Wild *Capsicum* in the area of the Amboró National Park in Bolivia

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Abstract

Bolivia is believed to be the source of the genus *Capsicum*; possibly *Capsicum chacoense* Hunz. is the species closer to the ancestor of all *Capsicum* species. About ten species of wild *Capsicum* grow in Bolivia: *Capsicum baccatum* L. var. *baccatum*, *Capsicum caballeroi* Nee, *Capsicum cardenasii* Heiser & Smith, *Capsicum ceratocalyx* Nee, *Capsicum chacoense* Hunz., *Capsicum coccineum* (Rusby) Hunz., *Capsicum eshbaughii* Barboza, *Capsicum eximium* Hunz., *Capsicum minutiflorum* (Rusby) Hunz. A couple of possible new species are under investigations. Many cultivated species are also grown and sometimes present in wild forms, especially *Capsicum pubescens* Ruiz & Pav., *Capsicum frutescens* L., *Capsicum baccatum* L. var. *pendulum* (Willd.) Eshbaugh. These species are preserved in herbaria and described in articles through drawings, but few or no images are available. We wished to produce a better documentation of live plants and their details; so we planned a trip to Bolivia starting in the area where most of the less known species are concentrated. We visited the area around the Amboró National Park, from Santa Cruz de la Sierra up to Samaipata, Mairana and Comarapa (South side of the Park) and the area near Buena Vista (North side of the Park). We found populations of *C.minutiflorum* (Rusby) Hunz., *C.caballeroi* Nee, *C.eximium* Hunz., *C.baccatum* L. var. b*accatum*, *C.coccineum* (Rusby) Hunz., fully described and documented them with many detailed images. These species are well differentiated and each of them has particular characteristics. The Bolivian wild *Capsicum* appear to be quite rare. The search for some relevant species was not successful. Some areas where *Capsicum* were found in the past seem no longer suitable for wild species, because of the increase of agriculture and grazing. Unlike the wild species of South-East Brazil, Bolivian wild species are known by the locals who use them, know their common names (ulupica, aji de monte, arivivi) and their characteristics, including flowering and fruiting time. The exploration and the search for wild species in the Amboró Park Area in the past were limited to the peripheral areas of the park; probably more populations and perhaps new species live inside the Park, in areas difficult to reach and unexplored so far.

Keywords: ***Capsicum*, wild species, Bolivia, Amboró**

1. Introduction

Bolivia is believed to be the source of the genus *Capsicum*; possibly *Capsicum chacoense* Hunz. is the species closer to the ancestor of all *Capsicum* species.[1]

The most recent point of view on the origin and differentiation of the species of *Capsicum*[2] confirms this hypothesis, on the basis or morphology, geographical distribution, crossing tests, citogenetical and biochemical analisys, genoma etc.

About ten species of wild *Capsicum* grow in Bolivia:

Capsicum baccatum L. var. *baccatum*
Capsicum caballeroi Nee
Capsicum cardenasii Heiser & Smith
Capsicum ceratocalyx Nee
Capsicum chacoense Hunz.
Capsicum coccineum (Rusby) Hunz.,
Capsicum eshbaughii Barboza
Capsicum eximium Hunz.
Capsicum minutiflorum (Rusby) Hunz.

A couple of possible new species are under investigations; the main of these is the enigmatic *Capsicum pubescens* Ruiz & Pav. ssp. *arachnoideum* which could be the wild ancestor of *Capsicum pubescens* Ruiz & Pav (M.Nee, personal communication).

A possible new species was also recently collected in the province of Tomina, department of Chuquisaca.[3]

Many cultivated species are also grown and sometimes present in wild forms, especially *Capsicum pubescens*, *Capsicum frutescens* L., *Capsicum baccatum* L. var. *pendulum* (Willd.) Eshbaugh.

Botanists in the past did an enormous work of collection and documentation[4] and many of these species are preserved in herbaria and described in articles through drawings; however, few or no live images are available. In the last years many articles on wild *Capsicum* were published and an increased interest in the species of this genus can be noticed, especially in Bolivia[3]; nevertheless, images and detailed descriptions are scarce or totally absent.

We wished to produce a better documentation of live plants and their details; so we planned a trip to Bolivia on November-December 2015, starting in the area where most of the less known species are concentrated. Our goal was to document live plants and their habitat with good quality photographic images and to observe the characteristics of these species in the wild. Few images showing all the relevant details are better than many descriptions, even if, of course, the herbarium material is always irreplaceable. Therefore photos will be the most important part of our oral presentation.

Another important aim is to keep the interest on wild *Capsicum* species hoping to stimulate their study and conservation.

We are both members of the Italian Association "Pepperfriends" which has the statutory aim to deepen and spread the knowledge on *Capsicum* (especially wild ones) and to help preserving the biodiversity of this genus. Claudio Dal Zovo have previously completed four trips to South East Brazil (in 2011-2013) documenting about ten species endemic in that area.[5] Even at the beginning of this trip a day was spent in Brazil, visiting the Reserva Biológica at Paranapiacaba to clarify some points on *Capsicum dusenii* Bitter.

2. Material and Methods

We visited the area around the Amboró National Park, from Santa Cruz de la Sierra along the old road to Cochabamba, up to Samaipata, Mairana, Comarapa and El Empalme, on the South side of the Park, and the area near Buena Vista, in the North side of the Park.

The Amboró National Park covers an area of over 4,000 km² in the department of Santa Cruz; together with the adjacent Carrasco National Park, it's one of the most important conservation unit in South America. The Park is surrounded by a protected area called ANMIA (Área Natural De Manejo Integrado Amboró) or IMNA (Integrated Management Natural Area).

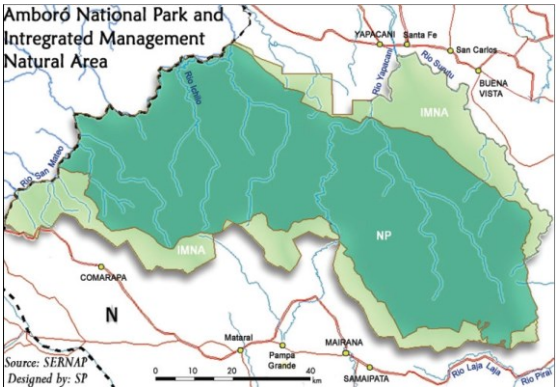

Fig. 1: Amboró National Park and IMNA

The Park contains many different habitats[6], being located at the confluence of several unique floristic regions: the tropical Amazon lowlands to the north and southeast, the subantarctic high Andes to the west and southwest, the subtropical Tucumán-Bolivian forests to the south, the semiarid inter-Andean valleys and the wet-tropical yungas forests that characterize the eastern slopes of the central Bolivian Andes.

The altitude varies from about 200-300 m asl in tropical evergreen rain forest along the northwestern border to over 3000 m in cool cloud forest on the highest peaks on the southwestern border.

The trip lasted two weeks, between late November and early December 2015. The park is the best place to start the exploration because endemic little known species not present elsewhere grow in it. The locations visited are in the provinces of Andrés Ibáñez, Florida, Manuel Maria Caballero, Vallegrande and Ichilo. The first stop was the wide Jardin Botanico of Santa Cruz de la Sierra, East of the city. Then we visited Quebrada Salada at Tarumá, the surroundings of the Rio Piraì at Bermejo, La Yunga de Mairana, Quebrada Seca at Mairana, the road from El Empalme to Khara Huasi, the high-altitude forest North of Comarapa (entering deeply in the park), Mataral, Vallegrande, the area South of Buena Vista along the Surutú river, the river bends towards El Carmen, the ANMIA area beyond the river up to La Chonta, the Park at the entrance of La Chonta.

To prepare the trip we studied almost all the literature available on the subject, including herbarium sheet labels. We received a lot of precious information by Prof. Michael Nee and Prof. Joshua Tewksbury. We planned a path to visit as much as possible of the sites where *Capsicum* species were collected in the past, compatibly with the available time. The dates of previous collections were also important to choose the best months to find both flowers and immature and ripe fruits. We have prepared a very accurate sheet to record the characteristics of the species without forgetting important details.

3. Results

Thanks to a precise planning, a well-established experience and a bit of luck, we found almost all the species that grow in the area. Also the trip period was the right one; we often found plants bearing flowers and fruits in various stages of maturation.

We found populations of the following wild species:

C.minutiflorum (Rusby) Hunz.
C.caballeroi Nee
C.eximium Hunz.
C.baccatum L. var. b*accatum*
C.coccineum (Rusby) Hunz.

Also individuals of the cultivated species *C.frutescens* were found in the wild.

These populations were fully described and documented with many detailed images.

The search for some other relevant species was not successful. We did not find *C.eshbaughii* and *C.pubescens* ssp. *arachnoideum*. Furthermore, we did not find a possible "new species" reported at La Yunga de Mairana, near the "bosque de helecios gigantes", at 2190 m (*Capsicum* sp, Serrano et al., 5482 NY).

Fig. 2: Capsicum caballeroi Nee

Capsicum caballeroi Nee (ají de monte, ulupica de yunga) grows in the "bosque nublado" (cloud forest) at 1900-2600m on South-West area of Amboró.[7]

We didn't find it in many of the sites where it was collected in the past; we only found it along the dirt road from El Empalme to Khara Huasi, West of Comarapa, at 2450 m asl.

In the site where our images were taken grow 2 very old plants and 1 young, small plant. The two adult plants do not seem healthy, bearing only few, small leaves; however they bear many flowers and fruits.

Plants are tall shrubs (up to 2.5 m). Leaves are lanceolate, light green, sometimes alternate along the branch in pairs of the same shape and size, coriaceous, almost glabrous or with sparse simple trichomes. Flowers are pendulous or intermediate, not geniculate, 1-2 per node, with long pedicel (3-5 cm). Calyx has 10 teeth, 5 long and 5 shorter (2-3 mm). Corolla is campanulate (15-20 mm long), bright yellow without spots; this is the main feature of this species. Anthers are yellow. Buds are tapered, bright yellow. Fruits are roundish, compressed in the apex, or irregular, with a diameter of 12-14 mm, pendulous, light green when immature, bright red when ripe, soft, deciduous (but not easy to pick up; may dry on the plant), very hot. Seeds are straw, 10-25 per fruit, large (3 mm diameter), reniform, regular in shape and size. Chromosomes number is not documented.

Fig 3: Capsicum coccineum (Rusby) Hunz

Capsicum coccineum (Rusby) Hunz. (ají de monte, aribibi silvestre, tà yejti) grows in the tropical evergreen forest (300-400m) on East side of Amboró. [8] [9] [10]

We only found it inside the Park at the entrance of La Chonta.

Plants are herbaceous or slender climbing shrubs. Leaves are ovate, sometimes in pairs of the same shape and different size, almost glabrous. Flowers are erect, geniculate, with short pedicel, many per node. Calyx has up to 10 teeth, 5 long and 5 shorter alternating. Corolla is stellate, creamy yellow with purplish-brown spots; anthers are yellow, stylus violaceous. Fruits are roundish, 7-8 mm in diameter, erect, green when immature, bright red when ripe, soft, very hot. Seeds are straw, few per fruit. The chromosomes number is not documented. The petioles are bent just a few mm above the junction with the stem; when the leaf dehisces, it leaves this few mm as a stub, which could help the plant in climbing among other plants.

We are not sure that this species is the same growing in Perù and Brazil.

Fig. 4:
Capsicum minutiflorum (Rusby) Hunz

Capsicum minutiflorum (Rusby) Hunz. grows in subtropical semi-deciduous forest (300-1000m) on South-East Amboró.[11] [10]

We found some isolated plants in the Jardin Botanico, four adults plants and other young plants along the Rio Piraì at Bermejo, other plants in the bends of the Surutú river near El Carmen. The plants prefer shady, moist places.

Plants are small trees (up to 3 m). Leaves are ovate, coriaceous, dark green, often in opposite pairs of the same shape and different size, almost glabrous with sparse unicellular trichomes. Flowers are erect, geniculate, with long pedicel (2-3 cm), 1-5 per node. Calyx has 5 teeth 2 mm long. Corolla is stellate (often quite closed), tiny (10-15 mm), creamy yellow with green marks; anthers are yellow. Buds are greenish. Fruits are roundish (sometimes with slightly pointed apex), 8-10 mm in diameter, erect or intermediate, green when immature, dark or bright red when ripe,

soft; their heat is variable, sometimes almost absent. Seeds are straw or brownish, irregularly shaped (roughly triangular), 2x3 mm, many per fruit; they are straw in fresh fruits, but become brownish after short air exposition. Seeds in some fruits dried on a plant (prostrate and with the stem partially broken) were brownish. The chromosomes number is not documented.

Fig. 5: Capsicum eximium Hunz

Capsicum eximium Hunz. (ulupica) grows in subtropical deciduous dry forest at 1700-2100m on South-West area of Amboró and Vallegrande. [12]

This species is spread in a wide area, for example even in the mesothermic valleys of the Department of Chuquisaca.

We found four adult plants at Comarapa (1900 m), bearing flowers and fruits. At Vallegrande (2080 m) we found many young plants flowering, but with very few immature fruits, because of rains delay.

Plants are tall shrubs (up to 3 m). Leaves are small, ovate with acute apex. Pubescence is variable in all parts of plant. Flowers are erect, pendulous or intermediate, not geniculate, with short peduncle (1-2 cm), multiple (2-4) per node. Calyx has 5 long teeth. Corolla is stellate, whitish or purple with green spots; anthers are yellow/gray. Buds are whitish or violaceous. Fruits are roundish, 5-8 mm in diameter, erect or intermediate, green when immature, dark red when ripe, soft, very hot. Seeds are brownish, irregularly shaped, few per fruit (4-5), small (2 mm diameter). Genoma has 24 chromosomes.

Fig. 6:
Capsicum baccatum L. var *baccatum*

Capsicum baccatum L. var. *baccatum* was found in many places around the Amboró limits and in the Jardin Botanico of Santa Cruz. [13] [14]

Plants are shrubs or small trees. Leaves are ovate with acute apex, sometimes slightly pubescent. Flowers are erect, geniculate, with long pedicel, 1-2 per node. Corolla is stellate, white with yellowish-greenish spots; anthers are yellow or grayish. Fruits are roundish with diameter of 8-10 mm, elliptic or elongated (up 20-30 mm), erect, green when immature, red when ripe, soft, quite hot. Calyx has 5 small teeth. Seeds are straw. Genoma has 24 chromosomes.

Fig. 7: Capsicum frutescens L.

Capsicum frutescens L. (aribibi, arivivi) was found along the dirt road to La Chonta (entrance to the East area of Amboró).

Plants are small trees. Leaves are ovate with acute apex, dark green, glabrous. Flowers are erect, strongly geniculate, with long pedicel, 1-2 per node. Calyx is

toothless. Corolla is stellate, greenish without spots; anthers are purple. Fruits are elongated (20 mm long, 6-8 mm in diameter), erect, green when immature, red when ripe, soft, very hot. Seeds are straw, many per fruit. Genoma has 24 chromosomes.

4. Discussion

The Bolivian wild species of *Capsicum* of Amboró are well differentiated and present many particular characteristics.

The most intriguing feature is the campanulate corolla of *C.caballeroi*. Only few species of *Capsicum* have the corolla campanulate: the first exception to the usual stellate corolla was found precisely in Bolivia: *C.cardenasii*.[15] Afterwards, the astonishing campanulate-urceolate corolla, entirely lilac-fuchsia, of *Capsicum friburgense* Bianchetti & Barboza was found in South-East Brazil.

Perhaps even the little-known *Capsicum scolnikianum* Hunz., has a similar corolla, but not so closed as in these species.

The heat (pungency) of fruits is very variable.

It's unexpectedly high in *C.caballeroi*.

C.minutiflorum heat varies from medium to almost inappreciable. Some populations of this species lacking any pungency were mentioned in literature; however, in all the fruits that we tasted the heat was detectable. The presence of individuals with pungent and not pungent fruits within the same species and the same population is probably important to understand the evolution of the genus *Capsicum*. [16] [17]

The variability of morphological traits in *C.eximium* is very interesting. In this area most flowers have withish corolla with green spots, but some individuals show a more or less purplish corolla; also buds can be white or purple even in plants growing side to side. In other areas of Bolivia (for example in the North of the Department of Chuquisaca), *C.eximium* has an entirely purple corolla (with greenish spots inside). Around Vallegrande many plants had very small flowers, but anthers of normal size; as a result the flowers appeared strange, with anthers of abnormal size. The pubescence of this species varies from plant to plant; some plants are quite or very pubescent. However, in very pubescent individuals we never found calyx with 10 teeth, feature that, together with pubescence and type of trichomes, differentiates *C.eshaughii* from *C.eximium*.

The Bolivian wild *Capsicum* appear to be quite rare. When found, there are always few individuals, not large populations of tens or hundreds of individuals (which is often the case in South-East Brazil). In South-East Brazil some species grow in very narrow areas (in some cases, few hundreds m^2), but other species may form large populations spread on a wide area. In Bolivia the wild species seem always spread on a wide area, but always in single individuals or very small populations. Only *C.eximium* and *C.chacoense* (not described in this article because it grows elsewhere) form quite large populations spread on a wide area.

Some species were not found in sites where they were present in the past. We visited promising sites, but in many cases we didn't find plants of *Capsicum* (but always a large number of *Solanum* sp.)

Some areas where *Capsicum* were found in the past seem no longer suitable for wild species, because of the increase of agriculture and grazing. For example, at La Yunga de Mairana, near the "bosque de helecios gigantes", at an altitude of about 2200 m, sites where *C.caballeroi* and a possible new species were found are now cultivated and fenced. However, these species should not be at risk of extinction because there can rely on a wide, still intact and partially unexplored habitat.

We had no luck in finding *C.eshbaughii* Barboza. Very few known sites exist for this species; it was collected near Mairana many years ago and initially described as *C.chacoense* or *C.baccatum* var *baccatum*. Later it was classified as *Capsicum eximium* var *tomentosum* Eshbaugh &

Smith [18]. Recently G.E.Barboza described it as species apart. [19]

We located Quebrada seca, one of the two original sites, the dry bed of a small river covered with dense vegetation. However, we didn't find this species nor other *Capsicum*. Perhaps the environment was too dry, the plants could have been in vegetative pause and start again after more rainfall. Further investigations will be necessary to verify if this species is still in the wild.

In the area around Mataral we didn't find *C.eximium* and especially *C.pubescens* ssp. *arachnoideum*. Locals told us that many plants of *C.eximium* grow in the area, but they were "palo seco" (only stem and branches, no leaves) because of scarce rainfall. The enigmatic "*arachnoideum*" was found sporadically, not in recent times; very few information are available on the places where it was found.

C.caballeroi, *C.minutiflorum* and *C.coccineum* don't appear to be close to any domesticated species.

C.baccatum var *baccatum* should be the wild ancestor of cultivated *C.baccatum*.[13]

C.eximium is related to *C.cardenasii* and probably *C.pubescens*; these species cross easily each other. Natural crosses between *C.pubescens* and *C.eximium* should be quite common and characterized by soft fruits larger than fruits of *C.eximium*. [20]

Plants of this type are commonly grown by people keen on Capsicum around the world and they are known with the name Rocopica (rocoto+ulupica). However, there is no information on this subject in literature. At the moment it is not clear if a true wild ancestor for *C.pubescens* exists.

Unlike the wild *Capsicum* of South-East Brazil, Bolivian wild species are well known by the locals who use them, know their common names (ulupica, aji de monte, arivivi) and their features, including flowering and fruiting time. Locals in Vallegrande, Comarapa and Mataral were able to give us precise indications on where to find plants and their vegetative stage. Locals in Buena Vista knew yellow-flowered *ulupicas* (probably *C.coccineum*) growing inside the Park. However, in towns that we visited, fruits of ulupicas were not sold in the markets; only locotos (*C.pubescens*) and Aji (*C.baccatum* var *pendulum*) were available.

The exploration and the search for wild species in the Amboró National Park Area in the past were limited to the peripheral areas of the park; probably more populations and perhaps new species live inside the Park, in areas difficult to reach and unexplored so far. So, there is still much to be explored.

5. Aknowledgements

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6. References

[1] M.J.McLeod, S.I.Guttman and W.H.Eshbaugh. Early evolution of chile peppers (Capsicum). Economic Botany 36:361–368, 1982.

[2] E.A.Moscone, M.A.Scaldaferro, M.Grabiele, N.M.Cecchini, Y.Sanchez Garcia, R.Jarret, J.R.Daviña, D.A.Ducasse, G.E.Barboza and F.Ehrendorfer. The Evolution of Chili Peppers (Capsicum - Solanaceae): a Cytogenetic Perspective. VIth International Solanaceae Conference, 2007, Acta Hort.745, ISHS.

[3] T.Avila, M.Atahuachi, X.Reyes, T.Claure and M.Van Zonneveld. Collection, taxonomic identification and cropping methodologies development for some species of Capsicum in Bolivia. The 21st International Pepper Conference (2012).

[4] W.H.Eshbaugh. Capsicum germplasm collecting trip – Bolivia 1987. Capsicum Newsletter 7, 24-26 (1988).

[5] C.Dal Zovo, G.Csilléry, G.Gatto. Exploring South-East Brazilian Wild Capsicum. Proceedings of the XV EUCARPIA Meeting on Genetics and Breeding of Capsicum and Eggplant. Pages 591-599. Torino, Italy (2013).

[6] M.Nee. Flora de la Región del Parque Nacional Amboró, Bolivia. Editorial FAN, Santa Cruz de la Sierra, Bolivia. Vol 2. (2004). (http://www.nybg.org/botany/nee)

[7] M.Nee, L.Bohs and S.Knapp. New species of Solanum and Capsicum (Solanaceae) from Bolivia, with clarification of nomenclature in some Bolivian Solanum. Brittonia, 58(4) pp. 322–356 (2006).

[8] H.H.Rusby. New species from Bolivia collected by R.S.Williams - II. Bulletin of the New York Botanical Garden 8(28):117 (1912)

[9] H.H.Rusby. Additions to the genus Lycianthes Dunal. Bulletin of the Torrey Botanical Club 53:209-213 (1926)

[10] A.T.Hunziker. Synopsis of the genus Capsicum. Huitieme Congrès International de Botanique. Paris 1954. Compte Rendu des Séances, Rapport & Comm. 4 (2):73-74 (1956)

[11] H.H.Rusby. Descriptions of new genera and species of plants collected on the Mulford biological exploration of the Amazon valley, 1921-1922. Memoirs of the New York Botanical Garden 7:343-344 (1927)

[12] W.H.Eshbaugh. Variation and evolution in Capsicum eximium Hunz. Baileya 21:193-198 (1982).

[13] W.H.Eshbaugh. A nomenclatural note on the genus Capsicum. Taxon 17:51-52 (1968).

[14] W.H.Eshbaugh. A biosystematic and evolutionary study of Capsicum baccatum (Solanaceae). Brittonia 22(1):31-43 (1970).

[15] C.B.Heiser, P.G.Smith. New species of Capsicum from South America. Brittonia 10:194-198,201 (1958).

[16] D.J.Levey, J.J.Tewksbury, M.L.Cipollini, T.A.Carlo. A Field test of the directed deterrence hypothesis in two species of wild chilli. Oecologia DOI 10.1007/s00442-006-0496-y (2006).

[17] J.J.Tewksbury, K.M.Reagan, N.J.Machnicki, T.A.Carlo, D.C.Haak, A.L.Calderón Peñaloza, D.J.Levey. Evolutionary ecology of pungency in wild chilies. PNAS vol.105 no.33 pp.11808-11811 (2008).

[18] W.H.Eshbaugh, P.G.Smith. A new variety of chilli pepper, Capsicum eximium var tomentosum (Solanaceae). Baileya 18:13-16 (1971).

[19] G.E.Barboza. Lectotypifications, synonymy, and a new name in Capsicum (Solanoideae, Solanaceae). PhytoKeys 2: 23–38 (2011)

[20] W.H.Eshbaugh. Chili peppers in Bolivia. Plant Genetic Resources Newsletter 43:17-19 (1980).