990).

Geographic references were found with the aid of 1) Gall (1978, 1981, 1983a,b), 2) United States Department of the Interior (1984), 3) the 1:50,000-scale topographic maps (259 sheets), and the 1:250,000-scale topographic maps (13 sheets) from the Instituto Geográfico Militar, 4) the 1:100,000-scale Mapa Vial Turístico, 1980 road map from the Instituto Geográfico Militar. These geographic resources, and comparable resources from recent expeditions to Mexico, Costa Rica, Venezuela, Colome- bia, Ecuador, Bolivia, Argentina, and Chile, are a growing and valuable component to the Potato Introduction Station Herbarium (PTIS) library (Bamberg and Spooner, 1994).

We concentrated collecting on those areas under-represented by germplasm accessions. Local residents aided in our collections of wild potatoes, that are known locally as papa ardilla (squirrel potato), papa del monte (mountain potato), papa silvestre (wild potato), and papa del zorro (fox potato). "Solanum agrimoniifolium" additionally is known as papa de marrana (pig potato) and tisbotch (Gentry and Standley, 1974). Latitude and longitude data were obtained by a global positioning system. Readings were taken as decimal fractions of minutes rather than as seconds.

Herbarium vouchers were deposited at AGUAT, PTIS, and WAG, with some at BIGUA. By written agreement with ICTA, all germplasm were exported to The Netherlands and The United States for disease screening in quarantine and later increases at CGN and NRSP-6. ICTA will obtain seeds of the first increase.

RESULTS AND DISCUSSION

Geography

Guatemala covers 108,889 km². It is divided into 22 Departments (Figure 1). The northern half of the country consists mostly of tropical lowlands below 1000 m and harbors no wild potatoes. Elevations above 1350 m (the lowest elevations for wild potatoes in Guatemala) occur only in the southern half of the country.

Guatemala has west to east and northeast running mountain chains (Figure 2), with the greatest elevations in the west. The northernmost chain is the Sierra de los Cuchumatanes, Sierra de Chamá, Sierra de Santa Cruz, and Montañas Mayas. South of these are the Sierra Madre, Sierra de Chaucús, Sierra de las Minas, Montañas del Mico, Montañas de Copán, Sierra del Merendón, and Montañas de Omoa (Gall, 1981; Piedra Santa-A., 1994). All 33 of Guatemala's volcanoes, with elevations from 1027 m to 4240 m, occur in the Sierra Madre (Figure 2). Many wild potato populations occur on these volcanoes, the five highest of which are Volcán Tajumulco (Dept. San Marcos, 4240 m), Volcán Tacaná (Dept. San Marcos, 4003 m), Volcán Acatenango (Depts. Chimaltenango, Escuintla, Sacatepéquez, 3075 m), Volcán Santa María (Dept. Quetzaltenango, 3772 m), and Volcán de Agua (Depts. Escuintla, Sacatepéquez, 3760 m).

Logistics

Figure 3 details our collection route. All potato popula-
FIGURE 1
Departments in Guatemala.

FIGURE 2
Mountain ranges in Guatemala.

FIGURE 3
Route map for this expedition. Area 1 is the Cambre de María Tecún (see Recommended areas for in-situ preserves for wild potatoes in Guatemala). Areas 2-4 are potential sites for wild potatoes but where they not yet been found (see Recommended areas for future collecting in Guatemala).

tions in Guatemala can be approached within a 12 hour drive from Guatemala City, conveniently located in the center of the upland areas in southern Guatemala. Collecting at many localities, however, requires one or two days of hiking, sometimes covering a vertical distance of 1000 m or more. Many roads are not paved and are in poor condition by the end of the rainy season in mid to late October (Figure 4). A four-wheel drive vehicle is needed, and was rented in Guatemala City.

Gall (1978, 1981, 1983a,b), and United States Department of Interior (1984) provide an excellent compilation of place names. A serious problem for finding localities in the field, however, is the lack of up-to-date road and topographic maps. The most current road map is a single 1:1,000,000-scale map reprinted from one first published in 1980. There are no individual department road maps. The 1:50,000-scale and 1:250,000-scale topographic maps are based largely on 1964 data. Changes past these dates must be determined in the field, or from a knowledgeable collaborator. An additional complication is the general lack of road signs in most areas.
Previous Potato Collecting in Guatemala

Twenty-five individuals or teams have collected wild potatoes in Guatemala. Aguilar G., Brekon and Brekon, Baeke, Beaman, Flores C., Gibson and Laskouski, Johnson, Molina and Molina, Muench, Purpus, Rojas, Schwabe, Skutch, Smith, Standley, Stevens, Steyermark, Roe, Stevens, Veliz and Veliz, von Türcheim II, Uehde, and Williams collected wild potatoes as part of more general collecting expeditions. The most extensive of these were those of Standley and Steyermark. Their collections formed much of the material for Flora of Guatemala published in serial form in Fiedlione, Botany from 1946-1977 (Solomum published in Gentry and Standley, 1974).

Graham collected in Mexico and Guatemala to gain material for studies of late blight and crossability relationships of the Mexican and Central American diploid wild potatoes (Graham et al., 1959; Graham and Dionne, 1961). Hawkes, Hjerling, and Lester collected in Guatemala as part of a potato collecting expedition in the southwestern United States, Mexico, Guatemala, Honduras, and Nicaragua (Hawkes, 1959). All germplasm collections in Guatemala were made by Graham, who collected 6 collections of S. aprimonifolium, S. clarum, and S. morelliforme; and Hawkes, who made ten collections of S. aprimonifolium, S. bulbocastanum, S. clarum, S. demissum, and S. morelliforme.

Phenology

Timing is one of the most important aspects of planning a germplasm collecting expedition. In Guatemala, herbarium specimens of wild potatoes were collected in all months but April and May. Most germplasm was collected during September to November. We collected germplasm of all five species throughout the expedition, but had to return to some populations of S. aprimonifolium in November to collect mature fruits (but some populations of this species had mature fruits in mid-September). We apparently were too late for ideal collecting for S. demissum. Considering these data, and the greater efficiency of collecting in the dry season (Figure 4), we suggest the best times to collect true seeds of wild potatoes in Guatemala would be during August to November (August for S. demissum).

Taxonomic treatment. Note: Germplasm collections are noted in the taxonomic treatment in “Additional collections examined” by an asterisk after herbarium codes. Our new collections should be available from NRSP-6 and CPRDLO, CGR in a couple of years after passage through quarantine and a first seed increase. We have examined all herbarium specimens except those listed as JGH (personal herbarium of Jack Hawkes, University of Birmingham, England). These are listed in a database of herbarium specimens announced for distribution in Hawkes (1997); these specimens are to be transferred to K but were not available for distribution during the planning of this expedition or writing this paper. Collections before Oct 13 are labeled Spooner, Martinez and Hoekstra, 7,004-7,062 (abbreviated SMH in the text), while those after Oct 17 are Spooner, Martinez and van den Berg 7054-7076 (abbreviated SMV). Our inclusion of a complete list of all known collections will greatly aid collectors and will be useful for those wishing to borrow these specimens.

Key to the Guatemalan wild species of Solanum sect. Petota

1. Leaves pinnately dissected; corolla pentagonal to rotate.
2. Leaves with 2-4 pairs of lateral leaflets; fruits globose to ovoid .......................... S. demissum.
3. Leaves with 4-7 pairs of lateral leaflets, fruits conical .......................... S. aprimonifolium.
4. Leaves entire; corolla stellate.
5. Pseudostipular leaves auriculate; corollas creamy white; plants typically growing in hot and dry habitats in shallow or rocky soil .......................... S. bulbocastanum.
6. Pseudostipular leaves, when present, linear to narrowly ovate; corollas pure white or pure white and purple; plants epiphytic or growing in epiphytic-like conditions in moss.
7. Plants typically epiphytic; leaves elliptic to narrowly ovate, 1.9-3.2 times as long as wide ... S. morelliforme.
8. Plants typically growing in moss in upland pine or juniper forests; leaves broadly ovate, 1.3-1.8 times as long as wide .......................... S. clarum.

Plants terrestrial, to 2 m tall; stems 8-13 mm wide at base, green to purple, simple to branched; leaves odd pinnate, nearly glabrous to finely pubescent above and below, blades 13-30 cm long, 10-19 cm wide, petioles 1-5 cm long; 4-7 lateral leaflet pairs, ovate to elliptical, apex acuminate, base oblique, rounded to cuneate, sessile to subsessile; 4-14 interconnected leaflets, linear to ovate, sessile; terminal leaflet ovate to elliptical, apex acute to acuminate, base attenuate; pseudostipular leaves auriculate, 2-10 cm long; inflorescence pseudoterminal and lateral, with 8-38 flowers; pedicell 15-30 mm long; calyx 5-10 mm long, lobes 3-8 mm long, long attenuate; corolla purple, rotate with short acumens, 2-3 cm in diameter; filaments 1.5-2 mm long, anthers 4-5.5 mm long, cordinates at base; style exceeding stamens by 2-3 mm; fruits conical, rounded to pointed at tip, up to 5 cm long, medium to deep green. Chromosome number: 2n = 4x = 48.

**Distribution** (Figure 5) and Ecology—*Solomonum agrimonifolium* grows from 1600-3800 m, in wet and disturbed habitats, in organic soils, often in areas of cloud forests (wet upland tropical forests characterized by a profusion of epiphytes and clouds even in the dry season), in full sun to partial shade. Common habitats are recently logged or otherwise disturbed areas in valleys, stream beds, or in upland marshes.

*Solomonum agrimonifolium* grows from southern Mexico (Oaxaca and Chiapas) south to HONDURAS. Merazán: Montaña La Tigra, 22 mi from Tegucigalpa on road to San Juanico, SW of San Juanico, 2000 m, 24 Nov 1958, Hawkes et al., 2035 (C); Montaña La Tigra, between Tegucigalpa and San Juanico, SW of San Juanico, 2200 m, 29 Nov 1958, Hawkes et al., 2137 (C); Montaña La Tigra SW of San Juanico, 2000 m, 24 Nov 1958, Molina 8677 (F); above Ranchito Quemado on Montaña La Tigra, 2000 m, 10 Dec 1968, Molina 8770 (F).

Additional specimens examined: Guatemala. Chimaltenango: N facing slope of Volcán Acatenango, a one-hour walk above Soledad, 1 km WSW of record 7051, 1:250,000-scale map ND 15-8, 14°31.1’N, 90°53.1’W, 2880 m, 13 Oct 1995, **SMH 7050** (AGUAT, BIFGA, PTIS, WAG)**; N facing slope of Volcán Acatenango, a one-hour walk above Soledad, 1:250,000-scale map ND 15-8, 14°31.3’N, 90°52.7’W, 2840 m, 13 Oct 1995, **SMH 7051** (AGUAT, WAG)**. El Progreso: between Finca Piamonte and top of Montaña Piamonte, along Jova Pacayal, 2500-3000 m, on summit, no date, Seyemena 43672 (F). Hueluetenanango: Cuchumatanes Mountains, road from Hueluetenanango to Concepción, 3 km from Concepción, roadside, 2695 m, 5 Sep 1976, Bauke 153 (GH, MO); Chimaltenango, 2800 m, 23 Oct 1956, Graham 145 (JGH, K, LL [photos BM, K, PTIS]), 145A (PTIS)**, 145B (JGH, PTIS)**; above San Juan Ixcoy, Sierra de los Cuchumatanes, 2600-2700 m, 23 Aug 1956, Graham 145 (K, LL [photo], K, S, US); between Xoxlac and Nucapuxilac, Sierra de los Cuchumatanes, 1650-2500 m, 17 Jul 1942, 2 km walk N of San Juan Atitlán, footpath to Todos Santos, 1 km walk S of collection 7062, 1:250,000-scale map ND 15-3, 15°28.6’N, 91°37.4’W, 2730 m, 23 Oct 1995, SMV 7061 (AGUAT, PTIS, WAG)**; 3 km walk N of San Juan Atitlán, logging path diverging from main path to Todos Santos at a point 2 km N of San Juan Atitlán, 1 km NE of collection 7061 and 500 m S of collection 7063, 1:250,000-scale map ND 15-3, 15°28.7’N, 91°37.3’W, 2830 m, 23 Oct 1995, SMV 7062 (AGUAT, PTIS, WAG)**; 3.5 km walk N of San Juan Atitlán, logging path diverging from main path to Todos Santos at a point 2 km N of San Juan Atitlán, 500 m S of collection 7062, 1:250,000-scale map ND 15-3, 15°28.9’N, 91°37.3’W, 2880 m, 23 Oct 1995, SMV 7063 (AGUAT, PTIS, WAG)**; 24.3 km N of town square of Santa Elena, 5.5 km S of town square of San Mateo Ixtatán, Rt 9N, 1:250,000-scale map ND 15-4, 15°49.2’N, 91°30.5’W, 3020 m.
25 Oct 1995, SMV 7073 (AGUAT, PTIS, WAG)*, SMV 7074 (AGUAT); Steyermark 48961 (F); top of Sierra Chemalito, Sierra de los Cuchumatanos. 3 1/2 mi W of Santa Eulalia, 3100-3150 m, 2 Aug 1942, Steyermark 49938 (F [photos BM, K]); Cerro Pimpix, above San Ildefonso Ixtahuacan, forested summit, 1600-2800 m, 15 Aug 1942, Steyermark 50555 (F); trail between Todos Santos and San Juan Attiea, Sierra de los Cuchumatanos, 2600-2700 m, 7 Sep 1942, Steyermark 51942 (F). Quezaltenango: between San Martin Chile Verde and Mujulía, lower slope of Volcán Lucandón, 1900 m, 18 Aug 1956, Graham 136 (JGH, LL); road from San Martin Chile Verde to Colonia, above Majuliá, 17.5 km from San Mateo, roadside, 2100 m, 4 Nov 1958, Hawkes et al. 18685 (C, JGH, US); Volcán Zunil, 3100-3200 m, 27 Dec 1976, Schwieter s.n. (MEXU); Mpio. Zunil, 2 hour walk E of Fuente de Agua Termales Georgianas (located 8 km SE of Pan-American Highway from town of Zunil), W-facing slope of Volcán Zunil, 1:250,000-scale map ND 15-8, 14°54'S, 91°25'W, 2900 m, 22 Sep 1995, SMH 7019 (AGUAT, PTIS, WAG)*; Fuentes Georgianas, western slope of Volcán de Zunil, 2850 m, 4 Mar 1938, Standley 67499 (F); above Majuliá between San Martin Chile Verde and Colonia, 1800 m, 1 Feb 1941, Standley 85459 (F, US); Volcán Santo Tomás, 2500-3700 m, 22 Jan 1940, Steyermark 34442 (F). San Marcos: San Luis, 4.4 mi W of Ixchiguán, road to Tacaná, 3400 m, 13 Aug 1959, Beanman 3252 (ENC, LL, US); Volcán Tacaná, entering Mexico from Unión de Juárez, near border with Mexico, 9 Jul 1966, Flores-C S-950 (MEXU); outer slopes of Tajumulco volcano, Sierra Madre Mountains, ca 10 km W of San Marcos, 2400-2700, 3 Jan 1965, Gibson and Laskowski 27192 (F), village of San Andres Chapil, 8 km on Route 12 from San Marcos to Tejutla at km 255 from Guatemala, below the cliffs, 2750 m, 3 Nov 1958, Hawkes et al. 1851 (C, JGH, PTIS)*; 12 km from San Marcos, road to Tejutla, (entering forest from left by small bridge), 3000 m, 3 Nov 1958, Hawkes et al. 1853 (C, JGH); 13 km from San Marcos, road to San Rafael de la Cuesta, in clearings and sides of paths, 2400 m, 3 Nov 1958, Hawkes et al. 1854 (C, JGH, US); 12.4 km W of town square of San Marcos, road to San Rafael Pie de la Cuesta, N side of road in valley, 1:250,000-scale map ND 15-7, 14°56.8'N, 91°51.3'W, 2340 m, 23 Sep 1905, SMH 7021 (AGUAT, PTIS, WAG)*; 1.0 km NW of town square of Ixchiguán, road to Tacaná, ca 50 m N of road, 1:250,000-scale map ND 15-3, 15°10.3'N, 91°56.8'W, 3380 m, 24 Sep 1995, SMH 7026 (AGUAT, PTIS, WAG)*; N slope of Volcán Tajumulco, W-facing valley, a 10 minute hike S into woods from a point 2.5 km W of road from San Marcos to Tacaná to town of Tajumulco, 1:250,000-scale map ND 15-3, 15°04.6'N, 91°52.8'W, 2780 m, 26 Sep 1995, SMH 7034 (AGUAT, PTIS, WAG)*; Barranco Eminencia, above San Rafael Pie de la Cuesta, 2100-2400 m, 14 and 15 Mar 1939, Standley 68461 (F); Barranco Eminencia, road between San Marcos and San Rafael Pie de la Cuesta, in upper part of the barranco between Finca La Lucha and Buena Vista, 2500-2700 m, 6 Feb 1941, Standley 86448 (F); along road between San Sebastián at km 21 and km 8, 8 to 18 mi NW of San Marcos, moist thciknees near waterfall, 2700-3800 m, 15 Feb 1940, Steyermark 35728 (F); between La Vega Ridge and Río Vega and along NE slopes of Volcán Tacaná, to 3 mi from Guatemala-Mexican boundary, in vicinity of San Rafael, along stream in narrow shaded barranco, 2500-3000 m, 29 Feb 1940, Steyermark 36178 (F); wet mountain forest near Aldea Fraternidad, between San Rafael Pie de la Cuesta and Palo Corral, W facing slope of Sierra Madre Mountains, 1500-2400 m, 10-18 Dec 1963, Williams et al. 25754 (US), 26292 (F). Sololá: between Quezaltenango and Los Encuentros, by mountain stream, 3050 m, 7 Aug 1956, Graham 116 (LL); 17.0 km W of the intersection of the road from Nahuala to Guatemala City, and the old road W to Totonicapán, ca 20 m N of road, 1:250,000-scale map ND 15-8, 14°51.5'N, 91°11.7'W, 3000 m, 28 Sep 1995, SMH 7036 (AGUAT, PTIS, WAG)*. Totonicapán: Mujulía, 1900 m, 16 Oct 1956, Graham 136 (PTIS)*; Cerro El Chiché, 1 mi E of Totonicapán, road to Los Encuentros [note: our field work indicated 1 mi E is a typographical error for 10 mi E], 3300 m, 5 Nov 1958, Hawkes et al. 1880 (JGH, US); Cerro El Quiché, 1 mi E of Totonicapán, road to Los Encuentros [see note above], km 163.5 from Guatemala City, by a stream on the lower side of the road, 3300 m, 5 Nov 1958, Hawkes et al. 1891 (JGH, PTIS, US)*; Cerro el Quiché, 1 mi E of Totonicapán, road to Los Encuentros, km 163.5 from Guatemala City, by a small stream, upper side of the road, 3300 m, 5 Nov 1958, Hawkes et al. 1892 (C, JGH, US); 10.2 km E of town square of Totonicapán, 4.8 km from deviation of road to Santa Cruz del Quiché, old road to Los Encuentros, 1:250,000-scale map ND 15-8, 14°54.8'N, 91°19.1'W, 3150 m, 15 Sep 1995, SMH 7006 (AGUAT, PTIS, WAG)*.

Solanum agrimonioides is one of 40 species identified by Hawkes (1990) in series Conicibaccata Bitter. According to Hawkes (1990), the other Mexican and Central American representatives of ser. Conicibaccata are S. oxyacarpum Schiede [4-t (2EBN)], restricted to Mexico; S. longiconicum Bitter [4-t (2EBN)] from Costa Rica and Panama, and S. woodsonii Correll (ploidy and EBN unknown) from Costa Rica, Panamá, and Venezuela.

Correll (1962), on the other hand, identified some Costa Rican and Panamanian collections as S. ocyacarpum, and
considered *S. longiconicum* to be synonymous with *S. oxy-
carpum*. Gentry and Standley (1974) identified *Steyermark
43672* (specimen at F) from Guatemala, Department El Pro-
greso, as *S. oxyarpum*, a specimen collected after Correll
(1962), and not commented on by Hawkes (1990). All of
these taxa are morphologically very similar, and dis-
guished with difficulty only by reliance on apparently over-
lapping ranges of character states (Castillo and Spooner,
1997).

The confusion regarding identity of these collections in
ser. Conicifolius questions the species boundaries among
*Solanum agrimonijolium*, *S. longiconicum* and *S. oxy-
carpum*. They are considered as distinct by number and size
of lateral and interstitial leaflets and leaf pubescence (Cor-
rell, 1962; Gentry and Standley, 1974; Hawkes, 1990). We con-
servatively treat all our Guatemalan collections as *S.
armonijolium* until we further study additional Mexican
and Central American members of this complex.

*Solanum bulbocastanum* Dunal subsp. *partitum* (Cor-
*Solanum bulbocastanum* var. *partitum* Correll, Agric
Verapaz: Patal, 1600 m, growing in thicket, July 1908. H.
von Tüxen *H. 2316* (holotype: US 124469 [photo: PTIS];
isotypes: G [photos: NY, US], NY [photos: PTIS,
US], Z [photo: NY]).

Plants terrestrial, 3-10 dm tall; stems 2-4 mm wide at
base, green to brownish-purple, simple to branched; leaves
simple, densely puberulent to pubescent above and below,
narrow to broadly ovate to rhomboid, blades 3-10 cm long,
1.5-4 cm wide, apex acute to acuminate, base attenuate, peti-
oles 1-4 cm long; pseudostipular leaves arauculate, 2 cm
long; inflorescence pseudoterminal and lateral, with 7-20
flowers; pedicel 10-25 mm long; calyx 3-4.5 mm long, lobes
1.25 mm long, acute to mucronate; corolla deeply stellate,
1.5 mm in diameter; creamy white; filaments 1-2 mm long,
anthers 2-6 mm long, sterile at base without rounded ari-
style; style exceeding stamens by 1.5-2.5 mm; fruits globose,
1 cm in diameter; green. Chromosome number: $2n = 2x = 24$.

**Distribution (Figure 6) and Ecology** — *Solanum bulbob-
castanum* subsp. *partitum* grows from 1550-2300 m, among
grasses, cacti, scrub and oak forests, often in shallow or
rocky soil. It grows in drier habitats than most other wild potato
species in Guatemala. It persists in grazed areas but is readily
eaten by grazing animals before flowering, and it is therefore
difficult to find fruiting populations. All of our fruit
collections in such areas were made in areas of difficult
access, such as steep rocky slopes, piles of stones, rock
walls, or among the dense vegetation of spiny shrubs or cacti.
It is an inconspicuous plant with a widely scattered distribu-
tion throughout the dry areas of Guatemala and likely is
under-collected.

**Additional specimens examined** — GUATEMALA. Baja
Verapaz: road from Salamá to Cobán, Patal, summit of road, 16
mi from Salamá, by roadside, 1700 m, 1 Nov 1958, 
Hawkes *et al.* 1922 (JGH); road from Salamá to Cobán, Patal,
summit of road, 16 mi from Salamá, 1650 m, 1 Nov 1958,
Hawkes *et al.* 1938 (JGH); road from Salamá to Cobán, Patal,
summit of road, 11 mi from Salamá, 1350 m, 11 Nov 1958,
Hawkes *et al.* 1942 (JGH); 8.8 km N from town square of
Salamá, old road to Cobán, 1:250,000-scale map ND 15-4,
15°49.9'N, 90°17.5'W, 1430 m, 5 Oct 1985, SMH 7040
(AGUAT, PTIS, WAG)*; 11.5 km N from town square of
Salamá, old road to Cobán, 50 m W of private road past power
line, 1:250,000-scale map ND 15-4, 15°10.3'N, 90°17.7'W, 1640
m, 5 Oct 1985, SMH 7042 (AGUAT)*; 18.8 km N from town
square of Salamá, old road to Cobán, 1:250,000-scale map ND
15-4, 15°12.9'N, 90°17.7'W, 1420 m, 5 Oct 1985, SMH 7043
(AGUAT, PTIS, WAG)*. Guatemala: Chilioni (note: no
Chilioni located in references, but a Chilioni in U.S. gazetteer
of Guatemala at 14°45'S, 90°33'W, where we mapped this
record), 1500 m, 21 Jun 1921, Rojas 83 (US). Huehuet-
Nango: between Huehuetenango and San Sebastián, junction of Huehuetenango and Pan American Highways, 1580 m, 31 Oct 1958, Hawkes et al. 1789 (JGH, US); road from Huehuetenango to Quezaltenango, 5 km S of Malacatancito, in damp gully above the road, 1800 m, 31 Oct 1958, Hawkes et al. 1796 (JGH, PTIS); between Kms 100 and 107, vicinity of Campo Bolas, way to Mirador, Sierra de los Cuchumatanes, 2000 m, Molina and Molina 26381 [note: we cannot locate this or the following record] (F); vicinity of Campo de Bolas, way to El Mirador, Sierra Cuchumatanes, 2000 m, 12 Sep 1971, Molina and Molina 26302 (F); between Puerto Negro and Los Alisos, way to Aguacatán, 1600 m, 16 Sep 1971, Molina and Molina 26547 [note: we cannot locate Puerto Negro and Los Alisos, and mapped this record with other records in Huehuetenango E of Aguacatán] (F); along RN at junction of entrance to Huehuetenango, 5000 m W of road, 1250,000-scale map ND 15-3, 15°46.0′N, 91°30.3′W, 2000 m, 18 Sep 1995, SMH 7010 (AGUAT, BIGUA, PTIS, WAG); 3.1 km NW of the road entrance to Huehuetenango, Et. CAI, 200 m uphill (SW) of road, 1250,000-scale map ND 15-3, 15°18.8′N, 91°31.1′W, 1900 m, 18 Oct 1995, SMV 7656 (AGUAT, PTIS, WAG); 3.1 km NW of entrance to Huehuetenango, Et. CAI, 400 m uphill (SW) of road, 1250,000-scale map ND 15-3, 15°19.3′N, 91°32.9′W, 2000 m, 18 Oct 1995, SMV 7037 (AGUAT, BIGUA, PTIS, WAG); along road between Huehuetenango and San Sebastián H, 2000 m, 12 Aug 1942, Steyermark 50404 (F); dry slopes between San Idefonso Ixtahuacán and Cuicó, 1350-1600 m, 16 Aug 1942, Steyermark 50687 (F). Quezaltenango: no exact locality, except 14°45′N, 91°31′S, Roe et al. 685 (MICH, MO, US). Sacatepéquez: road between Palín and Antigua, ca. 1.2 km by road S of Santa María de Jesús, 14°29′N, 90°42′W, 1900 m, 7 Jul 1976, Breckon and Breckon 2082 (F). Sololá: slopes of Volcán San Pedro, 2150 m, 20 Sep 1971, Molina and Molina 26659 (F); trail between village of San Pedro, via San Juan, San Cristóbal Buena Vista, and NW slopes of Volcán Santa Clara, 1800-2300 m, 8 Jun 1942, Steyermark 47308 (F). Locality not specific: 1938, Aguilar G. 221 (F); 1938-1943, Aguilar G. 564 (F).

All of our collections have the deeply divided corolla lobes conforming to subsp. partitum (Correll) Hawkes (Correll, 1962; Gentry and Standley, 1974; Hawkes, 1990). Spooner and Sytsma (1992) showed the unexpected result that based on chloroplast DNA restriction site data, S. bulbocastanum (ser. Bulbocastanae Rydb.) and S. carodiophyllum (ser. Pinonatseca [Rydb.] Hawkes) were sister taxa and in a separate clade from all other Mexican and Central American diploid species, exclusive of S. verrucosum Schltdl. (ser. Tuberosa [Rydb.] Hawkes); series affiliations after Hawkes (1990). Rodríguez and Spooner (1997) showed this result to be maintained with many additional accessions of all three subspecies of S. bulbocastanum and two of the three subspecies of S. carodiophyllum (the remaining subspecies, S. carodiophyllum subsp. ehrenbergii Bitter was in the clade of Mexican diploid species). Because chloroplast DNA is predominately maternally inherited in sect. Petota, the true species relationships of S. bulbocastanum must await data from biparentally inherited markers.


Plants typically growing in moss in upland pine or juniper forests, erect, 1.5-3 dm tall; stems 1-3 mm wide at base, green to purple, simple to branched; leaves simple, fine pubescent above and below, elliptic to broadly ovoid, blades 2.6 cm long, 1.5-4.2 cm wide, apex acute to acuminate, base attenuate to truncate to coriaceous, petioles 1-3 cm long, pseudodipterous leaves absent or linear to narrowly ovate, to 2 cm long; inflorescence pseudoterminal and lateral, with 4-15 flowers; pedicels 10-15 mm long; calyx 1.5-2 mm long, lobes 0.7-1 mm long, acute to mucronate; corolla deeply stellate, 15-20 mm in diameter, purplish at tip, grading to white at base; filaments 1-1.5 mm long, anthers 3.5-5 mm long, corolla at base without rounded auricles; style exceeding stamens by 2-3 mm; fruits spherical, 5-8 mm in diameter, yellowish to green. Chromosome number: 2n = 2x = 24.

Distribution (Figure 7) and Ecology—Solanum clarum grows from 2900-3800 m, in high-altitude pine or fir forests, usually in association with Acacia elongata L. (SMV 7076), Alchemilla pectinata HEB (SMV 7070), and Perennei ciliata (Schlecht. and cham.) Small (SMV 7071). Most populations of S. clarum consisted of hundreds of individuals in all stages of development from emerging plants to plants with mature fruits. However, flowers were rarely seen, and fruits generally were difficult to locate. We obtained mature fruits from all populations encountered, and we advise germplasm collectors to persevere if populations seem to lack fruits with initial inspection.

Additional specimens examined: GUATEMALA. Huehuetenango: Sierra de los Cuchumatanes, between Tojiah and Chemal at km 319.5, Ruta Nacional 9 N, 3380 m, 30 Jul 1960, Beamann 3793 (LL, MSC); Sierra de los Cuchumatanes, slopes of Cerro Chemal, 28 mi from Huehuetenango, 3300 m,
FIGURE 7
Geographic distribution of *Solanum clarum*. A circle designates an area represented by a germplasm collection; x designates an area without a germplasm collection.

30 Oct 1958, *Hawkes et al. 1776* (JGH), 1777 (JGH), 1778 (JGH); 31 km N of town square of Huehuetenango, Rt. 9N, above Casario Chialal, 3.5 km N of road junction to Todos Santos, ca 1 km uphill, W of road, 1:250,000-scale map ND 15-3, 15°28.5’N, 91°30.5’W, 3370 m, 16 Sep 1995, SMH 7007 (AGUAT, PTIS, WAG)*; 4.3 km NW of road from Huehuetenango to Santa Eulalia, road to Todos Santos Cuchumatán, 100 m N of road, 1:250,000-scale map ND 15-3, 15°27.0’N, 91°31.2’W, 3280 m, 20 Oct 1995, SMV 7059 (AGUAT, WAG)*; from Huehuetenango a point 4 km N of junction of road to Todos Santos, 1:250,000-scale map ND 15-3, 15°29.2’N, 91°30.4’W, 3430 m, 24 Oct 1995, SMV 7064 (AGUAT, PTIS, WAG)*; 3 km N of town square of Huehuetenango, Road 9N, 3.5 km N of road junction to Casario Chialal, 2 km uphill, W of road, 1:250,000-scale map ND 15-3, 15°29.4’N, 91°30.9’W, 3500 m, 24 Oct 1995, SMV 7065 (AGUAT, PTIS)*; 31 km N of town square of Huehuetenango, Rt. 9N, 3.5 km N of road junction to Casario Chialal, 2 km uphill, W of road, 1:250,000-scale map ND 15-3, 15°28.5’N, 91°30.9’W, 3500 m, 24 Oct 1995, SMV 7066 (AGUAT)*; 6 km E of Huehuetenango-Soloma Road (9N), road past Huito to Tuiníma, 1 km E of Huito, 1:250,000-scale map ND 15-3, 15°30.1’N, 91°27.5’W, 3350 m, 25 Oct 1995, SMV 7067 (AGUAT, PTIS, WAG)*; 24.3 km N of town square of Santa Eulalia, 5.5 km S of town square of San Mateo Ixtatán, Rt. 9N, 1:250,000-scale map ND 15-4, 15°49.2’N, 91°30.5’W, 3020 m, 26 Oct 1995, SMV 7072 (AGUAT, PTIS, WAG)*; ca. 10.5 mi SW of San Juan Ixcoy, Ruta Nacional 9N, Sierra de los Cuchumatanes, common, 18 Jul 1971, Stevens 1262 (MSC); alpine areas in vicinity of Tunmá, Sierra de los Cuchumatanes, 3400-3500 m, 7 Jul 1942, *Steyermark 48385* (F); Cerro Chenal, summit of Sierra de los Cuchumatanes, 3700-3800 m, 8 Aug 1942, *Steyermark 50294* (F, NY, US).

**Quezaltenango**: (see locality of type, above). **Sacatepéquez**: above Santa María de Jesús, N facing slope of Volcán de Agua, in the long grass by the trail, 2900 m, 8 Nov 1958, *Hawkes et al. 1909* (JGH, PTIS, US)*. **San Marcos**: 1.0 km NW of town square of Ichigüán, road to Tacaná, ca 50 m N of road, 1:250,000-scale map ND 15-3, 15°10.3’N, 91°56.8’W, 3380 m, 24 Sep 1995, SMH 7027 (AGUAT, PTIS, WAG)*; 7.2 km NW of town square of Ichigüán, 20 m S of road, 1:250,000-scale map ND 15-3, 15°10.3’N, 91°58.4’W, 3360 m, 24 Sep 1995, SMH 7028 (AGUAT, PTIS, WAG)*; 2.5 hours hike SW of town of Tacaná, towards village of San Rafael, at area of village of Chemalón, 1:250,000-scale map ND 15-3, 15°11.1’N, 92°04.4’W, 3260 m, 25 Sep 1995, SMH 7029 (AGUAT, PTIS, WAG)*. **Sololá**: km 152 between Quezaltenango and Los Encuentros, 3100 m, 7 Oct 1958, Graham 188 (L); road from Totonicapán to Los Encuentros, km 143 from Guatemala City, 3200 m, 5 Nov 1958, Hawkes et al. 1895 (JGH).

**Totonicapán** near margin of small stream in semi-open meadow, near Cerro Quiché, Tecum Uman Ridge at km 154, Ruta Nacional No. 1, 20 km E of Totonicapán, 3340 m, 14 Aug 1960, Beamann 4176 (LL, MSC, US); between Totonicapán and Los Encuentros, 19 Oct 1956, 3000 m, Graham 138 (JGH, PTIS)*; near the Quezaltenango border, 22 mi N of Quezaltenango, Cerro Calel, 3100 m, 2 Nov 1958, Hawkes et al. 1813, 1824, 1827 (same, but 3200 m in shade of Abies), 1839* (same, but 3250 m), 1849 (same, but 3200 m as epiphyte on Abies) (all JGH, US); 22 mi N of Quezaltenango, near the Guatemalan border, 3250 m, 2 Nov 1958, Hawkes et al. 1833 (JGH, PTIS)*; Cerro El Chiché, 1 mi E of Totonicapán, road to Los Encuentros, just below the summit on NW side, rare, 3400 m, 5 Nov 1958, Hawkes et al. 1889 (JGH); 20 km from Totonicapán, road to Los Encuentros, Cerro Quiché, 3400 m, 5 Nov 1958, Hawkes et al. 1894 (JGH, PTIS)*; 4.1 km E of town square of Calel, road to the Pan-American Highway which begins at Puente Pologuia, 1:250,000-scale map ND 15-3, 15°04.3’N, 91°33.5’W, 3020 m, 20 Sep 1995, SMH 7011 (AGUAT, PTIS, WAG)*; along old road N of Quezaltenango, going through Buenabaj to Calel, 1 km S of intersection of this road from Calel to Pan-American Highway, ca 4 km E of Calel, 1:250,000-scale map ND 15-3, 15°02.8’N, 91°33.9’W, 3010 m, 20 Sep 1995, SMH 7014 (AGUAT, PTIS)*; along old...
road from Los Encuentros to Totonicapán, 2 km W from border of Departments Sololá/Totonicapán, 1:250,000-scale map ND 15-8, 14°51.6N, 91°13.7W, 2260 m, 12 Oct 1995, SMH 7046 (AGUAT, PTIS, WAG); along old road from Los Encuentros to Tocotoncapán, 4 km W of border of Departments Sololá/Totonicapán, 1:250,000-scale map ND 15-8, 14°52.6N, 91°13.7W, 3220 m, 12 Oct 1995, SMH 7048 (AGUAT, PTIS, WAG); along old road from Los Encuentros to Tocotoncapán, 7.5 km W of border of Departments Sololá/Totonicapán, 1:250,000-scale map ND 15-8, 14°52.9N, 91°14.8W, 3220 m, 12 Oct 1995, SMH 7049 (AGUAT); 7.3 km E of town square of Totonicapán, 4.8 km from old road to Santa Cruz del Quiché, old road to los Encuentros, ca 200 m uphill (S) of road, 1:250,000-scale map ND 15-8, 14°54.8N, 91°19.1W, 3180 m, 17 Oct 1995, SMV 7055 (AGUAT, PTIS, WAG); 12.4 km E of Tocotoncapán, 9.9 km E from deviation of road to Santa Cruz del Quiché, old road to Los Encuentros, 1:250,000-scale map ND 15-8, 14°54.4N, 91°17.7W, 3150 m, 27 Oct 1995, SMV 7075 (AGUAT, PTIS).

*Solanum clarum* and *S. molliforme* were classified by Hawkes (1990) in the ser. *Bulbosanthes* (also containing *S. bulbocastanum*) and the monotypic ser. *Molliformia* Hawkes, based on floral, reproductive, serological, and ecological differences (ser. *Bulbosanthes* terrestrial, ser. *Molliformia* epiphytic). Our collections showed *S. clarum* to most commonly grow on the ground in moss, in shaded epiphytic like conditions, and occasionally as an epiphyte. Based on chloroplast DNA data, *S. clarum* and *S. molliforme* are united as sister taxa, and *S. bulbocastanum* and *S. clarum* divided into distinct clades (Spooner and Sytsma, 1992). Other reproductive and cytological characters supporting *S. clarum* and *S. molliforme* as sister taxa are summarized in Spooner and Sytsma (1992).


Plants terrestrial, a basal rosette when growing in open rocky grazed areas, to erect to 6 dm tall when growing in protected or shady conditions; stems 1-3 mm wide at base, green to purple, simple to branched; leaves odd pinnae, nearly glabrous to finely pubescent above and below, blades 2-5.15 cm long, 1.5-10 cm wide, pectinol 1-5 cm long; 2-4 lateral leaflet pairs, ovate to elliptical, apex obtuse to acute, base rounded to cuneate, sessile to subsessile; 0-10 interjected leaflets, ovate, sessile to subsessile; terminal leaflet larger than the laterals, ovate to elliptical, apex acute to obtuse, base rounded to cuneate; pseudosiphon leaves auriculate, 1.5 cm long; inflorescence pseudoterminal and lateral, with 5-10 flowers; pedicel 3-15 mm long; calyx 4-8 mm long, lobes 3-5 mm long, acute; corolla white to purple, or white above and purple below, rotate with short acumens, 1.5-1.3 cm in diameter; filaments 1-1.5 mm long, anthers 2-4.5 mm long, corolla at base; style equaling or exceeding stamens by 2 mm; fruits globose to ovoid, rounded at tip, 1-2.5 cm in diameter, medium to deep green. Chromosome number: 2n = 6x = 72.

Distribution (Figure 8) and Ecology—*Solanum demissum* grows from 2250-3800 m in pine or juniper forests, or in rocky open pastures. It varies tremendously in size and habit, with plants growing in open grazed areas smaller.

Additional specimens examined: GUATEMALA. Huehuetenango: Sierra de los Cuchumatanes, at edge of Llano de Tierra Blanca, near trail to Todos Santos from Llano de San Miguel near Chimal, 5 km W of km 311, Ruta Nacional 9 N, 3505 m, 5 Aug 1959, Beacon 3100 (LL, MSC); Sierra de los Cuchumatanes, slopes of Cerro Chenal, 28 m from Huehuetenango, 3500 m, 30 Oct 1985, Hawkes et al. 1778 (JGH); summit of Cerro Chenal, 28 m from Huehuetenango, 3450 m, 30 Oct 1968, Hawkes et al. 1780, 1781 (JGH); Sierra de los Cuchumatanes, slopes of Cerro Chenal, open place, 28 m from Huehuetenango, 3500 m, 30 Oct 1958, Hawkes et al. 1782 (JGH, PTIS); near Chemal, Sierra de los Cuchumatanes, 15 Sep 1941, Johnston 19609 (F); between Yac and Todos Santos Cuchumatán, Todos Santos, 3600 m, 7 Aug 1977, Smith 628 (F); 49 km N of town square of Huehuetenango, road diverting W of N to Chancholco, 1250,000-scale map ND 15-3, 15°53’N, 91°31’W, 3400 m, 16 Sep 1995, SMH 7008 (AGUAT, PTIS, WAG); alpine areas in vicinity of Tunimá, Sierra de los Cuchumatanes, 3400-3500 m, 7 Jul 1942, Steyerm. 48369 (F); vicinity of Chemal, summit of Sierra de los Cuchumatanes, rocky limestone outcrops around entrance to cave, in shade, 3700-3750 m, 8 Aug 1942, Steyerm. 50247 (F, NY, US); Todos Santos, 3000 m, 8 Jun 1995, Veliz and Veliz 95.4962 (BIGUA). Sacatepéquez: slopes of Volcán de Agua, above Santa María de Jesús, in trail, 2250-3000 m, 11 Feb 1939, Standley 65276 (F). Totonicapán: Cerro El Chiché, 1 mi E of Totonicapán, road to Los
Encuentros, shade of small cave, base of cliff, NW facing slope, 3350 m [note: our field work indicated 1 m E is a typographical error for 10 m E], 5 Nov 1956, Hawkes et al. 1887 (JGH, as note only [in database announced in Hawkes, 1997], no specimen); 7.3 km E of town square of Totonicapán, 4.8 km E from deviation of road to Santa Cruz del Quiché, old road to los Encuentros, 200 m uphill (S) of road, 1:250,000-scale map ND 15-8, 14°54.8′N, 91°10.1′W, 3180 m, 17 Oct 1965, SMV 7054 (AGUAT, PTIS, WAG).

This self-pollinated species readily sets fruit in nature and is one of the most common wild potato species in genebanks. All of these collections were from northern to southern Mexico, where the species is widespread, and there was only a single germplasm collection from Guatemala. It has been recorded from three general areas in the Departments of Huehuetenango, Sacatepéquez, and Totonicapán. We found it in Huehuetenango (SMH 7008) and Totonicapán (SMV 7054). The former was found only as an isolated and persistent fruit, but seeds from these led to a germplasm increase; the latter lacked flowers and fruits and the tubers we collected died before being increased.

Hawkes (1990) included Solanum demissum in series Demissa Buk., containing five other hexaploid species from Mexico. The morphological characters defining this series are unclear. Spooner et al. (1995) showed that on the basis of morphology, the species is more similar to S. albicans (ser. Aculalia Juz.) from South America than to any other species in ser. Demissa.


Plants typically epiphytic in pine or oak trees, rarely growing in rotting wood or moss at base of trees, erect to ascending, 1-6 dm tall; stems 2-3 mm wide at base, green to purple, simple to branched; leaves simple, finely pubescent above and below, elliptic to narrowly ovate, blades 3-14 cm long, 1.5-4.4 cm wide, apex acute to acuminate, base attenuate, petioles 1-4 cm long; pseudostipular leaves absent or linear to narrowly ovate, to 2 cm long; inflorescence pseudodermal and lateral, with 7-15 flowers; pedicel 10-15 mm long; calyx 1.5-2 mm long, lobes 0.7-1 mm long, acute to mucronate; corolla deeply stellate. 15-20 mm in diameter, white to white tinged with purple; filaments 1-1.5 mm long, anthers 4-5.5 mm long, with basal rounded auricles; style about equaling stamens; fruits spherical, 5-8 mm in diameter, yellowish to green. Chromosome number: 2n = 2x = 24.

**Distribution** (Figure 9) and Ecology—Solanum morelliforme grows from 1600-3000 m, almost exclusively as an epiphyte on horizontal branches of mature elm, pine, or oak trees. Occasionally, the species is found on the ground in the woods, in rotting wood of fallen trees, or in moss, both epiphytic-like conditions (see *S. clarum*, above). We were unable to locate the species at some previously documented localities that have been logged and reforested. Because the fruits and seeds of all members of sect. Petota are not wind borne, the species probably is distributed in the droppings of birds or tree-dwelling animals.

A collection first reported here extends the known distribution of *S. morelliforme* south to HONDURAS. Momzán: at Lapaterique river bank thicket, epiphyte on oak tree, 1600 m, 11 Aug 1961, Molina and Molina 28100 (F).

Additional specimen examined: GUATEMALA. **Chimaltenango**: above Tecpán, 2400 m, 10 Oct 1956, Graham 120 (LL, PTIS)*; above Tecpán, 2500 m, 11 Oct 1956, Graham 122 (LL); above Tecpán, 2400 m, Oct 1965, Graham 8-743 (ENCB); Santa Elena (note: we cannot find this locality on map), 2400-2700 m, 18 Jul 1933, Sketch 444 (F); plains, 2200 m, near Tecpán, 3 Aug 1933, Sketch 525 (MIC, US).

**Huehuetenango**: 11.8 km N of town square of Santa Eulalia, road to San Mateo Ixtatán, Road 9N, 50-250 m W of...
Los Encuentros, 1:250,000-scale map ND 15-8, 14°55.3'N, 91°19.0'W, 2960 m, 15 Sep 1995, SMH 7005 (AGUAT, PTIS, WAG)*; along old road N of Quezaltenango, going through Buenavista to Cale, 1 km S of intersection of this road and new road from Cale to Pan-American Highway, ca 4 km E of Cale, 1:250,000-scale map ND 15-3, 15°03.8'N, 91°33.9'W, 3010 m, 20 Sep 1995 SMH 7013 (AGUAT, PTIS, WAG)*; 6.5 km E of town square of Totonicapán, along road to Santa Cruz del Quiché, ca 100 m N of junction of road to Santa Maria Chiquimula, ca 100 m N of road, 1:250,000-scale map ND 15-8, 14°55.6'N, 91°20.3'W, 2810 m, 15 Sep 1995, SMH 7004 (AGUAT, BIGUA, F, PTIS, WAG)*.

**Habitat Destruction and its Effect on Wild Potato Populations in Guatemala**

Guatemala has changed considerably since the many collections of wild potatoes in the 1940’s and 1950’s. Our expedition searched most of the known populations. Many populations now apparently are extirpated due to habitat destruction. Much of the primary forest is being cut for firewood, structural timbers, and clearing for agriculture, and logging is a common practice in almost all of the primary forests we visited. In many areas, forests harboring wild potatoes are now reduced to small isolated stands, surrounded by cleared and grazed areas.

Population has nearly doubled in Guatemala from 4.3 million persons in 1964 (Dirección General de Estadística, 1971), to an official count of 8.3 million in 1994 (Instituto Nacional de Estadística, 1995), or a more realistic estimate of slightly over 10 million in 1994 (UNICEF, 1994). The median number of children each Guatemalan woman is projected to have during the years 1995-2000 is 4.2, resulting in an estimated population by the year 2000 of 12 million (UNICEF, 1994). Sixty-two percent of Guatemala’s population is rural, and 76% of the population live below the poverty line (UNICEF, 1994), placing growing needs on the use of Guatemala’s remaining primary forests that harbor wild potatoes.

Deforestation has accelerated rapidly in Guatemala. In 1978-1988, the average deforestation was 60,000 hectares per year (Ministerio de Agricultura, Ganadería y Alimentación, Dirección General de Bosques y Vide Silvestre, 1994). Sixty-two percent of this wood is lost to forest fires, 35% is used for domestic firewood, and 2% is used for industrial purposes, including domestic house construction and export. Twenty-three percent of deforestation occurs in coniferous forests (Ministerio de Agricultura, Ganadería y Alimentación,
Dirección General de Bosques y Vide Silvestre, 1984), concentrated in the uplands of western Guatemala where wild potatoes grow. Another growing cause of deforestation in Guatemala is attack by a bark boring beetle Dendroctonus spp. that is killing entire stands of pine forests, especially the upland pine Pinus radiata. The most severe attacks are in the upland western Departments of Huehuetenango, Totonicapán, Quetzaltenango, Sololá, and San Marcos (Instituto Nacional Forestal, 1982).

Any prediction of the survival of Guatemalan wild potatoes can only be a rough guess, based on observation of areas where potatoes now grow, their disappearance in recently disturbed areas, and a guess of how many natural areas will remain in the future. *Solanum morreliforme* usually grows in large trees, and is probably the most susceptible to disappearance by logging. *Solanum clarum* usually grows only in the shade of large trees among moss or pine needles, and is readily eaten by grazing animals. *Solanum agrimoniifolium* grows in much more disturbed habitats, but almost always in areas of recently cleared primary forests in deep, moist, organic soils, and it also is readily eaten by grazing animals. *Solanum bulbocastanum* grows among shrubs of dry grazed areas, and is probably the least susceptible to elimination. Natural areas are disappearing rapidly, and some of our collections will be the last available for some areas.

**Recommended Areas for Future Collecting in Guatemala**

We focused collecting in areas where potatoes previously have been collected but that lacked germplasm collections. We additionally searched areas with appropriate elevations for wild potatoes but without any records for them. These included three mountains in the Departments of Guatemala, Jativa, and Chimatanango with elevations from 2000-3000 m (labeled on Figure 3 as areas 2-4), but we found no wild potatoes there. These three localities had some mesic and relatively undisturbed sites with much epiphytic vegetation apparently ideal for the growth of *S. agrimonii-folium* and *S. morreliformae*. Because we devoted only one day each to these areas, it is possible we overlooked wild potatoes there.

Our 43 new collections, and the 16 prior collections of Graham and Hawkes (Table 1), provide good germplasm representation for all the species in Guatemala regarding numbers of populations and geographic coverage (Figs. 5-9, Table 1). Consequently, future potato germplasm collecting in Central America should be conducted in less collected countries, such as Costa Rica (conducted in 1996, paper in progress), Honduras, and Panama.

If wild potato collecting is done again in Guatemala, we suggest the following areas that we did not explore to expand geographic coverage:

1. Political instability prevented us from exploring the three volcanoes south of Lago Atitlán in the Department of Sololá with elevations from 2905-3133 m (Volcán Atitlán, Volcán San Pedro, Volcán Tolimán). There are no records there, but these may be rich areas for any of the five species known for Guatemala.

2. Political instability also prevented us from exploring the far eastern part of the Sierra de los Cuchumatanes, in the Department of El Quiche, north of the road from Río Blanco to Usio, with some elevations over 2700 m.

3. The mountains in the extreme southwestern portion of the Sierra de los Cuchumatanes, in the Department of Huehuetenango, north of Cuilco.

4. The extreme northern portion of the Sierra de los Cuchumatanes, in the Department of Huehuetenango, north of San Mateo Ixtatán.

5. The Sierra de las Minas in the eastern part of the Department of El Progreso, and the western part of the Department of Zacapa, where the sierra is highest. We spent two days searching unsuccessfully for *S. agrimoniifolium* (Steigermark 43672) north of the town of Jute de la Cobana (see above), and there were many appropriate habitats for this species there.

6. *Solanum bulbocastanum* grows in much drier sites than the other Guatemalan species, and our collecting experience shows it to persist in some grazed areas. The species probably is under-collected because it is inconspicuous. In Guatemala, the species occurs from 1350-2300 m (Table 1), and it may occur in dry regions at these elevations, present in many places in southern Guatemala.

**Recommended Areas for In-situ Preserves for Wild Potatoes in Guatemala**

Two areas are notable for the concentration of wild potatoes and some remaining natural areas: 1) The Cumbre de María Tecun in the Department of Totonicapán (Figure 3), and 2) scattered areas in the Sierra de los Cuchumatanes (Figure 2). Both harbor populations of all of Guatemala's wild potato species except *S. bulbocastanum*. Both areas are listed in Guatemala's protected areas law (Ley de Áreas Protegidas, Decreto 480) to have official protection under this law but lacking practical enforcement until it is formally studied, and given a push for protection.
Table 1.—Numbers and distribution of germplasm of the five species of wild potatoes from Guatemala.

<table>
<thead>
<tr>
<th>Species</th>
<th>Accessions from Mexico before the expedition</th>
<th>Accessions from Guatemala before the expedition (division by Department)</th>
<th>Total current Guatemalan accessions (division by Department)</th>
<th>Elevations of occurrence in Guatemala</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Solanum agridiamum</em></td>
<td>3</td>
<td>6: 3 (H), 1 (SM), 1 (T), 1 (Qe)</td>
<td>19: 2 (C), 8 (H), 2 (Qe), 4 (SM), 1 (So), 2 (T)</td>
<td>1500-3800 m</td>
</tr>
<tr>
<td><em>S. bulbocastanum</em></td>
<td>40</td>
<td>1 (H)</td>
<td>7: 8 (B), 4 (H)</td>
<td>1350-2300 m</td>
</tr>
<tr>
<td><em>S. dianthum</em></td>
<td>1</td>
<td>4: 1 (So), 3 (T)</td>
<td>2: 7 (H), 3 (SM), 1 (So), 10 (T)</td>
<td>2500-3800 m</td>
</tr>
<tr>
<td><em>S. demissum</em></td>
<td>140</td>
<td>1 (H)</td>
<td>2 (H)</td>
<td>2250-3800 m</td>
</tr>
<tr>
<td><em>S. tuberosum</em></td>
<td>8</td>
<td>4: 1 (C), 2 (Qe), 1 (Qe)</td>
<td>10: 1 (C), 2 (Qe), 2 (H), 1 (Qe), 1 (SM), 5 (T)</td>
<td>1500-3950 m</td>
</tr>
</tbody>
</table>

1Department abbreviations are: Baja Verapaz (B), Chimaltenango (C), Guatemala (G), Huehuetenango (H), El Progreso (P), Quetzaltenango (Qe), Quiché (Q), San Marcos (SM), Sacatepéquez (Sa), Sololá (So), Totonicapán (T).

2Does not include the nine accessions collected in Mexico by Rodríguez et al. (1965) that are still in U.S. quarantine.

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LITERATURE CITED


