Passiflora
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THIS MONTH'S ISSUE ***Passiflora arborea. Passiflora edulis*** **in Ibadan. Colombian** ***Tacsonia*** ***and more....***

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Inside Cover: *Passiflora* 'Star of Bristol' by Myles Irvine
Back cover: *Passiflora grandiflora.* La Barbadine

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18 Hampton Court Parade
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Passiflora 'Star of Bristol'

Contents Issue 10

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Consumer awareness and consumption of Passion fruit in Ibadan Metropolis

Adegbite, O.O., Akinyemi, S.O.S., Amao, I.O and Adeoluwa, O.O
National Horticultural Research Institute, P.M.B 5432, Idi-Ishin, Ibadan, Nigeria *Corresponding author: olayinkadegbite@gmail.com*

ABSTRACT

Passion fruit (*Passiflora edulis*) is regarded as a powerhouse of nutrients having several antioxidants and vitamins. Despite this, its consumption is yet to receive wide acceptance among Nigerians. This study was carried out to assess consumer awareness and to identify factors that influence decisions on Passion fruit consumption. A three-stage sampling technique was used in selecting 100 respondents using semi-structured questionnaires. The data utilized in the study was obtained from 75 of these who were fruit consumers. Data was analyzed using Descriptive statistics and the 3-point Likert scale rating technique.

Results on consumer awareness indicated that only 41.3% of the respondents have heard about Passion fruit. Taking those aware as a sub-sample size (100%), the major nutritional benefit identified by respondents (55%) is high vitamins and mineral content while 43.6% got the information through friends and family. About 60% had seen Passion fruit before while 36.4% tasted or consumed Passion fruit for the first time in the last 2 to 3 years. Only 4.6% of those aware ever purchased Passion fruit. At N250/kg (about 50 USA Cents a pound) from a grocers they are seen as expensive.

Respondents ranked the availability of Passion fruit, awareness on the nutritional benefits and taste as the first three major factors that encouraged Passion fruit consumption. Ignorance of the nutritional benefits, only seasonal availability and market price are the major barriers to purchase and fruit consumption. The study recommends increasing promotional interventions for Passion fruit production, marketing and consumption to increase availability, driving demand and to prompt significant change in consumer behavior.

Keywords: *Passiflora edulis*, Consumer behavior, Nutrition and Health benefits.

INTRODUCTION

Passion fruit (*Passiflora edulis*) has been observed to be a rich store of nutrients, having high amounts of antioxidants, phytochemicals, minerals, vitamins and dietary fiber (Gahakwa et al., 2012) which could help alleviate some nutritional and health problems. Passion fruit is highly appreciated for its taste, both for fresh consumption and processed, including jams, jellies, fruit juice and many other foodstuffs. (Santos, 2012) Sometimes Passion fruit is added to food simply to enhance its aroma and taste (PSI, 2012). The fruit contains numerous small, black wedge-shaped seeds that are individually surrounded by edible orange-coloured arilswhich contain the juice (Joy, 2010). The oil extracted from the seeds, with properties similar to sunflower and soybean oil, is edible and of industrial importance (Bayeri, 2011).

Passion fruit is also widely used for medicinal purposes such as treatment of asthma, hypertension, articular degenerative diseases and cancer (PSI, 2012). Extracts of the yellow Passion fruit ((*Passiflora edulis* f. *flavicarpa*) can kill cancer cells in vitro and the phytochemicals responsible for these anti-cancer effects are thought to be carotenoids and polyphenols (Patel et al., 2009). The fruit is also used in the treatment of mood disorders (such as depression, anxiety, stress), insomnia, headaches, migraines, general pain, stomach problems and to relieve menstrual cramps and premenstrual syndrome (Joy, 2010). Based on these attributes, Passion fruit is gaining prominence among the diverse groups of people in the world (Das et al., 2013).

The genus which comprises about 530 species (Joy and Sherin, 2012), has about 40 species that could be considered edible. Of these, the two major recognized edible forms are the purple Passion fruit (*Passiflora edulis*) and the yellow Passion fruit (*Passiflora edulis* f. *flavicarpa*). The former grows best under subtropical climates while the latter prefers tropical conditions (Van Ee, 1999). The yellow Passion fruit, whose origin has been linked to Southern Brazil, was introduced from Europe and Asia into Nigeria in the 1980s (Alegbejo, 2004). Since then the yellow Passion fruit has been successfully adapted for development in Nigeria (Bayeri, 2011). The establishment and expansion of local large scale processors of fruit juice, expanding export markets and increasing population of health conscious consumers (Wangungu, 2012) in the last decade have made the Passion fruit sub-sector lucrative around the world.

Consumer awareness is the level of knowledge about a product purchased (Uwamariya, 2014). Fruit consumers worldwide are becoming more concerned about the health benefits of the fruits they consume. Despite Passion fruit having great potential to fascinate fruit consumers with its unique taste and delicious fruit juice (Das et al., 2013), Nigerians are not fully informed of its nutritional and health benefits. Passion fruit is still considered as a fruit for the elites in Nigeria. This might be one of the reasons for its underutilization and acceptance among consumers.

The World Health Organization, (2013) estimated that approximately 1.7 million (2.8%) deaths per annum worldwide are linked to malnutrition from low fruit and vegetable consumption., Effective promotion of fruit consumption will go a long way in achieving the aim of any food and nutrition policy interventions. (Rekhy and McConchie, (2014) Passion fruit

Previous research studies on Passion fruit (Bayeri, 2011; Aiyelaagbe and Abiola, 2008; Joseph-Adekunle and Fagbayide, 2008; Aiyelaagbe et al., 2005) had focused on the fruit production with regards to analyzing the effects of

nutrient application on seed quality, seedling emergence, growth and yield. However, the consumption of a fruit is as important as its production because consumer demand drives production. Based on the foregoing, it is imperative to assess the awareness and consumption of Passion fruit. The specific objectives are to:

- Determine the socioeconomic characteristics of the respondents.
- Assess consumer awareness and consumption of Passion fruit.
- Identify factors that can influence decision on Passion fruit consumption and constraints.

METHODOLOGY

Study area

The study area is Ibadan Metropolis, the capital city of Oyo state located in southwestern Nigeria in the southeastern part of the state about 120 km east of the border with the Republic of Benin. It is in the forest zone close to the boundary between the forest and the savanna. The city ranges in elevation from 150m in the valley area, to 275m above sea level on the major north-south ridge which crosses the central part of the city. Ibadan has a tropical wet and dry climate with a lengthy wet season and relatively constant temperatures throughout the course of the year. The mean total rainfall for Ibadan is 1420.06 mm, falling in approximately 109 days. There are two peaks for rainfall, June and September. The mean maximum temperature is 26.46°C, minimum 21.42°C and the relative humidity is 74.55%. The city's total area is 1,190 sq mi (3,080 km2). It lies at latitude 7°23'47''N and longitude 3°56'0''E. Its population according to 2006 census was 2,559,853 (NPC, 2006) split between 11 Local Government areas in Ibadan Metropolitan, consisting of five urban local governments in the centre of the city and six semi-urban local governments in the outer city. The five urban Local Government Areas in the metropolis are Ibadan North, Ibadan North East, Ibadan North West, Ibadan South East and Ibadan South West.

Method of data collection

The study utilized primary data collected with the aid of

semi-structured questionnaire using a three-stage sampling technique. The first stage involves the selection of the urban local government areas in Ibadan metropolis centre because exotic fruits are sold and purchased in these areas. Fruit consumers in these areas will be useful in providing information that can be utilized by the study. The second stage involves the random selection of Ibadan South west, Ibadan Northwest and Ibadan North local government areas. The third stage involves the random selection of 100 respondents. However data utilized by the study were obtained from 75 fruit consumers. Data collected from the respondents include; socioeconomic characteristics, basic characteristics of consumer awareness and consumption, consumer awareness on the nutritional benefits of Passion fruit, factors that can increase frequency of consumption and constraints to Passion fruit consumption. Percentage response on consumer awareness of the nutritional benefits of Passion fruit and consumption were based on the number of respondents that have heard about Passion fruit while responses on factors that can increase frequency of consumption and constraints to Passion fruit consumption were based on the total number of respondents.

Method of data analysis

The study utilized descriptive statistics (frequency, percentage and mean) to analyze the socioeconomic characteristics of the respondents; consumer awareness and consumption of Passion fruit. A 3-point likert scale rating technique was used to identify the factors that can influence decision on the purchase of Passion fruit consumption in the study area as well as constraints to consumption. Responses were ranked in the order: "Major Influence", "Minor Influence" and "Does not influence". A score of 3, 2 and 1 were assigned to each response respectively. The mean score was calculated as follows:

$$MS = (\sum (RO)/ F \quad (1)$$

Where R is the rating point, O is the number of observations and F is the total number of sampled respondents.

P. edulis f. *flavicarpa*

P. edulis f. *flavicarpa*

Responses were based on a weighted mean of the 3-point scale (3+2+1 =6/3 =2) and any variable with a mean point above 2.0 was considered a strong factor that influences decision on the purchase of Passion fruit. This was also used to identify the major constraints to consumption.

RESULTS AND DISCUSSION

Socioeconomic characteristics of Respondents

Results revealed that most of the respondents were female (64.9%) between the age of 20-40 years (91.2%) (Table1). About 54.7% of the respondents are single, having tertiary education (85.7%) with 84.9% less than N80,000 monthly income. This implies that majority of the sampled respondents are physically and psychologically active and educated consumers who are likely to appreciate the nutritional potentials of fruits and can influence decision on Passion fruit consumption among household members when they transit to wives and mothers. Rasmussen et al., (2006) reported that girls and women consume larger amounts of fruit and vegetables than boys and men. Also Ruel et al., (2004) found that female-headed households allocated a large share of their budget to fruit and vegetable consumption. Based on the results in Table 1 as indicated by the preferential consumption of fruits among respondents, the most consumed fruits include: banana, orange, pineapple, watermelon, mango and apple while the least consumed fruits include pawpaw, Passion fruit, grape, pear, guava and cashew. Layade and Adeoye (2014) also reported that the most preferred fruit by students was banana (34%), followed by water melon (27%) and the least preferred were pawpaw (2%) and cashew (1%).

Consumer awareness and consumption of Passion fruit

This study revealed that 41.3% of fruit consumers have heard about Passion fruit (Table 2). This indicates a low level of awareness. However, the majority of the consumers that are aware of this fruit really understand the nutritional benefit especially the vitamin and mineral content. Fifty five percent of them are aware of the Vitamin A, B, C and mineral content, as source of antioxidants and phytochemicals (39%) and pleasant taste and aroma (37.5%). Only twenty five percent are aware that Passion fruit can be used to prevent cardiovascular diseases, cancer as well as using it to treat Insomnia and sleep disorders. Friends and family are the major source of information (43.6%) on the awareness of the nutritional and health benefits of Passion fruit. About 60% had seen Passion fruit before while 36.4% tasted or consumed Passion fruit for the first time in the last 2 to 3 years. Only 4.6% of

those aware ever purchased Passion fruit (N250/kg from grocery). This implies that Passion fruit consumption is relatively new in the study area and existing consumers are infrequent buyers of the fruit. Consumer preference for source of subsequent purchase is rural/urban market (61.1%) while 38.5% are willing to pay N50/fruit.

Factors that can influence decisions on Passion fruit consumption

These include: Availability/ ease of access to buy the fruit, Availability of the fruit juice/mixed with other fruit juices, Appearance of the fruit, Amount of cash at hand, Market price of the fruit, Season, size, Doctor's recommendation, Colour, Taste and Awareness of the nutritional and health benefits of the fruit (Table 3). The mean values from the 3-point likert scale rating technique indicated that, Availability (2.66), Awareness of the nutritional and health benefits (2.56) and Taste (2.46) were the three most important factors that can influence decision of respondents to consume Passion fruit. This contradicts the finding of Jones, (2011) who reported that Passion fruit consumer purchase decision is mainly driven by appearance, feel and price.

Constraints on Passion fruit Consumption

Identified constraints to Passion fruit consumption in the study area include: Ignorance of the nutritional benefits of Passion fruit, none availability throughout the season, market price of the fruit, do not like the fruit and sales of Passion fruit in expensive stores and supermarkets. Considering the mean values from the 3-point likert scale rating technique, results revealed that the three major constraints to Passion fruit consumption include: Ignorance of the nutritional benefits (2.59), Non availability in the market throughout the season (2.50) and Market price of the fruit (2.49) (Table 4). This supports the findings of Jones, (2011) that barriers to purchasing Passion fruit are availability and price. Moreover, the opinion that consumers do not like Passion fruit constitutes the least constraint to consumption (1.95). This indicates an opportunity to explore the potentials of Passion fruit among fruit consumers by increasing awareness of the nutritional benefits as well as increasing production and marketing to reduce non availability.

CONCLUSION AND RECOMMENDATION

Passion fruit consumption is yet to receive wide acceptance among fruit consumers in the study area despite its numerous nutritional and health benefits. Only 41.3% of the fruit consumers have heard about Passion fruit which indicated a low level of awareness. Fruit consumers that are aware of the nutritional benefits of Passion fruit really understand it has high vitamins and mineral content. Passion fruit consumption is relatively new in the study area and existing consumers are infrequent buyers (only 4.6% of those aware, purchased Passion fruit for the first time in the last 2-3 years). Availability of Passion fruit, Awareness of the nutritional benefits and taste are the major factors that influence decision on Passion fruit consumption. Increased awareness and consumption of Passion fruit will not only provide nutritional and health benefits but will also develop the industry and provide economic benefits to the country. The study therefore recommends increase in promotional interventions and campaigns for Passion fruit production, marketing and consumption. This will increase availability, drive demand as well as prompt significant change in consumer behavior towards the fruit.

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Table 1: Socioeconomic characteristics of respondents

Variable	Characteristics	Percentage
Sex	Male	35.1
	Female	64.9
Age (Years)	20-30	62.0
	31-40	28.2
	41-50	7.0
	51-60	2.8
	20-30	62.0
Marital Status	Single	54.7
	Married	45.3
Level of Education	Non-formal	-
	Primary	1.4
	Secondary	11.1
	Tertiary	85.7
Household Size	0-4	32.9
	5-9	63.0
	10-14	2.7
	15 and Above	1.4
Monthly Income	< N20,000	40.4
	N20,000 – N49,000	30.2
	N50,000 – N79,000	13.2
	≥N80,000	15.1
Preferential consumption of Fruits	Orange	+++
	Pineapple	+++
	Banana	+++
	Pawpaw	**
	Mango	+++
	Passion fruit	**
	Grape	**
	Pear	**
	Guava	**
	Watermelon	+++
	Apple	+++

Source: Field survey, 2014
Note: +++ = Most consumed fruits; ** = Least consumed fruits

Table 2: Basic characteristics of Passion fruit consumer awareness and consumption

Variable Description	Yes (Percentage)	No (Percentage)
Consumer Awareness		
Heard of Passion Fruit	41.3	58.7
Awareness of Nutritional & health benefits of Passion fruit		
High Vitamin C content, Vitamin A, Vitamin B and minerals	55.0	45.0
Source of Antioxidants and phytochemicals	39.0	61.0
Lowering High blood pressure	27.5	75.5
Treating Insomnia and sleep disorders	25.0	75.0
Relieving Asthma symptoms	30.0	70.0
Help in the prevention and control of Diabetics	27.5	75.5
Help in the prevention of cardiovascular diseases and cancer	25.0	25.0
Pleasant taste and aroma	37.5	62.5
Source of Information on Passion fruit Awareness		
Self	22.5	77.5
Radio	2.5	97.5
Television	5.1	94.9
Agricultural Magazines	12.8	82.7
Friends and family	43.6	56.4
Research organization	23.1	76.9
Academic Institutions	14.7	85.3
Medical recommendation/Hospital	2.5	97.5
Consumer experience with Passion fruit	**Characteristics**	**Percentage**
Seen Passion fruit before	Yes	60.0
	No	30.0
Tasted /consumed Passion fruit before	Yes	36.4
	No	63.6
When tasted/consumed	≤ 2010	-
	2011-2012	21.4
	2013-2014	78.6
Frequency of Consumption	≤ 5 months	2.3
	6-12 months	2.3
	Less often	31.8
	Not at all	63.6
Purchased passion fruit before	Yes	4.6
	No	95.5
Amount paid to purchase Passion fruit	N250/kg	
Source of purchase	Urban market	50.0
	Grocery store	50.0
Consumer preference for source of subsequent purchase of Passion fruit	Farm gate	5.6
	Rural/Urban market	61.1
	Grocery store	13.9
	Street/Road side hawkers	19.5
Amount willing to pay per fruit	≤N20	19.2
	N30	7.7
	N40	3.9
	N50	38.5
	>N50	30.8

Source: Field survey, 2014

Wiki

Table 3: Factors that can influence decision on Passion fruit consumption

Factors	Major Influence	Minor Influence	Does not Influence	Mean	Rank
Availability/ease of access to buy the fruit	77.3	11.4	11.4	2.66	1
Availability of the fruit juice/mixed with other fruit juices	57.1	31.0	11.9	2.45	4
Appearance of the fruit	46.3	36.8	17.1	2.29	7
Amount of cash at hand	46.3	26.8	26.8	2.20	9
Market price of the fruit	50.0	33.3	16.7	2.33	5
Season	47.6	33.3	19.0	2.29	7
Size	24.4	34.1	41.5	1.83	10
Doctor's recommendation	54.8	21.4	23.8	2.31	6
Colour	21.4	38.1	40.5	1.81	11
Taste	63.4	19.5	17.1	2.46	3
Awareness of its nutritional & health benefits	86.0	7.0	7.0	2.56	2

Source: Field Survey, 2014

Table 4: Constraints on Passion fruit consumption

Constraints	Major Influence	Minor Influence	Does not Influence	Mean	Rank
Ignorance of the nutritional benefits	73.8	14.3	11.9	2.61	1
Non-availability in the market throughout the season	84.1	4.5	11.4	2.50	2
Market price of the fruit	58.1	32.6	9.3	2.49	3
Do not like the fruit	26.8	41.4	31.7	1.95	5
Sales of Passion fruit in expensive groceries and supermarkets	51.2	26.8	22.0	2.29	4

Source: Field survey, 2014

Wiki

Collecting passionflowers... for science!

Harlan T. Svoboda
Department of Environmental & Plant Biology,
Ohio University
Email: hs923311@ohio.edu

Figure 1 © University of South Florida Herbarium

The importance of biological collections for scientific research cannot be overstated in our changing world. Collections of pressed plant specimens—called herbaria—have existed since the 16th century and currently house upwards of 350 million sheets worldwide.

Field botanists often have their own style when collecting, but there are specific conventions that should be followed to produce a scientifically valuable specimen. General procedures can be found from a number of resources including a book, The Herbarium Handbook, published by the Royal Botanical Gardens, Kew.
The vining habit of most *Passiflora* species presents unique difficulties in preparing specimens, particularly when trying to physically press the unruly plants. (The complex and intricate flowers aren't easy to press, either!) The purpose of this article is designed to help Passiflora enthusiasts and amateur botanists collect and prepare passionflower specimens for preservation in a herbarium for future scientific study. These best practices are based on several thousand specimens that I have looked at and use for my research.

From the start it is important to keep in mind what your final product is going to be: an important specimen that will last for centuries—perhaps millennia—preserved in herbarium. There is no telling what the future may hold in terms of possibilities for the scientific applications of herbarium collections. (Do you think Linnaeus thought we would be able to extract DNA from specimens and discover their evolutionary relationships?!)

1) FIELD OBSERVATIONS

Some of the most important information for a good collection comes from observations made in the field (or garden, greenhouse, yard, etc.) and for that reason you should always bring a notebook with you while collecting.

- Record any information that won't be readily observed on the pressed specimen. This could include color of the flower and fruit (as these tend to fade over time after pressed), or the height of the plant.
- If you can identify some of the locally abundant plant species ("associated taxa"), include these also. It may be particularly interesting to record what plant, if any, the vine is growing on.
- Make an estimate of the local abundance of the plant you are collecting.
- Consider local environmental variables, which might include: habitat (e.g., forest vs. savannah), soil type (sand vs. rich loam), light intensity (sunny vs. shade), slope, and anything else that can't be observed from the specimen alone.
- If possible, record the precise GPS coordinates of the location. This can be accomplished with a dedicated GPS device or even an app on your smartphone. Alternatively, you can use www.gps-coordinates.net to find the location and retrieve the coordinates at a later time.
- The elevation (in meters) should be recorded, if possible.
- Photographs of the plant's habit, flowers, fruits, etc. can be an invaluable addition to the specimen. These should be printed out and will end up being attached to the specimen as an additional resource.

2) COLLECTING

The ideal specimen should include as many organs of the plant as possible.

- If possible—and if the plant has all of the parts—collect a portion of the stem with attached leaves, a flower, and fruit. (If there is no portion that contains all parts, you can collect individual leaves/flowers/fruits to press and attach separately.)
- Roots can also be collected and don't need to be attached to the rest of the specimen. Shake off any excess dirt to clean it off as best as possible.
- If enough material exists, collect additional leaves to be pressed separately. These will end up in a "fragment packet" on the sheet and are often crucial for any subsequent studies requiring DNA.
- Although not necessary, it is a good idea to collect duplicates of the same plant to make one or more duplicate specimens that can later be sent to multiple herbaria.

3) PRESSING THE SPECIMEN

Figure 2. A typical plant press.

Plant presses (**Figure 2**) can be found online for purchase, or can easily be made at home with some wood pieces and straps. Additional materials needed include corrugated cardboard and newspaper.

- Designate a unique "collector number" for each of the specimens you have collected. (Duplicate specimens will all have the same number.)

- To keep track of each specimen and its accompanying number, you can write it on a slip of paper to be pressed with the plant, attach a stringed ID tag, or simply write it directly on the newspaper.

- The collected specimen(s) should fit neatly inside of a newspaper sheet. The plant will have to fit on a 16.5in x 11.5in (42cm x 29cm) herbarium sheet when mounted.

- Between the sheets of newspaper, carefully arrange the specimen as you want it to look when completely finished. (It is often impossible to adjust the position/form of the plant after it is completely dried—think of it as "plant rigor mortis"—without damaging it.) Good examples can be seen in **Figures. 1, 3 and 6.**

- As you slowly close the newspaper, try to make the plant as flat and non-overlapping as possible (e.g., avoid having many leaves on top of leaves if possible).

- Turn a few leaves over so that some show the underside and some show the topside. This is helpful so that specialists can see and study both leaf surfaces when the specimen is later glued down.

- Additional materials (e.g., extra leaves or flowers collected earlier) can be pressed in the same newspaper as long as it belongs to the same collector number. These will either be glued on the sheet separately or placed in a fragment packet.

- Place cardboard on top of the specimen in the newspaper and repeat the procedure for all remaining specimens.

- Apply pressure to the plant press (the more the better) as you tighten the straps; or just place something really heave on top of it. (I often stand directly on the press while I tighten the straps.)

- It is ideal for the specimens to dry quickly to avoid molding and rotting. (I have had success leaving the entire press in my car for a few days during the summer.)

Fig. 3 © Missouri Gardens Herbarium. An exemplary herbarium specimen. On this sheet the leaves are spread out (some of which show the underside), there are very little overlapping areas, and the flower is flattened appropriately.

4) MAKING THE LABEL*

Other than the plant itself, the usefulness of the specimen is dependent on the quality of the label. Labels are often "good," "bad," or "ugly" (**Figure 4**) but can be improved by following the example of **Figure 5**.

- The name of the species you collected. If you're not entirely sure about the identity of a plant, leave a blank spot on the label so that someone else can come along later and fill that in.

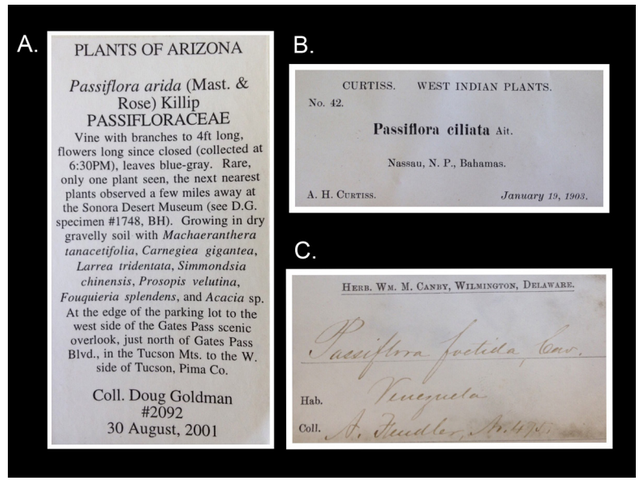

Figure 4. Specimen labels with varying amounts of information (the "good, the bad, and the ugly"). A. An example of a good label with most of the appropriate data; B. An example of a label missing important information; C. A label that provides almost no usable information.

PLANTS OF ATHENS COUNTY

***Passiflora incarnata* L.**

USA, Ohio, Athens County
Next to sidewalk leading to the N entrance of the Field Station; Open field, with *Paspalum* sp., *Ligustrum sinense*, *Hibiscus* sp., *Viola sororia*.
39.35367 -82.09529
Elev. **268 m**
Herbaceous vine climbing over shrubs. Flowers lavender-white with dark purple and white corona filaments. Fruit pale green and slightly inflated when ripe.

H. T. Svoboda 327 24 Oct 2016

Floyd Bartley Herbarium, Ohio University

Figure 5. An example of a specimen label with the necessary data present.

Figure 6 © Duke University Herbarium

- Include all pertinent locality information, including country, state, county, proximity to nearest city, etc. and GPS coordinates, if available.

- Environmental data collected on-site (e.g., elevation, habitat, soil type, etc.) and any associated taxa.

- Any morphological data (e.g., fruit color, height, etc.) collected on-site.

- The collector's name and unique collector number.

- The date on which the specimen was collected.

- Because of the differences in date formats between countries, write out the month (i.e., "12 March 2017" instead of "3/12/17" since the latter could be interpreted as either "March 12th" or "December 3rd" depending on one's native formatting).

- If you know for a fact that the plant you collected from is cultivated, indicate that with the word "Cultivated" somewhere on the label.

*NOTE: If you print your label(s) yourself, it MUST be on cotton paper!! This is sold commercially usually as "résumé paper."

5) PERMANENT PRESERVATION

Once the plant is completely dried and the label is ready to go, the specimen is ready to be preserved in a permanent collection, as most herbaria gladly accept donations of specimens.

- Find your local herbarium using the Index Herbariorum database (www.sweetgum.nybg.org/science/ih/) and contact the curator or collections manager at that institution.

- Specimens are typically donated in their original newspaper "home" with any additional materials (e.g., extra leaves, photographs, your label, etc.) also inside.

If you have any questions, need a specimen label template, or want to learn more about specimen preservation, please contact me.

Kew Herbarium © RBG Kew.

Genetic Resources of Colombian *Tacsonias* (*Passiflora* supersection *Tacsonia*): A biological treasure still to discover, use and conserve

John Ocampo[1], Geo Coppens d´Eeckenbrugge[2], Gustavo Morales[3]

[1] *Universidad Nacional de Colombia Palmira branch - UNAL/CIAT*
[2] *Centre de Coopération Internationale en Recherche Agronomique pour le Développement – CIRAD, UMR AGAP, Montpellier, France.*
[3] *Jardín Botánico de Bogotá José Celestino Mutis – JBB / Currently Aldea Proyectos S.A.S - Aldea*

History and taxonomy

The first report of *Tacsonia* appeared in 1789 in the book *Genera Plantarum* published by A. L. de Jussieu, who considered the species *P. mixta* and *P. adulterina* described in 1781 by Linnaeus junior (L. f.) sufficiently distinct from previously described species of *Passiflora*, to justify the creation of a new genus within Passifloraceae. *Tacsonia* was maintained as a genus and divided in different sections by de Candolle (1828), Reichenbach (1828), Rafinesque (1838), Roemer (1846), Karsten (1857, 1858), and Master (1872). Later, Triana & Planchon (1873), Harms (1925) and Killip (1938) recognised *Tacsonia* at the subgenus level and the latter described 38 species in his work *The American species of Passifloraceae*. In 1988, Escobar (1988) revised the Colombian species, including new ones, dividing the subgenus *Tacsonia* into 11 sections and three series. More recently, the classification of Feuillet & MacDougal (2003) downgraded *Tacsonia* to the supersection level in subgenus *Passiflora*. The subgenera *Manicata*, *Rathea* and *Tacsoniopsis*, recognized by Escobar (1988, 1989), were integrated as sections of *Tacsonia*. Currently, supersection *Tacsonia* comprises 65 species, including five species described in the 21st century (*P. tarminiana* Coppens & Barney, *P. carrascoensis* P. Jørg. & R. Vasquez, *P. unipetala* P. Jørg., Muchhala & J. M. MacDougal, *P. kuethiana* B. Esquerre, and *P. salpoense* S. Leiva & Tantalean).

Morphology

The species of supersection *Tacsonia* are woody vines, usually climbers with tendrils, axillary stipules and petiolar nectary glands (**Figure 1** pp. 26-27). In addition *Tacsonia* exhibit large, brilliant pink, violet or scarlet red flowers with unique floral features such as, a cylindrical elongate floral tube or hypanthium reaching up to 14 cm long, a corona reduced to short tubercles (ca. 1 mm long) or short filaments, and a limen-operculum system that limits the access to the nectary chamber. Their fruits are smooth, glabrous or pubescent, and have an impressive interspecific variation in size, shape and colors (**Figure 2** and **5** p.29).

Although supersection *Tacsonia* (Juss.) Feuillet & J. M. MacDougal constitutes a very young group (Abrahamczyk et al. 2014) and exhibits a high number of common traits, its species display large intraspecific variability in size and colors for many traits, such as leaves and flowers (Ocampo & Coppens d´Eeckenbrugge 2017). However, there are many cases in low level taxa as sections and series, where two or more species are difficult to distinguish (e.g. *P. cremastantha* Harms vs. *P. leptomischa* Harms).

Reproductive biology

Tacsonia species are diploid, with $2n = 18$ (De Melo et al. 2001) and according to Escobar (1985, 1989), self-compatibility is the rule in *Tacsonia* and section *Manicata*, producing seeds and fruits after controlled self-pollination. With cross pollination however, fruit set is increased. (Primot et al. 2005; pers. obs. Gustavo Morales). Out of the 65 species recorded 37 are pollinated primarily by the sword-billed hummingbird, *Ensifera ensifera* Lesson;. (**Figure 3**). The remaining species have smaller sized hypanthiums, i.e. from 1 to 3 cm long, (Abrahamczyk et al. 2014) and are pollinated by several species of short-billed hummingbirds or bats.

Distribution and ecology

The uplifting of the Andes created new habitats and favored local isolation, inducing high speciation rates in many taxa. Supersection *Tacsonia* provides a particularly striking example, with its exclusively South American distribution, from Venezuela to Bolivia **(Figure 4** p. 28**)**, in cloud forests (**Figure 11** pp. 40-41, **Figure 12** pp. 42-43) of the Tropical Andes and the Sierra Nevada de Santa Marta (northeastern Colombia) from 1700 to ca. 4300 m, at the limits of 'páramo' and 'puna' (Ocampo et al. 2014). The páramo is the ecosystem of the regions of the tropical Andes above the continuous forest line, yet below

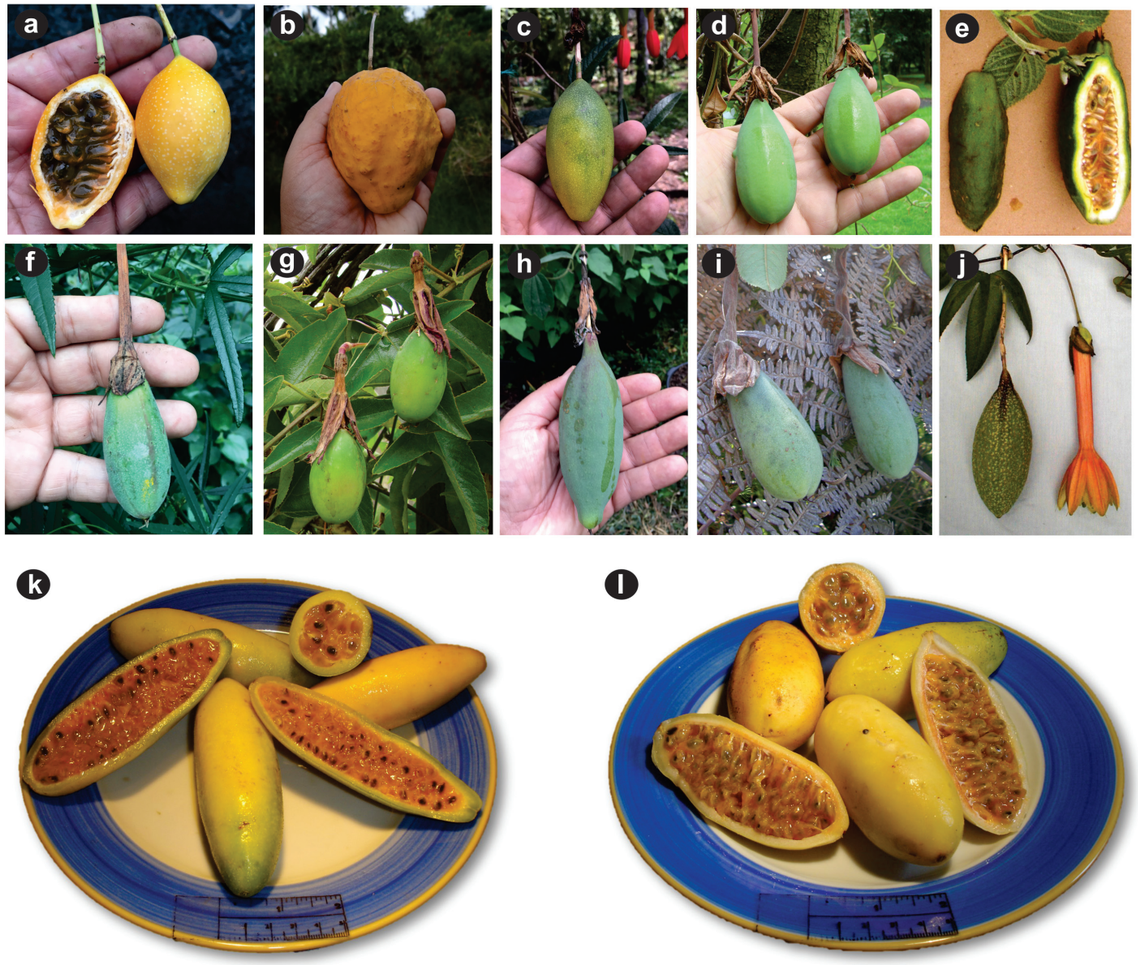

Figure 2. Fruit variability. a *P. adulterina*, b *P. parritae*, c *P. rugosa* var. *rugosa*, d *P. cumbalensis*, e *P. teneriferensis*, f *P. tripartita* var. *tripartita*, g *P. manicata*, h *P. antioquiensis*, i *P. mixta*, j *P. linearistipula*, k *P. tarminiana*, l *P. tripartita* var. *mollissima*. © John Ocampo.

Figure 3. The sword-billed hummingbird (*Ensifera ensifera*) © Peter Rockstroh

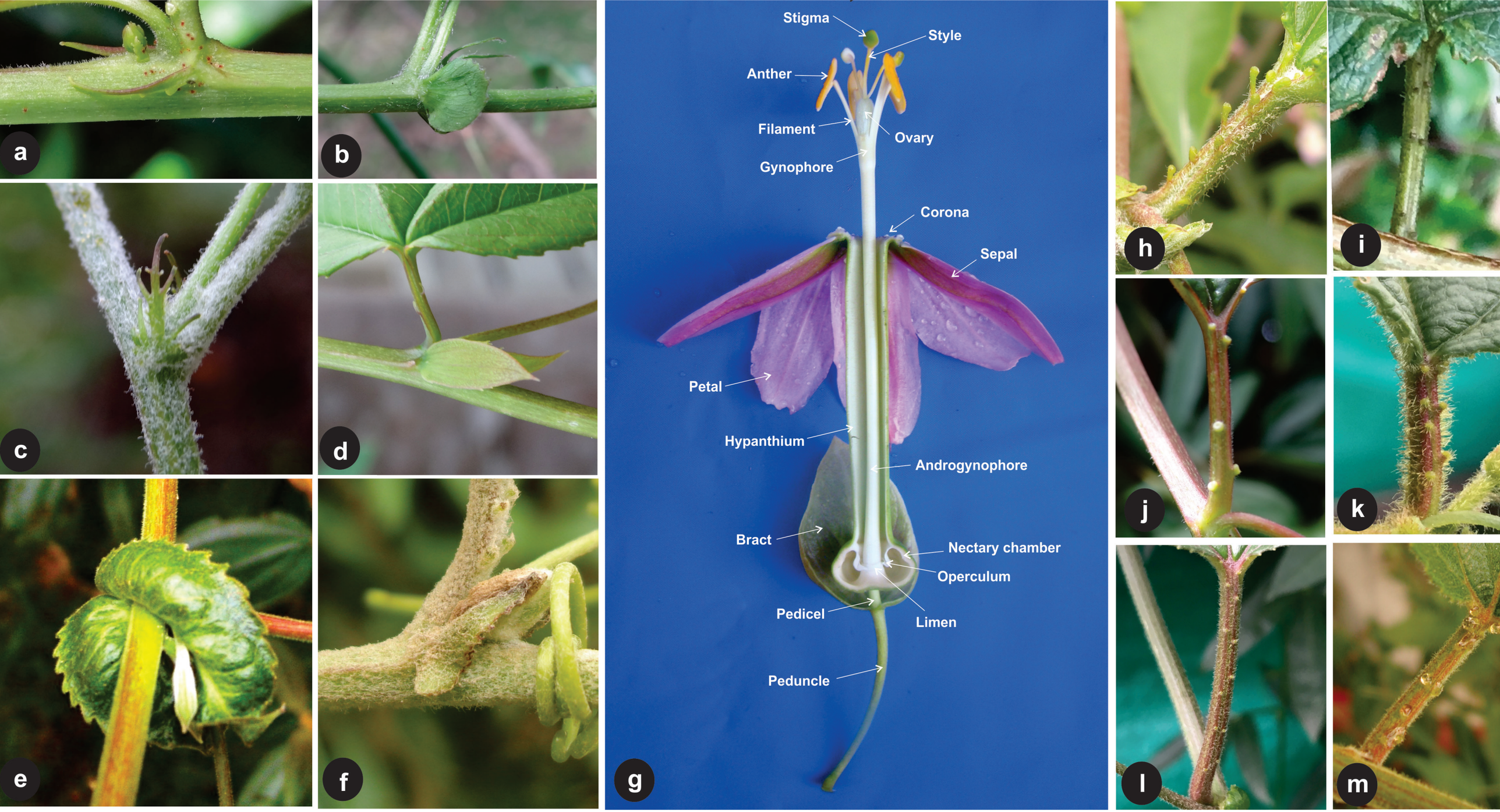

Figure 1. Morphological variability in the supersection *Tacsonia*. (a, j) *P. parritae*, (b, i) *P. tripartita* var. *tripartita*, (c) *P. pinnatistipula*, (d) *P. colombiana*, (e, h) *P. mixta*, (f) *P. crispolanata*, (g) *P. tarminiana*, (i) *P. cremastantha*, (k) *P. rugosa* var. *rugosa*, (m) *P. antioquiensis*. © John Ocampo.

the permanent snowline and the puna are the grasslands within that area.

This group of 65 inventoried species shows a marked adaptation to growing in forests on highland slopes with abundant everyday rainfall (2000 to 3000 mm on average per year) and temperatures range from 0 to 15 ºC (Schwerdtfeger 2004). The *Tacsonia* group is monophyletic and diverged from the remaining *Passiflora* approximately 10.7 Ma ago (underwent radiation at 9–8 Ma), during a major uplifting phase of the northern Andes (Abrahamczyk et al. 2014).

Economic importance

Many of the *Tacsonia* species are of economic importance because of their fruit quality, their adaptability for cultivation as ornamental vines, or their medicinal properties (Coppens d´Eeckenbrugge 2003; Zucolotto et al. 2011). Among these species, 22 are reported as having edible fruits and two (*P. tarminiana* and *P. tripartita* var. *mollissima* (Kunth) Holm-Nielsen & Jørgensen) have been cultivated for centuries by the indigenous people of the Andean region under different names such as *tacsos, curubas* or *puru puru* (Ulmer & MacDougal 2004; Ocampo et al. 2014). These *tacsos* or *curubas* are represented in almost all the tropical Andes and are found escaped in the wild in Mexico, La Réunion Island (France), East Africa, Hawaii (U.S.A), New Zealand, and even in the Canary Islands (Schwerdtfeger, 2004), particularly *P. tarminiana*, which is known as *banana passion fruit* or *banana poka*. The fruits of these species (**Figure 5**) are consumed as fresh fruit and are used in preparations as juices, cocktails, ice cream and other desserts. The nutritional information content on these species is scarce and there are only few reports of *P. tripartita* var. *mollissima*, which stands out for its high Vitamin A and C, and mineral content.

Colombian curubas

Colombia's location and variety of ecosystems places the country in second place only to Brazil with regard to biodiversity, but it is in first place measured per square kilometer. (Myers et al. 2000). The country has a complex topography and is divided into six main biogeographic regions (Amazonia, Andes, Caribbean, Orinoquia, Pacific and Insular), covering an area of 1,141,748 km^2. The Andean region has a highly varied topography with a wide range of altitudes (from 100 to 5400 m), and three long mountain ranges separating two main inter-Andean valleys from the other regions. Colombia is the region richest in *Passiflora* with 174 recorded species mainly distributed in the Andean region (84%) between 1000 to 3000 m, with the most common ones thriving in disturbed habitats, such as roadsides, cultivated land, and secondary forests (Ocampo et al. 2007, 2010). Among the species reported, 71% are threatened to some degree and three are considered extinct. The genus *Passiflora* is considered as an indicator of biodiversity in Colombia as its species have ecological

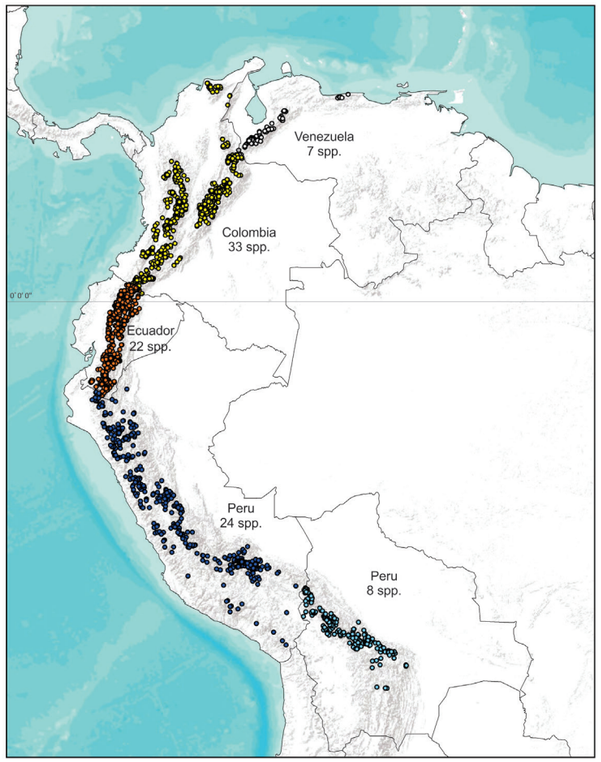

Figure 4. Spatial distribution of the species of supersection *Tacsonia*.

interactions with many organisms, comprising herbivores (particularly *Heliconius* spp. butterflies), protective ants, pollinators, and the plant communities providing them physical support and access to sunlight (Escobar 1988; Holm-Nielsen et al. 1988; Ocampo et al. 2010).).

Supersection *Tacsonia* displays the highest *Passiflora* species richness and endemism in Colombia with 33 reported species (**Figure 6** p. 30) that are divided into nine sections (Ocampo et al. 2014) and distributed from 1700 to 3840 m. (**Table 1** p. 48-49). Among them, 22 are endemic to Colombia and most have a restricted distribution to only one department (e.g. *P. cremastantha*, *P. formosa* T. Ulmer, *P. jardinensis* L. K. Escobar, *P. pamplonensis* Planch. & Linden ex Triana & Planch, *P. quindiensis* Killip, *P. tenerifensis* L. K. Escobar and *P. uribei* L. K. Escobar). The most important reference works that documented all species of *Tacsonia* and described nine new species between the years 1986 to 1992 were carried out by Linda K. Albert de Escobar (1988, 1989). Additionally, Escobar proposed sections *Colombiana*, *Parritana* and *Fimbriatistipula*, whose species are mostly distributed in Colombia. Section *Colombiana*, distributed in the center of the cordilleras, and from the northeast and up to the Venezuelan Andes, is often characterized by a very long peduncle and linear-lanceolate stipules. In addition to this important taxonomical work, several collaborative projects have focused on Passifloraceae, within the frame

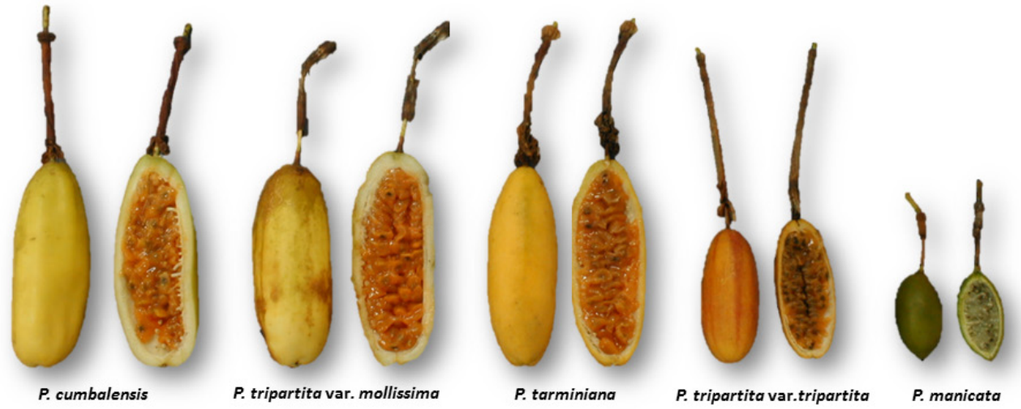

Figure 5. Examples of *Tacsonia* fruit © John Ocampo

of regional projects, supported by institutions such as Bioversity International, Colciencias, International Center for Tropical Agriculture (CIAT), Corpoica, Universidad de Caldas and the Ministry of Environment (MADS). They have generated a considerable amount of information such as the identification of species (*P. tarminiana*), new to science or to the country, and the study of the genetic resources of these species (Coppens d´Eeckenbrugge et al. 2001; Segura et al. 2002, 2003, 2005; Ocampo et al. 2004; Primot et al. 2005).

Several authors have reported easy interspecific hybridization in supersection *Tacsonia*, involving cultivated as well as wild materials (Escobar 1985, Primot et al. 2005). The interspecific hybrids may be viable and fertile or exhibit serious anomalies for several generations, as in the case of *P. tripartita* var. *mollissima* x *P. cumbalensis* (H. Karst.) Harms (Schöeniger 1986). Spontaneous hybridizations in the wild may have led to some over classification in this supersection. For instance, of the 33 species reported for Colombia, five (*P. cremastantha*, *P. formosa*, *P. pamplonensis*, and *P. purdiei* Killip) are known only from the type material. Whether this is due to high endemism, ancient extinction or atypical specimens resulting from hybridization, cannot be ascertained unless a second specimen is recorded, as could be done for *P. linearistipula* (Ocampo et al. 2007).

It is important to note that *P. formosa* was described as a new species from the same specimen considered as an atypical specimen of *P. lanata* (Juss.) by Escobar (1988). Over classification may be suspected even in better-known species as *P. parritae* (Mast.) Bailey, and *P. jardinensis* L.K. Escobar. Indeed, in populations of the former, we have observed sufficient morphological variation to include the few known specimens of the latter, which seems to represent just an isolated population. Likewise, in several cases, experts or *Passiflora* enthusiasts may have underestimated intraspecific variation in widely distributed and highly polymorphic species, or even intra-individual variation, splitting well known species in several new species only distinguished by a few quantitative or color traits (Ocampo & Coppens d´Eeckenbrugge 2017). For instance, a revision of field, herbarium and literature data leads us to consider that three species reported for Colombia in 2016 (*P. quinonesiae*, *P. splendida* and *P. creuci-caetanoae*) are likely synonyms for *P. cuatrecasasii*, *P. cremastantha*, and *P. rugosa* var. *rugosa*, respectively.

Most endemic species of *Tacsonia* were found in highlands difficult to access, and it is reasonable to expect more species to be described from currently poorly explored areas, such as the South of Huila, Tolima, Santander and Norte de Santander departments. The limited number of explorations in these regions of the northern Andes raises expectations that Colombia may harbor many yet unknown species, and future studies should encompass new regions, including protected and conflict areas (Ocampo et al. 2010).

Commercial and cultivated species

The most popular species are called *curubas* in Colombia and *tacsos* in Ecuador and Perú. The two most important curuba taxa are *P. tripartita* var. *mollissima* and *P. tarminiana* (**Figure 2** p. 25 **and Figure 5** p. 29). Both of them can escape from cultivation in man-disturbed habitats, and populations originating in the wild have been rarely observed (Ocampo et al., 2007). *P. tarminiana* however may present serious problems as an invasive species, as in Hawaii and New Zealand. These two curubas are mostly used to prepare refreshing beverages as juices. Their cultivation is ancient, and they were semi domesticated by the indigenous people of South America well before the Spanish conquest (National Research Council 1989). Their intensive commercial exploitation is quite recent however, dating from the 1950's. Pérez-Arbeláez (1956), in his work *Useful Plants of Colombia*, mentioned *curubas* as a promising species due to their easy growth and abundant fructification. In the same decade, Jaramillo (1957) published the results of the first agronomical trial

Figure 6. Species diversity of the supersection *Tacsonia* distributed in Colombia: (a) *P. cumbalensis*, (b) *P. lanata*, (c) *P . linearistipula*, (d) *P. cremastantha*, (e) *P. crispolanata*, (f) *P. adulterina*, (g) *P. antioquiensis*, (h) *P. parritae*, (i) *P. tarminiana*, (j) *P. tenerifensis*, (k) *P. flexipes*, (l) *P. jardinensis*, (m) *P. rugosa* var. *rugosa*, (n) *P. truxilensis*, (o) *P. tripartita* var. *tripartita*, (p) *P. cuatrecasasii*, (q) *P. mixta*, (r) *P. tripartita* var. *mollissima*, (s) *P. trianae*, (t) *P. fimbriatistipula*, (u) *P. manicata* and (v) *P. pinnatistipula*. © John Ocampo (a, b, c, d, f, g, h, i, j, k, l, m, o, p, q, r, u, v), Gustavo Morales (s, t), Miguel Molinari (n) and Sebastián Rendón (e).

Figure 7. *Passiflora mixta*
© John Ocampo

of commercial cultivation of *curuba* in Colombia. Since then, other studies have followed. Thus, Campos (1992, 2001) includes important contributions regarding the main agricultural practices (pruning, irrigation, among others), and a description of the curuba de Castilla (*P. tripartita* var. *mollissima*) and the curuba India (*P. tarminiana*). More research is required to allow higher yields and chemical treatment aimed at tackling different phytosanitary problems, mostly related to fungi, flies, and nematodes.

Today, Colombia is the country with the widest commercial cultivation of curubas (*P. tripartita* var. *mollissima* and *P. tarminiana*) along its three cordilleras, above 1800 m, mainly in the departments of Boyacá, Cundinamarca, Nariño and Tolima. These fruit crops are a useful source of income for small-scale farmers, thanks to their long production season, and have contributed to farmer stability in the Colombian countryside. National statistics do not differentiate between these two species and for the last years 1556 hectares have been reported with an average production of 10 tons per hectare, and a total yearly production of 23,000 tons (Agronet 2017). Additionally, curuba de Castilla is being exported to Germany, Hong Kong and Netherlands, but volumes are not significant regarding the potential these species have.

P. tripartita var. *mollissima*

The curuba de Castilla o tumbo is a vigorous vine with a useful life of up to ten years and even more under favorable phytosanitary conditions. Its flowers are pendant with a green hypanthium and a campanulate corolla of a dark magenta pink color (rarely white color). The fruit (**Figure 2** p. 24**, Figure 5** p. 29 and **Figure 8**) is pale yellow, oblong, rounded at both ends, 9-15.5 x 3.5-5 cm, with an average weight of 90 g. The orange pulp makes up for 60% of the fruit, it has a pH of 3.0 to 3.5, °Brix of 8 to 9 and more than 100 seeds (Campos & Quintero 2012). The main phytosanitary problems are anthracnose (*Colletotrichum gloerosporoides* Penz Sacc.) that mostly attacks fruits, and nematodes of genus *Meloidogyne* spp. and *Fusarium* sp. affecting roots, and And the worm of the *Pyrausta perelegans* Hampson (moth) boreing the flower buds (Campos 2001).

P. tarminiana

The curuba India or curuba Quiteña, (**Figure 9** p. 34-35) is very similar to curuba de Castilla, with pendulous flowers and reflex corolla of a light rose pink color (rarlely white color). The fruit (**Figure 2** p. 24**, Figure 5** p. 29 and **Figure 10** p. 36-37) is elongated and fusiform, 8-11 x 3-4 cm, it has a deeper yellow color, sometimes tinted with reddish orange, with an average weight of 80 g. The pulp is of a paler orange color and less astringent, as compared to de Castilla, and makes 58% of the fruit weight; °Brix is

Figure 8. *P. tripartita* var. *mollissima* fruit and juice © John Ocampo

Figure 9.*Passiflora tarminiana*
© John Ocampo

Figure 10. *P. tarminiana* flower and fruit © John Ocampo

10 to 11 and pH 2.5 (Campos & Quintero 2012).

This species is hardier than *P. tripartita* var. *mollissima*, more resistant to anthracnose, and adapted to a wider environmental range. Thus, it can be cultivated as low as 2000 m, where curuba de Castilla does not grow, although it produces smaller fruits in these conditions.

P. tripartita var. *tripartita* and *P. tripartita* var. *azuayensis*

P. tripartita var. *tripartita* and *P. tripartita* var. *azuayensis* are found in the southern part of Colombia, in Ecuador and in northern Perú in the wild state or in home-gardens. These curubas can be differentiated from their *P. tripartita* var. *mollissima* sister taxon by the less abundant pubescence in their vegetative parts their deeper leaf lobulation. These two botanical varieties produce fruits that are generally smaller with a more colorful pericarp, between yellow and reddish orange (**Figure 5** p. 29), particularly in the intercarpelar zones. Its pulp is less abundant, sweeter and tastier than the ones of curuba de Castilla and curuba India. However, these varieties are less vigorous and less productive.

P. mixta

P. mixta commonly known as curubito de Indio, tumbo, and xamppajrrai (quechua), is the most widely distributed species in super-section *Tacsonia*, all along the Andes, from Venezuela to Perú and Bolivia where it grows from 1700 to 3700 m. Its morphology is similar to that of *P. tripartita*, but it is distinguished by its more rigid peduncles that maintain its flowers in a more or less horizontal to erect position (**Figure 7**. p. 31). In the type that is most common in Colombia and in the northern part of Ecuador, the mature fruit is relatively small (4-8 x 2-4 cm), a hard, green pericarp, a yellow tint at maturity; the pulp is greyish or greenish, rarely yellow, with a not so pleasant taste. Most plants with yellow fruit pulp originated from spontaneous introgressions with *P. tripartita* var. *mollissima*. In northeastern Colombia, Venezuela, and Perú, we have observed types of *P. mixta* with larger fruits, hard pale yellow skin and orange and sweet pulp. In Ecuador, some fruits present a soft, yellowish green pericarp, similar to that of *P. tripartita* var. *mollissima*, with orange pulp. In certain cases, fruits of *P. mixta* are sold in rural markets but its cultivation is rare. The species main interest lies in its affinity and sexual compatibility with *P. tripartita* var. *mollissima*, its hardiness, and its adaptability to more variable conditions, in particular to relatively warmer and drier climates at lower altitudes. It has a reputation of being resistant to fungi, such as *Colletotrichum* sp., *Oidium* sp., *Alternaria passiflorae* J.H. Simmonds, and nematodes *Meloidogyne* spp. (Sañudo & Jurado 1990). We have however often observed accessions susceptible to the first two of these pathogens, indicating that there are also variations in these characters.

P. cumbalensis var. *goudotiana*

P. cumbalensis var. *goudotiana*, curuba bogotana, chupadora, or the rosy passionfruit is cultivated near Bogotá, **(Figure 14** p. 47) in home-gardens between 1800 and 3000 m, and produces an obovoid curuba similar to the commercial curuba, but with a bright red skin. Some types produce big yellow fruits with abundant, aromatic and sweet pulp (**Figure 5** p. 29**)**, and are consumed the same way as *P. tripartita* var. *mollissima*. Eleven botanical varieties of *P. cumbalensis* have been described in the countries where these curubas grow (Escobar 1988; Holm-Nielsen et al. 1988), based on flower color variations, leaf shape, nectariferous glands and leaf pilosity. Fruit size is 5-11 x 2-5 cm (Escobar 1988). Some wild types give very good fruits but their phenology is very distinct compared to *P. tripartita* var. *mollissima* and they do not adapt well to cultivation. According to Schoëniger (1986) *P. cumbalensis* is allogamous and may show inbreeding depression. According to Sañudo & Jurado (1990), *P. cumbalensis* var. *cumbalensis* is resistant to the fungal diseases (*Oidium* sp., *C. gloerosporoides*, *A. passiflorae*) that affect curuba de Castilla.

P. pinnatistipula

P. pinnatistipula Cav. is called gulupa (Colombia), tacso or puru puru (Ecuador, Perú), or tin-tin (Perú). It is native to Perú, Bolivia and Chile and is cultivated in home-gardens from Chile to Colombia between 2500 to 3800 m. Its fruits are round or subglobose, 4 to 6 cm in diameter, with a greyish green to yellow pericarp, which is thin and coriaceous, but brittle. The pulp is greyish to yellowish, sweet or slightly acid and very scented. It can be consumed directly or in preparations, but its yield is low because the seeds are relatively thick and hard. Plants fruit several times a year (Escobar 1981) with a limited yield and resistance to pathogen fungi (Sañudo & Jurado 1990).

P. x *rosea*

P. x *rosea* is a natural hybrid from *P. pinnatistipula* and *P. tripartita* var. *mollissima*. It is produced easily when the two species are cultivated in the same area. Moreover, it is very similar to *P. pinnatistipula* and is distinguished by the length of its anthers and its anomalous androgynophore; the stipules are more foliaceous and the bracts are coalescent at their base. Fruit ovoid, 8 x 2.5 cm in diameter with pubescent pericap. Generally, the anthers are petaloid and sterile. Like *P. pinnatistipula* it is also resistant to *A. passiflorae* (Sañudo & Jurado 1990), but its fruit production is normally very limited, which seems to be due to the relative incompatibility of the parental genomes.

P. antioquiensis

Curuba antioqueña (*P. antioquiensis* Karst.) is characterized by having a shorter hypanthium, as compared to other tacsos, and a reduced corona of thin filaments (**Figure 6** p. 30). It is distributed along the Central and Western Cordilleras of Colombia, between 1800 and 2700 m. The tradition regarding its cultivation has been lost and it has become a rare habitant of home-gardens. It seems to need particular microclimatic conditions to thrive and it can be difficult to obtain regular production of flowers and fruits. It has been naturalized in New Zealand (Heenan & Sykes 2003); reports of wide cultivation, there or in Australia, have never been documented (the Atlas of Living Australia only mentions 19 specimens from New Zealand and one from Papua New Guinea). Its spectacular crimson red flower that hangs off an extremely long peduncle (30-50 cm) has made it appreciated as ornamental. Its fruits are fusiform, of 5-9 x 2-3 cm (**Figure 2** p. 35), with a yellowish green pericarp, fragile and greyish to orange arils that reminding the taste of a *maracuyá*, but sweeter. According to Sañudo & Jurado (1990), *P. antioquiensis* is resistant to fungal diseases.

Inter-specific hybridizations and breeding

The most important commercial species are susceptible to several pests and diseases with considerable negative effects on production. Thanks to the number of species and botanical varieties producing edible fruits of commercial size, supersection *Tacsonia* has a high potential for crop diversification and economic development. This has induced research institutions in Andean countries to prioritize their characterization and the evaluation of wild and cultivated populations (National Research Council 1989), and develop strategies for conservation and improvement of these genetic resources. Indeed, the breeding potential of cultivars for curuba or tacsos is not restricted to *P. tripartita* var. *mollissima* or *P. tarminiana* (Coppens d´Eeckenbrugge 2003).

Colombia could focus its efforts in exploring and studying different types of curubas as it is the country with the highest diversity of species and the best home market for curubas. In this way, these curubas (*P. cumbalensis*, *P. antioquiensis*, *P. leptomischa, P. flexipes* Tr. & Planch., *P. cremastantha* and *P. parritae*) are just as tasty as granadillas and could be developed for direct consumption (Quintero 2009; Ocampo et al. 2007). In the first place, the criteria to obtain new curuba cultivars involve the selection of ideotypes with higher yielding plants with larger fruits, good post-harvesting behavior and that are resistant to *C. gloerosporioides* so they can respond to market requirements.

Spontaneous interspecific hybrids that involve both wild and cultivated forms have been regularly observed by producers and have been reported by numerous authors, suggesting weak interspecific barriers in supersection *Tacsonia.* Escobar (1981) reported cases of spontaneous hybrids between *P. tripartita* var. *mollissima*, *P. cumbalensis*, *P. mixta*, *P. mathewsii* and *P. fimbriatistipula* Harms, remarkable for their vigor, their larger leaves, stipules, bracts and flowers compared to their parental species, with a similar or superior pollen viability. Escobar (1981) also observed hybridizations between *P. tripartita* var. *mollissima* (female parent) and a range of species including *P. ampullacea*, *P. pinnatistipula*, *P. mixta*, *P. mathewsii* and *P. tripartita* var. *tripartita*, which had superior fertility to that of intraspecific crosses and spontaneous self-pollinations.

Studies conducted by Schoëniger (1986) show that interspecific barriers cannot be underestimated in supersection *Tacsonia.* According to this author, spontaneous hybrids between *P. tripartita* var. *mollissima* (female) and *P. mixta* (male) show tolerance to the fungi *Oidium* sp. and *C. gloerosporoides*. The F2 obtained through self-fertilization showed a considerable variation with many transgressive segregation cases, and a high proportion of these hybrids showed an abundant flowering but little or no fructification. Regarding hybridizations of *P. cumbalensis* x *P. tripartita* var. *mollissima*, Schoëniger (1986) reported that the F_1 showed morphological affinity with the male parent. However, the fruits were more similar in shape to the ones of *P. cumbalensis*, but with a high variability in weight (30 to 90 g), a little resistant pericarp, many seeds, and slightly acid and less succulent arils than in *P. tripartita* var. *mollissima*. The F2 obtained through self-fertilization and the R1 (back-cross onto *P. tripartita* var. *mollissima*) showed low germination, high diversity in fruit shape, and its production varied from three to more than 100 fruit per plant.

Sañudo and Zuñiga (1991) also pollinated *P. tripartita* var. *mollissima* with pollen from *P. pinnatistipula*, *P. tripartita* var. *tripartita*, *P. cumbalensis* and *P. mixta*. The hybrids obtained with *P. tripartita* var. *tripartita* showed a higher hybrid vigor and a better juice quality than *P. tripartita* var. *tripartita*; the ones obtained from *P. cumbalensis* showed an increase in fruit size; and the ones from *P. mixta* gave less enduring fruits with an excellent pulp but with many seeds and little juice. All these hybrids inherited resistance to *C. gloerosporioides* anthracnose from one of their parents.

Studies carried out by Quintero (2000) produced cultivars from high yielding plants of *P. tripartita* var. *mollissima* called `Ruizquin´ 1 and 2 that were obtained through *in vitro* propagation with good consumer acceptance in Colombian markets. In high rainfall periods however, they showed high susceptibility to *C. gloerosporioides.* The same author and his son (Quintero 2009) obtained interspecific hybrids between *P. tripartita* var. *mollissima* x *P. mixta* called `Momix´, a cultivar that responds to market expectations

Figure 11. Cloud forest in Cundinamarca (Silvania) © John Ocampo

Figure 12. Habitat disturbed in Colombia Andes (Genova, Quindío) © John Ocampo

Figure 13. Gustavo Morales conservationist of Colombian species of the supersection *Tacsonia* (*P. rugosa* var. *rugosa*). © John Ocampo.

Figure 14. Enthusiasts, Miguel Molinari (right) and Hernán D. Bernal (left) collecting and photographing *P. cumbalensis* var. *goudotiana* in Cundinarmarca (Sibaté) © John Ocampo

with an excellent yield and good fruit size. It also shows tolerance to *C. gloerosporioides*, and it can be consumed directly and in juice, with either water or with milk due to its higher ºBrix (12-13º). Interspecific compatibility among the most common species of supersection *Tacsonia* (*P. tripartita* var. *mollissima*, *P. tarminana* and *P. mixta*) has also been reported by Primot et al. (2005). The easy hybridization as well as the vegetative fertility and vigor of the hybrids confirm prior observations of spontaneous and experimental hybrids in *Tacsonia.*

P. manicata

Another member of the supersection *Tacsonia* that has been assessed with regard to curuba breeding is *P. manicata* (Juss.) Pers. This species is distributed along the Andes from Venezuela until the north of Perú, between 1500 and 3000 meters, with a shorter floral tube and a complex filamentous corona (**Figure 6** p. 30). The fruit is ovoid, of 3-6 x 3-4 cm with a green coriaceous pericarp when mature (**Figure 5** p. 29), greyish arils, slightly succulent and with a sweetish taste. However, its fruit cannot be considered as edible, as its mature state cannot be clearly distinguished from its immature state, during which the fruits can have toxic and psychotropic effects (hence the name "diablito" in Ecuador (Yockteng et al. 2011)). The interest of this species lays in its hardiness, and its adaptation to warmer and drier environments, and its cross ability with curubas: *P. antioquiensis* (Martín & Nakasone 1970), *P. tripartita* var. *mollissima* (in both crossing directions) and *P. edulis* (as the male parent). The fertility of these two hybridizations are half of the fertility after intraspecific pollination (Escobar 1985; Ocampo et al. 2016). *P. manicata* is resistant to nematodes and fungal diseases (*C. gloerosporoides*, *Oidium* sp. and *A. passiflorae*) and can be used as rootstock for *P. tripartita* var. *mollissima* (Campos 2001).

Breeding priorities

Supersection *Tacsonia* offers good options to improve and diversify the curubas that are currently being commercialized. The first priority would be to better explore the resistance characters present in *P. tripartita* var. *tripartita* and *P. tripartita* var. *azuayensis*, *P. mixta*, *P. schlimiana*, *P. mathewsii* and in the types of *P. cumbalensis* that have yellow fruit in benefit of *P. tripartita* var. *mollissima* and *P. tarminiana*. The second priority would be to reevaluate the red curuba *P. cumbalensis*; doing this, we would be rescuing this domesticated curuba before it becomes extinct. Likewise, the semi domesticated forms of *P. antioquiensis* should be rescued, and, resources being available, *P. leptomischa*, *P. flexipes* and *P. cremastantha.* This could define another focus for commercial fruits (if fruit quality is adequate) or from plants used as ornamentals. *P. pinnatistipula* could also contribute if there were selections with less seed size and better pulp yield.

Conservation status

Colombia has 22 endemic *Tasconia* species inventoried with a narrow distribution, implying a high extinction risk. The country has undergone recent transformation of large portions of its natural ecosystems, in particular in the Andean region due to agricultural development (e.g. coffee, sugar cane, rice, bananas and potato plantations) and extensive livestock production (pastures), mining, hydroelectric generation complexes (dams), and illicit crop plantations. Indeed, the extinction of *Tacsonia* species would entail the loss of interdependent organisms such as nectar feeding bats and hummingbirds. In this context, most of the 33 Colombian *Tacsonia* species (57%) are under some degree of threat according to the IUCN criteria (Ocampo et al. 2007, 2014), and one is considered probably extinct - EX. (**Table 1** p. 51). Thus, 10% are under the criteria Critically Endangered (CR), 35% Endangered (EN), and 12% Vulnerable (VU), which clearly illustrates the alarming situation for the supersection.

Tacsonia in Colombia

Conservation or restoration efforts for *Passiflora* supersection *Tacsonia* habitats must be integrated in a more general management strategy at the landscape level (**Figure 12** p. 42-43). The latter can be ensured by coordinating existing actions for watershed protection, management of private and low-level public reserves, creation of environmental corridors, and improvement of agricultural practices that integrate the landscape. *Ex situ* conservation in botanical gardens and seed banks (e.g. cryopreservation, González-Benito et al. (2009)) is another strategy that must be implemented when critical habitats are destroyed. This strategy has begun to be implemented in the Botanical Garden of Bogotá "José Celestino Mutis" for some time now by Gustavo Morales (**Figure 13** p. 44-45), who has led expeditions to collect many species of *Tacsonia* in Colombia (**Figure 14** p. 45-46). He established living collections and began with seed preservation of the most endangered species, such as *P. adulterina*, *P. antioquiensis*, *P. colombiana*, *P. cremastantha*, *P. crispolanata*, *P. cuatrecasasii*, *P. cumbalensis*, *P. jardinensis*, *P. formosa*, *P. parritae*, *P. pinnatistipula*, *P. manicata*, *P. mixta*, *P. rugosa* var. *rugosa*, *P. trianae*, *P. tarminiana*, *P. tripartita* var. *mollissima/tripartita* and *P. uribei*. This example of conservation must be followed by other governmental institutions such as universities and research centers in the Andean countries so that future generations can enjoy this biological wealth.

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Table 1 Official species of the supersection *Tacsonia* inventoried for Colombia. Asterisk (*) indicates endemic species.

Species	Elevation (m.a.s.l.)	IUCN	Synonymous
Section *Colombiana*			
Series *Colombianae*			
Passiflora adulterina L.f.,1781 *	2600 - 3600	NT	*T. adulterina* (L. f.) Juss., 1781
Passiflora crispolanata L.Uribe, 1954 *	2500 - 3500	NT	*P. boyacana* Killip, 1960
Passiflora cuatrecasasii Killip, 1960 *	2200 - 3500	NT	*P. quinonesiae* Bonilla et al. 2016
Passiflora formosa T. Ulmer, 1999 *	3000 - 3100	EN	
Passiflora lanata (Juss.) Poir., 1811 *	2200 - 3500	VU	*T. lanata* Juss., 1805
Passiflora pamplonensis Planch.& Linden ex Triana & Planch., 1873 *	2000 - 3000	CR	
Passiflora rugosa var. *rugosa* (Mast.) Triana & Planch., 1873 *	3000 - 3500	EN	*P. eriocaula* Harms, 1922; *P. creuci-caetanoae* Bonilla et al., 2016
Passiflora rugosa var. *venezolana* L.K. Escobar, 1986	2500 - 3500	EN	
Passiflora trianae Killip, 1938 *	3000 . 3500	EN	*P. trisecta* Planch. & Linden ex Triana & Planch., 1873; *P. rigidifolia* Killip, 1960
Passiflora truxillensis Planch. & Linden, 1873	1800 - 3000	EN	
Series *Leptomischae*			
Passiflora antioquiensis H. Karst., 1859 *	1800 - 2700	NT	*P. antioquiensis* var. *trisecta* H. Karst., 1859; *P. vanvolxemii* (Hook.) Triana & Planch., 1873
Passiflora coactilis (Mast.) Killip	2700	EN	*P. mariae* (Sodiro) Harms, 1925
Passiflora cremastantha Harms, 1922 *	2000 - 2500	CR	*P. splendida* Bonilla et al. 2016
Passiflora flexipes Triana & Planch., 1873 *	2500 - 3380	VU	*T. flexipes* Triana & Planch., 1883
Passiflora leptomischa Harms, 1922 *	2000 - 2800	NT	
Passiflora tenerifensis L.K. Escobar, 1988 *	2800 - 3100	CR	
Series *Quindiensae*			
Passiflora linearistipula L.K. Escobar, 1988 *	2650 - 3170	EN	
Passiflora quindiensis Killip, 1938 *	2900 - 3100	EN	*P. elegans* Triana & Planch., 1873
Section *Elkea*			
Passiflora cumbalensis var. *caucana* L. K. Escobar, 1988	2300 - 2800	LC	
Passiflora cumbalensis var. *cumbalensis* (H. Kast.) Harms, 1894	3000 - 3800	NT	
Passiflora cumbalensis var. *goudotiana* (Triana & Planch.) L.K. Escobar, 1987	1950 - 3000	LC	
Passiflora tarminiana Coppens & Barney, 2001	2000 - 2900	VU	
Passiflora tripartita var. *tripartita* (Juss.) Poir., 1811	3000 -3100	VU	*P. psilantha* (Sodiro) Killip, 1924
Passiflora tripartita var. *azuayensis* Holm-Nielsen & Jørgensen, 1988	2000 - 2650	NT	
Passiflora tripartita var. *mollissima* (Kunth) Holm-Nielsen & Jørgensen, 1988	2200 - 3500	LC	*P. tomentosa* var. *mollissima* (Kunth) Triana & Planch, 1873
Section *Fimbriatistipula*			
Passiflora fimbriatistipula Harms, 1894 *	2130 - 3240	EN	
Passiflora uribei L.K. Escobar, 1988 *	2500 - 2700	EN	
Section *Insignes*			
Passiflora pinnatistipula Cav.,1799	2000 - 3600	NT	*P. pennipes* Sm., 1819 nom. Illeg.; *P. chilensis* Miers, 1826
Section *Manicata*			
Passiflora manicata (Juss.) Pers., 1807	1500 - 2700	LC	*P. manicata* var. *communis* Kunth, 1817; *P. meridensis* H. Karst.,1859
Section *Parritana*			
Passiflora jardinensis L.K. Escobar, 1988 *	2750 - 3000	EN	
Passiflora parritae (Mast.) L.H. Bailey, 1916 *	2500 - 3020	EN	*P. salmonea* Harms, 1894
Section *Tacsonia*			
Passiflora mixta L. f., 1781	1700 - 3700	LC	*P. longiflora* Lam., 1789; *P. brachychlamys* Harms, 1929
Passiflora schlimiana Triana & Planch., 1873 *	2400 - 3220	EN	
Section *Tacsoniopsis*			
Passiflora bracteosa Planch. & Linden, 1873	2200 - 3000	EN	*T. infundibularis* Mast., 1883
Passiflora purdiei Killip, 1938 *	2008 - 2505	EX	
Section *Rathea*			
Passiflora andina Killip, 1938	2800	CR	*P. floribunda* (H. Karst.) Triana & Planch. ex Harms , 1925
Passiflora colombiana L.K. Escobar, 1986 *	2000 - 2500	CR	
Section x *Inkea*			
Passiflora x *rosea* (H. Karst.) Killip, 1938	2500 - 3500	VU	*Poggendorffia* × *rosea* H.Karst., 1857; *T.* × *rosea* (H.Karst.) Sodiro, 1903

Passiflora arborea

By Rebecca Hilgenhof, Tropical Nursery Supervisor, Royal Botanic Gardens, Kew

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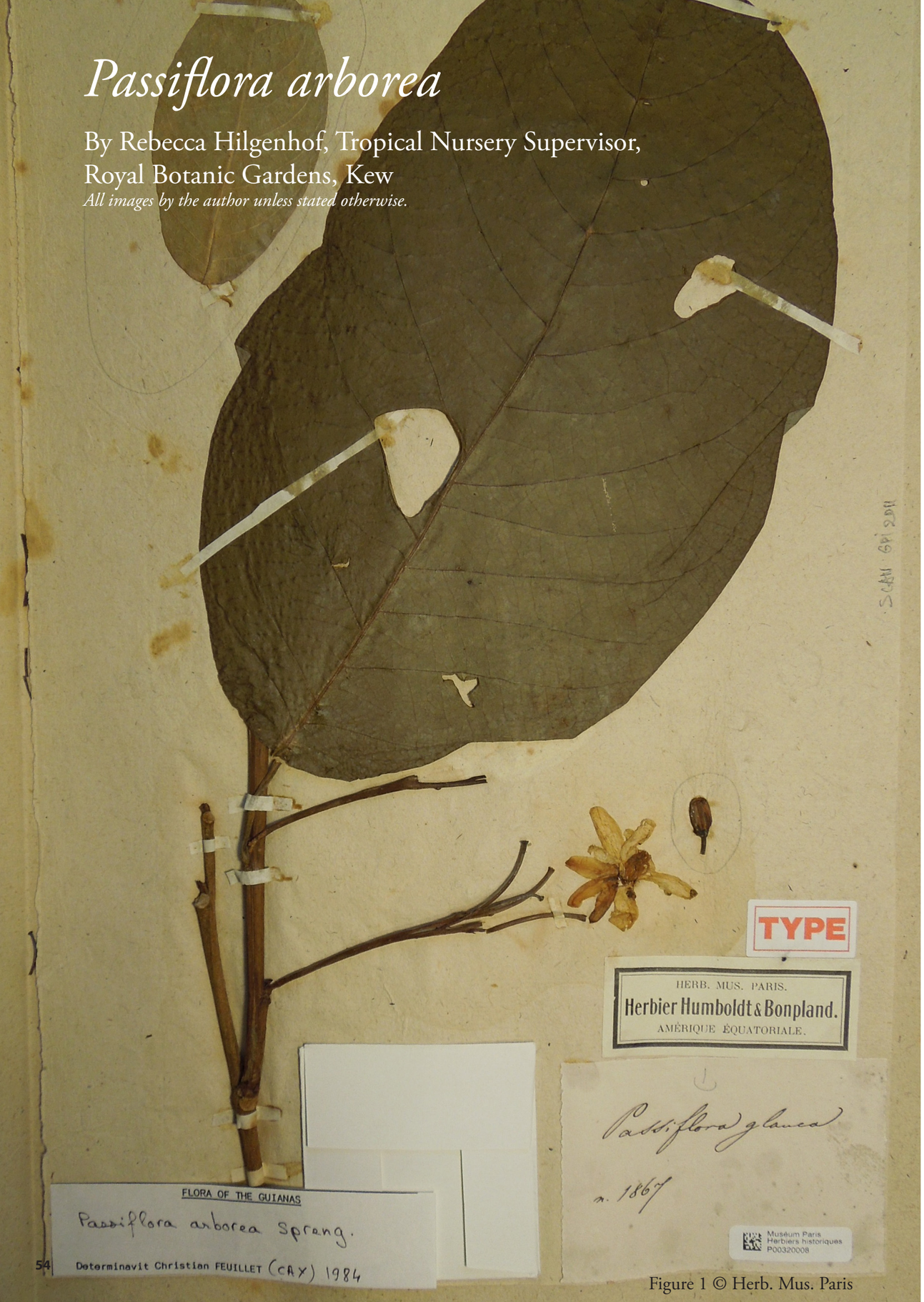

Figure 1 © Herb. Mus. Paris

Introduction

Passiflora arborea Spreng. (1826) (**Figure 1**) is one of 138 species of passionflowers currently cultivated at the Royal Botanic Gardens (RBG), Kew in the United Kingdom.

The genus *Passiflora* L. contains around 575 species (Aguirre-Morales, Bonilla-Morales & Caetano, 2016) of mostly climbing plants native to the Americas, but also a small number can be found in Asia and Australasia. Mainly cultivated for their extraordinary blooms, most species are regarded as easily grown container plants.

P. arborea is an exception, it is neither a climber nor regarded as easy to grow. It is a tree-like species of which there are only 9 in the entire genus (Aguirre-Morales, Bonilla-Morales & Caetano, 2016). They have a freestanding arboreal habit that is not only defined by secondary thickening or outwards growth, but also the lack of tendrils, otherwise typical of members of *Passiflora*. All species that are regarded as true trees, shrubs or treelets are part of the subgenus *Astrophea* (DC.) Mast.

At first representatives of this subgenus were only cultivated by lepidopterists as the food source for the larvae of their treasured *Heliconius* butterflies. Only more recently have they sparked the attention of the *Passiflora* enthusiast. Likewise, amongst botanic garden collections these arboreal species have now become more desirable additions. Plant research institutions, such as the RBG, Kew, not only grow these unique plants for their display value, but equally *ex-situ* cultivation allows them to work with living specimens to assist botanical studies. At the same time, cultivating these curiosities can also provide a better understanding of their rather unusual growth habits. This information is of importance for *in-situ* and *ex-situ* conservation as many of these species are under pressure in their natural habitat and may need protection in the near future.

This article will provide insight into *P. arborea* with regard to its taxonomic treatment both currently and in the past. It will cover the distribution and habitats where plants naturally occur in as well as their herbivore interactions and how they impact the plant's growing pattern. It will also touch upon the species morphology so that it can be distinguished from its close relatives, as this is of great importance for successful *ex-situ* cultivation. Recommendations for long-term cultivation success will be provided on the basis of experience of growing this species at the RBG, Kew.

From the species discovery to the recent taxonomical treatment

Lead by a drawing of a tree-like *Passiflora* encountered by José Celestino Mutis and a group of accompanying botanical artists during the Royal Botanical Expedition to the new Kingdom of Granada (1783-1816), Humboldt & Bonpland were the first to make a herbarium collection of an arboreal species. Although, Mutis found his specimen in a place he called la Mesa, not far from Santa Fé (Colombia), they made their collection the type of *P. arborea* on the Quindio Trail in La Valza, Los Volcancitos, Tolima (Colombia). In the type description they state to have found the species several times in the Mountains of Quindiu at elevations of 2000m above sea level. Subsequently in 1806, Bonpland describes the species from the type collection in *Plantae Aequinoctiales* under the name *Passiflora glauca*, thus it being the first arboreal species named (**Figure 2** p. 56). *P. emarginata* Humb. & Bonpl. (1806), a closely related species, was described in the same publication, making it a close second (**Figure 3** p. 57). At the time Bonpland mentions that he believed that the two species might belong to a separate new genus from *Passiflora,* as the plants described display an unusual growth habit for passionflowers as well as lacking the tendrils. He decided however to let Jussieu the author of *Familles naturelles* decide as he had already started his work on the "order" Passifloreæ.

In 1826, Sprengel invalidates the name *P. glauca* for Bonpland's tree passionflower as it had been already in existence for another taxon, *P. glauca* Aiton (1789), today known as *P. stipulata* Aubl. (1755) (John M. MacDougal, pers. comm. February, 2017). The new name replacing Bonpland's is *P. arborea* (Sprengel, 1826). In 1822, de Candolle, who based his generic approach for the most part on the concept of Jussieu (1789) & Persoon (1807), subdivided the genus *Passiflora* into seven sections. He seemed unaware of Sprengel's name change and continued to list the species under the name *P. glauca*. Regardless of this minor error, he describes sect. *Astrophea* and places the species in it. Roemer (1846) raised all of DeCandolle's section to generic level, naming Bonpland's species, *Astrophea glauca.* Later Bentham and Hooker accept DeCandolle's earlier concept of the genus *Passiflora*, making *Astrophea* yet again a section in *Passiflora*. In Masters' 1871 & 1872 revision of the genus he separates it into four subgenera, one being *Astrophea*. He maintains the correct taxon name, *P. arborea*.

Other historical accounts that follow the valid treatment of the species name are Triana & Planchon (1873) and Spruce ex Masters (1883). The later provided detailed information on the invalidation of *P. glauca* Bonpl. In Harms' (1893) first edition of *Die natürlichen Pflanzenfamilien* he considers *Astrophea* to be a section of *Passiflora*, whilst in the second edition (1925) he works on subdividing the group into three sections (*Euastrophea*, *Pseudoastrophea*, and *Botryastrophea*). *P. arborea* is placed into *Euastrophea.* In Killip's 1938 monograph *The American Passifloraceae* he adopts Harms' sections of *Astrophea* and implements three of his own (*Dolichostemma*, *Cirrhipes*, and *Leptopoda*). *P. arborea* remains in *Euastrophea*, which then comprised 17 species (Ulmer & Ulmer, 1997). Included were all arboreal species known to science at the time, plus a couple of species (e.g. *P. ovata* Martin ex DC.) that may

PASSIFLORA glauca.

De l'Imprimerie de Langlois.

Figure 2

PASSIFLORA emarginata.

De l'Imprimerie de Langlois.

Figure 3

Figures 2 & 3 Aimé Jacques Alexandre Bonpland

possess tendrils. This treatment was used for many years, and was accepted by subsequent literature (Vanderplank, 1991, 1996, 2000; Escobar, 1994; Ulmer & Ulmer, 1997; Klock, 2001; Feuillet, 2002).

In 2003, Feuillet & MacDougal published the *New Infrageneric Classification of Passiflora*. In their work the subgenus *Astrophea* is one of four contained in *Passiflora*. Later Krosnick et al. (2009) reinstate a fifth subgenus, *Tetrapathea* (DC.) Green. Feuillet & MacDougal subdivide the subgenus *Astrophea* (DC.) Mast into 2 main supersections: *Astrophea* (DC.) MacDougal & Feuillet, and *Pseudoastrophea* (Harms) Feuillet & MacDougal. Each of which is once again subdivided into lower ranks such as sections (*Astrophea* DC., *Capreolata* MacDougal & Feuillet, *Leptopoda* Killip ex Feuillet & Cremers, *Pseudoastrophea* (Harms) Killip & *Botryastrophea* (Harms) Killip) and series (*Botryastrophea* (Harms) MacDougal & Feuillet and *Carnae* Feuillet). Here *P. arborea* is placed in supersection and section *Astrophea*.

The subgenus *Astrophea* is the third largest in *Passiflora* with over 60 species of scandent shrubs, woody lianas, freestanding trees or treelets. Of these 9 species, including *P. arborea,* are accepted within section *Astrophea* (Aguirre-Morales, Bonilla-Morales & Caetano, 2016). All of these species are freestanding trees or shrubs that lack tendrils.

Identifying *Passiflora arborea*

In general, all species those are included in sect. *Astrophea* are morphologically very similar. This makes distinguishing them somewhat difficult. Aside from all being true freestanding trees with no tendrils they also have the following in common. Simple leaves that can grow very large e.g. in *P. macrophylla* Spruce ex Mast. they can grow up to 90cm long (Ulmer & MacDougal, 2004). The 1-2 pairs of sessile extrafloral nectaries are located on midrib towards the leaf base. The stipules are very small and marcescent, meaning they soon become deciduous but remain on the plant. Flowers are usually white, sometimes greenish with yellow corona. Their growth is episodic as spurts of new growth are followed by apparent inactivity (Ulmer & MacDougal, 2004).

To distinguish *P. arborea* from other closely related species it is important to understand what it actually looks like. The 'description section' of this paper displays a translation of Bonpland's original text, this is accompanied by additional measurements that are taken from specimens in RBG, Kew's living collection. As growing plants under cultivation can impact on the plant's appearance these measurements might differ from those of wild material.

According to Killip (1938) mature plants can grow up to 6-10 m tall. A pot grown specimen at RBG, Kew measures at present a total of 160cm in height. The branches are light brown with parallel longitudinal grooves and covered in lenticels, **(Figure 4)** whereas the trunk tends to be greyish-green in colour and even more grooved. **(Figures 5** and **6)** Normally the plants are glabrous except the white ovary that is covered in fine white hairs and the midrib margin on new emerging leaf growth, which are densely covered in soft brown trichomes that wither as the material matures (**Figures 7 & 8)**. Mature leaves are tough with a sharply pointed tip **(Figure 9** p. 60**)** that at times can also be tapering to a long apex or are occasionally emarginate. Two or occasionally one pair of extrafloral nectaries are located at the leaf margin towards the base of the leaf lamina **(Figure 8)**. The single inflorescence is forked twice and can produce 2-4 blooms that effuse a very pleasant sweet cocoa butter-like fragrance. They are white with two series of mostly yellow coronal filaments **(Figure 10** p. 61**)**. Some sources (Ulmer & Ulmer, 1997; Klock, 2001) state up to three series but this seems to be an adopted error of historical descriptions such as Bonpland's (1806) original description or Killip's (1938) later account. The most likely explanation for this is that in the older days botanist have counted as to what we refer to as the operculum these days as a corona series. Evidence for this is that the operculum isn't at all mentioned in early papers. The sepals and petals are usually 3-4-times longer than the campanulate floral tube (Adriana Carolina Aguirre Morales, pers. comm. February, 2016). The membrane-like operculum is erect and 2 mm long **(Figure 11** p. 61**)** .

On average flowers on Kew's specimen measured around 6 cm in diameter. On some occasions it has been observed that individual bloom measured up to 8 cm in diameter. An explanation for this could be the maturity of the specimens. However, it has been observed that if a normally 2-forked inflorescence is not forked it may consequently produce only a single flower that is bigger than the rest present on the same specimen (**Figure 12** p. 62**)**.

Ulmer & Ulmer (1997) comment on the variations in floral size displayed in relevant literature. Another explanation for differences in descriptions could be that some of the records are not taken from the true *P. arborea* but a close related species. Nevertheless, the two reasons stated could impact heavily on this variation. Also with regard to the shape of the fruit the literature is inconsistent. When Bonpland described the species at the time fruit were not present. More recent publications such as Ulmer & MacDougal (2004) state that the fruits are ellipsoid to ovoid. We now know that these are actually spherical.

The seeds have a netted pattern **(Figure 26?? bot illus** p. 72**)** and are covered in green yellow arils, which are filled with a juice of unpleasant petroleum-like smell. Ocampo et. al. (2007) state that the fruits are edible though not much other evidence has been found on this. This statement could be arguable as *P. lindeniana* fruits for example are known to have a very bad taste and although not poisonous they seem not suitable for human consumption.


Figure 4


Figure 5


Figure 6


Figure 7


Figure 8

Figure 9

Figure 10

Figure 11

Figure 12

Nowadays, we understand that there are species-specific features that need to be considered to verify species. In regards to vegetative growth in non-fertile specimens is it important to pay attention to the colour and texture of the bark, presents or absence of lenticels, colour of pubescence on new emerging growth, shape of leaf base and apex and last but not least the number of pairs of extrafloral nectaries situated on the petiole near the leaf base. If flowers are present identifying features are: how often is the inflorescence dichotomous, shape of floral tube, size of floral tube in relationship to the length of the tepals, shape of the operculum, shape and length of outer corona, shape of androgynophore, particularly the lower half and its length in relation to floral tube, absence or presence of hairs on the ovary, colour and appearance of the three stigmas.

Distribution and the plant's natural growing environment

Most species of *Passiflora* are native to the Americas but as many as 24 (Vanderplank & Rodriguez, 2010) can be found in Asia and Australasia. The arboreal species are mostly distributed in South America with the focus on the north-eastern regions of the continent. In fact, one species *P. tica* Gómez-Laur. & Gómez extends even further north as far as Central America. Since first being discovered *P. arborea* was thought to have a wide distribution within what was then known as New Granda, today divided into Colombia, Ecuador, Panama, and Venezuela. We understand now that the true *P. arborea* has so far only been reliably recorded for Colombia. Holm-Nielsen et al (1988) in *Flora of Ecuador* also consider Ecuador within its natural range, but in 2004 Ulmer & MacDougal state that the collections made at the time belonged to a few other species, including *P. putumayensis* Killip. Nevertheless the range of this species could potentially stretch further south into Ecuador and equally northwest into Venezuela, as the habitat conditions in both countries are very similar to those found in Colombia (Adriana Carolina Aguirre Morales, pers. comm. May, 2016). Within Colombia Hernández and Jørgensen (2017) list the species to occur in the following departments: Antioquia, Boyacá, Caldas, Chocó, Cundinamarca, Huila, Magdalena, Norte de Santander, Qindío, and Risaralda.

P. arborea naturally thrives in moist forest habitats of the Andean stretch where it can be found at altitudes between 1099 - 2413m (Aguirre-Morales, Bonilla-Morales & Caetano, 2016). Here average temperatures lie generally between 13 – 18°C, occasionally up to 23°C (Adriana Carolina Aguirre Morales, pers. comm. May, 2016).

Natural herbivore interaction

In the natural habitat there are only few herbivores that visit *P. arborea*. Like several other *Passiflora* spp. it is associated with the colourful *Heliconius* butterflies. These 'maracuja' butterflies, or Longwings, lay their eggs on the foliage of *Passiflora* spp. Some are known to very specific to this subgenus and have therefore a close and important relationship to the arboreal species. This has a great impact on the plant's natural growing behaviour. Two species, *Heliconius sapho* and *H. eleuchia* lay eggs on *P. arborea* (Clive Farrell, pers. comm. April 2016). Aside from *Heliconius* ssp. also other Lepidoptera L. are regularly found feeding on the tree-like *Passiflora* during their larval stages. These are diurnal moths of the genus *Getta* Walker, which are thought to mimic the appearance of *Heliconius* butterflies. In the case of *P. arborea* the species is *Getta baetifica* Druce, a relatively common moth endemic to the western slopes of the Andes in Colombia and Ecuador (Miller & Brower, 2009). Also *P. macrophylla* is known to be the food source of this diurnal moth. The plants have evolved a unique episodic growing pattern, thought to be in order to avoid the pressure of these natural predators that are capable of storing and reusing the plant's toxin for their own defence. This relationship is referred to as coevolution.

Conservation status

Still today, there is very little known about the species in section *Astrophea*. Many are considered as quite rare due to vast habitat destruction and the introduction of non-native invasive species. The first account of the rarity of these species was in the 1997 Edition of the IUCN Red List of Threatened Plants. It only lists two species, *Passiflora tica* and *P. emarginata*, both are considered as 'Rare'. Further work in regards to the conservation status of taxa in sect. *Astrophea* has been carried out by Hernández & García (2006). They list *P. arborea* with the status 'Least Concern'. In fact they consider most species as 'Least Concern', only *P. engleriana* Harms & *P. lindeniana* Planch. ex Triana & Planch are granted the status 'Endangered', whereas *P. grandis* Killip is regarded as 'Data Deficient'. More recently Ocampo et. al. (2007), Ocampo & Forero (2015) and Aguirre-Morales, Bonilla-Morales & Caetano (2016) discussed the conservation status for all species in subgenus Astrophea, all consider *P. arborea* as 'Near Threatened'. As major threats to the species Ocampo et. al. (2007) list loss of the plant's habitats through livestock farming, monoculture, excessive mining, uncontrolled forest fires, as well as climate change seems to have made an impact.

Cultivation guide

The cultivation of all species in subg. *Astrophea* but particularly sect. *Astrophea* is regarded as very challenging. Only a few authors of recent literature (Ulmer & Ulmer, 1997; Vanderplank, 1991, 1996 & 2000; Klock, 2001; Ulmer & MacDougal, 2004, Ulmer & Ulmer; 2005; Ulmer

Figure 13

& Ulmer; 2012; Hilgenhof, 2012) and a small number of articles (Gilbert, 1996; Vecchia, 2002; Vanderplank & Magdalena Rodriguez, 2010; Vanderplank *et al.* 2014) focus on the cultivation of this subgenus.

The first arboreal specimens that were introduced into cultivation were thought to be mainly *P. arborea*. At this stage, very little was known about the tree-like species. All lack tendrils and most have white and yellow flowers, **(Figure 13)** so consequently they were easily confused with another. Once looked at more closely, they turned out to be other, close related species from sect. *Astrophea*, such as *P. lindeniana, P. sphaerocarpa* Triana & Planch. or *P. tica*. In 2004, Ulmer & MacDougal stated that through this confusion that it was doubtful if *P. arborea* really existed back then in cultivation. Unfortunately, not many records were taken at the time and this statement remains unresolved.
This paper covers all that is essential for their cultivation, as it appears to be the first time that what we believe to be the true *P. arborea* has been actively observed and recorded in *ex-situ* culture. Successful cultivation of *P. arborea* is heavily reliant on a good understanding of the environmental conditions this species inhabits in the wild and how this influences its growing behavior. These and other impacting factors in *ex-situ* cultivation are discussed below.

Cultivation

For cultivation in Europe, *P. arborea* and its close relatives are best grown in greenhouses. Nearly all arboreal species occur in higher altitude ranges of the Andes and will therefore need a temperate growing environment. This includes *P. arborea* as it is reported to occur between 1099 - 2413m (Aguirre-Morales, Bonilla-Morales & Caetano, 2016). Those few that occur in lowland rainforest habitats

Figure 14

at altitudes as low as sea-level (e.g. *P. macrophylla* & *P. putumayensis*) will need a tropical greenhouse to flourish.

Temperature

At RBG, Kew *P. arborea* (**Figure 14** p. 65) is part of the behind-the-scenes Temperate Collections and as such is kept in a temperate glasshouse with many other exotic plant species from similar growing environments. A single treelet is planted out in temperate fern zone of the Princess of Wales Conservatory. In both places the controlled climates are similar to that which the plants would experience in the wild.

From what we know about temperatures in the natural habitat the plants hardly ever experience them being higher than 23°C (occasionally to 28°C) for long periods during the summer and in winter the temperatures stay generally above 10°C (Meteoblue, 2017) even at night. To accommodate this, RBG, Kew's glasshouses are run accordingly. During the winter, temperatures are kept at a minimum of 10°C during the night and 12°C during the day. RBG, Kew have not tried to grow them at lower temperatures, however Ulmer & Ulmer (2005) suggest a minimum temperature of 5°C. Providing cooler temperatures throughout the winter allows the plants to slow down and go dormant. The resulting rest period when plants remain growth inactive during the winter months, is required by the tree species particularly when cultivated in the northern hemisphere as light levels are reduced and yet another growth factor is limited. Throughout this time, the arboreal *Passiflora* spp. tend to hold onto their foliage if not kept too dry.

Dryness in combination with low temperatures can sometimes accidentally trigger plants to shed their foliage. Preferred summer temperatures should not exceed 25°C for which reason the greenhouses at RBG, Kew are vented once 18°C has been reached. During the summer months, when temperatures easily rise above the preferred maximum, the plants are moved outside under a shaded area. With regard to temperatures, measurements taken from the soil are more important than the air, so ensuring the pots stay cool at all times will increase plant's wellbeing.

Humidity

Humidity is another impacting element in regards to the plants health. It plays a particular important role when plants come into growth and expand their large leaves. An additional mist or fog system for those that originate from high humid cloud forest habitats is under normal circumstance not necessary, as long as they ambient relative humidity is well above 60%. When plants are kept outside in the summer the humidity is extremely difficult to control. This does not limit the plant's healthy leaf development as long as their increased water demand is cared for. In case humidity is too low a regular mist or placing water-filled containers around the plants, so that through evaporation the moisture content in the air is increased, can help to reduce this problem. During the summer this has also the positive affect that the surrounding air is cooled down.

Air movement

Air movement is yet another factor that should be taken in account to ensure a healthy development of the plants. Providing air movement with the assistance of fans inside the greenhouse helps not only to reduce the temperatures in the summer but also pest and disease levels are limited as these cannot establish easily. The most important aspect nevertheless is that *P. arborea* is a 'true' tree. These do not only grow upwards and tall but equally sideways and wide. This laterally growth is commonly termed, secondary thickening. It is important to ensure a strong growth of the trunk through the exposure of winds. Staking as growth control should only be necessary when specimens are young to ensure an upright growth. Once these are established the support will become redundant. If supports are kept on the plant for too long or is attached too tightly this could potentially result in a weak and rather etiolated tree.

Light levels

Another factor of the growing environment is light levels, which includes day length and light intensity. When growing plants in Europe these reduce during the winter. From experience there is no need to provide an artificial light source to boost the plant growth. The reduction of this growth factor in the cooler month in combination which others such as temperatures will help the plants to undertake the winter dormancy required. Once light levels increase in spring the plants will burst back into growth. Just before the new foliage is produced the plant will drop any old leaves that have remained on the plant over the winter. Over the summer months enough natural light is available. At the peak of summer there might even be too much, if this stresses the plants shading may need.

Containers

At RBG, Kew plants are generally grown containerized if not planted out on public display. Used are a variety standard pots that are available through commercial trade. When plants are designated for display, they may also be grown on in 'airpots'. These were originally manufactured for tree nurseries to ensure a healthy root system. The advantage of these rather specialized pots, with multiple pointing outwards holes in the sides, is that the fibrous root system is continuously pruned off through the impact

Figure 15

Figure 16

of air movement and light, preventing the roots from getting pot bound. Equally the pots are easy to be opened sideways which allow an easier handling of the root ball with far less disturbance than with conventional pots. For successful flowering the plants require enough root run as this can potentially take place with each spurt of new growth. However, plants grown in standard pots will only flower only once per season if not potted regularly and tend to be more susceptible to pests and diseases. Grown in airpots on the other hand this potentially can be increased through the less limited root run. In 2015, an air-pot grown specimen produced three healthy sets of new growth. Each resulted into a week long flowering display with up to 80 blooms during each period.

Substrate

As growing substrate at RBG, Kew a multipurpose compost is used. Kew's 'Potting On', is composed of 25% coir, 35% composted bark, 15% sterilized soil, 10% grit, 10% sand and 5% wood fibre. Alternatively, other commercially available standard substrates that provide a good moisture holding capacity, and equally allow an adequate soil aeration to take place, can be used. The soil pH should be neutral to slightly acid. When it comes down to re-potting a specimen it is very important that plants are not potted to deep and are kept at the correct nursery-line. Being a woody plant they can easily suffer and potentially die from under-potting and as a result become weak and are more susceptible to pest and disease. The trunk of a healthy plant should always taper slightly towards the root collar.

Water

In conjunction with the right potting technique and correct medium, the appropriate water requirements are important to consider. As previously mentioned, the plants remain relatively growth inactive through the winter and therefore the potting medium should be allowed to dry out to avoid root rot. Nevertheless, it should retain small amounts of moisture to avoid sudden leaf drop. If leaves do get aborted, watering needs to be decreased even further unless the soil is already too dry. Once plants come back into growth in spring the water demand will increase rapidly and particularly during the development of new soft growth the plants should be kept on the moist side to avoid premature leaf and flower bud drop. If plants go through multiple attempts of producing new vegetative growth without establishing these successfully they will consequently exhaust their energies reserves. This could result in losing them or at least promote severe dieback. Once the foliage is mature the plants are less prone to lose

it during periods of drought. At this stage plants can be allowed to dry out more between watering. When grown in airpots an automatic drip-irrigation system may be required. This should be adjusted according to the needs of the plants giving the stage of growth and time of the year.

Pests and diseases

In greenhouse culture the plants may be subject to the attack of pest and diseases. Under glass there are a number of commonly found pests that like to nourish on these. This could lead to unsightly damage that will remain on the plant until a new flush of growth appears, or in the worst case scenario the plant does not recover and will die. Examples for these pests are mealy bugs (Pseudococcidae spp.), scale insects (Coccoidea spp.), Western flower thrips (*Frankliniella occidentalis*) and occasionally aphids. Like any other *Passiflora* species the plants are especially favored by glasshouse spider mites (*Tetranychus urticae*) and nematodes (*Nematoda* spp.).

A heavy pest infestation in most cases can be traced back to the wrong growing environment or incorrect potting height as both weaken the plant and make it more susceptible and less able to recover. At RBG, Kew pest and diseases are controlled using Integrated Pest Management practices. Using beneficial organisms to control the pest problem is not only safer for the environment, it also avoids the risk of spray damage to the foliage particularly if immature.

Fungal diseases generally do not present a big problem. Only occasionally plants are affected by powdery mildew (various spp. in the order Erysiphales). As these fungi are caused by watering stress it can be easily eradicated through the appropriate water supply. Other leaf damage that can be encountered under cultivation is caused whilst young and soft growth is exposed to either too low or too high temperatures. When newly emerging growth experiences unexpected temperature drops during spring the leaves tend to lack chlorophyll around the leaf margins and appear white (**Figure 15** p. 67). This also reduces the eventual leaf size as well as flower buds that are potentially aborted. On the other hand, if during the leaf production temperatures rise too high above the preferred maximum and relative humidity as a consequence is reduced the leaf surface becomes distorted and covered in yellow spots (**Figure 16**).

Figure 17

Figure 18

Propagation

The propagation of all tree-like *Passiflora* species is regarded as difficult. Vegetative propagation through cuttings has a low success rate, as they do not root easily. Seeds on the other hand seem to be more promising but unfortunately these are only rarely available. A variety of techniques have been practiced at RBG, Kew. The following paragraph describes various ways that can lead to successful reproduction of *P. arborea* and its close relatives.

Sexual propagation

As indicated earlier the easiest way to obtain plants is to sow seeds. Best germination is achieved by using fresh material, in which case germination may take place just after a month (**Figure 17** p. 69). No matter if seeds are fresh or old it is important to remove the arils or any residues of these as they contain chemicals that will inhibit germination. Afterwards the seeds should be soaked in warm water for 24h prior sowing to remove any remaining inhibitors and equally allow the seed to absorb moisture needed for germinating. During this process it is advisable to renew the water at least once or twice. At RBG, Kew seeds are sown onto a low-nutrient, sterile and free draining compost, containing 50% coir and 50% fine sand. As this medium offers virtually no nutrients the lower half of the sowing container is filled with a general potting mix so the seedlings don't start to show signs of deficiencies once the energy of the cotyledons has been used up. After the seeds are sown on the surface of the sowing medium they are covered up with a layer of ornamental grit. This layer should be at least as deep as the seed is thick. To encourage fast germination the seed container is placed onto a heated bench with provides a constant 22°C bottom heat. For the initial germination process it is advisable to provide enough humidity as otherwise the cotyledons can struggle to emerge from the surrounding membrane. This can be achieved by placing them into a mist tent or even simpler into a sealed Ziploc bag. After successful germination the seeds need to be transferred into a less humid environment to avoid damping off. Once the seedlings have produced two to three true leaves and are well-established (**Figure 18**) they can be pricked out and potted on separately using the general potting compost. Keeping the seedling on a heated bench for a while will encourage a good root growth and consequently a quick establishment.

Asexual propagation

The most commonly used method of asexual or clonal propagation is via the means of cuttings. There are two

Figure 19

Figure 20

different types that have been proven to be successful at RBG, Kew. The first type is semi-ripe apical or internodal stem cuttings. The material chosen is new stem growth where the leaves have just started to harden off but have not yet reached full maturity. Suitable propagation material is generally available from early spring to late autumn during their growing season. The second type is apical or internodal deciduous hardwood cuttings. These are generally taken during the winter when the plants are growth inactive, choosing mature wood (**Figure 19** p. 71). Both are discussed below.

The following methods apply to both types of cuttings material used. Slight differences are pointed out within the text. Most success was achieved by using cuttings that are 10-15 cm long, bearing 6-8 nodes. As the cuttings will remain in the propagation unit for at least three months (slightly longer for hardwood cutting) until the first roots appear, it is important to use slightly larger material to ensure enough energy reserves are available for the rooting process. All leaves along the stem are removed and only the upper ones are kept. These relatively large leaves are reduced in size to minimize the surface area and consequent transpiration, preventing the cutting from losing too much water. From experience, most of the foliage will be aborted within the first week of being propagated. The basal cut below a node of the cutting should be cut in an angle so that the area of exposed cambium is greater. Once the cut on the base is made it should be either placed straight away in the moist propagation medium or at least stored in a jar of water to avoid air travelling up the vascular system as this will most likely lead to failure. It is also important to not touch the wound at any time, as this will also have a negative impact on the rooting success. Root formation is generally very slow but with the addition of rooting hormones such as as IBA (Indole-3-butyric acid) or NAA (naphthylacetic acid) this can be improved upon.

At RBG, Kew the cuttings are placed in enclosed propagation units. For this an enclosed and heated propagation bench has been proven to be most successful. The timber base of the bench is filled with a low-nutrient and sterile medium compose of equal parts of sand, peat and coarse Perlite. The medium should have a depth of at least 15cm to ensure an even temperature and moisture level throughout. The bottom heat should be maintained at 19°C. A slightly cooler air temperature (16°C) will guarantee best rooting results. In order to achieve a constant humidity of 90-100% and avoid the cuttings drying out the bench is covered with white polythene plastic. For both types of cuttings it takes at least 3 months until a good root system has been developed.

Air layering

Another form of vegetative propagation that is occasionally practiced to multiply specimens is air-layering. This has not yet been trialled on *P. arborea* but has proven to be successful for other arboreal species, such as *P. lindeniana*. The best material for this method seems to be mature 1-year old wood as it allows enough support for the air-layer not to snap accidentally, but at the same time enough meristematic tissue is present to form callus and eventually roots. The wood should have at least a thickness of 7mm.

At RBG, Kew two cuts are made, one from above and one from below the branch. Each should be deep enough to expose the heartwood but together they should not produce a weak point, which may break due to the weight of the top growth. In case the material is too thin wounding one side should give the same result. Once the branch has been prepared without touching the wound, rooting hormone is applied to it. It is then wrapped with moist Sphagnum moss to prevent drying out. Then it is covered with a layer of transparent plastic which allows one to check on the progress of root development without any disturbance and finally this is enclosed by a third layer of black plastic. The black plastic blocks out the light as generally roots don't grow within it. The whole assembly is fixed tightly together on the base with a piece of string and more loosely on the top so water can be applied easily if too dry.

Grafting

Another way to reproduce the plants is via grafting. Hereby, the scion of *P. arborea* is inserted into the rootstock of another species of *Passiflora*. At RBG, Kew *P. arborea* has been successfully established on *P. macrophylla*. The method that has proven successful is Side-Veener grafting.

A scion, a semi-ripe branch containing multiple buds is used. It is trimmed one side to match the shallow wedge shaped slice that has been removed from the *P. macrophylla* rootstock near the base. With this method, the top growth of the rootstock in this case *P. macrophylla* remains until the graft has taken. It is important that the cuts fit perfectly together so that both cambiums are sitting flush. The cuts should at no time to be touched. Both the scion and rootstock are fixed together with an elastic band and sealed with grafting tape (**Figure 20**). It will take at least 3 month until both pieces have moulded together.

The disadvantage of using *P. macrophylla* is that the plants tend to die back naturally and this may cause weakening of the graft's attachment point. On the other hand if one has success with grafting the cool condition loving *P. arborea* onto the rootstock of *P. macrophylla,* the plant can be grown under slightly warmer conditions. Grafting *P. arborea* onto any other species has not yet been trialled in RBG, Kew. Vanderplank & Magdalena Rodriguez (2010) reported about their accomplishment of grafting *P. lindeniana* onto the base of *P. caerulea*, making the species a little more cold resistant.

Flowering under cultivation

At RBG, Kew the first flowering took place on the 21st of April 2014. Flowering, like in all arboreal species, can potentially occur with each spurt of new growth. Pot grown plants tend to flower once a year. If potted on after the first bloom the plants can be encouraged to produce more new growth and consequently further blooms. At RBG, Kew the specimen that had been planted out on display has been recorded as flowering up three times per season, from early spring to late summer. The reason for this appears to be the unrestricted root run. In the UK depending on the temperatures early in the year the first flowers are to be expected mid to late April. From the first sign of new growth and flower buds breaking around mid February it will, depending on the environmental factors, take around 10 weeks until the first flower buds open. With increased maturity of the plant the number of flowers will increase. In 2015, one of RBG, Kew's specimens produced 80 blooms during one flowering event. *P. arborea* like all true trees it is 'orgy-flowered'. This means that all buds will open over the course of 1-2 weeks. Individual flowers only last for a day.

Pollinators

The pollinator of *P. arborea* as in most *Astrophea* ssp. has not been recorded successfully. Ulmer & MacDougal (2004) and Ocampo & Forero (2015) suggest that the species is most likely to be pollinated by large bees as others in the section are. This is very likely by looking at the floral morphology, colour and scent. At RBG, Kew one phenomena that has been observed on various occasions amongst the flowering specimens is that pollen is displayed on the upper surface of the styles (**Figure 21**). The explanation of how the pollen got there is that it was already shed and deposited on the styles whilst the bud was still closed. Other genera in the plant kingdom are known to have this so-called secondary pollen presentation but this has not yet been recorded for any *Passiflora* spp. It is the developmental relocation of pollen from the anthers onto another floral organ, which then functions as the pollen-presenting organ for pollination. Evidence for this being

Figure 21

Figure 22

not just a coincidence is that the upper surface where the pollen is generally found is uneven and capable of holding onto the grains. The purpose of this in *P. arborea* could be to attract a wider range of pollinators in the habitat to increased likelihood of successful pollination. It is possible that the species is not only pollinated by bees as suggested but also potentially by other animals such as bats, beetles or even hummingbirds. Yet more evidence for a potential nocturnal pollinator is that flowers at RBG, Kew have been recorded to be open during the night when the then not yet reflexed tepals could act as a sonar reflector **(Figure 13** p. 64**)**. Adriana Carolina Aguirre-Morales confirms the sighting of bats around specimens of *P. arborea* when out in the field at night. She also says that 'the strong smell of both flowers and fruits could potentially attract these mammals but this has never been confirmed. It is apparent that more research is needed.

Seeds have been successfully obtained by cross-pollinating two individuals from RBG, Kew's living collection. Under controlled conditions the pollen of one clone is transferred onto the stigmatic surface of another. Few of the pollination attempts are successful. In the best case scenario two individuals are flowering at the same time and fresh pollen is used. Trials to reuse cold stored and dehydrated pollen so far failed. Flowers tend to be already open in the early morning, sometimes even open during the night before and will close by the end of the day. The ripe pollen in some seems to be released from the thecae in the afternoon whereas in others this will take place in the morning or even before the flower has even opened. The right timing for successful pollination is still not yet clear. At RBG, Kew many flowers had to be cross-pollinated to sustain only few viable seeds. Eventually, two globose fruits carrying a combined total of 41 seeds were successfully produced. It takes about three month for the fruits to mature. At first they are white and covered in fine white hairs (**Figure 22**). As the fruits matures the colour changes to greenish-yellow

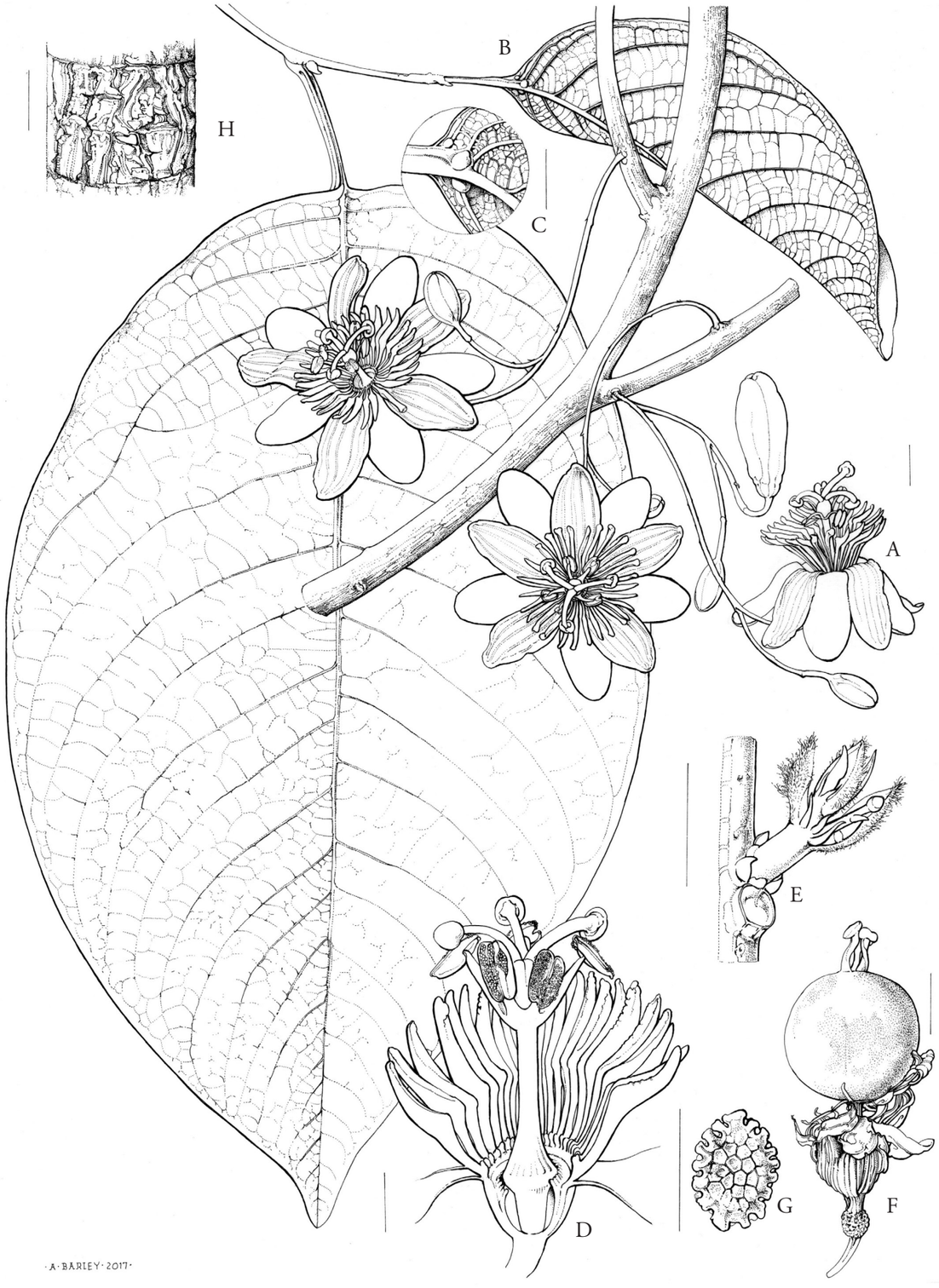

Figure 23 *Passiflora arborea*. A. Flowers: scale = 10mm. B. Leaves: scale = 10mm. C. Leaf close up of nectaries: scale = 5mm. D. Flower longitudinal section: scale = 5mm. E. Emerging shoot close up: scale = 10mm. F. Fruit: scale = 10mm. G. Seed: scale = 5mm. H. Trunk: scale = 10mm. Drawn by Anita Barley, from cultivated specimens at RBG, Kew.

and just before they reach full maturity and drop off they turn brown including all other remaining floral parts. At RBG, Kew a single fruit contained up to 21 individual seeds. Each seed is covered by a greenish-yellow aril that emits a very unpleasant petroleum-like scent.

Conclusion

In conclusion, *Passiflora arborea* is a very unusual and equally beautiful species of *Passiflora* that makes a valuable addition to any plant collection. Providing the right growing conditions with an understanding of their natural growth patterns it is a relatively easy species to grow. One is rewarded for all efforts when the species comes into bloom filling the whole glasshouse with its very pleasant fragrance. As for the future, *ex-situ* cultivation of this species may be of great importance as they extend of the natural population of the real *P. arborea* and the threats these are under is still relatively unexplored.

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Species Description:

Bonpland (1806)

Translated from the Latin

Lofty tree – with a habit of tripetalate magnolia, bark smooth greenish-ash grey. Attenuate branches, cylindrical, perfectly open. Leaves entire, large, very thin, green above, middle of the rib underneath with glands, very many solidary glands on the lower axils of the veins: petiole scarcely an inch long, furrowed on the inside. Two linear stipules, at the base of each petiole, opposite. Few white flowers, sweet smelling, in a forked/branched peduncle with leaves many times shorter, bearing bracts. Calyx egg shaped underneath, with an open 10 split limb all the lacinae oblong, pretty much equal like petals. Triple corona in multiple parts: bigger outside radiate, filaments at first rounded, subsequently arched in the manner of a sickle, put together there with the yellow ones; another two on the inside are very short, on thickish plates. Stamens, pistil and fruit like the rest of this genus.

Translated from the French

Tree: 6m tall, much resembles the three petaled Magnolia; trunk is straight, cylindrical, around 3m tall, divided in many branches of which the inferior ones are more open and sometimes drooping towards the tip. Bark smooth, uniform, coloured like ash.
Leaves: alternate, oblong, very-entire (the young ones often 2 feet long) very thin, tender green above, glaucous beneath, with marked (prominent) veins, the middle one bearing small glands in the axils of the inferior veins.
Petiole: thin, 2 cm long, slightly furrowed inwards, convex outwards.
Glands: spherical, yellowish, very variable in number: we can observe from 2 to 6.
Stipules: 2, linear, opposite at the base of each petiole. Persistent for some time.
Flowers: white located in the axils of the leaves, and aligned dichotomously on a peduncle, with small persistent bracts.
Calyx: inferior, almost campanulate, oval in the lower part, deeply divided in 10 parts, 5 of those divisions are exterior and 5 are interior: all are spread out, oblong and of equal length.
No Corolla
Corona: triple series (nectaries Linn.); the exterior one longer, formed of white cylindrical strips in the lower part; arched, yellow and compressed in the upper part. The two other corona series are composed of small and numerous blades, almost fleshy, close to one another.
Stamens: 5, united at the base in a straight tube, white, cylindrical: anthers oval, bilocular, opening longitudinally on the sides; pollen is a nice yellow.
Pistils: Ovary spherical, glabrous, with a short stipe: style divided up to half way, then splits into three parts: stigmas, three at the head, fleshy
Fruits: not observed

The botanical drawing (**Figure 23**) and the following description are based on specimens observed under cultivation at RBG, Kew. This data, in particular dimensions, may vary slightly to those wild occurring specimens as these potentially come across fewer growth limiting factors.

Hilgenhof (*Coll. 22,* 2014, Kew Herbarium)

Treelets: glabrous (except initially tomentose with brown hairs on midrib margin of abaxial leaf surface on newly emerging leaves), without tendrils; stem: terete, striate when young, covered in lenticels, semi-ripe and mature growth lignified, brown turning to greyish-brown in colour, newly emerging stems soft and green; stipules: setaceous, to 2mm long, soon deciduous, occasionally persisting on the plant; petioles: 2-2.5 cm long, glandless; leaves: simple, dark green, oblong to lanceolate, 15-37 x 10-24 cm, acute to sometimes acuminate at apex, obtuse to rounded at base, 2 (occasionally 1) pairs of sessile glands at the midrib near base, subcoriaceous at full maturity but soft and membranous during the development, pinnately veined, entire; peduncles: 1- to 2-dichotomous; bracts: setaceous, 0.2 cm long; floral tube: campanulate to cylindrical-campanulate, 0.9 cm long x 1.2 cm wide; flowers: 6 (-8) cm diam., with cocoa butter-like scent, inflorescence: 2- to 4-flowered; sepals: white, oblong, 3 (-4) x 0.8-1 (-1.3) cm; petals: white, subequal to sepals; corona: 2 series, outermost upper ¾ yellow, lower ¼ white, 1.6-1.7 (-1.9) cm, falcate, laterally compressed, dilated, innermost to 0.2 cm long, ligulate, yellow at apex and white at base; ovary: ovoid, white, puberulent; stigmas: 3, styles white, stigmatic surface pale yellow; anthers: 5, filaments greenish, pollen bright yellow; androgynophore: greenish white, getting gradually wider from base upwards, widest point located just above the operculum from there it tapers towards the apex; operculum: 2 mm long, erect, membranous, wider at apex; limen: absent; fruit: globose, puberulous, to 2.4 cm diam. at majority, turning to greenish- yellow; seeds: 2-21 per fruit, 0.5 x 0.4 x 0.1 cm, reticulate, surrounded by greenish-yellow arils containing juice with a petroleum-like scent.

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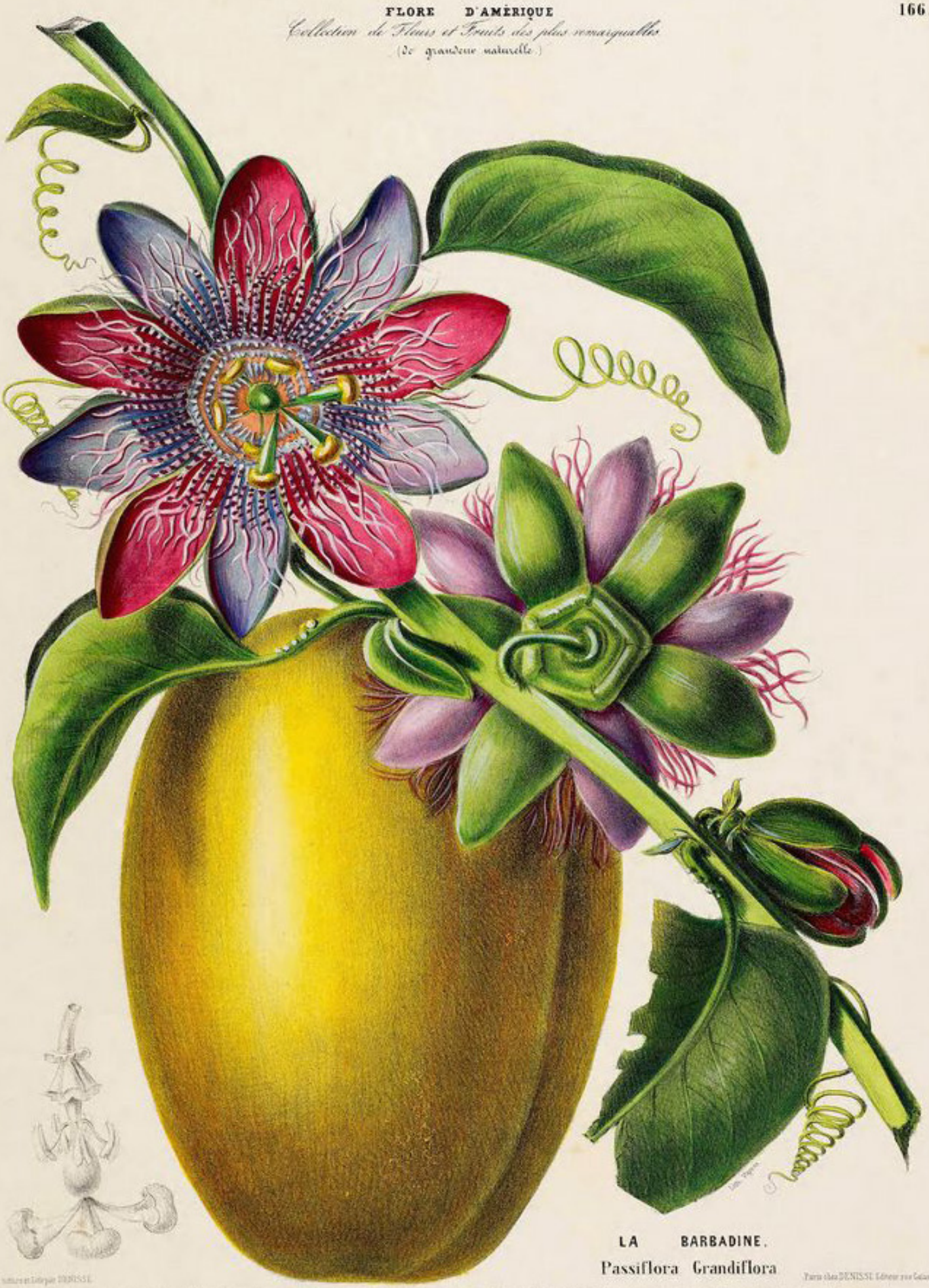
Cloud forest in Cundinamarca © John Ocampo

Collection de Fleurs et Fruits des plus remarquables

(de grandeur naturelle.)



LA BARBADINE.

Passiflora Grandiflora

Cette plante s'attache elle même aux arbres voisins par le moyen des vrilles axillaires simples et carrées à angles aigus, on l'emploie souvent dans les jardins d'agrément à garnir les tonnelles de verdure, le fruit est bon à manger avec du sucre, on peut aussi en faire du bon vin.