STUDENT PROJECT: *PASSIFLORA* SUBGENUS *ASTROPHEA* – CURIOSITIES AMONGST THE PASSIONFLOWERS

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ABSTRACT

This paper examines an unusual group of *Passiflora* L., providing an overview of all aspects related to the members of *Passiflora* subgenus *Astrophea* (DC.) Mast. It gives an account of their classification, morphology, distribution, habitats and ecology in order to provide a better understanding of the species included in this group. These examinations are factored into the recommendations for successful *ex situ* cultivation which is generally regarded as difficult. More depth of information on cultivation is provided for the four species most commonly found under cultivation: *Passiflora jussieui* Feuillet, *P. lindeniana* Planch. ex Triana & Planch., *P. macrophylla* Spruce ex Mast. and *P. pittieri* Mast. Despite the problems these plants present in cultivation they are rewarding additions to any plant collection which in future is likely to be of great importance due to many being threatened in their natural habitats. This project is an extract from the author's dissertation that was written for the Kew Diploma in Horticulture in 2012.

INTRODUCTION

Members of the genus *Passiflora* (*P.*), commonly called passionflowers, are predominantly perennial vines or lianas that climb by means of tendrils. There are currently about 580 species known to science. The subgenus (subg.) *Astrophea* is the third biggest of five subgenera with sixty-six members. These are scandent shrubs, woody lianas or free-standing trees or treelets. A small percentage of these species have entirely lost their adaptation to climb and it is thanks to this and the tendency to have tree- or shrub-like habits that makes this subgenus unique.

Representatives of the subg. *Astrophea* are mainly distributed in tropical South America with two species extending into Central America. Nearly all of the species are considered to be quite rare and still very little is known about these plants. They were first raised in cultivation in butterfly conservatories as a host plant for the caterpillars of the *Heliconius* Kluk (longwings). Initially only cultivated by lepidopterists, they sparked the interest of private collectors and botanic gardens alike thanks to their unique habit of growth and very attractive flowers. In recent years, despite increasing interest, only a few individuals are occasionally found in cultivation. This is due to the limited availability of plant material as well as because growing these plants is considered to be difficult.

The dissertation of which this Student Project is an extract was inspired by the personal interest and passion of the author for this extraordinary group of plants. The

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aim was to gain an understanding about the subg. *Astrophea*, its natural behaviour and how this affects *ex situ* cultivation.

Methodology

The majority of research for this dissertation was obtained by using a range of techniques.

Available literature of published or electronic origin was consulted where possible. With these sources and consultation with experts, a list of species in subg. *Astrophea* was established. The accuracy of the list was verified by cross-referencing with a number of plant indices (International Plant Names Index, 2005; Plant List, 2010; Tropicos®, 2011) and proofreading by Emil Kugler in 2011–2012. Having referenced the species list with the Botanic Gardens Conservation International (BGCI) Database (Botanic Gardens Conservation International Database, 2011) and a number of experts, an accurate assessment of the species found in cultivation was acquired. Using this list, an electronic questionnaire was circulated to 20 individuals who work with botanic garden or private collections. The questionnaire asked relevant exploratory questions about the cultivation of these plants, giving the participants the opportunity to share unconstrained information. A return rate of 60 per cent was achieved, with a total of twenty-one forms completed by twelve individuals covering the four most commonly cultivated species (see Appendix 2). For this reason, these will be the focus of discussion with regard to the cultivation of the plants.

Finally, personal knowledge of the cultivation of *Passiflora* subg. *Astrophea* was supplemented by experience gained working with plants in the collection at the Royal Botanic Gardens, Kew (RBG, Kew).

Literature review

Historical account of subg. *Astrophea*

The genus *Passiflora* was constituted by Linnaeus in 1737. However, it was not until 1806 that the first two members (*P. glauca* H. & B. syn. and *P. emarginata* Bonpl.) of the yet to be constituted subg. *Astrophea* were described.

The first account of subg. *Astrophea* was made in the publications of DeCandolle (1822, 1828), described in Killip (1938). Over the next 200 years the concept of the classification of section (sect.) *Astrophea* DC. (1822) varied greatly and was looked at by Roemer (1846), Bentham & Hooker (1862–1883), Masters (1871) and Harms (1893 & 1925). Later, Killip (1938), in his monograph on the American Passifloraceae, a publication that for many years has been regarded as one of the most comprehensive accounts of the genus *Passiflora*, raised *Astrophea* to subgeneric level, recognising forty-six species which are subdivided into six well-defined sections (*Dolchiostemma*, *Cirrhipes*, *Leptopoda*, *Euastrophea*, *Pseudoastrophea* and *Botryastrophea*). The taxonomic treatment of Killip (1938) had been used for more than half a century and was accepted in subsequent literature – Vanderplank (1991; 1996; 2000), Ulmer &

Ulmer (1997) and Klock (2001) – as well as in the work of Escobar (1994) and Feuillet (2002).

In 2004, Feuillet & MacDougal published their *New Infrageneric Classification of Passiflora*, in which the subg. *Astrophea* is divided into two main supersections (supersect.), each once again subdivided into two or three sections and one section again split into two series (ser.) (Feuillet & MacDougal, 2004). Currently Hansen is working on the revision and completion of the work of the late Escobar (1994) for the project Flora Neotropica.

Present literature

In current literature on the genus *Passiflora*, subg. *Astrophea* is often neglected and the representatives are barely mentioned: Vanderplank (1991; 1996; 2000) and Ulmer & Ulmer (1997; 1999). The most elaborate account is made in Ulmer & MacDougal's monograph (2004) on the genus *Passiflora*, as they dedicate a whole chapter to the subgenus.

***Passiflora* subg. *Astrophea* in cultivation**

The members of subg. *Astrophea* are real curiosities and are regarded as highly difficult to grow. For this reason the cultural requirements are only touched upon briefly in most books and are mainly part of the general species characterisation as in Vanderplank (1991; 1996; 2000) and Klock (2001). A particularly noteworthy approach on the treatment of cultivated *Astrophea* species (ssp.) is made by Ulmer & Ulmer (1997) and Ulmer & MacDougal (2004).

In recent years, species of subg. *Astrophea* have become more available for *ex situ* cultivation, resulting in an increased demand for relevant literature. Enthusiasts who achieve success in maintaining and breeding individuals of the subgenus, in *ex situ* and *in situ* cultivation, voluntarily share their knowledge in the form of articles: Meerman (1996), Gilbert (1996), Vecchia (2002), Gilbert (2004), MacDougal (2007), Vanderplank & Magdalena Rodriguez (2010).

INTRODUCTION TO *PASSIFLORA* SUBGENUS *ASTROPHEA*

Classification

Passiflora subg. *Astrophea* is the third biggest of five subgenera (*Astrophea*, *Deidamioides* (Harms) Killip, *Decaloba* (DC.) Rchb., *Passiflora* and *Tetrapathea* (DC.) Green in *Passiflora*. The type species for the subgenus is *P. arborea* Spreng. (*P. glauca* syn.).

The genus *Passiflora* is classified in the tribe Passifloreae DC., within the subfamily Passifloroideae Burnett of the family Passifloraceae Juss. ex A. Roussel, in the order Malpighiales Martius of the Dicotyledons (Stevens, 2001 onwards). See Fig. 1 for the further subdivision of the subgenus into supersections and sections.

***Passiflora* L.**
1. **Subgenus *Astrophea*** (DC.) Mast.
   1.1. Supersection *Astrophea* (DC.) MacDougal & Feuillet
      1.1.1. Section *Astrophea* (DC.)
      1.1.2. Section *Capreolata* MacDougal & Feuillet
      1.1.3. Section *Leptopoda* Killip ex Feuillet & Cremers
   1.2. Supersection *Pseudoastrophea* (Harms) Feuillet & MacDougal
      1.2.1. Section *Pseudoastrophea* (Harms) Killip
      1.2.2. Section *Botryastrophea* (Harms) Killip
         1.2.2.1. Series *Botryastrophea* (Harms) MacDougal & Feuillet
         1.2.2.2. Series *Carnae* Feuillet

Fig. 1 Systematic classification of the subgenus *Astrophea* (Feuillet & MacDougal, 2004).

Morphology

Habit: small trees, scandent shrubs, woody vines or lianas; true trees found in sect. *Astrophea* (for example *P. lindeniana*) have a secondary xylem of concentric rings (Ulmer & MacDougal, 2004) also found in many species of the sect. *Botryastrophea* (Escobar, 1994).

Stem: terete; new emerging growth erect or occasionally prostrate (Ulmer & MacDougal, 2004).

Tendrils: well developed in some ssp., absent in sect. *Astrophea* or reduced to short spines for example in *P. spinosa* (Poepp. & Endl.) Mast.

Stipules: small, setaceous or narrowly linear (Vanderplank, 1991), soon deciduous.

Leaves: alternate; leaf blade: simple, unlobed, pinnate venation; nectar glands: if present inconspicuous and located near or at the margin (Fig. 11j) (Ulmer & MacDougal, 2004).

Petiole: petiolar glands: 1 or 2 pairs, sessile or scar-like, abaxial or adaxial near apex or on the leaf midvein close to the blade base (Ulmer & MacDougal, 2004).

Flowers: singly, in pairs or multiple flowered inflorescences (Ulmer & Ulmer, 1997) derived from the leaf axils of young shoots (for example in sect. *Astrophea*) or branch from the nodes of old lignified wood (sect. *Botryastrophea*) (Escobar, 1994). A quite primitive condition is found in some species such as *P. cirrhipes* Killip, where the peduncle of the terminal flower is transformed into a tendril (Feuillet, 2002). See Fig. 2 for a drawing of the flower and structure.

Bracts: tiny, bristle-like to narrowly linear; scattered along the peduncle (Killip, 1938).

Pedicel: jointed (Feuillet, 2002), sometimes unusually long, for example *P. leptopoda* (sect. *Leptopoda*) (Ulmer & MacDougal, 2004).

Sepals and petals: 5, equally sized or the sepals slightly larger, greenish-white to white (for example sect. *Astrophea*) or orange, reddish to purple (sect. *Botryastrophea* only).

Hypanthium (floral tube): campanulate, funnel-shaped or cylindric (Feuillet, 2002), short and inconspicuous (in sect. *Astrophea*) or long and obvious (sect. *Botryastrophea*) (Killip, 1938).

Corona filaments: 2 to 5 series, dilated in the upper half (Vanderplank, 1991), greenish yellow or yellow to orange in colour, sometimes with purple speckles (sect. *Pseudastrophea* for example *P. candida*), plumose in 2 species of sect. *Leptopoda* (Feuillet & Cremers, 1984) or reduced in sect. *Botryastrophea* (Ulmer & MacDougal, 2004).

Androgynophore: column-like structure bearing both the androecium and gynoecium. In some species of sect. *Pseudastrophea* (for example *P. kawensis* Feuillet) an umbrella-like structure is found partway up the androgynophore (Feuillet, 1994).

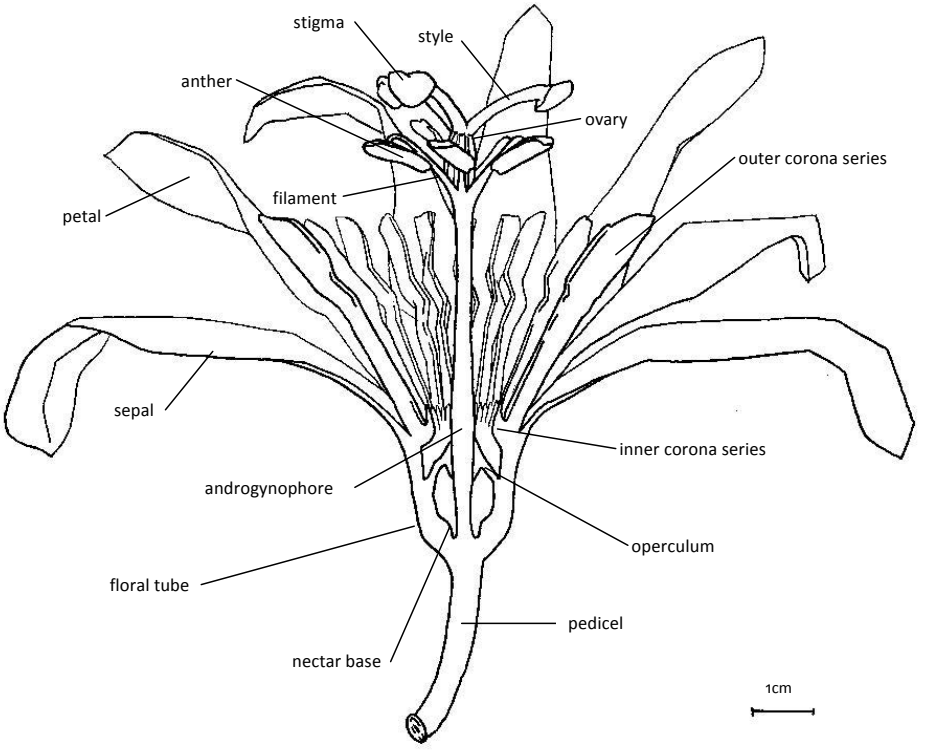

Fig. 2 Drawing of the longitudinal section through the flower of *P. macrophylla*. Drawing: R. Hilgenhof.

Ovary: superior, ovoid, oblong to ellipsoid, 3-angled, broadly truncate at apex (Vanderplank, 1991), situated at the androgynophore apex, containing multiple ovules with parietal placentation.

Stamens: 5, more or less radially symmetrically arranged (Ulmer & MacDougal, 2004).

Stigma: 3, situated above ovary, projecting from the angles (Killip, 1938).

Operculum: tubular and erect, or spreading, membranaceous base, apex fringed or cleft partway (Ulmer & MacDougal, 2004).

Distribution

Nearly all representatives of subg. *Astrophea* are indigenous to South America, with two exceptions amongst the members of supersect. *Astrophea*; *P. tica* Gómez Laur. & Gómez (Costa Rica to Colombia) and *P. pittieri* (Belize to Colombia) (see Fig. 3). Both are native to Central America.

The main area of distribution is in the tropical lowland countries of northern South America, of which Brazil, with a total of 24 taxa, accommodates by far the greatest number of species. Generally, the countries along the Amazon basin are known to contain a large variety of species. For example, all members of sect. *Botryastrophea* are found exclusively in this part of the world (Ulmer & MacDougal, 2004).

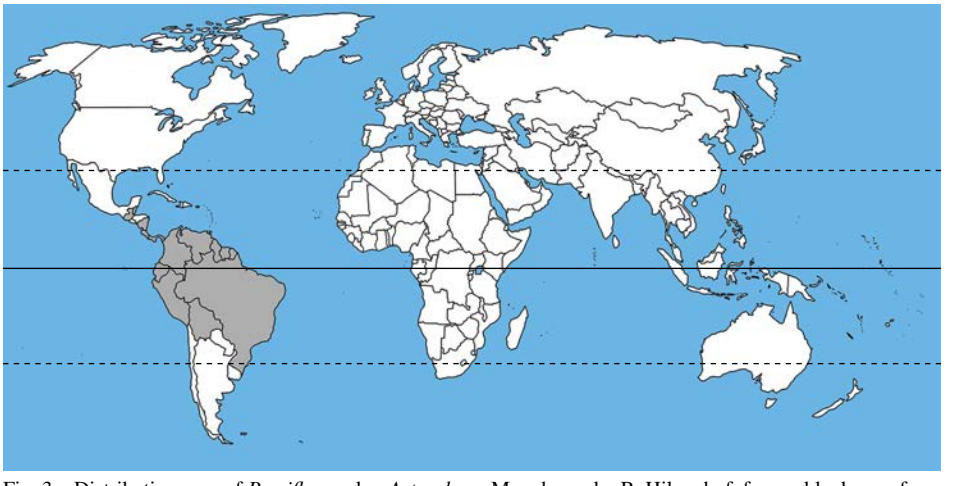

Fig. 3 Distribution map of *Passiflora* subg. *Astrophea* . Map drawn by R. Hilgenhof, from a blank map from Vectorya (2011).

Habitat

The majority of species in subg. *Astrophea* are found in a variety of tropical lowland forest habitats (Ulmer & MacDougal, 2004). For example, the low-altitude rainforest habitats of the three Guianas accommodate a total of twenty-two species, which are divided into four distinct habitat types: savanna with shrubs and trees (*P. quelchii* Br.), unflooded forest (*P. amoena*) (Fig. 4 a+b), cascading streamside forest (*P. leptopoda*) and riverine forest (*P. vescoi* Rignon & Rignon) (Feuillet, 2011). In Brazil, other rainforest habitats have been recorded; some species are indigenous to montane rainforest habitats (for example *P. elliptica* Gardner) at altitudes of just above 800m, and others to coastal forest, the so-called *restinga*, where species (for example *P. pentagona* Mast.) are found growing in well-drained, sandy soil conditions (Ulmer & MacDougal, 2004). Even though most species are found in low-altitude habitats of the tropics there are some that occur in much higher elevations, reaching well above 1,000m above sea level (for example *P. arborea*). One of the species with the highest altitude records is *P. lindeniana*. It is native to the cloud forest of the lower Andean mountains in Venezuela (Vanderplank & Magdalena Rodriguez, 2010), where it is found in advanced altitudes of up to 2,700m. There, the species may experience temperatures that drop as low as 2–4°C during the night (Vanderplank & Magdalena Rodriguez, 2010).

Fig. 4 (a) The forest liana *Passiflora amoena* in its natural habitat, French Guiana (b) close-up of flower. Photos: R. Hilgenhof.

Conservation status

Since the early days of studying *Passiflora*, almost all members of subg. *Astrophea* were regarded as considerably rare, with many known only from the type collections (Killip, 1938). *P. quelchii* is such an example, as it has been found only a few times (Ulmer & Ulmer, 1997) since it was discovered in 1901. Generally speaking, species in subg. *Astrophea* are scarce in the wild and many, particularly those of supersect. *Astrophea*, are considered to be endangered or already extinct (MacDougal, 2007).

The International Union for Conservation of Nature (IUCN) Red List of Threatened Species (2011) currently lists twenty-seven members of the genus *Passiflora*; only one of them is part of subg. *Astrophea*. The single species inheriting the status Vulnerable D2 is *Passiflora trochlearis* Jørg. because its habitat in the Ecuadorean Andes is threatened (Jørgensen & Pitman, 2004).

There are, however, many others that are endangered, but do not occur on any of the threatened species registers. *P. lindeniana* is one of these species. The two biggest threats this rare tree is facing is felling for firewood and deforestation of its natural habitat (Vanderplank & Magdalena Rodriguez, 2010). In 1993, this led to a decline in population from twenty known mature specimens to only four, but luckily in the last decade four stands of adult trees have been discovered and the population has since begun to stabilise (Vanderplank & Magdalena Rodriguez, 2010). Unfortunately, they are now confronted with a new threat: an insect pest which has had a grave impact on the regeneration of the wild population (Vanderplank & Magdalena Rodriguez, 2010).

These are only two examples but nearly all species of the subg. *Astrophea* are of conservation concern. Further investigation on population dynamics and the possible threats these species face is in serious need of review in order to determine their IUCN status.

ECOLOGY

Representatives of subg. *Astrophea* have unique relationships with other organisms within their ecosystem. These interactions have a major impact on the growing behaviour of many individuals. For their cultivation it is important to gain an understanding of these natural growing behaviours as this greatly influences how the plants perform in the man-made environment.

Co-evolution

The most important group of herbivores associated with members of the genus *Passiflora* are the colourful *Heliconius* butterflies from the neotropics. Larval stages of these maracuja butterflies feed exclusively on the leaves of *Passiflora* spp. Although the foliage is known to contain defence toxins, the caterpillars have evolved over time and can tolerate these poisonous substances. As a result of this co-evolution, *Passiflora* spp. feature a great diversity of leaf forms, sizes and colours. Many species

have developed additional defence mechanisms such as egg-mimicries and extra-floral nectaries. Nearly all passionflowers are known for their close relationship with *Heliconius* butterflies and in most cases these will feed on more than one *Passiflora* spp. This is different from many of the heliconiine butterflies that are associated with the members of subg. *Astrophea*. Nearly all are monophagous and will exclusively feed on only one taxon.

The 'Holstein' butterfly (*Heliconius sapho* Drury) is famous for its complex relationship with *Passiflora pittieri* in Belize. Larvae of the butterfly can only feed on young leaves (Fig. 5) as toxin levels found in mature foliage are lethal (Meerman, 2002). In addition to the chemical defence they become very tough and leathery when mature, and hence are difficult for the early instars to eat (Gilbert, 2004). *P. pittieri* is a so-called episodic grower. This behaviour is presumably a result of co-evolution as for most of the year the plant remains inactive and does not provide any suitable food for the caterpillars. During this period the butterfly is unable to lay eggs and has developed the ability to survive for up to six months on the pollen of *Psiguria* Neck. ex. Arn. vines, until the *Passiflora* starts producing new foliage (Meerman, 2002). Once the plant begins to produce high quantities of new shoots, the Holstein butterfly deposits clusters of eggs on the shoot meristem (Meerman, 2002). New growth is quite stunted at first but the plant will then grow very quickly. As the shoots expand the eggs are equally distributed over the whole area of new growth (Meerman, 2002), minimising the risk of larval cannibalism and ensuring that there is enough food for each individual. The eggs are timed to hatch as soon as enough young foliage has developed (Meerman, 2002). This mass feeding of the *Heliconius* butterfly larvae, resulting in total consumption of new growth, limits the size of most plants found in the wild (Gilbert, 2004).

Fig. 5 Larvae of *H. sapho* and/or *H. hewitsoni* on *P. pittieri* at Butterfly World, Florida. Photo: R. Hilgenhof.

Heliconius butterflies are not the only Lepidoptera L. known to feed on passionflowers in subg. *Astrophea* during their larval stages. Representatives of the genus *Eueides* Hübner and a few species of neotropical diurnal moths of the genus *Getta* Walker are also known for rearing their offspring exclusively on *Astrophea* spp. (Miller & Brower, 2009).

MEMBERS OF THE SUBGENUS *ASTROPHEA* IN CULTIVATION

The following section provides cultural guidelines for *Astrophea* spp. found in cultivation and is accompanied by more detailed plant-specific information for the four most commonly cultivated species. The recommendations were obtained through personal experience with plants in the living collection at RBG, Kew and supplementary information gathered through the questionnaires completed by a number of plant breeders and growers: Dr N. Abdul Karim (2011), A. Kirillov (2011), J. Lopez (2012), C. Magdalena Rodriguez (2011), R. McPhail (2011), E. Peters (2011), A. Seringer (2011), T. Ulmer & B. Ulmer (2012), H. Van Aalst (2011), J. Vanderplank (2012), M. Vecchia (2012) and J. West (2012) (see Appendix 2).

Cultivation of Astrophea species

Compared to species in other subgenera of *Passiflora*, the members of subg. *Astrophea* are rarely found in cultivation (Fig. 6). Although these curiosities are great additions for any plant collection, they are relatively difficult to obtain and if a plant is brought into cultivation, growing it successfully can be a challenge.

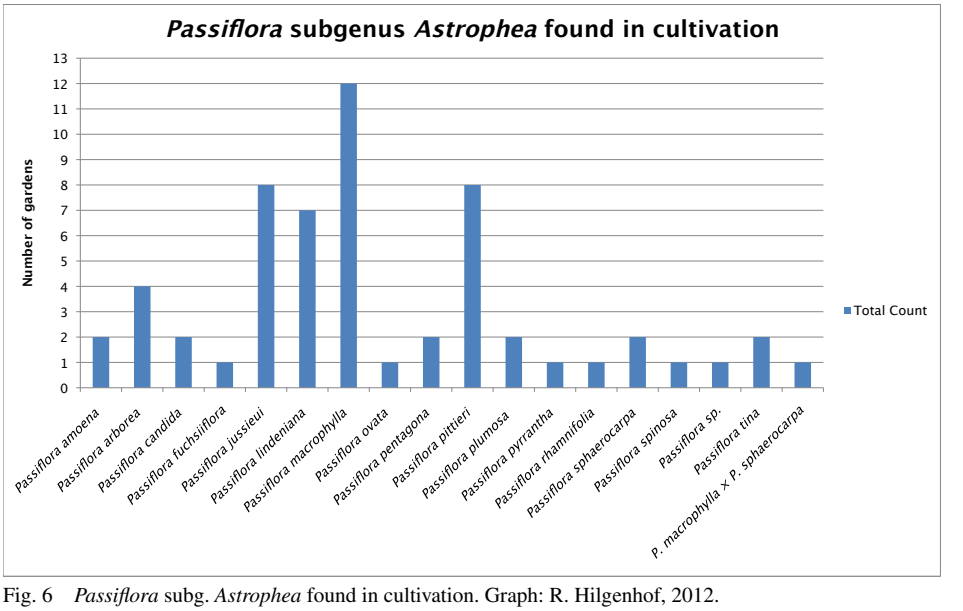

Fig. 6 *Passiflora* subg. *Astrophea* found in cultivation. Graph: R. Hilgenhof, 2012.

Many of these plants fail in cultivation because they have an unpredictable growing pattern. This can be attributed to co-evolution with *Heliconius* butterflies, as well as the environmental conditions that these species are associated with. For this reason specialist knowledge is required to successfully cultivate *Astrophea*, in particular those with a tree-like habit which are known to have episodic growth. This is distinguished by long periods of apparent dormancy during which plants may even drop their leaves entirely, followed by flushes of new growth.

The following paragraphs provide useful guidance for the successful cultivation of subg. *Astrophea.*

Astrophea spp. are indigenous to the warmer regions of South and Central America, so in order to achieve success in less favourable climates a glasshouse is essential. The majority of species occur in warm and humid climates and require a tropical growing environment, whereas others, like *P. lindeniana*, which are found growing at higher elevations, need to be cultivated in temperate or subtropical conditions.

The temperature requirement in cultivation may vary depending on which species is grown. Species native to temperate regions, such as *P. lindeniana*, hardly ever experience temperatures that rise above 26°C, but they can cope with temperatures that drop to 2–4°C (Vanderplank & Magdalena Rodriguez, 2010). It is essential to replicate these conditions within the growing environment. Recommended temperatures range from a minimum of 10°C during winter to a maximum of 30°C during summer. When the maximum temperatures are exceeded, plants respond by etiolating; in some species (for example *P. lindeniana*, *P. sphaerocarpa*) the young, soft foliage tends to show signs of yellowing distortion as well. This condition seems to be less of a problem for mature leaves, as these are tough and leathery. Tropical species, on the other hand, are exposed to warmer climates and therefore grow well in higher temperatures ranging from 18 to 35°C. These species cope easily with short-term increases in temperature above the maximum but temperatures below the minimum requirements should be avoided. In addition, these warmth-loving species will benefit from soil temperatures maintained at 24°C (Vanderplank, 2012).

By looking at the area of natural distribution, the necessary humidity levels needed by a species can be ascertained. In French Guiana, for example, the humidity levels in tropical regions vary from an average minimum of 63.5 per cent to average maximum of 98 per cent. When growing these species within a glasshouse an average humidity of 80 per cent should be maintained throughout their growing season, but this can be reduced when they show signs of dormancy. Similarly the humidity in the temperate regions, such as the mountain areas of Venezuela, has a minimum of 50 per cent and a maximum of 99 per cent, therefore an ideal humidity under glass would be maintained at 75 per cent. An increase in humidity is advisable when new growth is noticed, to avoid it being aborted.

In nature, *Astrophea* spp. experience constant levels of daylight, roughly 10 to 12 hours all year round. When cultivated outside their country of origin, for example in Europe, these conditions are only achieved during the summer months; therefore

supplementary lights during the winter are recommended (Vanderplank, 2012), although they are not essential. Some species are considered to be canopy species, whereas other species tend to grow in the understory (for example *P. macrophylla*), so in order to cultivate these plants within the glasshouses the canopy species require higher light conditions and the understory species need to be semi-shaded. The amount of light provided to the plants can sometimes determine their type of growth. *P. pittieri*, for example, will grow liana-like in poor light conditions, but in full sun will develop a shrub-like growth habit (Gilbert, 2004). Flower development is also regulated through the supply of light; in general, flower buds will only be produced if this is sufficient.

Container-grown plants are watered as required but should never be left to dry out completely. The demand for water will increase as new growth appears (Fig. 11f). The plants will take up more water as they develop into maturity. Young leaves are very soft and if the plant comes under water stress they dry out very quickly and growth could be aborted. On the other hand, species may go through periods where they shed their leaves completely, during which time they will consequently need less water. It is beneficial to use either rain water or tap water treated through reverse osmosis plus additional acid injection, as most plants such as the Guianan species experience acid rains in their natural environment (Vecchia, 2012).

A variety of organic-based standard potting media (pH 5.5–6.5) with low clay or loam content appear to be suitable for growing this species, as long as free drainage is guaranteed. In order to ensure good drainage, inorganic materials such as lava stones, pumice and perlite can be added. When potting on, the depth of planting is important as the wrong level can be fatal. Repotting should always be kept to the natural nursery line. Slow-release fertiliser contained in the growing medium will ensure a constant supply of nutrients throughout the growing season, but new flushes of growth appear to respond well to additional feeds. In cultivation under glass the plants are generally grown in containers and it is advisable to attempt to pot up the plants just before they start a new flush of growth. The advantage with this is that plants increase in size more readily and flower production is more likely. Most species require a little pruning and this is mainly carried out to reshape the specimen or encourage flowering for those species that bloom on young shoots.

In cultivation, plants are exposed to a variety of common glasshouse pests, such as mealy bug (Pseudococcidae), scale insect (Coccidae) and occasionally aphids (Aphidoidea). If effectively controlled they generally do not pose a problem. Nematodes (*Meloidogyne*) and red spider mites (*Tetranychus urticae*) are more of an issue as the species of subg. *Astrophea*, like many other *Passiflora* spp., are susceptible to these. If outbreaks become severe, organic or inorganic pesticides can be used. Care should be taken when applying these chemicals to young foliage as it could result in chemical burn (Fig. 11g).

Seed propagation

The most successful method of propagation is by seed. In most cases these are sourced from wild plants. In cultivation viable seeds are hardly ever obtained as the plants are self-incompatible and plants of the same species rarely flower at the same time, and therefore there can be no exchange of pollen. Seeds are sown on sterile, low-nutrient compost. They are covered with a layer of sowing compost two to three times the thickness of the seed. Some plant breeders prefer to soak the seeds for three to five days in a water bath (Ulmer & Ulmer, 2012) in order to soften the seed coat as well as to dispose of inhibiting hormones by changing the water (Vecchia, 2012). For successful germination these are placed in an enclosed high-humidity (up to 100 per cent) environment, providing temperatures of 20–30°C with supplementary bottom heat maintained at 25°C. Germination generally takes place after three to four weeks, depending on the quality of seed material, but it can occur after just two weeks (Vanderplank, 2012). While the seedlings begin to emerge it is helpful to provide occasional misting as this helps to soften the endocarp and enables good development of the emerging cotyledons. Seedlings should be well established and contain at least two pairs of true leaves before pricking out into small individual pots. For good establishment after pricking out, the seedlings should be kept in the sowing environment for a further five to six weeks. The best time to harden off the seedlings is as soon as two or three more true leaves have grown. When these become leathery they are less susceptible to changes in climatic conditions, unlike the young foliage. Seed material is so seldom available that one often has to resort to vegetative propagation methods.

Clonal propagation

Amongst species with a tree-like growth, clonal propagation methods such as cuttings are not particularly successful but they are achievable with care. Cuttings are best taken in summer as growth is more abundant and suitable propagation material is readily available. In addition to increased plant growth activity, the cuttings benefit from the increase in light quality and rooting is more likely. When semi-ripe apical or internodal cuttings with three to four nodes are used, success rates are greater. Leaves that are immature or too large in size should be reduced to about ⅓ or ¼, whereas the mature leaves of small-leafed species do not need to be decreased in size as their ‘leathery’ cuticle reduces wilting (Magdalena Rodriguez, 2011). The cuttings can be placed in enclosed propagation units with ideal temperatures maintained at 20–30°C. Relative humidity of 90–100 per cent is desirable to avoid dehydration of the cutting (Magdalena Rodriguez, 2011). Additional bottom heat, preferably 21–24°C, may help to increase the speed of the rooting process (Magdalena Rodriguez, 2011). Root formation is generally very slow but with the addition of rooting hormones (indol-3-ylbutyric acid, naphylacetic acid) after approximately three weeks, root formation could be expected in some such as *P. jussieui*. Rooting media need to be low-nutrient and near sterile and

those with the best results have been a combination of one or more of coir, peat, perlite and vermiculite.

Other vegetative propagation techniques such as layering or air-layering may be more successful than cuttings. In these techniques the propagule roots while remaining connected to the mother plant, which supplies the energy it needs. The use of layering is unexplored for most species, but it is likely to work well with those plants of liana- or vine-like habit. The use of air-layering is greatly recommended for the propagation of the tree-like species. Other methods, such as grafting, have also been tried on some species with great success such as *P. lindeniana* (see the section on this species below).

DESCRIPTIONS OF THE FOUR MOST COMMONLY CULTIVATED *ASTROPHEA* SPECIES

Passiflora jussieui

Formerly known as *Passiflora citrifolia* (Juss.) Mast., *P. jussieui* occurs in the lowland rainforest of French Guiana and Suriname. As a member of sect. *Capreolata* it is closely related to the true trees but, unlike these, *P. jussieui* is a climbing shrub. The shrub-like growth habit is displayed whilst the plants are young but, as they mature, they become more liana-like (Feuillet, 2010). The species bears well-developed tendrils, so at first sight it could easily be mistaken for the representatives of other subgenera, and only on close examination does it reveal the typical characteristics of the members of subg. *Astrophea* (see *Morphology*).

P. jussieui is quite commonly cultivated and considered to be comparatively easy to grow. Throughout most of the year within Europe, the species will require a glasshouse (temperature: 19–30°C; humidity: 80 per cent; light exposure: semi-shade to full sun) for cultivation. This species flowers readily in cultivation, however flowers (Fig. 7) occur only on mature specimens. It has also been observed that specimens grown in pots show a decreased flower production when pot-bound (Vanderplank, 2012), therefore regular repotting is advised.

Propagation, which is relatively successful in this species, is best done asexually by cuttings. Seed material, in particular of cultivated specimens, is rarely available. Semi-ripe apical or internodal cuttings with two to four nodes were reported to have shown very promising rooting results by a number of plant breeders. As with many other *Astrophea* spp., cuttings take best when placed in enclosed propagation units. With the addition of rooting hormones root formation could be expected from as early as three weeks. For more information, see *Cultivation of Astrophea species* above.

Passiflora lindeniana

Passiflora lindeniana is the largest of all the true trees. Mature specimens in the wild are recorded to grow as tall as 20m, accomplishing a basal girth of 1.25m (Vanderplank &

Fig. 7 *Passiflora jussieui* flowering in the behind-the-scenes collection at RBG, Kew. Photo: M. Jones, 2013.

Magdalena Rodriguez, 2010). Like all members in sect. *Astrophea* this species has lost its tendrils entirely.

It is found growing naturally at higher elevations where temperatures are low, therefore plants should be grown in a temperate glasshouse (summer temperature: 20–25°C, winter temperature: min. 10°C; humidity: 60–90 per cent; light exposure: semi-shade to full sun). In some parts of Europe it is possible to grow the species outdoors during the summer as long as temperatures do not exceed a maximum of 25°C and the nights are frost-free. Compared to other members of the subgenus, this species cannot be regarded as easy to cultivate. Not only are plants in the wild known to shed their leaves at certain times of the year, in cultivation this can also take place during the winter months in response to unfavourable climatic conditions. The exact reason for this is not known. During this period of dormancy, as with many other tree-like species, watering will need to be reduced. Once new growth appears, the water supply should be increased.

P. lindeniana is orgy-flowered. This means all the flower buds open over the course of just a few days. This phenomenon is rarely seen in cultivation, as it is difficult to induce flower production. In Europe, the first record of a flowering plant was made by the Flora und Botanischer Garten Köln, Germany, in June 2009, only one month before the first flowering plant in the UK was recorded at RBG, Kew (Fig. 8 a+b).

Seeds are the easiest and most successful way of propagating this species (Fig. 11c), and material is available on a regular basis. For the best germination results follow the guidelines described in *Cultivation of Astrophea Species*. Clonal propagation of the species with cuttings is also possible but known to be very difficult. More promising vegetative propagation methods are air-layering (Fig. 11 d+e) or grafting onto the rootstock of other tree-like species such as *P. macrophylla*. This has

Fig. 8 *Passiflora lindeniana* (a) flowering for the first time at RBG, Kew in July 2009, (b) close-up of the flower. Photos: N. Johnson, 2009.

the advantage that plants are less susceptible to warmer soil conditions. Vanderplank (2012) also had great success by butt-grafting the species onto the hardy *P. caerulea* (subg. *Passiflora*) rootstock, with a resulting increased tolerance to cold and damp soil conditions.

Passiflora macrophylla

Passiflora macrophylla is a medium-sized (4–6m) understory tree that is found growing in the tropical lowland forests of Ecuador and Columbia. Like its close relative *P. lindeniana*, typical climbing aids for the genus *Passiflora* no longer remain for this species. *P. macrophylla* produces enormous leaves by which it can be easily distinguished from others in the subgenus. In fact, they are the biggest in the entire genus and can, in mature wild plants, reach a length of up to 1m. The foliage is held at the tip of the otherwise leafless, generally unbranched stem. In cultivation, an impressive length of up to 53cm has been recorded by the author.

The species is one of the most commonly found species in cultivation (see Appendix 2). Originating in tropical conditions, it is only suitable for cultivation in a tropical glasshouse that is warm (18–35°C), with high humidity (above 80 per cent) and semi-shaded conditions. The plant should be watered as needed but never allowed to dry out entirely. Water demand is decreased as the plant is leafless but increased as soon as new growth appears (Fig. 11 h+i). This is particularly critical when the leaves expand to their enormous size, as this involves a major uptake of water by the plant. If the cultural conditions are favourable, the plants may even flower in cultivation (Fig. 9).

The best way of propagating this species is through semi-ripe apical or internodal cuttings as seed material is only occasionally available from a specialist seed supplier.

Fig. 9 The first bloom of *Passiflora macrophylla* at RBG, Kew in July 2010, (a) flower open, showing the reflexing position of petals and sepal, (b) flower buds. Photos: R. Hilgenhof, 2010.

Passiflora pittieri

Passiflora pittieri is one of the only two species of subg. *Astrophea* that occur in Central America. It is well known and researched in relation to its co-evolution with the maracuja butterflies, *Heliconius sapho* and *H. hewitsoni.* For this reason it is often grown by lepidopterists as a food source for caterpillars, but it is becoming increasingly coveted by botanic gardens and private collectors. Like *P. jussieui* it is placed in sect. *Capreolata*. During its juvenile stage they are shrubs lacking tendrils, which at maturity grow into large lianas with well-developed climbing aids. They are known to be long-lived but very slow-growing (Ulmer & MacDougal, 2004), as they undergo long periods of growth inactivity (see also *Co-evolution* above). Gilbert (2004) documented that in over 20 years an initially small, shrub-like plant which he grew in Costa Rica increased its stem diameter at the base to 20cm.

P. pittieri requires tropical growing conditions and, in Europe, is most suitably grown in a tropical glasshouse environment (temperature: 18–30°C; humidity: 60–90 per cent; light exposure: semi-shade to full sun). In cultivation, flower production (Fig. 10) is generally quite successful if the right conditions are present and hand pollination is carried out. Viable seeds have been collected on multiple occasions (Gilbert, 2004). If these are available, propagation by seed is the easiest option. Unfortunately this is rarely

Fig. 10 *Passiflora pittieri* flower. Photo: R. Hilgenhof, 2012.

the case, therefore plants have to be propagated by cuttings. Good results were achieved by a variety of plant breeders by using semi-ripe apical or internodal cuttings (Fig. 11 a+b). With this type of material and the application of rooting hormone, root formation can take place in as little as four weeks or can take a couple of months.

Hybrids

Hybrids are the offspring of cross-breeding between species and hybrids of *Passiflora* are very popular, with numerous hybrids having been bred. However, this is not the case with species in subg. *Astrophea*, and only one cross of *P. macrophylla* and *P. sphaerocarpa* is known in cultivation. This hybrid was created by Butterfly World founder Ron Boender, who is known for his large collection of *Astrophea* spp.

CONCLUSIONS AND RECOMMENDATIONS

Subg. *Astrophea* is a bizarre and wonderful group of *Passiflora*, which make great additions to private and botanic garden collections. The dissertation from which this account has been extracted summarises most of the information available on *Passiflora* subg. *Astrophea* and it is hoped that it will aid the cultivation of this species in the future.

This group of plants, although problematic and difficult to grow, can be successfully kept as *ex situ* collections if the right conditions and cultural techniques are applied. In order to achieve this, correct species identification is important. After careful studies of the subgenus a greater understanding has been achieved; however, there is still scope for further research, particularly with regard to the conservation status of individual species. The study of their behaviour in response to cultivation techniques has proved invaluable. However, it is not possible to replicate the natural growing conditions within glasshouses. Adjustments therefore need to be made in order to grow the plants outside of their natural habitat. In future this may be of great importance because of the potential need to conserve these species *ex situ*.

The future cultivation of these species would benefit from networks between individuals who grow these plants. This will allow not only the exchange of knowledge but also the exchange of plant material between organisations. This exchange will make it possible for these species to become more widespread in cultivation.

Fig. 11 (a+b) rooted cutting of *P. pittieri* before and after being potted up (c) *P. lindeniana* seedlings (d+e) air-layer of *P. lindeniana* and callus formation (f) young growth of *P. pittieri* (g) chemical burn, (h+i) new growth development on *P. macrophylla* (j) extrafloral nectar gland on the leaves of *P. macrophylla*. Photos: R. Hilgenhof.

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APPENDIX 1: SPECIES LIST *PASSIFLORA* SUBGENUS *ASTROPHEA*

***Passiflora* L. subgenus *Astrophea* (DC.) Mast.**			
Species name	**Publication**	**Distribution & elevation**	**Synonyms**
Supersection *Astrophea* (DC.) MacDougal & Feuillet			
Section *Astrophea* DC.			
Passiflora araguensis Escobar (1990)	Phytologia, 69: 364 1990	Venezuela[1]	
Passiflora arborea Spreng. (1826)	Syst. Veg., 3: 42 1826	Colombia, Ecuador, Panama[1] 1000–3000m[1]	*Passiflora glauca* Dryand. (1789) *Passiflora glauca* Bonpl. (1806) *Astrophea glauca* Roem. (1846) Synonym *of Passiflora tica* Gómez & Gómez (?) The Plants List (2005); unresolved
Passiflora callistemma Escobar (1994)	Syst. Bot. 19: 205 1994.	Colombia[1]	
Passiflora caucaense Holm-Niels. (1974)	Botaniska Notiser 127(3): 348–350, f. 4–5 1974.	Colombia[1] 1700–2000m[1]	
Passiflora emarginata Bonpl. (1806)	Pl. Aequinoct. 1:, t. 23 1806.	Colombia[1] 1007–2100m[1]	*Astrophea emarginata* (Bonpl.) Roem. (1846)
Passiflora engleriana Harms (1893)	Nat. Pflanzenfam. 3(6a): 72 1893.	Colombia[1] 1700–2240m[1]	
Passiflora frutescens Ruiz & Pav. ex Killip (1938)	Publ. Field Mus. Nat. Hist., Bot. Ser. 19: 527 1938.	Peru, (Colombia)[1] (1000) 1500–2000m[1]	
Passiflora lindeniana Planch. ex Triana & Planch. (1873)	Ann. Sci. Nat V Bot. 17: 1873	Venezuela[1] 1400–2700m[1]	
Passiflora macrophylla Spruce ex Mast. (1883)	J. Linn. Soc. Bot. 20: 31 1883	(Colombia), Ecuador[1] (0) 6–2500m[1]	*Passiflora lorifera* Mast. & André (1883) *Passiflora gigantifolia* Harms (1894)
Passiflora ocanensis Planch. & Lind. ex Triana & Planch. (1873)	Ann. Sci. Nat. V. Bot. 17: 183 1873	Colombia[1] 1000–1700m[1]	
Passiflora pubera Planch. & Lind. ex Triana & Planch. (1873)	Ann. Sci. Nat., Bot., sér. 5 17: 185 1873	Colombia[1]	*Passiflora sphaerocarpa* var. *pilosula* Mast. (1883)
Passiflora putumayensis Killip (1938)	Publ. Field Mus. Nat. Hist., Bot. Ser. 19: 532 1938	Colombia, Ecuador, (Peru)[1] 1100–1900 (2000)m[1]	

Species name	Publication	Distribution & elevation	Synonyms
Passiflora schultzei Harms (1929)	Notizbl. Bot. Gart. Berlin-Dahlem 10: 808 1929	Colombia[1]	
Passiflora sphaerocarpa Triana & Planch. (1873)	Ann. Sci. Nat., Bot. V, 17: 184 1873	Colombia[1] 88–1700m[1]	
Passiflora tica Gómez-Laur. & Gómez (1981)	Phytologia 49(1): 56–57 1981	Colombia, Costa Rica, Panama[1] 750–2780m[1]	*Passiflora arborea* Spreng. (1826) (?), The Plants List (2005); unresolved
Section *Capreolata* MacDougal & Feuillet			
Passiflora cauliflora Harms (1907)	Verh. Bot. Vereins Prov. Brandenburg 48: 185 1907 publ. 1907	Brazil, Peru, Venezuela[1] 70–1600m[1]	
Passiflora ceratocarpa Silveira (1930)	Arch. Jard. Bot. Rio de Janeiro 5: 221 1930	Brazil, French Guiana, Guyana[1]	
Passiflora cerradense Sacco (1971)	III Simpósio sôbre o Cerrado, São Paulo: 212–214 1971	Brazil	
Passiflora chlorina Escobar (1989)	Phytologia 67: 132 1989	Brazil[1] 950m[1]	
Passiflora faroana Harms (1929)	Notizbl. Bot. Gart. Berlin-Dahlem 10: 809 1929	Brazil[1]	
Passiflora haughtii Killip (1938)	Publ. Field Mus. Nat. Hist., Bot. Ser. 19: 519 1938	Colombia[1] 100–700m[1]	
Passiflora hexagonocarpa Barb. Rodr. (1888)	Vellosia 1: 27 1888	Brazil[1]	
Passiflora jussieui Feuillet (2010)	Journal of the Botanical Research Institute of Texas 4(2): 611–613, f. 1 2010	French Guiana, Suriname[2]	*Passiflora citrifolia* Salisb. (1796), nom. illeg. *Tacsonia citrifolia* Juss. ex DC. Mast. (1828) *Distephana citrifolia* (Juss. ex DC.) Roem. (1846) *Passiflora citrifolia* (Juss. ex DC.) Mast. (1871)
Passiflora maguirei Killip (1948)	Bull. Torrey Bot. Club 75: 415 1948	Guyana, Venezuela[1]	
Passiflora mariquitensis Mutis ex Uribe (1954)	Mutisia 21: 1 1954	Colombia[3]	
Passiflora mutisii Killip (1938)	Publ. Field Mus. Nat. Hist., Bot. Ser. 19: 529 1938	Colombia[1]	

Species name	Publication	Distribution & elevation	Synonyms
Passiflora nuriensis Steyermark (1968)	Acta Bot. Venez. 3: 188 1968	Venezuela[1]	
Passiflora pittieri Mast. (1897)	Bot. Gaz. 23: 246 1897	Belize, (Bolivia), Costa Rica, Colombia, Ecuador, Guatemala, (Nicaragua), Panama[1] 0–1219m[1]	
Passiflora quelchii Br. (1901)	Trans. Linn. Soc. London, Bot. 6: 31 1901	Guyana, (Suriname)[1] 300–400m[1]	
Passiflora tina Boend. & Ulmer (2001)	Sendtnera 7: 6 2001	Ecuador[1] 700m[1]	
Passiflora vescoi D. Rignon & L. Rignon (2003)	Adansonia III, 25: 219 2003	French Guiana[1]	
Section *Leptopoda* Killip ex Feuillet & Cremers			
Passiflora leptopoda Harms (1917)	Notizbl. Bot. Gart. Berlin-Dahlem 6: 347 1917	Brazil, French Guiana, Guyana, Suriname[1] 300–400m[1]	*Astrophea glaberrima* Klotzsch
Passiflora plumosa Feuillet & Cremers (1984)	Proc. Kon. Nederl. Akad. Wetensch., C 87: 381 1984	French Guiana[1]	
Supersection *Pseudastrophea* (Harms) MacDougal & Feuillet			
Section *Pseudastrophea* (Harms) Killip			
Passiflora alliacea Barb. Rod. (1902)	Contr. Jard. Bot. Rio de Janeiro 3: 59 1902	Brazil[1]	
Passiflora candida (Poepp. & Endl.) Mast. (1871)	Trans. Linn. Soc. London 27: 629 1871	Brazil, French Guiana, Guyana, Suriname, Venezuela[1] 1135m[1]	*Tacsonia candida* Poepp. & Endl. (1838) *Distephana candida* (Poepp. & Endl.) Roem. (1846) *Passiflora guedesii* Huber (1902)
*Passiflora cardonae** Killip (1939)	Brittonia 3: 172 1939	Guyana, Venezuela[1]	
Passiflora cirrhipes Killip (1938)	Publ. Field Mus. Nat. Hist., Bot. Ser. 19: 522 1938	Bolivia, Peru[1] 400–900m[1]	
*Passiflora costata** Mast. (1872)	Fl. Bras. 13(1): 545 1872	Brazil, French Guiana, Guyana, Peru, Suriname, Venezuela[1]	*Passiflora eminula* Mast. (1883) *Passiflora hydrophila* Barb. Rod. (1888) *Passiflora inundata* Ducke (1925)

Species name	Publication	Distribution & elevation	Synonyms
Passiflora deficiens Mast. (1883)	J. Bot. 21: 34 1883	Guyana[1]	
Passiflora elliptica Gardner (1842)	London J. Bot. 1: 173 1842	Brazil[1]	*Decaloba elliptica* (Gardner) Roem. (1846)
Passiflora grandis Killip (1938)	Publ. Field Mus. Nat. Hist., Bot. Ser. 19: 531 1938	Colombia[1] 1135m[1]	
Passiflora haematostigma Mart. ex Mast. (1872)	Fl. Bras. 13(1): 574, pl. 108, f. 1 574 1872	Brazil[1] 740m[1]	*Passiflora platystyla* Mast. (1883)
Passiflora kawensis Feuillet (1994)	Novon 4: 236 1994	French Guiana, Guyana[1] 300–400m[1]	
Passiflora mansoi (Mart.) Mast. (1871)	Trans. Linn. Soc. London 27: 629 1871	Brazil[1]	*Tacsonia mansoi* Mart. (1839) *Passiflora mansoi* var. glabra Hoehne (1915) *Passiflora mansii* (Mart.) Mast.
Passiflora ovata Mart. ex. DC. (1828)	Prodr. 3: 322 1828	French Guiana, Venezuela[1] 5–600m[1]	*Astrophea ovata* (Mart., Joseph ex DC.) Roem. (1846)
Passiflora pentagona Mast. (1872)	Fl. Bras. 13(1): 545 1872	Brazil[1] 500m[1]	
Passiflora phaeocaula Killip (1927)	J. Wash. Acad. Sci. 17: 430 1927	Brazil, Venezuela[1] 315–320m[1]	
Passiflora rhamnifolia Mast. (1872)	Fl. Bras. 13(1): 545 1872	Brazil[1] 1270m[1]	
Passiflora sclerophylla Harms (1917)	Notizbl. Königl. Bot. Gart. Berlin 6: 347 1917	Brazil, Guyana, Venezuela[1] 1200–2000m[1]	
*Passiflora skiantha** Huber (1906)	Bol. Mus. Paraense Hist. Nat. 4(4): 591–592, f. 5 591 1906	Peru, (Ecuador)[1] (200–300m)[1]	
Passiflora tessmannii Harms (1926)	Notizbl. Bot. Gart. Berlin-Dahlem 9: 978 1926	Peru, Ecuador[1] 200–230m[1]	
Passiflora trochlearis Jørg. (1997)	Novon 7(4): 379, f. 1 379 1997	Ecuador[1] 650–800m[1]	
Passiflora venosa Rusby (1896)	Mem. Torrey Bot. Club 6: 42 1896	Bolivia[1] 235–1045m[1]	
Section *Botryastrophea* (Harms) Killip **Series *Botryastrophea*** (Harms) MacDougal & Feuillet			
Passiflora pinardia Buc'hoz (1781)	Herb. Pl. Med. Chin. t. 30 1781		

Species name	Publication	Distribution & elevation	Synonyms
Passiflora pyrrhantha Harms (1926)	Notizbl. Bot. Gart. Berlin-Dahlem 9: 977 1926	Ecuador, Peru, Venezuela[1] 0–1490m[1]	
Passiflora rusbyi Mast. (1890)	Bull. Torrey Bot. Club 17(18?): 282 1890	Bolivia, Brazil, Ecuador[1] 320m	
Passiflora securiclata Mast. (1893)	Bull. Misc. Inform. Kew 1893: 12 1893	Brazil, (Colombia), Guyana, (Peru), Venezuela[1] 30–150 315m[1]	*Tacsonia spinescens* Klotzsch (1848) *Passiflora retrosa* Killip (1924)
Passiflora spicata Mast. (1872)	Fl. Bras. 13(1): 545 1872	Brazil, Guyana[1]	
Passiflora spinosa (Poepp. & Endl.) Mast. (1871)	Trans. Linn. Soc. London 27: 630 1871	Brazil, Colombia, Ecuador, Peru, Venezuela[1] 50–1400m[1]	*Tacsonia spinosa* Poepp. & Endl. (1838) *Distephana spinosa* (Poepp. & Endl.) Roem. (1846) *Tacsonia coccinea* Barb. Rod. (1891)
Section *Botryastrophea* (Harms) Killip **Series *Carnae*** Feuillet			
Passiflora amoena Escobar (1994)	Syst. Bot. 19 (2): 203–205 1994	French Guiana, Guyana, Suriname[1] 75–780m[1]	
Passiflora ascidia Feuillet (2002)	Brittonia 54: 20 2002	Guyana, Venezuela[1] 690–750m[1]	
Passiflora balbis Feuillet (2002)	Brittonia 54: 20 2002	Brazil, Guyana, Venezuela[1] 100–150m[1]	
Passiflora fuchsiiflora Hemsl. (1898)	Hooker's Icon. Pl. 26: t. 2553 1898	French Guiana, Guyana, Suriname, Venezuela[1]	
Passiflora holtii Killip (1938)	Publ. Field Mus. Nat. Hist., Bot. Ser. 19: 560 1938	Brazil, Venezuela[1] 120m[1]	
Passiflora longiracemosa Ducke (1922)	Arch. Jard. Bot. Rio de Janeiro 3: 221 1922	Brazil, Guyana, Venezuela[1]	
Passiflora saulensis Feuillet (2002)	Brittonia 54: 24 2002	French Guiana[1]	

* Systematic classification data deficient.
1. Missouri Botanical Garden, 2011 – country/elevation specifications in () are unresolved
2. Smithsonian Tropical Research Institute (2011). Species search [online]. Available online: www.stri.si.edu/ (accessed January 2012).
3. OCAMPO PÉREZ, J. *et al.* (2007). Diversity of Colombian Passifloraceae: Biogeography and an Update List for Conservation. *Biota Colombiana* 8(1), 1–45.

APPENDIX 2: SURVEYED GARDENS AND PRIVATE COLLECTIONS FROM WHICH COMPLETED QUESTIONNAIRES WERE OBTAINED, AND THE SPECIES CULTIVATED THERE.

	Collection name and grower who supplied information	**Country**	**State/ City/ County**	**Species name**
1	Blumen & Passiflora T. Ulmer & B. Ulmer (2012)	Germany	Witten	*P. lindeniana*
2	Collezione di Passiflora M. Vecchia (2012)	Italy		*P. jussieui* *P. lindeniana* *P. macrophylla*
3	Fairchild Tropical Botanic Garden J. Lopez (2012)	USA	Florida	*P. pittieri*
4	Flora und Botanischer Garten Köln A. Seringer (2011)	Germany	Cologne	*P. lindeniana*
5	Grassy Knoll Exotic Plants E. Peters (2011)	USA	Oregon	*P. lindeniana* *P. pittieri*
6	Passifloratuin H. Van Aalst (2011)	Netherlands		*P. macrophylla*
7	Private Collection McPhail R. McPhail (2011)	Netherlands	Gouda	*P. jussieui*
8	Reserva Rio Guaycuyacu J. West (2012)	Ecuador		*P. macrophylla*
9	Royal Botanic Gardens, Kew C. Magdalena Rodriguez (2011)	UK	London	*P. jussieui* *P. lindeniana* *P. macrophylla* *P. pittieri*
10	Singapore Botanic Garden Dr N. Abdul Karim (2011)	Singapore		*P. macrophylla*
11	The National Collection of Passiflora J. Vanderplank (2012)	UK	Somerset	*P. jussieui* *P. lindeniana* *P. macrophylla* *P. pittieri*
12	The Principal Botanic Garden of N.V. Tsitsina of the Russian Academy of Sciences A. Kirillov (2011)	Russia	Moscow	*P. pittieri*