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Photosynthetic pathways in Bromeliaceae: phylogenetic and ecological significance of CAM and C_3 based on carbon isotope ratios for 1893 species

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A comprehensive analysis of photosynthetic pathways in relation to phylogeny and elevational distribution was conducted in Bromeliaceae, an ecologically diverse Neotropical family containing large numbers of both terrestrial and epiphytic species. Tissue carbon isotope ratio ($\delta^{13}C$) was used to determine the occurrence of crassulacean acid metabolism (CAM) and C_3 photosynthesis in 1893 species, representing 57% of species and all 56 genera in the family. The frequency of $\delta^{13}C$ values showed a strongly bimodal distribution: 1074 species (57%) had values more negative than −20‰ (mode = −26.7‰), typical of predominantly daytime carbon fixation via the C_3 pathway, whereas 819 species (43%) possessed values less negative than −20‰ (mode = −13.3‰), indicative of predominantly nocturnal fixation of carbon via the CAM pathway. Amongst the six almost exclusively terrestrial subfamilies in Bromeliaceae, Brocchinioideae, Lindmanioideae and Navioideae consisted entirely of C_3 species, with CAM species being restricted to Hechtioideae (all species of *Hechtia* tested), Pitcairnioideae (all species belonging to a xeric clade comprising *Deuterocohnia*, *Dyckia* and *Encholirium*) and Puyoideae (21% of *Puya* spp.). Of the other two subfamilies, in the overwhelmingly epiphytic (plus lithophytic) Tillandsioideae, 28% of species possessed CAM photosynthesis, all restricted to the derived genus *Tillandsia* and tending towards the more extreme epiphytic ‘atmospheric’ life-form. In Bromelioideae, with comparable numbers of terrestrial and epiphytic species, 90% of taxa showed CAM; included in these are the first records of CAM photosynthesis in *Androlepis*, *Canistropsis*, *Deinacanthon*, *Disteganthus*, *Edmundoa*, *Eduandrea*, *Hohenbergiopsis*, *Lymania*, *Pseudananas*, *Ronnbergia* and *Ursulaea*. With respect to elevational gradients, the greatest number of C_3 bromeliad species were found at mid-elevations between 500 and 1500 m, whereas the frequency of CAM species declined monotonically with increasing elevation. However, in *Puya*, at least ten CAM species have been recorded at elevations > 3000 m, showing that CAM photosynthesis is not necessarily incompatible with low temperatures. This survey identifies five major origins of CAM photosynthesis at a higher taxonomic level in Bromeliaceae, but future phylogenetic work is likely to reveal a more fine-scale pattern of gains and losses of this trait, especially in ecologically diverse and widely distributed genera such as *Tillandsia* and *Puya*. © 2015 The Linnean Society of London, *Botanical Journal of the Linnean Society*, 2015, **178**, 169–221.

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INTRODUCTION

Bromeliaceae is the largest family of vascular plants essentially restricted in distribution to the Neotropics, and is notable for the great variety of habitats in which representatives are found. Containing about 3350 species in 56 genera (Luther, 2012; Govaerts, Luther & Grant, 2013), Bromeliaceae shows a distribution centred on tropical and subtropical latitudes, with just a small number of species extending to the southern USA in the north and to central Chile and Patagonia in the south (Smith & Downs, 1974). A single species is found outside the Neotropics, *Pitcairnia feliciana* (A.Chev.) Harms & Mildbr., which is endemic to sandstone outcrops in Guinea, West Africa (Smith & Downs, 1974; Porembski & Barthlott, 1999), apparently as the result of a long-distance dispersal event in the Miocene (Givnish *et al.*, 2004). As a family, Bromeliaceae also shows a striking diversity of growth habits, with life-forms ranging from soil-rooted terrestrial plants through lithophytic forms to epiphytic species that are wholly independent of the soil substrate for water and nutrient acquisition (Pittendrigh, 1948; Tomlinson, 1969; Smith & Downs, 1974; Benzing, 1980, 2000; Smith, 1989; Givnish *et al.*, 1997; Smith & Till, 1998). Indeed, it is estimated that 56% of all Bromeliaceae are obligately or facultatively epiphytic, making this the second largest family of vascular epiphytes after Orchidaceae, given that true epiphytes in Araceae, a family of comparable size to Bromeliaceae, are less common than climbers and vines (Zotz, 2013).

Although long recognized as a natural family, the phylogenetic position of Bromeliaceae has proven difficult to resolve. Earlier suggestions based on morphological similarities of an affinity with Rapateaceae and Velloziaceae (Smith, 1934; Dahlgren, Clifford & Yeo, 1985) were eventually superseded by molecular data, with the first phylogenetic study with DNA sequence information placing Bromeliaceae close to Rapateaceae and Mayacaceae (Chase *et al.*, 1993; Clark *et al.*, 1993), with which it shares biogeographical similarities. However, the family occupies an isolated position on a long branch, and further sequence information, coupled with increased taxon sampling, has led to a consensus that Bromeliaceae shows a sister group relationship to Typhaceae (including Sparganiaceae) and, together, these two families represent the earliest diverging lineage of Poales *sensu* APG III (Davis, 1995; Soltis *et al.*, 2000; Givnish *et al.*, 2004, 2007, 2010; APG III, 2009; Bouchenak-Khelladi, Muasaya & Linder, 2014; Magallón *et al.*, 2015). Molecular chronograms (dated molecular phylogenetic trees) suggest that the most recent common ancestor of these two families lived in the Middle to Late Cretaceous (Givnish *et al.*, 2011; Magallón *et al.*, 2015), and that this node subtends a long unbranched stem, implying considerable extinction, leading to a relatively recent crown group radiation, starting in the late Oligocene–early Miocene, that accounts for all present-day bromeliad diversity (Givnish *et al.*, 2011, 2014; Bouchenak-Khelladi *et al.*, 2014).

The ecological diversity of Bromeliaceae has stimulated considerable taxonomic and phylogenetic work on the family. Both terrestrial and epiphytic forms occupy habitats ranging from wet tropical forest to semi-desert, and occur from sea level to elevations approaching 5000 m. Particularly large species numbers are found among the terrestrial forms of exposed and often semi-arid habitats, and the epiphytes of Neotropical montane forests. An appreciation of the importance of Bromeliaceae in such biota has been paralleled by continued taxonomic research and species descriptions. The number of validly named taxa has risen from 2088 species in 48 genera in *Flora Neotropica* (Smith & Downs, 1974, 1977, 1979), to 2600 species in 56 genera quoted by Smith & Till (1998), and to 3350 species in recent lists of accepted species names (Luther, 2012; Govaerts *et al.*, 2013). So to what does the family owe its ecological success and taxonomic diversity?

Members of Bromeliaceae exhibit a number of key innovations closely associated with their wide range of habitats, one of which is the multicellular peltate epidermal trichome that is a synapomorphy for the family (Mez, 1904; Tietze, 1906; Tomlinson, 1969; Smith & Till, 1998). Although, in the majority of terrestrial species, the trichomes appear to be non-absorptive and to serve a protective function, in the epiphytic forms they play a crucial role in water and nutrient absorption through the leaf surface. In species with pronounced water-impounding tanks (phytotelmata) formed by the rosulate overlapping leaf bases, the absorptive trichomes are concentrated towards the leaf bases and are responsible for the nutritional independence of the epiphytic forms from the substrate. In the more extreme 'atmospheric' epiphytes in the genus *Tillandsia* L., the leaves are narrower, tanks are lacking and the entire leaf surfaces are covered by an indumentum of absorptive trichomes (Schimper, 1888; Billings, 1904; Mez, 1904; Benzing, 1980, 2000; Smith, 1989). Indeed, the contribution made by the absorptive trichomes to nutrient uptake via detritus collecting in the tanks in terrestrial species growing in oligotrophic habitats (e.g. *Brocchinia* Schult.f. growing on the summits of the tepuis in the Guiana Shield) might have been a key adaptation that facilitated the eventual evolution of the fully epiphytic life-form (Medina, 1974; Givnish *et al.*, 1997). The vast majority of epiphytic species are found in two main lineages in the family: in subfamily Tillandsioideae, essentially all of which are epiphytic (or lithophytic), and subfamily Bromelioideae, in which the earlier diverging forms were terrestrial and epiphytism was a later innovation (Smith & Downs, 1974; Crayn, Winter & Smith, 2004; Schulte, Barfuss & Zizka, 2009; Sass & Specht, 2010; Silvestro, Zizka & Schulte, 2014).

Another key innovation in Bromeliaceae was the appearance in many species of the modified form of photosynthesis known as crassulacean acid metabolism (CAM). This represents a water-conserving mode of photosynthesis in which atmospheric CO_2 is taken up predominantly at night rather than during the daytime, and is regarded as one of the classic examples of a metabolic adaptation to environmental stress (Kluge & Ting, 1978; Osmond, 1978; Winter, 1985; Winter & Smith, 1996). CAM has been observed in 33 families of vascular plants and is estimated to occur in > 6% of vascular plant species (Winter & Smith, 1996). The prevalence of the water-conserving CAM mode of photosynthesis among terrestrial succulents has long been established, not just in the eponymous Crassulaceae, but also in families such as Agavaceae and Cactaceae, characteristic of semi-desert habitats in the Neotropics. However, the realization that this mode of photosynthesis was also widespread among tropical epiphytes, especially in Bromeliaceae and Orchidaceae, only became clear with the publications of Nuernbergk (1961), Coutinho (1963, 1969), McWilliams (1970), Medina (1974) and Medina & Troughton (1974). Indeed, so great is the number of CAM species in these two families alone that, in total, there may be approximately as many epiphytic as terrestrial CAM taxa (Winter *et al*., 1983; Winter & Smith, 1996).

The widespread occurrence of both photosynthetic types in Bromeliaceae has provided many valuable opportunities for testing the functional significance of the CAM pathway. Early ecophysiological research showed that CAM photosynthesis in bromeliads is prevalent in two main ecological types: the succulent, spiny terrestrial taxa, such as *Bromelia* L. and *Dyckia* Schult. & Schult.f., characteristic of seasonally dry or exposed habitats (McWilliams, 1970; Medina, 1974; Medina & Troughton, 1974; Medina *et al*., 1977); and the epiphytic forms, such as *Aechmea* Ruiz & Pav. and *Tillandsia*, which occupy more exposed or microclimatically arid microsites in forest canopies (McWilliams, 1970; Medina, 1974; Griffiths & Smith, 1983). Indeed, the progressive increase in the proportion of epiphytic bromeliad species showing CAM photosynthesis along an environmental gradient of decreasing rainfall represents one of the strongest pieces of evidence for CAM as an ecological adaptation to limiting water availability (Griffiths & Smith, 1983). Further ecophysiological research on CAM photosynthesis in bromeliads has focused on topics such as the influence of environmental variables on photosynthetic performance in the extreme 'atmospheric' epiphytes, such as *Tillandsia usneoides* (L.) L. (Kluge *et al*., 1973; Martin, Christensen & Strain, 1981; Martin & Siedow, 1981), the significance of developmental heteroblasty for plant performance and survival (Zotz, Wilhelm & Becker, 2011), the extent and physiological significance of recycling of respiratory CO_2 into nocturnal acid accumulation (Griffiths *et al*., 1986; Griffiths, 1988; Loeschen *et al*., 1993; Martin, 1996), and factors affecting the inducibility of nocturnal CO_2 fixation in facultative CAM plants, such as *Guzmania monostachia* (L.) Rusby ex Mez (Medina, 1974; Medina & Troughton, 1974; Smith *et al*., 1985; Freschi *et al*., 2010; Beltrán *et al*., 2013). The relationship between CAM photosynthesis, productivity and water-use efficiency has been studied in the pineapple [*Ananas comosus* (L.) Merr.: Neales, Patterson & Hartney, 1968; Medina *et al*., 1991, 1993; Martin, 1994], the third most important tropical fruit crop (Bartholomew, Paull & Rohrbach, 2003).

CAM photosynthesis in plants has traditionally been identified through measurement of the characteristic inverse rhythm of stomatal opening, nocturnal CO_2 uptake and concomitant nocturnal accumulation of malic acid in the assimilatory tissue, commonly referred to in the earlier literature as the 'de Saussure effect', in recognition of the Swiss chemist who first recorded the simultaneous uptake of O_2 and CO_2 at night by the cactus *Opuntia* Mill. (de Saussure, 1804). These measurements require access to living plants, ideally in their natural habitats, as some facultative species may not display CAM photosynthesis when cultivated under more benign conditions, such as in gardens or the laboratory. An additional method to distinguish photosynthetic pathways in plants is to measure the relative abundance of the two stable isotopes of carbon, ^{12}C and ^{13}C, in tissue samples by mass spectrometry; this can be expressed relative to a standard as the $\delta^{13}C$ value in units of per mil (‰) (Smith & Epstein, 1971; Osmond *et al*., 1973). The diagnostic value of $\delta^{13}C$ derives from the discovery that the enzyme responsible for initial fixation of CO_2 in CAM and C_4 photosynthesis, phospho*enol*pyruvate carboxylase (PEPC), discriminates less against the heavier ^{13}C isotope than does ribulose-1,5-bisphosphate carboxylase–oxygenase (Rubisco), the primary CO_2-fixing enzyme in C_3 plants (O'Leary, 1988). As a consequence, CAM and C_4 plants show less negative $\delta^{13}C$ values than do C_3 plants. Typically, C_3 plants show $\delta^{13}C$ values averaging around −27‰, with the majority falling in the range −23‰ to −31‰; values less negative than −23‰ in angiosperms are characteristic of arid habitats, whereas values more negative than −31‰ tend to be found in shaded and humid forest understories (Kohn, 2010). In contrast, plants performing CAM or C_4 photosynthesis typically show $\delta^{13}C$ values in the range −20‰ to −9‰ (Osmond *et al.*, 1973; O'Leary, 1988). As the distinctive Kranz anatomy found in the vascular bundles of almost all C_4 plants is not known in Bromeliaceae (Tomlinson, 1969; Robinson & Taylor, 1999), the $\delta^{13}C$ ratios of plant biomass are sufficient in this family to distinguish the CAM and C_3 pathways. The determination of $\delta^{13}C$ values by means of mass spectrometry requires sample sizes of the order of only 1 mg of dry biomass, and can be performed on large numbers of samples with relatively rapid processing times. The ability to use dried plant tissue, such as herbarium samples of specimens collected in their natural habitat, means that this approach is well suited to providing information on plant functional types to complement systematic and phylogenetic investigations of noteworthy study groups.

The present study is intended to provide an updated assessment of the systematic distribution of CAM and C_3 photosynthesis in Bromeliaceae based on a large survey of $\delta^{13}C$ ratios, and to interpret this in an ecological and evolutionary context on the basis of recent molecular phylogenetic work on the family. Apart from the well-established correlation between CAM photosynthesis and habitat aridity, a previous phylogenetic study of Bromeliaceae based on two plastid loci (*matK* and the *rps16* intron) and 51 taxa provided evidence for a minimum of three independent origins of CAM in the family (Crayn *et al.*, 2004). Several phylogenetically important groups were not included in that sample, and relationships were not resolved in some parts of the tree (Crayn *et al.*, 2004), but further molecular systematic studies in Bromeliaceae in the last few years (including more comprehensive sampling, additional data and new analysis methods) have advanced considerably our understanding of evolutionary relationships in the family (Barfuss *et al.*, 2005; Schulte, Horres & Zizka, 2005; Givnish *et al.*, 2007, 2011, 2014; Horres *et al.*, 2007; Schulte & Zizka, 2008; Schulte *et al.*, 2009; Jabaily & Sytsma, 2010; Silvestro *et al.*, 2014). This has led to a revision of the traditional classification of three subfamilies (Pitcairnioideae, Tillandsioideae and Bromelioideae), which had been based mainly on floral and seed characters (Bentham & Hooker, 1883; Harms, 1930; Smith & Downs, 1974). Tillandsioideae and Bromelioideae have been confirmed as monophyletic, but 'Pitcairnioideae', a terrestrial assemblage previously united by characters such as epigeal germination, relatively simple epidermal trichomes, usually superior ovaries, capsular fruits and weakly elaborated, winged seeds (Smith & Till, 1998), has been shown to be polyphyletic, consequently being split into six subfamilies: Brocchinioideae, Hechtioideae, Lindmanioideae, Navioideae, Pitcairnioideae *s.s.* and Puyoideae (Givnish *et al.*, 2007, 2008, 2011). It is thus of interest to determine how the distribution of CAM photosynthesis in Bromeliaceae can be interpreted in the now much better understood phylogenetic context.

We present here the results of carbon isotope measurements on 2124 specimens of Bromeliaceae, corresponding to 1893 species, or 57% of the currently described diversity in the family. This represents the largest isotopic survey ever conducted on a single family of vascular plants. We discuss the distribution of CAM photosynthesis in Bromeliaceae in relation to the phylogenetics, historical biogeography and present-day ecology of the various lineages. This information sheds further light on the evolutionary origins of CAM photosynthesis and identifies some unresolved questions that could be addressed by further work in selected clades at a finer taxonomic level.

MATERIAL AND METHODS

Taxon sampling

To assess the relative abundance and distribution of C_3 and CAM photosynthesis in Bromeliaceae, tissue $\delta^{13}C$ values were determined for 2124 samples. The complete list of taxa sampled, taxonomic authority, accession and voucher details, date of collection, type of tissue sampled, carbon isotope ratio and ecological information on collection elevation and plant life-form are provided in Table 1.

Samples of dried tissue for carbon isotope analysis were collected from the following herbaria: FR, HB, K, MO, NY, OXF, SEL, SP, US and VEN. As a general sampling strategy, tissue was taken from specimens exhibiting adult morphology. Wherever possible, the leaf lamina was sampled or, alternatively, the leaf base or inflorescence axis. In the few instances in which vegetative material was not available, samples of bract, fruit wall or flower tissue were taken. Collection information was recorded from the herbarium sheets and ecological information from the sheets or from published treatments (Smith & Downs, 1974, 1977, 1979) or field knowledge (H. E. Luther, pers. comm.).

As the plant tissue carbon isotope ratio can be influenced by the isotope composition of the source CO_2 (Farquhar, Ehleringer & Hubick, 1989), the most recently collected specimens available were sampled in order to minimize any effect of changing atmospheric carbon isotope composition over time (Keeling, Mook & Tans, 1979; Mook *et al.*, 1983). The great majority of samples were obtained from specimens collected since 1980. A small number of samples were obtained from living plants (from Marie Selby Botanical Gardens, Sarasota, FL, USA, and the personal collection of E. Leme, Rio de Janeiro, Brazil). From these, a silica-dried leaf fragment was used.

For 138 species, more than one independent specimen (i.e. different individual) was analysed (120 in duplicate, 12 in triplicate, five in quadruplicate and one in quintuplicate). In addition, approximately 69 specimens were only provisionally identified. After allowance for replicates and exclusion of specimens that were only provisionally identified, this represented a total of 1893 species from all 56 genera, or 57% of the total species number of *c*. 3350 for the family recognized by Luther (2012). We followed the taxonomic concepts of Luther (2012) for genera, except that the monotypic *Pseudaechmea ambigua* L.B.Sm. & Read is treated as *Billbergia ambigua* (L.B.Sm. & Read) Betancur & N.R.Salinas (Betancur & Salinas, 2006), the monotypic *Pseudananas sagenarius* (Arruda) Camargo is included in *Ananas* Mill. (Govaerts *et al*., 2013), and *Pepinia* Brongn. is included in *Pitcairnia* L'Hér. (Govaerts *et al*., 2013). Total species numbers for each genus are based on Govaerts *et al*. (2013), but taking into account the synonymy identified by Luther (2012).

In this study, all but 16 species of Bromeliaceae investigated for their photosynthetic pathway by $\delta^{13}C$ analysis in the earlier literature were resampled. For ease of reference, the $\delta^{13}C$ values for 14 of these species have been incorporated into Table 1 with the appropriate citations. Two species have been excluded because some samples were derived from cultivated material and there remains ambiguity about the photosynthetic pathway shown by these taxa in their natural habitats [*Dyckia selloa* (K.Koch) Baker: Griffiths (1984); *Puya boliviensis* Baker: Medina *et al*. (1977) as '*P. copiapina* Phil.' and Rundel & Dillon (1998)]. Some names used in earlier literature on bromeliad physiology have since been placed in synonymy, and these are listed in Table S1 (see Supporting Information).

Carbon isotope determination and data analysis

The natural abundance of ^{12}C and ^{13}C was measured for each sample at the Duke University Phytotron (Durham, NC, USA) using an SIRA Series II isotope ratio mass spectrometer (Micromass, Manchester, UK) operated in automatic trapping mode after combustion under oxygen (DUMAS combustion) of samples of approximate mass of 3 mg in an NA1500 Series 1 elemental analyser (Carlo Erba Instrumentazione, Milan, Italy). The reference CO_2 was calibrated against the original standard Pee Dee belemnite (PDB) from *Belemnitella americana* by use of a secondary Vienna V-PDB standard. A system check of analysis of combustion and mass spectrometer measurement was performed after every ten samples using two working standards of cellulose (Sigma–Aldrich Corp., St. Louis, MO, USA) with $\delta^{13}C$ values of −24.10 ± 0.03‰ and −23.55 ± 0.06‰. The ^{12}C and ^{13}C values were corrected for oxygen isotope contribution using the measured $\delta^{18}O$ and the method of Craig (1957). The carbon isotope ratio ($\delta^{13}C$ value) was determined using the following formula:

$$\delta^{13}\mathrm{C}\ (‰) = \left[\frac{{}^{13}\mathrm{C}_{\mathrm{sample}}/{}^{12}\mathrm{C}_{\mathrm{sample}}}{{}^{13}\mathrm{C}_{\mathrm{PDB}}/{}^{12}\mathrm{C}_{\mathrm{PDB}}} - 1\right] \times 1000.$$

Replicate measurements made on the technical standards indicated an instrument precision of ± 0.02‰. $\delta^{13}C$ values for the experimental material analysed in the present study are quoted to the nearest 0.1‰.

Values less negative than −20‰ were interpreted as indicative of carbon assimilation occurring predominantly via the CAM pathway, whereas values more negative than −20‰ indicate carbon fixation occurring predominantly via the C_3 pathway (Griffiths & Smith, 1983; Pierce, Winter & Griffiths, 2002a; Winter & Holtum, 2002; Crayn *et al*., 2004).

Table 1. Carbon isotope ratios for 2124 samples of Bromeliaceae (including 15 previously published values) representing 1893 species, with taxonomic authority, information on source of material and ecology of the species

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	$\delta^{13}C$ (‰)	Elevation¶ (m)
Brocchinioideae Givnish					
***Brocchinia* Schult. & Schult.f.**					
B. acuminata L.B.Sm.	F. Delascio & R. Lopez *s.n.* (SEL)	1988	ll	−24.8	1800
B. amazonica L.B.Sm.	G.T. Prance *et al*. 28982 (US)		lb	−26.3	
B. delicatula L.B.Sm.	R. Liesner 16650 (MO)	1984	ll	−27.9	780
B. gilmartiniae G.S.Varad.	1981-0556A (MSBG)		ll	−23.9	
B. hechtioides Mez	J. Pipoly 10769 & G. Samuels (SEL)	1987	lb	−23.7	650–670
B. maguirei L.B.Sm.	B. Maguire & L. Politi *s.n.* (US)	1949	lb	−19.6	1500
B. melanacra L.B.Sm.	F.A. Michelangeli 139 (SEL)	1995	lb	−27.4	1800

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	δ^{13}C (‰)	Elevation¶ (m)
B. micrantha (Baker) Mez	W. Kress 86-1851 *et al.* (SEL)	1986	ll	–25.7	396
B. paniculata Schult. & Schult.f.	J. Steyermark *et al.* 126265 (US)		ll	–29.7	
B. prismatica L.B.Sm.	F. Guanchez 2009 (US)		ll	–26.1	
B. reducta Baker	D. Clarke 930 (SEL)	1996	lb	–27.7	980
B. rupestris (Gleason) B.Holst	B. Hoffman 2291 (NY)		ll	–30.9	80–90
B. steyermarkii L.B.Sm.	O. Huber 13559 (SEL)	1994	lb	–24.1	
B. tatei L.B.Sm.	G. Varadarajan 1207 (SEL)	1984	ll	–27.6	2000
B. uaipanensis (Maguire) Givnish [= *Ayensua uaipanensis* (Maguire) L.B. Sm.]†	G. Varadarajan 1199 (SEL)	1984	lb	–21.9	1800–1850
B. uaipanensis (Maguire) Givnish [= *Ayensua uaipanensis* (Maguire) L.B. Sm.]†	Varadarajan 1203 (VEN)	1984	ll	–23.0	2100–2200
B. vestita L.B.Sm.	C. Brewer-Carias *s.n.* (US)		lb	–25.0	
Bromelioideae Burnett					
***Acanthostachys* Link**					
A. pitcairnioides (Mez) Rauh & Barthlott	J. Grant 90-00827 (US)		ll	–26.0	1300
A. strobilacea (Schult. & Schult.f.) Klotzsch	S. Tressens *et al.* 4512 (MO)	1993	lb	–16.1	
***Aechmea* Ruiz & Pav.**					
A. abbreviata L.B.Sm.	D. Rubio 347 (MO)	1989	lb	–15.3	250
A. aciculosa Mez & Sodiro	W. Palacios 13631 (MO)	1995	br	–14.3	550
A. aculeatosepala (Rauh & Barthlott) Leme	C. Luer *et al.* 11867 (MO)	1986	ll	–14.0	1600
A. allenii L.B.Sm.†	M. Nee & R. Warmbrodt 10368 (MO)		ll	–12.6	450
A. allenii L.B.Sm. (= *Ronnbergia petersii* L.B.Sm.)†	M. Remmick 155 (SEL)	1989	lb	–15.4	
A. alopecurus Mez	D. Cathcart *s.n.* (SEL)	1995	lb	–13.3	
A. amorimii Leme	J. Jardim *et al.* 645 (NY)		lb	–14.7	
A. angustifolia Poepp. & Endl.	R. Liesner 14163 (MO)	1983	lb	–15.2	
A. apocalyptica Reitz	A. Price *s.n.* (SEL)	1994	lb	–14.4	
A. aquilega (Salisb.) Griseb.	R. Liesner & A. González 11963 (MO)		ll	–12.4	0–100
A. araneosa L.B.Sm.	H. Luther *et al. s.n.* (SEL)	1980	lb	–14.2	
A. arenaria (Ule) L.B.Sm. & M.A.Spencer	R. Vásquez & N. Jaramillo 7656 (MO)		lt	–14.2	122
A. aripoensis (N.E.Br.) Pittendr.	W. Milliken, Bevan & Smart 53 (MO)		ll	–14.7	3400
A. bambusoides L.B.Sm. & Reitz	G. Martinelli 1551 (US)		lb	–12.0	
A. bicolor L.B.Sm.	H. Luther *s.n.* (SEL)		lb	–16.4	1000
A. biflora (L.B.Sm.) L.B.Sm. & M.A.Spencer	L. Besse 1965 (MO)		ll	–13.0	
A. blanchetiana (Baker) L.B.Sm.	R. Harley 17963 (US)		lb	–13.1	0
A. blumenavii Reitz	H. Luther *s.n.* (SEL)	1979	lb	–14.0	
A. bracteata (Sw.) Griseb.	R. Liesner & J. Dwyer 1605 (MO)		lb	–11.8	
A. brassicoides Baker	W. Kress *et al.* 86-1855 (SEL)		ll	–13.5	430
A. brevicollis L.B.Sm.	R. Leisner & G. Carnevali 22345 (MO)		lt	–17.7	
A. bromeliifolia (Rudge) Baker†	E. Zardini & R. Velázquez 17163 (MO)		ll	–14.7	
A. bromeliifolia (Rudge) Baker†	S. Blackmore & G. Heath 1997 (MO)		lb	–15.0	
A. caesia E.Morren ex Baker	K. Dorr *s.n.* (SEL)	1981	ll	–15.5	
A. callichroma Read & Baensch	J. Anderson *s.n.* (SEL)	1996	lb	–12.2	
A. calyculata (E.Morren) Baker	R. Atkinson 9 (MO)		lb	–11.0	
A. campanulata L.B.Sm.	C. Kelloff *et al.* 721 (US)		lb	–16.7	1500
A. candida E.Morren ex Baker	R. Braga 22 (US)		lb	–11.9	
A. carvalhoi E.Pereira & Leme	H. Luther *s.n.* (SEL)	1988	lb	–15.4	
A. castelnavii Baker	J. Steyermark 122195 *et al.* (MO)		lb	–19.4	
A. cathcartii C.F.Reed & Read	J. Steyermark & G. Davidse 116519 (MO)		ll	–11.5	
A. caudata Lindm.	P. Dusén *s.n.* (MO)		ll	–12.0	
A. chantinii (Carrière) Baker	N. Pitman 285 (MO)		ll	–13.6	
A. chlorophylla L.B.Sm.	R. Foster *s.n.* (SEL)	1980	lb	–15.9	
A. coelestis E.Morren var. *albomarginata* M.B.Foster	H. Luther *s.n.* (SEL)	1996	lb	–13.7	
A. comata (Gaudich.) Baker	Anon. (MO 2136765)		lb	–15.9	
A. confusa H.Luther	S. & H. Smith *s.n.* (SEL)		lb	–15.0	
A. conifera L.B.Sm.	R. Read & G. Daniels 3455 (US)		br	–13.2	
A. contracta (Mart. ex Schult. & Schult.f.) Baker	J. Revilla 339 (MO)		ll	–17.4	
A. correia-araujoi E.Pereira & Moutinho	H. Luther *s.n.* (SEL)	1992	ll	–16.3	
A. corymbosa (Mart. ex Schult. & Schult.f.) Mez	J. Pipoly 14969 *et al.* (MO)		ll	–17.1	130
A. costantinii (Mez) L.B.Sm. (= *A. stelligera* L.B.Sm.)	J. Coêlho de Moraes 862 (US)		ll	–10.9	
A. cucullata H.Luther	S. Espinoza 223 (MO)		lb	–11.4	390
A. cylindrata Lindm.	P. Dusén 16104 (MO)		ia	–12.6	
A. dactylina Baker	J. Morales 2393 *et al.* (MO)		lb	–11.7	40
A. dealbata E.Morren ex Baker	H. Luther *s.n.* (SEL)	1990	ll	–13.9	
A. dichlamydea Baker	T. Walters *s.n.* (SEL)	1987	lb	–15.5	
A. digitata L.B.Sm. & Read	R. Read & G. Daniels 3426 (US)	1975	ll	–13.0	
A. disjuncta (L.B.Sm.) Leme & J.A.Siqueira (= *Hohenbergia disjuncta* L.B.Sm.)	W. Berg *s.n.* (SEL)	1999	ia	–12.5	
A. distichantha Lem. var. *schlumbergeri* E.Morren ex Mez	Anon. (MO 3273303)		ll	–13.4	1700
A. downsiana Pittendr.	Griffiths & Smith (1983)	1981	ll	–9.7	900
A. drakeana André	W. Palacios 8722 *et al.* (MO)		ll	–14.6	930

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	$\delta^{13}C$ (‰)	Elevation¶ (m)
A. echinata (Leme) Leme	I. Ramírez *et al*. 472 (MO)		ll	−15.4	100–120
A. egleriana L.B.Sm.	G. Martinelli 12342 *et al*. (MO)		ll	−14.5	
A. emmerichiae Leme	P. Pascal *s.n.* (SEL)	1985	ll	−13.6	
A. entringeri Leme	H. Luther *s.n.* (SEL)	1988	lb	−16.1	
A. eurycorymbus Harms	M. Foster 2408 (US)		ll	−10.8	583
A. farinosa (Regel) L.B.Sm. [= *A. farinosa* var. *discolor* (Beer) L.B.Sm.]	H. Luther *s.n.* (SEL)		ll	−15.3	
A. fasciata (Lindl.) Baker	G. Brown 3402 (SEL)	1994	lb	−15.6	
A. fendleri André ex Mez	J. Steyermark 116522 & G. Davidse (MO)		ia	−11.1	
A. fernandae (E.Morren) Baker	G. Prance & J. Ramos 23667 (US)		lb	−15.5	
A. ferruginea L.B.Sm.	A. Gentry 37570 *et al*. (MO)		ll	−13.3	
A. filicaulis (Griseb.) Mez	P. Carlberg *s.n.* (SEL)	1986	ll	−18.4	
A. flavorosea E.Pereira	H. Luther *s.n.* (SEL)	1998	lb	−14.7	
A. floribunda Mart. ex Schult. & Schult.f.	R. Barton *s.n.* (SEL)	1996	ll	−15.2	
A. fosteriana L.B.Sm. ssp. *rupicola* Leme	W. Berg *s.n.* (SEL)		ia	−11.2	30
A. fraseri Baker	H. Luther *s.n.* (SEL)	1992	lb	−18.4	
A. fraudulosa Mez	S. Mori *et al*. 11496 (US)		ll	−13.1	
A. fulgens Brongn.	H. Luther *s.n.* (SEL)	1991	lb	−13.5	
A. gamosepala Wittm.	A. Krapovickas 42117 & C. Cristóbal (MO)		ll	−13.1	
A. germinyana (Carrière) Baker	A. Gentry & M. Fallen 17582 (MO)	1976	ll	−28.3	100
A. gigantea Baker	J. Anderson *s.n.* (SEL)	1991	ll	−17.7	
A. gracilis Lindm.	H. Luther *s.n.* (SEL)		lb	−13.4	
A. gurkeniana E.Pereira & Moutinho	H. Luther *s.n.* (SEL)	1996	lb	−12.5	
A. haltonii H.Luther	H. Churchill 5988 *et al*. (MO)		ll	−12.8	500
A. hoppii (Harms) L.B.Sm.†	F. Hurtado 1623 & J. Shiguango (MO)		ll	−15.1	1100
A. hoppii (Harms) L.B.Sm.†	A. Gentry *et al*. 21872 (US)		lb	−15.2	
A. huebneri Harms	G. Prance 17928 *et al*. (MO)		ll	−18.2	
A. involucrata André	D. Cathcart & W. Berg *s.n.* (SEL)	1989	ll	−20.0	1500
A. kentii (H.Luther) L.B.Sm. & M.A.Spencer	W. Bert *s.n.* (SEL)	1992	lb	−14.4	700
A. kertesziae Reitz	W. Berg *s.n.* (SEL)	1993	lb	−13.7	
A. kleinii Reitz	C. Dills 34 (SEL)	1983	lb	−13.0	
A. kuntzeana Mez	E. Werdermann 2490 (MO)		ll	−10.8	250
A. lasseri L.B.Sm.	C. de Rojas & F. Rojas 3534 (MO)		ll	−13.1	1300–1500
A. leonard-kentiana H.Luther & Leme	A. Amorim *et al*. 2031 (SEL)	1997	lb	−14.9	
A. leptantha (Harms) Leme & J.A.Siqueira (= *Portea leptantha* Harms)	W. & S. Till 4002 (SEL)	1989	ia	−11.8	650
A. lingulata (L.) Baker	S. Mori & J. Kallunki 4683 (MO)		ll	−15.3	350
A. longicuspis Baker	S. Smith & A. Shuhler 205 (US)		ll	−13.5	
A. longifolia (Rudge) L.B.Sm. & M.A.Spencer	M. Aulestia & I. Mipo 3437 (MO)		lt	−14.8	240
A. lueddemanniana (K.Koch) Mez	R. Cedillo Trigos 3134 (MO)		ll	−13.5	
A. lymanii W.Weber	A. Seidel 954 (US)		lb	−13.5	50
A. macrochlamys L.B.Sm.	C. Cantaino *s.n.* (SEL)	1987	lb	−15.5	
A. maculata L.B.Sm.	T. Walters *s.n.* (SEL)	1987	lb	−13.3	
A. magdalenae (André) André ex Baker	M. Grayum 4946 *et al*. (MO)		ll	−14.3	450
A. manzanaresiana H.Luther	C. Cerón M. 2987 (SEL)		ll	−12.7	1200
A. marauensis Leme	W. Berg *s.n.* (SEL)	1993	lb	−12.9	
A. mariae-reginae H.Wendl.	I. Chacon G. 464 (MO)		ll	−13.9	100
A. melinonii Hook.	H. Irwin 55754 *et al*. (MO)		lb	−13.4	220
A. mertensii (G.Mey.) Schult. & Schult.f.	T. Croat 62193 (MO)		lb	−16.4	100
A. mexicana Baker	P. Moreno & W. Robleto 20494 (MO)		lb	−12.2	1000–1100
A. milsteiniana L.B.Sm. & Read	E. Beach *s.n.* (SEL)	1981	lb	−12.6	
A. miniata (Beer) Hort. ex Baker var. *miniata*	R. Harley 18344 *et al*. (MO)		ll	−13.7	0–100
A. mollis L.B.Sm.	H. Luther *s.n.* (SEL)	1991	ll	−17.6	
A. moorei H.Luther	M. Aulestia 1364 *et al*. (MO)		ll	−12.5	250
A. mulfordii L.B.Sm.	H. Luther *s.n.* (SEL)	1979	lb	−13.0	
A. multiflora L.B.Sm.	R. Read & G. Daniels 3452 (US)		ll	−15.3	
A. muricata (Arruda) L.B.Sm.	K. Baker & J. Collins *s.n.* (MO)		ll	−11.4	
A. nallyi L.B.Sm.	H. Luther *s.n.* (MO)		ll	−13.8	
A. napoensis L.B.Sm. & M.A.Spencer	F. Hurtado & D. Neill 1522 (MO)		lb	−16.5	320
A. nidularioides L.B.Sm.	A. Gentry 55964 *et al*. (MO)		ll	−15.6	130
A. nudicaulis (L.) Griseb.	W. Stevens 23854 (MO)		ll	−14.7	20–170
A. organensis Wawra	C. Johnson *s.n.* (SEL)	1992	ll	−13.8	
A. orlandiana L.B.Sm.	H. Luther *s.n.* (SEL)	1979	lb	−12.7	
A. ornata (Gaudich.) Baker (= *A. ornata* var. *nationalis* Reitz)	R. Worley *s.n.* (SEL)	1997	br	−13.0	
A. pabstii E.Pereira & Moutinho	J. Anderson 48 (SEL)	1995	lb	−13.0	
A. paniculigera (Sw.) Griseb.†	J. Steyermark 121461 *et al*. (MO)		lt	−14.0	850–890
A. paniculigera (Sw.) Griseb. [= *A. latifolia* (Willd. ex Schult. & Schult.f.) Klotzsch ex Baker]†	M. Foster & R. Foster 1871 (MO)		br	−10.9	1333
A. pectinata Baker†	Anon. (MO 1309463)		lb	−13.2	
A. pectinata Baker†	T. Walters *s.n.* (SEL)	1987	lb	−13.6	

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	δ13C (‰)	Elevation¶ (m)
A. pedicellata Leme & H.Luther	H. Luther *s.n.* (SEL)	1995	lb	−16.5	
A. penduliflora André†	C. Cerón & M. Cerón 3058 (MO)		lb	−17.8	350
A. penduliflora André (= *A.* cf. *nivea* L.B.Sm.)†	D. Neill & W. Palacios 6732 (MO)		lb	−15.2	
A. perforata L.B.Sm.	R. Read & G. Daniels 3433 (US)		ll	−10.9	
A. phanerophlebia Baker	H. Irwin 28245-A *et al.* (MO)		lb	−11.8	1200
A. pimenti-velosoi Reitz (= *A. pimenti-velosoi* var. *glabra* Reitz)	M. McNamara *s.n.* (SEL)	1992	lb	−12.0	
A. pineliana (Brongn. ex Planch.) Baker	W. Berendsohn 286 (MO)		lb	−14.8	
A. pittieri Mez	J. Morales 2231 *et al.* (MO)		lb	−11.6	
A. podantha L.B.Sm.	W. Thomas *et al.* 9327 (NY)		lb	−20.2	500–600
A. poitaei (Baker) L.B.Sm. & M.A.Spencer	V. Huashikat 2202 (MO)		ll	−17.6	200
A. politii L.B.Sm.	G. Romero & E. Melgueiro 2211 (MO)		lb	−13.7	
A. pseudonudicaulis Leme	H. Luther *s.n.* (SEL)	1997	lb	−15.0	
A. pubescens Baker	J. Pipoly 4407 (MO)		lb	−15.8	80
A. purpureorosea (Hook.) Wawra	E. Lobdell 876 (SEL)	1988	ll	−14.0	
A. pyramidalis Benth.	C. Dodson 7097 *et al.* (MO)		lb	−11.8	70
A. racinae L.B.Sm.	M. & R. Foster (MO)		br	−19.7	
A. ramosa Mart. ex Schult. & Schult.f.	H. Luther *s.n.* (SEL)	1997	lb	−13.8	
A. recurvata (Klotzsch) L.B.Sm.	S. Tressens 4700 *et al.* (MO)		ll	−17.1	
A. retusa L.B.Sm.	J. Hudson 852 (MO)		ll	−13.2	
A. rodriguesiana L.B.Sm.	G. Prance *et al.* 4789 (US)		lb	−14.1	
A. roeseliae H.Luther	H. Luther *s.n.* (SEL)		lb	−17.5	
A. romeroi L.B.Sm.	L. Holm-Nielsen 21514 *et al.* (SEL)	1980	ll	−13.5	200
A. rubens (L.B.Sm.) L.B.Sm.	J. Anderson *s.n.* (SEL)	1992	lb	−14.3	
A. rubiginosa Mez	R. Liesner & F. Delascio 21904 (MO)		ll	−16.1	180
A. seideliana W.Weber	H. Luther *s.n.* (SEL)	1993	lb	−12.6	
A. serrata (L.) Mez	J. Anderson *s.n.* (SEL)	1989	ll	−17.5	
A. servitensis André var. *exigua* L.B.Sm.	C. Skotak *s.n.* (SEL)	1993	lb	−13.7	
A. setigera Mart. ex Schult. & Schult.f.	T. Killeen 3142 (MO)		lb	−12.0	400
A. smithiorum Mez	J. Halton *s.n.* (SEL)	1980	lb	−12.2	300
A. spectabilis Brongn. ex Houllet	G. Bunting 12105 *et al.* (MO)		ll	−13.1	1450–1600
A. sphaerocephala Baker	P. Worley *s.n.* (SEL)	1997	ll	−12.8	
A. squarrosa Baker	T. Plowman & G. Martinelli 10129 (US)		lb	−11.6	1180
A. stenosepala L.B.Sm.	O. Marulanda & S. Márquez 1982 (US)		ll	−13.5	310
A. streptocalycoides Philcox	W. Palacios 9024 *et al.* (MO)		ll	−16.6	230
A. strobilacea L.B.Sm.	D. Neill 9578 (MO)		ll	−15.5	1000
A. strobilina (Beurl.) L.B.Sm. & Read	Berg *et al. S.n.* (SEL)	1992	br	−12.0	600–800
A. subintegerrima (Philcox) Leme (= *R. brasiliensis* E.Pereira & Penna)	H. Luther s.n. (SEL)		ll	−15.8	
A. tayoensis Gilmartin	H. Luther *s.n.* (SEL)		ll	−14.4	
A. tessmannii Harms vel aff.	S. Espinoza & T. Coba 423 (MO)		lb	−12.9	365
A. tillandsioides (Mart. ex Schult. & Schult.f.) Baker	L. Gómez *et al.* 20385 (MO)		ll	−15.6	100–250
A. tocantina Baker	G. Davidse & O. Huber 15162 (MO)		lb	−12.1	
A. tomentosa Mez	J. Falcaó *et al.* 868 (US)		ll	−13.3	
A. tonduzii Mez & Pittier ex Mez	H. Kennedy 494 (MO)		ll	−13.1	800
A. triticina Mez†	H. Luther *s.n.* (SEL)	1979	ll	−12.9	
A. triticina Mez†	M. & R. Foster 918 (US)		ll	−10.1	
A. turbinocalyx Mez [= *A. curranii* (L.B.Sm.) L.B.Sm. & M.A.Spencer]	A. de Carvalho *et al.* 3359 (MO)		ll	−14.5	
A. vallerandii (Carrière) Erhardt, Götz & Seybold (= *A. beeriana* L.B.Sm. & M.A.Spencer)	R. Vásquez 4364 *et al.* (MO)	1983	lt	−15.8	
A. vanhoutteana (Van Houtte) Mez	L. Smith 1443 (US)		ll	−12.4	800–1000
A. veitchii Baker	L. Gómez 18777 (MO)	1982	ll	−30.1	1300–1800
A. victoriana L.B.Sm. (= *A. victoriana* var. *discolor* M.B.Foster)†	H. Luther *s.n.* (SEL)	1989	ll	−15.4	
A. victoriana L.B.Sm. (= *A. capixabae* L.B.Sm.)†	H. Luther *s.n.* (SEL)	1995	lb	−14.4	
A. warasii E.Pereira [= *A. warasii* var. *intermedia* (E.Pereira) E.Pereira & Leme]	G. Waggoner *s.n.* (SEL)	1996	lb	−16.1	
A. weberbaueri Harms	W. Rauh 20347 (US)		ll	−14.2	1200
A. weberi (E.Pereira & Leme) Leme	W. Berg *s.n.* (SEL)		lb	−14.4	
A. weilbachii Didr. (= *A. weilbachii* var. *weilbachii* forma *viridisepala* E.Pereira & Leme)	J. Anderson *s.n.* (SEL)	1991	lb	−14.6	
A. williamsii (L.B.Sm.) L.B.Sm. & M.A.Spencer	R. Vásquez *et al.* 12548 (MO)		ll	−14.0	100
A. winkleri Reitz	C. Johnson *s.n.* (SEL)	1989	lb	−14.0	
A. wittmackiana (Regel) Mez	M. Hurst *s.n.* (SEL)	1992	lb	−16.4	
A. woronowii Harms	D. Neill & C. Iguago 9122 (MO)		ll	−14.1	250
A. zebrina L.B.Sm.	C. Cerón M. 2584 (MO)		ll	−13.9	
***Ananas* Mill.**					
A. ananassoides (Baker) L.B.Sm.†	A. Gentry 49568 *et al.* (MO)	1985	ll	−12.4	750–760

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	δ13C (‰)	Elevation¶ (m)
A. ananassoides (Baker) L.B.Sm. [= *A. nanus* (L.B.Sm.) L.B.Sm.]†	G. Davidse & O. Huber 15278 (US)		ll	−12.7	80–150
A. bracteatus (Lindl.) Schult. & Schult.f.†	J. Steinbach 1075 (MO)		br	−11.3	450
A. bracteatus (Lindl.) Schult. & Schult.f. (= *A. fritzmuelleri* Camargo)†	J. Silva 1082 & G. Hatschbach (MO)	1992	lb	−13.4	10
A. comosus (L.) Merr.	M. Lewis 37586 (MO)	1990	ll	−15.0	250
A. lucidus Mill.†	J. Steyermark 90813 (US)		ll	−13.7	510–525
A. lucidus Mill.†	J. Steyermark 105099 (VEN)		lb	−11.9	
A. parguazensis Camargo & L.B.Sm.	G. Davidse & J. Miller 26935 (MO)	1984	lb	−13.7	300–340
A. sagenaria (Arruda) Schult. & Schult.f. [= *Pseudananas macrodontes* (E.Morren) Harms]†	T. Pedersen 13639 (MO)	1983	ll	−12.9	
A. sagenaria (Arruda) Schult. & Schult.f. [= *Pseudananas sagenarius* (Arruda) Camargo]†	E. Zardini & A. Aguayo 10048 (MO)	1989	ll	−14.2	
***Androlepis* Brongn. Ex Houllet**					
A. skinneri (K.Koch) Brongn. ex Houllet [= *A. donnell-smithii* (Baker) Mez]†	P. Gentle 4884 (MO)	1944	lb	−14.2	
A. skinneri (K.Koch) Brongn. ex Houllet†	B. Holst 4085 (MO)	1992	lb	−13.7	700–750
***Araeococcus* Brongn.**					
A. flagellifolius Harms	R. Liesner 4131 (MO)	1977	ll	−16.7	120
A. goeldianus L.B.Sm.	J. Pires & L. Westra 48821 (US)		lb	−14.0	10–80
A. micranthus Brongn.	C. Sperling 6186 *et al*. (MO)	1982	ll	−18.3	225–250
A. parviflorus (Mart. & Schult. & Schult.f.) Lindm.	R. Harley 18090 *et al*. (MO)	1977	ll	−16.2	0–50
A. pectinatus L.B.Sm.	V. Nielsen 891 (MO)	1991	ll	−18.6	100
***Billbergia* Thunb.**					
B. alfonsi-joannis Reitz	M. Birchell *s.n.* (SEL)	1989	ll	−11.4	
B. amoena (Lodd.) Lindl. (= *B. amoena* var. *viridis* L.B.Sm.)	C. Dills *s.n.* (SEL)	1995	lb	−12.7	
B. brachysiphon L.B.Sm. var. *brachysiphon* (= *B. brachysiphon* var. *paraensis* L.B.Sm.)	G. Prance *et al*. 1535 (US)		ll	−14.4	
B. bradeana L.B.Sm.	E. Pereira 2236 (US)		lb	−12.6	1000–1700
B. brasiliensis L.B.Sm.	T. Walters *s.n.* (SEL)	1987	lb	−11.4	
B. buchholtzii Mez	G. Waggoner *s.n.* (SEL)	1982	ll	−16.6	
B. cardenasii L.B.Sm.	D. Beadle SU029 (SEL)	1992	ll	−14.4	
B. chlorantha L.B.Sm.	D. Beadle *s.n.* (SEL)	1995	br	−14.1	
B. decora Poepp. & Endl.	W. Lewis *et al*. 11338 (SEL)	1986	ll	−15.1	185
B. distachya (Vell.) Mez	R. Ferreyra 18235A (SEL)	1973	ll	−13.2	130
B. elegans Mart. ex Schult. & Schult.f.	H. Luther *s.n.* (SEL)	1992	ll	−16.6	
B. eloiseae L.B.Sm. & Read	H. Luther *s.n.* (SEL)	1990	br	−13.7	
B. euphemiae E.Morren (= *B. euphemiae* var. *purpurea* M.B.Foster)	L. Stein *s.n.* (SEL)	1983	lb	−29.6	
B. formasa Ule	M. Rimachi 7495 (US)		lb	−16.4	120
B. horrida Regel	Y. Mexia 4967 (MO)		lb	−11.4	300
B. incarnata (Ruiz & Pav.) Schult. & Schult.f.	M. Vargas & R. Fernandez 50 (US)		ll	−12.5	
B. iridifolia (Nees & Mart.) Lindl.	Y. Mexia 4998A (MO)		ll	−15.8	210
B. kautskyana E.Pereira	H. Luther *s.n.* (SEL)	1997	lb	−15.6	800
B. laxiflora L.B.Sm.	H. Boudet F. 2177 (US)		lb	−14.6	
B. leptopoda L.B.Sm.	H. Boudet F. & W. Boone 1973 (US)		lb	−14.1	
B. lietzei E.Morren	D. Beadle *s.n.* (SEL)	1990	ll	−13.6	
B. macrocalyx Hook.	J. Dragen *s.n.* (SEL)	1980	lb	−17.0	
B. macrolepis L.B.Sm.	J. Steyermark 117677 *et al*. (MO)		ll	−14.9	480
B. magnifica Mez	H. Luther *s.n.* (SEL)	1995	ll	−14.3	
B. manarae Steyerm.	H. Luther *s.n.* (MO)		ll	−15.8	
B. meyeri Mez	R. Guillén 4019 *et al*. (MO)		ll	−13.8	180
B. microlepis L.B.Sm.	A. Gentry 44301 *et al*. (MO)		ll	−12.8	1400–1500
B. morelii Brongn.	H. Luther *s.n.* (SEL)	1992	br	−14.6	
B. nutans H.Wendl. ex Regel	E. Zardini 7808 (MO)		ll	−15.6	
B. oxysepala Mez	E. Gudiño & G. Grefa 1771 (MO)		ll	−14.9	250
B. pallidiflora Liebmann	P. Magaña R. & E. Lott 1 (MO)		ll	−13.0	
B. porteana Brongn. ex Beer	H. Irwin *et al*. 20720 (MO)		lt	−13.5	1200
B. pyramidalis (Sims) Lindl.	Anon. (MO 2136683)		ll	−13.2	
B. robert-readii E. Gross & Rauh	H. Luther *s.n.* (SEL)	1990	ll	−14.6	
B. rosea Beer	P. Jackson SP-13A (MO)		lb	−12.6	
B. cf. *rupestris* L.B.Sm.	M. de Pardo *et al*. 87 (SEL)	1995	ll	−16.1	
B. sanderiana E.Morren	H. Irwin 19808 *et al*. (MO)		ll	−15.6	1750
B. saundersii Bull	L. Felipe & N. de Carvalito 622 (SEL)	1996	lb	−16.1	
B. stenopetala Harms	A. Dik 1487 (MO)		ll	−15.0	
B. stenopetala Harms vel aff.	C. Cerón 6356 (MO)		ll	−14.6	
B. tessmannii Harms	A. Gentry 42847 *et al*. (MO)		ll	−12.2	130
B. tweedieana var. *latisepala* L.B.Sm.	D. Beadle S4057 (SEL)	1990	ll	−13.3	
B. velascana Cárdenas	Beadle S029A (SEL)	1989	br	−13.1	

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	$\delta^{13}C$ (‰)	Elevation¶ (m)
B. violacea Beer	D. Smith 3984 (SEL)	1983	ll	−12.2	600
B. viridiflora H.Wendl.	G. Davidse & D. Holland 36324 (MO)		ll	−15.0	30
B. vittata Brongn.	H. Irwin 20042 *et al.* (MO)		ll	−11.3	1200
B. zebrina (Herb.) Lindl.	P. Dusén 10780 (MO)		br	−11.3	
***Bromelia* L.**					
B. agavifolia Brongn. ex Houllet	H. Luther *s.n.* (SEL)	1990	lb	−12.8	
B. alsodes H.St.John	E. Cabrera 4676 & H. de Cabrera (MO)		ll	−14.6	
B. antiacantha Bertol.	L. Smith & E. McWilliams 15374 (US)		ll	−12.8	0
B. arenaria Ule	G. Martinelli & J. Costa 7785 (US)		lb	−12.4	300–400
B. auriculata L.B.Sm.	J. Jangoux *et al.* 1809 (NY)		lb	−14.0	
B. balansae Mez	J. Ratter 5144 *et al.* (MO)	1985	ll	−15.4	
B. binotii E.Morren ex Mez	M. & R. Foster 787 (US)		ll	−12.3	
B. chrysantha Jacq.	R. Liesner & A. González 12051 (MO)	1981	ll	−13.8	0–100
B. eitenorum L.B.Sm.	G. & L. Eiten 10519 (US)		ll	−13.7	300
B. flemingii I.Ramírez & Carnevali	B. Holst 2307 *et al.* (MO)		ll	−13.4	400
B. glaziovii Mez	A. Castellanos 24425 (US)		ll	−12.5	
B. goeldiana L.B.Sm.	R. Liesner 24145 (MO)		ll	−16.4	850
B. granvillei L.B.Sm. & Gouda	G. Cremers 13122 (NY)		lb	−13.1	550
B. hemisphaerica Lam.	G. Hinton 1221 (MO)		lb	−12.2	1340
B. hieronymi Mez	A. Gentry 75147 *et al.* (MO)		ll	−12.7	350
B. humilis Jacq.	R. Liesner 11950 & A. González (MO)	1981	ll	−11.8	0–100
B. interior L.B.Sm.	Windisch 2137 (US)		ll	−9.9	800
B. irwinii L.B.Sm.	H. Irwin *et al.* 32980 (US)		lb	−11.1	1250
B. karatas L.	H. Iltis 30879 & R. Zuniga (MO)	1991	ll	−13.9	400–500
B. laciniosa Mart. ex Schult. & Schult.f.	Luther 3042 *et al.* (SEL)	1996	lb	−11.1	300–400
B. macedoi L.B.Sm.	J. Kirkbride 5059 (US)		lb	−9.4	900
B. morreniana (Regel) Mez	A. Ducke 11867 (US)		ll	−14.2	
B. palmeri Mez	E. Martínez S. 21386 (MO)		ll	−12.6	
B. pinguin L.	M. Guadalupe A. 416 (MO)	1985	ll	−14.5	
B. regnellii Mez	M. & R. Foster 553 (US)		lb	−10.9	
B. rondoniana L.B.Sm.	P. Hutchison 8596 (UEC)		ll	−13.5	
B. scarlatina (Henriq. ex Linden) E.Morren ex C.H.Morren	T. Plowman 7960 (US)		lb	−14.5	
B. serra Griseb.	M. Nee 40291 (MO)	1990	lb	−11.7	1400
B. superba Mez	W. & S. Till 9139 (SEL)	1992	ll	−13.6	480
B. cf. *sylvicola* S.Moore	T. Walters (SEL)	1987	lb	−12.4	
B. tarapotina Ule	P. Maas *et al.* 5984 (US)		ll	−14.2	200–300
B. trianae Mez	M. & R. Foster 1886 (US)		ll	−13.3	1000
B. tubulosa L.B.Sm.	B. Holst 2765 *et al.* (MO)	1986	ll	−14.0	500
B. villosa Mez	? (illegible) 4957 (US)		ll	−11.9	
***Canistropsis* (Mez) Leme**					
C. albiflora (L.B.Sm.) H.Luther & Leme	Berg & Anderson BAB 130 (SEL)	1997	ll	−19.5	
C. billbergioides (Schult. & Schult.f.) Leme	A. Krapovickas & C. Cristóbal 42154 (MO)	1988	ll	−15.5	
C. burchellii (Baker) Leme	H. Luther 396 (SEL)	1980	ll	−16.4	
C. correia-araujoi (E.Pereira & Leme) Leme	H. Luther *s.n.* (SEL)	1985	ll	−13.4	
C. exigua (E.Pereira & Leme) Leme	E. Leme 3175 *et al.* (SEL)	1995	ia	−23.8	50
C. microps (E.Morren ex Mez) Leme	E. Ailstock *s.n.* (SEL)	1983	lb	−15.6	
C. seidelii (L.B.Sm. & Reitz) Leme	A. Seidel 6-20 (US)		ll	−13.8	
***Canistrum* E.Morren**					
C. aurantiacum E.Morren	M. Mee *s.n.* (US)		ll	−12.2	
C. camacaense Martinelli & Leme	W. Thomas 11374 *et al.* (SEL)	1996	ll	−13.6	
C. fosterianum L.B.Sm.	S. Linhares *s.n.* (SEL)	1996	ll	−12.7	
C. lanigerum H.Luther & Leme	R. Read 84-94 (US)		ll	−19.3	
C. seidelianum W.Weber	G. Waggoner *s.n.* (SEL)	1987	lb	−17.2	
C. triangulare L.B.Sm. & Reitz	H. Luther *s.n.* (SEL)	1998	lb	−13.6	
***Cryptanthus* Otto & A.Dietr.**					
C. acaulis (Lindl.) Beer†	S. Antle *s.n.* (SEL)	1987	ll	−18.5	
C. acaulis (Lindl.) Beer (= *C. sinuosus* L.B.Sm.)†	Anon. (MO 2136691)		ll	−15.0	
C. bahianus L.B.Sm.	H. Luther *s.n.* (SEL)	1987	ll	−16.7	
C. beuckeri E.Morren	L. Mattos Silva 3062 *et al.* (SEL)	1994	lb	−17.3	
C. bivittatus (Hook.) Regel	Pierce *et al.* (2002a)	2000	ll	−14.8	
C. bromelioides Otto & A.Dietr.	H. Luther *s.n.* (SEL)		ll	−14.4	20–30
C. colnagoi Rauh & Leme	H. Luther *s.n.* (SEL)	1984	lb	−15.5	
C. correia-araujoi Leme	C. Colins *s.n.* (SEL)	1987	ll	−14.7	
C. dianae Leme	H. Luther *s.n.* (SEL)	1997	lb	−18.1	750
C. fernseeoides Leme	H. Luther *s.n.* (SEL)	1992	ll	−23.9	
C. fosterianus L.B.Sm.	A. Lima 54-1920 (US)		ll	−17.6	
C. glaziovii Mez (= '*C. glazioui* Mez', orth. var.)	H. Luther *s.n.* (SEL)	1990	lb	−26.5	
C. lacerdae Antoine	H. Luther *s.n.* (SEL)	1996	ll	−17.0	
C. leopoldo-horstii Rauh	G. Hatschbach *et al.* 29079 (US)		ll	−18.9	
C. lutherianus I.Ramírez	J. Raack 1 (SEL)	1990	lb	−17.6	

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	$\delta^{13}C$ (‰)	Elevation¶ (m)
C. marginatus L.B.Sm.	H. Luther *s.n.* (SEL)	1996	lb	−16.5	
C. maritimus L.B.Sm.	H. Luther *s.n.* (SEL)	1998	lb	−14.4	
C. microglazioui I.Ramírez	R. Louzada 12 *et al.* (SP)	2006	ll	−26.4	
C. pseudopetiolatus Philcox	I. Ramírez & H. Silva B. 490 (MO)		ll	−14.7	10–20
C. cf. *pseudopetiolatus* Philcox (= *C.* cf. *ruthae* Philcox)	J. Jardim 649 *et al.* (SEL)	1995	lb	−12.5	
C. pseudoscaposus L.B.Sm.	M. Remmick 117 (SEL)	1989	ll	−23.0	
C. scaposus E.Pereira	H. Luther *s.n.* (SEL)	1996	lb	−26.0	100–200
C. schwackeanus Mez	H. Irwin 19660 *et al.* (MO)	1968	ll	−24.4	1500
C. tiradentesensis Leme	R. Louzada 158 *et al.* (SP)	2009	ll	−28.1	
C. warasii E.Pereira	none		ll	−15.0	
C. warren-loosei Leme	H. Luther *s.n.* (SEL)	1998	ll	−17.0	
***Deinacanthon* Mez**					
D. urbanianum (Mez) Mez	A. Krapovickas 45260 *et al.* (MO)	1994	ll	−14.3	
***Disteganthus* Lem.**					
D. basilateralis Lem.†	Feuillet C. 9947 *et al.* (SEL)	1988	ll	−14.0	400–465
D. basilateralis Lem.†	G. Cremers 12247 (MO)	1991	ll	−13.3	50
D. lateralis (L.B.Sm.) Gouda	Granville *s.n.* (US)		lb	−14.0	160
***Edmundoa* Leme**					
E. ambigua (Wand. & Leme) Leme	E. Leme 1073 *et al.* (SEL)	1986	ll	−19.8	
E. lindenii (Regel) Leme var. *lindenii*	L. Smith & P. Reitz 6153 (US)		ll	−14.1	150
E. perplexa (L.B.Sm.) Leme	J. DaSilva *s.n.* (SEL)	1995	lb	−19.4	
***Eduandrea* Leme, W.Till, G.K.Br., J.R.Grant & Govaerts**					
E. selloana (Baker) Leme, W.Till, G.K.Br., J.R.Grant & Govaerts (= *Andrea selloana* (Baker) Mez)	M. Foster 615 (US)		ll	−14.3	
***Fascicularia* Mez**					
F. bicolor (Ruiz & Pav.) Mez var. *bicolor*	G. Zizka 8063 (FR)	2006	ll	−23.8	
***Fernseea* Baker**					
F. bocainensis E.Pereira & Moutinho	B. Holst 6182 (SEL)	1997	lb	−24.5	
F. itatiaiae (Wawra) Baker	L. Smith 1480 (US)		ll	−21.3	2000–2300
***Greigia* Regel**					
G. alborosea (Griseb.) Mez	J. Steyermark 127928 *et al.* (MO)	1982	ll	−24.0	2100–2240
G. aristeguietae L.B.Sm.	J. Steyermark & R. Liesner 118638 (VEN)		lb	−27.2	2150–2300
G. cochabambae H.Luther	M. Kessler 7253A *et al.* (SEL)	1996	ll	−30.4	2200
G. columbiana L.B.Sm.	F. Oliva E. & B. Manara 98-11 (SEL)	1998	ll	−26.9	3000
G. mulfordii L.B.Sm.	H. Griffiths, H.S.J. Lee & J.A.C. Smith, *s.n.* (cf. Martin, 1994)	1985	ll	−30.3	
G. oaxacana L.B.Sm. (= *G. juareziana* L.B.Sm.)	D. Breedlove 21493 & R. Thorne (MO)	1971	ll	−31.3	2000
G. ocellata L.B.Sm. & Steyerm.	Medina *et al.* (1986)		ll	−26.2	
G. rohwederi L.B.Sm.	O. Rohweder 528 (MO)	1951	ll	−29.5	2200
G. sphacelata (Ruiz & Pav.) Regel	G. Zizka 8085 (FR)		ll	−31.3	
G. stenolepis L.B.Sm.	J. Betancur & J. Sarmiento 3990 (NY)		lb	−28.6	3000–3300
G. sylvicola Standl.	L. Gómez 22416 *et al.* (MO)	1984	ll	−29.9	2400–2550
G. van-hyningii L.B.Sm.†	D. Van Hyning 5910 (US)		lb	−29.0	
G. van-hyningii L.B.Sm. (= *G. steyermarkii* L.B.Sm.)†	C. Beutelspacher B. 65 (MO)	1973	ll	−26.3	2000
G. vulcanica André	J. Clark 1874 *et al.* (MO)		ll	−23.1	3000–4000
***Hohenbergia* Schult.f.**					
H. abbreviata L.B.Sm. & Proctor	R. Howard & G. Proctor 14435 (US)		ll	−11.4	500
H. andina Betancur	H. Luther *s.n.* (MO)		br	−13.2	
H. antillana Mez	N. Britton & J. Cowell 2041 (US)		lb	−12.6	
H. augusta (Vell.) E.Morren	P. Worley *s.n.* (SEL)	1992	lb	−15.0	
H. belemii L.B.Sm. & Read	W. Thomas *et al.* 11395 (NY)		ia	−13.1	
H. blanchetii (Baker) E.Morren ex Baker	P. DeLeon 118 (SEL)	1963	lb	−11.1	
H. brachycephala L.B.Sm.	R. Read & G. Daniels 3418 (US)		ll	−14.9	
H. burle-marxii Leme & W.Till	R. Frasier *s.n.* (SEL)		ll	−15.3	
H. castellanosii L.B.Sm. & Read	H. Bullis Jr. *S.n.* (SEL)	1989	br	−13.3	
H. catingae Ule	R. Schery 494 (MO)		lb	−12.3	
H. correia-arauji E.Pereira & Moutinho	C. Johnson *s.n.* (SEL)	1988	br	−13.5	
H. distans (Griseb.) Baker	G. Proctor 27713 (US)		ll	−12.8	17–33
H. edmundoi L.B.Sm. & Read	A. Seidel 972 (SEL)	1985	lb	−14.9	
H. eriantha (Brongn. ex Baker) Mez	R. Belem 3494 (NY)		lb	−17.1	
H. eriostachya Mez	N. Britton 3419 (US)		lb	−10.9	
H. fawcettii Mez	E. Britton 3804 (US)		lb	−13.3	
H. inermis Mez	G. Proctor 21505 (US)		ll	−11.1	333–367
H. jamaicana L.B.Sm. & Proctor	G. Proctor 16452 (US)		ll	−13.0	217
H. littoralis L.B.Sm.	E. Oliveira 651 (MO)		lb	−11.8	
H. negrilensis Britton ex L.B.Sm.	H. Bullis *s.n.* (SEL)	1989	br	−12.5	
H. oxoniensis W.Weber	s.n. ('Brasilia') (OXF)	1982	ll	−11.5	

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	δ^{13}C (‰)	Elevation¶ (m)
H. penduliflora (A.Rich.) Mez	H. Hespenheide 1585 *et al*. (MO)	1965	ll	–10.6	733–800
H. polycephala (Baker) Mez	A. Gentry *et al*. 28453 (MO)	1980	lb	–12.4	540–550
H. portoricensis Mez†	F. & A. Axelrod 6700 (US)		ll	–13.2	700
H. portoricensis Mez (= *H. attenuata* Britton)†	H. Pfeifer & class 2867 (SEL)	1969	ll	–11.1	
H. proctorii L.B.Sm.	H. Anderson *s.n.* (US)		ll	–13.4	400
H. ridleyi (Baker) Mez (= *H. ramageana* Mez)†	J. Anderson *s.n.* (SEL)	1997	lb	–16.0	
H. ridleyi (Baker) Mez†	J. Marnier-Lapostolle *s.n.* (SEL)	1967	lb	–14.0	
H. rosea L.B.Sm. & Read	P. Worley *s.n.* (SEL)	1994	ia	–11.3	
H. salzmannii (Baker) E.Morren ex Baker	L. Smith *et al*. 7113 (US)		lb	–10.8	
H. spinulosa Mez	N. Britton 3149 (NY)		lb	–11.7	
H. stellata Schult. & Schult.f.	R. Worthington 18050 (MO)	1989	ll	–13.1	
H. urbaniana Mez	M. Dexter *s.n.* (SEL)	1991	ll	–14.5	
H. utriculosa Ule	W. Berg *s.n.* (SEL)	1997	lb	–12.4	
H. vestita L.B.Sm.	H. Irwin *et al*. 30693 (MO)	1971	ll	–11.5	1100
***Hohenbergiopsis* L.B.Sm & Read**					
H. guatemalensis (L.B.Sm.) L.B.Sm. & Read	E. Martínez 23007 *et al*. (MO)	1988	lb	–12.2	1630
***Lapanthus* Louzada & Versieux**					
L. duartei (L.B.Sm.) Louzada & Versieux	R. Louzada 28 *et al*. (SP)	2006	lb	–28.9	646
***Lymania* Read**					
L. alvimii (L.B.Sm. & Read) Read	A. Amorim 1077 *et al*. (SEL)	1993	ll	–17.3	
L. corallina (Brongn. ex Beer) Read	T. Plowman *et al*. 10078 (US)		ll	–15.7	60
L. globosa Leme	W. Thomas *et al*. 10714 (NY)		ll	–14.7	
L. marantoides (L.B.Sm.) Read†	T. Santos & E. Judziewicz 4202 (US)		ll	–14.2	150
L. marantoides (L.B.Sm.) Read†	A. de Carvalho *et al*. 3598 (SEL)	1991	ll	–14.4	
L. smithii Read	I. Ramírez *et al*. 479 (MO)		ll	–16.9	10–20
***Neoglaziovia* Mez**					
N. concolor C.H.Wright	R. Schury 528 (MO)		br	–11.7	
N. variegata (Arruda) Mez	G. Hatschbach & O. Guimarâes 45137 (MO)	1982	ll	–9.4	
***Neoregelia* L.B.Sm.**					
N. abendrothae L.B.Sm.	A. Abendroth 105 (US)		lb	–12.9	
N. amandae W.Weber	H. Luther *s.n.* (SEL)	1981	lb	–14.3	
N. cf. *ampullacea* (E.Morren) L.B.Sm.	H. Luther *s.n.* (SEL)	1980	br	–21.0	
N. cf. *angustifolia* E.Pereira	H. Luther *s.n.* (SEL)	1997	lb	–14.2	
N. bahiana (Ule) L.B.Sm.	H. Luther *s.n.* (SEL)	1994	lb	–17.8	1500
N. burlemarxii Read	M. Remmick 6 (SEL)	1989	lb	–13.3	
N. capixaba E.Pereira & Leme	H. Luther *s.n.* (SEL)	1994	lb	–14.2	
N. carcharodon (Baker) L.B.Sm.	A. Seidel 505 (SEL)	1962	lb	–12.8	
N. carolinae (Beer) L.B.Sm.	H. Luther *s.n.* (SEL)	1997	ia	–13.4	
N. cathcartii C.F.Reed & Read	H. Luther *s.n.* (SEL)		lb	–13.6	
N. chlorosticta (E.Morren) L.B.Sm.	G. Martinelli *s.n.* (SEL)	1995	lb	–14.3	
N. compacta (Mez) L.B.Sm.†	G. Staples via G. Ihrig 1000 (SEL)	1995	ll	–16.4	
N. compacta (Mez) L.B.Sm.†	E. Ule 4038 (US)		lb	–14.0	
N. concentrica (Vell.) L.B.Sm.	H. Luther *s.n.* (SEL)	1997	ll	–14.5	
N. coriacea (Antoine) L.B.Sm.	C. Putcamp *s.n.* (SEL)	1994	lb	–14.2	
N. correia-araujoi E.Pereira & Penna	L. Vinzant 1 (SEL)		lb	–13.7	
N. cruenta (Graham) L.B.Sm.	H. Luther *s.n.* (SEL)	1997	lb	–13.0	
N. cyanea (Beer) L.B.Sm.	Prinz *s.n.* (SEL)	1981	lb	–15.7	
N. eleutheropetala (Ule) L.B.Sm.	T. Croat 58668 (MO)		ll	–15.2	270
N. eltoniana Weber	T. Fonteura 207 *et al*. (SEL)	1991	ll	–13.5	
N. farinoa (Ule) L.B.Sm.	H. Luther *s.n.* (SEL)	1996	lb	–14.0	
N. fluminensis L.B.Sm.	A. Seidel 606 (US)		ll	–13.8	
N. fosteriana L.B.Sm.	H. Luther *s.n.* (SEL)	1993	lb	–14.8	
N. gavionensis Martinelli & Leme	H. Luther *s.n.* (SEL)	1993	ll	–14.1	
N. indecora (Mez) L.B.Sm.	H. Luther *s.n.* (SEL)		lb	–13.1	200
N. cf. *johannis* (Carrière) L.B.Sm.	H. Luther 305 (SEL)	1980	lb	–13.5	
N. lactea H.Luther & Leme	H. Luther *s.n.* (SEL)	1998	lb	–17.3	
N. laevis (Mez) L.B.Sm.	G. Hatschbach 20276 (MO)		ll	–16.6	
N. leviana L.B.Sm.†	R. Liesner 3400 (US)		lb	–16.7	120
N. leviana L.B.Sm.†	G. Carpevali *et al*. 2596 (VEN)		ll	–15.6	100
N. lilliputiana E.Pereira	H. Luther *s.n.* (SEL)	1992	lb	–18.1	
N. longisepala E.Pereira & Leme	Luther *et al*. 3088A (SEL)	1996	lb	–14.1	
N. lymaniana R.Braga & Sucre	E. Leme 2126 *et al*. (SEL)	1993	ll	–16.5	1200
N. macrosepala L.B.Sm.	M. Remmick 99 (SEL)	1989	br	–14.0	
N. magdalenae L.B.Sm. & Reitz	H. Luther *s.n.* (SEL)	1997	lb	–15.4	
N. cf. *margaretae* L.B.Sm.	H. Luther *s.n.* (SEL)		lb	–13.1	
N. marmorata (Baker) L.B.Sm.	M. Remmick 108 (SEL)	1989	lb	–19.2	
N. mooreana L.B.Sm.	Luther *et al*. 2736 (SEL)	1989	lb	–15.9	400
N. mucugensis Leme	M. Kellett *s.n.* (SEL)	1992	lb	–15.1	
N. myrmecophila (Ule ex G.Karst. & Schenk) L.B.Sm.	L. Urrego G. 881 *et al*. (MO)	1989	lb	–16.1	

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	δ13C (‰)	Elevation¶ (m)
N. nivea Leme	H. Luther *s.n.* (SEL)	1991	ll	−14.1	
N. olens (Hook.f.) L.B.Sm.	H. Luther *s.n.* (SEL)	1991	ll	−14.6	
N. cf. *oligantha* L.B.Sm.	H. Luther *s.n.* (SEL)	1980	lb	−14.8	
N. pauciflora L.B.Sm.	Anon. (US 2121538)		lb	−16.6	
N. pendula var. *brevifolia* L.B.Sm.	N. Pitman 616 (MO)	1994	br	−15.9	250
N. pineliana (Lem.) L.B.Sm.	Teuscher *s.n.* (US)		lb	−16.6	
N. rosea L.B.Sm.	H. Luther *s.n.* (SEL)	1990	lb	−13.8	
N. rubrovittata Leme	H. Hill *s.n.* (SEL)	1983	lb	−15.2	
N. sanguinea Leme	H. Luther *s.n.* (SEL)	1997	lb	−14.2	1000
N. sapiatibensis E.Pereira & I.A.Penna	H. Luther *s.n.* (SEL)		ll	−15.7	
N. sarmentosa (Regel) L.B.Sm.†	G. Waggoner *s.n.* (SEL)	1986	lb	−16.9	50
N. sarmentosa (Regel) L.B.Sm.†	L. Smith 1358 (US)		ll	−11.0	100–400
N. cf. *seideliana* L.B.Sm. & Reitz	M. Hurst *s.n.* (SEL)	1993	lb	−14.7	
N. simulans L.B.Sm.	Seidel *s.n.* (US)		lb	−13.7	
N. spectabilis (T.Moore) L.B.Sm.	M. Remmick 109 (SEL)	1989	lb	−13.5	
N. stolonifera L.B.Sm.	R. Vásquez 2290 *et al.* (MO)	1981	ll	−15.3	160
N. tarapotoensis Rauh	H. Luther *s.n.* (SEL)	1981	ll	−15.5	
N. tristis (Beer) L.B.Sm.	W. Berg *s.n.* (SEL)	1998	lb	−14.2	
N. wilsoniana M.B.Foster	R. Read & G. Daniels 3454 (US)		lb	−15.9	
N. wurdackii L.B.Sm.	J. Wurdack 2469 (US)		lb	−14.2	300–350
N. zaslawskyi E.Pereira & Leme	H. Luther *s.n.* (SEL)		lb	−15.8	
N. zonata L.B.Sm.	R. Wilson 34 (US)		lb	−11.6	
***Nidularium* Lem.**					
N. amazonicum (Baker) Linden & E.Morren ex Lindm.	R. Wilson *s.n.* (US)		ll	−24.3	
N. angustibracteatum Leme	J. DaSilva *s.n.* (SEL)	1990	lb	−14.2	
N. angustifolium Ule	H. Luther *s.n.* (SEL)	1991	ll	−15.6	
N. cf. *angustifolium* Ule	W. Berg *s.n.* (SEL)	1994	ll	−15.8	
N. antoineanum Wawra	E. Leme 2370 (SEL)	1994	br	−17.6	1300
N. apiculatum L.B.Sm.	S. Vogel 722 (US)		lb	−21.4	1500
N. bicolor (E.Pereira) Leme	M. & R. Foster *s.n.* (US)		lb	−16.6	
N. campos-portoi (L.B.Sm.) Leme	L. Smith & E. McWilliams 15369 (US)		ll	−25.8	
N. cariacicaense (Weber) Leme	A. Seidel *s.n.* (US)		ll	−14.4	
N. espiritosantense Leme	S. Martinelli *et al.* 8077 (US)		lb	−18.9	1000
N. cf. *ferdinando-coburgii* Wawra	A. Seidel 820 (SEL)	1982	ll	−22.6	
N. fulgens Lem.	E. Pereira 10579 (US)		lb	−14.2	
N. innocentii Lem.	A. Gentry 58842 *et al.* (MO)	1987	ll	−33.3	550–600
N. itatiaiae L.B.Sm.	J. Ferreira 1800 (US)		lb	−15.8	1200
N. jonesianum Leme	P. Reitz 6080 (US)		lb	−17.3	500
N. kautskyanum Leme†	G. Martinelli *et al.* 8075 (US)		ll	−18.2	1000
N. kautskyanum Leme†	H. Luther *s.n.* (SEL)	1992	ll	−17.9	
N. longiflorum Ule†	W. Berg *s.n.* (SEL)	1992	br	−27.7	
N. longiflorum Ule†	H. Luther *s.n.* (SEL)	1990	br	−25.3	
N. marigoi Leme†	L. Smith 1775 (US)		lb	−30.3	1960
N. marigoi Leme†	L. Smith 1775 (MO)		ll	−29.3	1960
N. minutum Mez	M. Garcia Lima 4 (US)		ll	−11.8	
N. picinguabensis Leme	M. McNamara *s.n.* (SEL)	1992	lb	−25.2	
N. procerum Lindm.	A. Krapovickas & C. Cristóbal 42133 (MO)	1988	ll	−14.8	
N. purpureum Beer	E. Ule 4131A (US)		lb	−13.2	
N. rubens Mez	R. Doering 24 (US)		ll	−32.6	
N. rutilans E.Morren†	P. Reitz 5821 (US)		lb	−18.4	50
N. rutilans E.Morren (= *N. regelioides* Ule)†	H. Luther *s.n.* (SEL)		lb	−15.9	
N. rutilans E.Morren†	H. Luther *s.n.* (SEL)	1980	lb	−15.9	
N. scheremetiewii Regel	Medina *et al.* (1977)		ll	−16.3	
***Ochagavia* Phil.**					
O. andina (Phil.) Zizka, Trumpler & Zöllner	G. Zizka 8097 (FR)		ll	−25.0	
O. carnea (Beer) L.B.Sm. & Looser	G. & U. Varadarajan 1489 *et al.* (SEL)	1987	lb	−21.5	700
O. elegans Phil.	O. Solbrig *et al.* 3838 (US)		ll	−22.4	
O. litoralis (Phil.) Zizka, Trumpler & Zöllner [= *Fascicularia litoralis* (Phil.) Mez]	L. Landrum 4505 (MO)	1982	ll	−27.4	600
***Orthophytum* Beer**					
O. albopictum Philcox†	G. Hatschbach & J. Silva 50093 (MO)	1985	ll	−15.5	
O. albopictum Philcox (= *O. mucugensis* Martinelli ms.)†	G. Martinelli 5519 (US)		ll	−13.1	700
O. alvimii W.Weber	H. Luther *s.n.* (SEL)	1999	ll	−16.1	
O. amoenum (Ule) L.B.Sm.	M. Arbo 5773 *et al.* (MO)	1992	lt	−13.2	950
O. benzingii Leme & H.Luther	H. Luther *s.n.* (SEL)		ll	−20.1	
O. burle-marxii L.B.Sm. & Read	W. Berg *s.n.* (SEL)	1993	ll	−17.6	
O. compactum L.B.Sm.	G. Hatschbach 27431 (US)		ll	−11.5	1200
O. disjunctum L.B.Sm.	H. Luther *s.n.* (SEL)	1999	br	−15.1	
O. duartei L.B.Sm.	A. Duarte 1953 (US)		lb	−17.5	
O. foliosum L.B.Sm.	H. Irwin 20968 *et al.* (MO)	1968	ll	−13.9	1200

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	δ13C (‰)	Elevation¶ (m)
O. fosterianum L.B.Sm.	G. & M. Hatschbach & J. Silva 55580 (MO)	1991	ll	−18.5	600
O. glabrum (Mez) Mez	G. Davidse 11578 *et al*. (MO)	1976	ll	−15.5	590
O. gurkenii Hutchison	H. Luther *s.n.* (SEL)	1991	ll	−14.5	
O. lemei E.Pereira & Penna	G. Hatschbach 44220 (MO)		lb	−14.4	
O. leprosum (Mez) Mez	G. Hatschbach 39718 (MO)	1977	ll	−13.9	
O. lucidum Leme & H.Luther	H. Luther *s.n.* (SEL)		ll	−15.8	
O. magalhaesii L.B.Sm.	G. & M. Hatschbach & J. Silva 52276 (MO)	1988	lb	−12.6	
O. maracasense L.B.Sm.	H. Luther *s.n.* (SEL)	1999	ll	−16.6	
O. mello-barretoi L.B.Sm.	H. Luther *s.n.* (SEL)	1995	ll	−14.5	
O. navioides (L.B.Sm.) L.B.Sm.	G. Martinelli 5521 (US)		ll	−26.4	1000
O. rubrum L.B.Sm.	M. Foster 2444 (US)	1952	ll	−15.4	
O. sanctum L.B.Sm.	W. Berg *s.n.* (SEL)	1997	ll	−14.2	
O. saxicola (Ule) L.B.Sm.	G. Davidse 11831 *et al*. (MO)	1976	lt	−14.3	280
O. vagans M.B.Foster	R. Burle Marx 8 (US)		ll	−17.5	
***Portea* K.Koch**					
P. alatisepala Philcox	J. Anderson BAB 134 (SEL)		ll	−13.0	
P. filifera L.B.Sm.	R. Read & G. Daniels 3419 (US)		ll	−17.3	
P. fosteriana L.B.Sm.	A. Seidel *s.n.* (SEL)	1962	br	−13.2	
P. grandiflora Philcox	J. Anderson *s.n.* (SEL)		lb	−19.0	777
P. kermesina K.Koch	D. Uggucioni *s.n.* (SEL)	1993	ll	−17.0	
P. orthopoda (Baker) Coffani-Nunes & Wanderley (= *P. petropolitana* Mez var. *extensa* L.B.Sm.)	E. Lobdell 1280 (SEL)	1989	lb	−16.2	
P. silveirae Mez	R. Belém & M. Magalhães 1073 (US)		ll	−15.1	
***Quesnelia* Gaudich.**					
Q. arvensis (Vell.) Mez	C. Dills *s.n.* (SEL)	1995	br	−12.9	
Q. augusto-coburgii Wawra	H. Luther *s.n.* (SEL)	1993	ll	−14.5	
Q. edmundoi L.B.Sm.	E. Beach *s.n.* (SEL)	1981	br	−12.7	
Q. humilis Mez	H. Luther *s.n.* (SEL)	1981	lb	−19.2	
Q. imbricata L.B.Sm.	G. Hatschbach & H. Haas 16831 (US)		ll	−12.9	1950
Q. lateralis Wawra	H. Luther *s.n.* (SEL)	1996	ll	−16.1	
Q. liboniana (De Jonghe) Mez	H. Luther *s.n.* (SEL)	1981	lb	−15.2	
Q. marmorata (Lem.) Read	H. Luther *s.n.* (SEL)	1980	ll	−14.0	
Q. quesneliana (Brongn.) L.B.Sm.	D. Araujc 3408 (SEL)	1979	ia	−13.1	
Q. seideliana L.B.Sm. & Reitz	W. Berg *s.n.* (SEL)	1995	lb	−13.8	
Q. strobilospica Wawra†	H. Luther *s.n.* (SEL)	1998	lb	−15.4	
Q. strobilospica Wawra [= *Q. blanda* (Schott ex Beer) Mez]†	A. Brade 19157 (US)		ll	−11.5	
Q. testudo Lindm.	M. Hurst *s.n.* (SEL)	1993	lb	−13.9	
***Ronnbergia* E.Morren & André**					
R. columbiana E.Morren	A. Gentry 40413 *et al*. (MO)	1983	lb	−11.4	50
R. deleonii L.B.Sm.	G. Tipaz *et al*. 1973 (MO)	1992	ll	−31.9	1800
R. explodens L.B.Sm.	S. Knapp 2235 (MO)	1981	lb	−29.1	1000
R. hathewayi L.B.Sm.	A. Chacón 165 (MO)	1989	ll	−31.0	600
R. killipiana L.B.Sm.	W. Hoover 1251 (MO)	1984	ll	−28.3	244–397
R. maidifolia Mez	A. Gentry 53576 (MO)	1986	ll	−31.5	1900–1960
R. morreniana Linden & André	G. Tipaz *et al*. 1875 (MO)	1992	ll	−30.0	1800
***Ursulaea* Read & Baensch**					
U. macvaughii (L.B.Sm.) Read & Baensch	E. Lott 1925 *et al*. (MO)	1983	ll	−12.0	
U. tuitensis (Magaña & E.J.Lott) Read & Baensch	Beach 78-03 (SEL)	1983	br	−13.6	
***Wittrockia* Lindm.**					
W. cyathiformis (Vell.) Leme	M. & R. Foster 1014 (US)		lb	−22.8	
W. gigantea (Baker) Leme	E. Leme *et al*. 2166 (SEL)	1993	lb	−13.6	
W. superba Lindm.	G. Hatschbach 42757 (US)		lb	−15.5	
W. tenuisepala (Leme) Leme	A. Seidel 1099 (SEL)	1995	ll	−18.9	
Hechtioideae Givnish					
***Hechtia* Klotzsch**					
H. argentea Baker (= *H.* aff. *argentea* Baker)	S. Zamudio R. 2923 (MO)	1978	lb	−11.9	2500
H. caerulea (Matuda) L.B.Sm.	G. Varadarajan 25 (SEL)	1983	ia	−15.8	
H. cf. *dichroantha* Donn.Sm.	H. Luther 403 (SEL)	1980	lb	−12.8	
H. epigyna Harms	L. Harrison *s.n.* (SEL)	1992	lb	−14.5	
H. fosteriana L.B.Sm.	M. Foster & O. van Hyning 2935 (US)	1957	ia	−11.5	2100
H. fragilis Burt-Utley & Utley	A. Salinas T. 7122 (MO)		lb	−13.0	1210
H. cf. *galeottii* Mez	A. Lau *s.n.* (SEL)	1997	fl	−13.5	
H. glabra Brandegee	D. Crayn *s.n.* (SEL)		ll	−12.6	
H. glauca Burt-Utley & Utley	D. Crayn *s.n.* (SEL)		ll	−13.6	
H. glomerata Zucc.	M. Remmick 139 (SEL)	1989	ll	−12.4	
H. guatemalensis Mez	R. Villacorta 131 (SEL)	1988	lb	−10.8	800
H. laevis L.B.Sm.	R. McVaugh 16035 (US)		fl	−12.2	500
H. lundelliorum L.B.Sm.	O. van Hyning 6066 (US)		lb	−15.2	

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	$\delta^{13}C$ (‰)	Elevation¶ (m)
H. lyman-smithii Burt-Utley & Utley	D. Cathcart *s.n.* (SEL)	1998	br	−11.9	
H. marnier-lapostollei L.B.Sm.	E. Matuda 38429 (US)		ll	−11.9	1500
H. melanocarpa L.B.Sm.	J. Marnier-Lapostolle *s.n.* (US)		ia	−12.1	
H. montana Brandegee	93-54 (MSBG)		ll	−13.1	
H. mooreana L.B.Sm.	Rzedowski 22627 (MO)	1966	ll	−12.7	750
H. pedicellata S.Watson	C. Pringle 3934 (US)		lb	−11.9	
H. podantha Mez	L. Gonzales Quintero 1984 (US)		br	−11.3	
H. purpusii Brandegee (= *H. lindmanioides* L.B.Sm.)	D. Crayn *s.n.* (SEL)		ll	−12.8	
H. aff. *reticulata* L.B.Sm.	D. Breedlove 19078 (US)		ia	−13.5	457
H. rosea E.Morren ex Baker (= *H. meziana* L.B.Sm.)†	R. Torres C. 4062 *et al.* (MO)	1983	ia	−13.7	
H. rosea E.Morren ex Baker (= *H. meziana* L.B.Sm.)†	E. Martinez S. 22256 *et al.* (MO)	1988	ia	−13.8	375
H. cf. *rosea* E.Morren ex Baker (= *H.* cf. *meziana* L.B.Sm.)	D. Cathcart *s.n.* (SEL)	1995	ll	−12.7	55
H. schottii Baker	I. Ramírez 531 *et al.* (SEL)		lb	−13.0	30–100
H. sphaeroblasta B.L.Rob.	Matuda 38471 (US)		lb	−13.3	
H. stenopetala Klotzsch	C. Jackson *s.n.* (SEL)	1987	lt	−13.7	
H. subalata L.B.Sm.	J. Rose 3556 (US)		ll	−11.2	
H. texensis S.Watson†	O. Sperry 1318 (US)		lb	−11.1	
H. texensis S.Watson†	R. Albert *s.n.* (US)		ll	−11.5	
H. texensis S.Watson (= *H. elliptica* L.B.Sm.)†	Kimnach & Lyons 1367 (US)		Ll	−15.4	
H. texensis S.Watson (= *H. zacatecae* L.B.Sm.)†	F. Lloyd 125 (US)		lb	−11.3	
Lindmanioideae Givnish					
***Connellia* N.E.Br.**					
C. augustae (M.R.Schomb.) N.E.Br.	O. Huber 9114 (US)		lb	−26.1	
C. caricifolia L.B.Sm.	O. Huber 11811 (SEL)	1986	ll	−24.8	2300
C. nutans L.B.Sm.	J. Steyermark & S. Nilsson 745 (NY)		ll	−25.3	1450
C. quelchii N.E.Br.	R. Liesner 23091 (SEL)	1988	br	−25.6	2550
C. varadarajanii L.B.Sm. & Steyerm.	O. Huber 12954 (SEL)		lb	−22.1	
***Lindmania* Mez**					
L. arachnoidea (L.B.Sm., Steyerm. & H.Rob.) Steyerm.	R. Liesner 24713 (SEL)	1988	ll	−23.8	2700
L. argentea L.B.Sm.	Varadarajan & Oliva 1161 (US)		lb	−26.6	
L. atrorosea (L.B.Sm., Steyerm. & H.Rob.) L.B.Sm.	B. Maguire *et al.* 65600 (US)		lb	−22.3	
L. aurea L.B.Sm., Steyerm. & H.Rob.	J. Steyermark *et al.* 128611 (MO)	1983	ll	−27.4	1850
L. brachyphylla L.B.Sm.	G. Varadarajan 1198 (SEL)	1984	lb	−25.5	2200–2300
L. cylindrostachya L.B.Sm.	O. Huber 12629 (SEL)	1988	ll	−22.5	1800
L. delasciana (L.B.Sm., Steyerm. & H.Rob.) L.B.Sm. ms.	J. Steyermark *et al.* 125912 (VEN)		ll	−24.8	2580
L. geniculata L.B.Sm.	B. Holst & F. Oliva-Esteva 3756 (US)		lb	−27.0	
L. aff. *geniculata* L.B.Sm.	G. Varadarajan 1206 (SEL)	1984	lb	−24.7	
L. gracillima (L.B.Sm.) L.B.Sm.†	J. Steyermark *et al.* 92757 (NY)		lb	−28.7	1220–1275
L. gracillima (L.B.Sm.) L.B.Sm.†	J. Steyermark *et al.* 92757 (VEN)		ll	−29.9	1220–1275
L. guianensis (Beer) Mez†	O. Huber 12950 & J. Pruski (SEL)		lb	−24.7	
L. guianensis (Beer) Mez (= *L. paludosa* L.B.Sm.)†	J. Steyermark *et al.* 117379 (US)		ll	−24.3	1490–1500
L. guianensis (Beer) Mez var. *vestita* (L.B.Sm.) L.B.Sm.†	O. Huber 11764 (SEL)	1986	lb	−25.6	1050
L. holstii Steyerm. & L.B.Sm.	B. Holst 3711 (US)		lt	−27.3	
L. huberi L.B.Sm., Steyerm. & H.Rob.	O. Huber & M. Colella 9003 (US)		ll	−25.3	
L. imitans L.B.Sm., Steyerm. & H.Rob.	J. Steyermark *et al.* 128474 (MO)	1983	ll	−26.2	1850
L. maguirei (L.B.Sm.) L.B.Sm.	C. Farney 883 (MO)	1985	ll	−25.4	2750
L. marahuacae (L.B.Sm., Steyerm. & H.Rob.) L.B.Sm.	J. Steyermark *et al.* 124364 (US)		ll	−27.3	
L. minor L.B.Sm.	J. Steyermark & J. Wurdack 678-A (US)		ll	−27.8	2165–2180
L. navioides L.B.Sm.	J. Steyermark 94051 (US)		ll	−26.6	2150–2200
L. nubigena (L.B.Sm.) L.B.Sm.	J. Steyermark 104024 (US)		ll	−22.9	1900
L. serrulata L.B.Sm.†	S. Renner 2049 (US)		ll	−24.4	2085–2100
L. serrulata L.B.Sm.†	O. Huber *et al.* 9013 (VEN)		ll	−27.1	1920
L. steyermarkii L.B.Sm.	J. Steyermark *et al.* 128080 (MO)	1983	ll	−21.8	2000
L. subsimplex L.B.Sm.	O. Huber 11364 (US)		lb	−26.1	2100
L. thyrsoidea L.B.Sm.	B. Holst 3214 & R. Liesner (MO)	1987	ll	−24.7	1000–1100
L. tillandsioides L.B.Sm.	J. Steyermark *et al.* 115871 (US)		ll	−24.1	2460–2500
L. wurdackii L.B.Sm.	R. Liesner 18542 (US)		ll	−25.1	1500–1600
Navioideae Harms emend. Givnish					
***Brewcaria* L.B.Sm., Steyerm. & H.Rob.**					
B. brocchinioides (L.B.Sm.) B.Holst†	A. Gröger 1015 (SEL)		ll	−29.2	
B. brocchinioides (L.B.Sm.) B.Holst†	J. Duivenvoorden *et al.* 189 (US)		lb	−25.6	
B. duidensis L.B.Sm., Steyerm. & H.Rob.†	G. Tate 575c (NY)		lb	−20.7	2000
B. duidensis L.B.Sm., Steyerm. & H.Rob.†	J. Steyermark *et al.* 126410 (VEN)		lb	−27.9	1230
B. hechtioides (L.B.Sm.) B.Holst†	J. Steyermark 105127 (NY)		lb	−26.2	1230–1240
B. hechtioides (L.B.Sm.) B.Holst†	J. Steyermark 105127 (VEN)		lb	−25.0	1230–1240
B. hechtioides (L.B.Sm.) B.Holst†	J. Steyermark 105127 (VEN)		ia	−24.5	1230–1240
B. hohenbergioides (L.B.Sm.) B.Holst†	L. Delgado 933 (SEL)		ll	−27.5	
B. hohenbergioides (L.B.Sm.) B.Holst†	C. Brewer-Carias *s.n.* (US)		lb	−25.2	1000
B. hohenbergioides (L.B.Sm.) B.Holst†	O. Huber 1230 (VEN)		lb	−26.7	

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	$\delta^{13}C$ (‰)	Elevation¶ (m)
B. marahuacae L.B.Sm., Steyerm. & H.Rob.†	J. Steyermark & F. Delascio 129196 (NY)		lb	−24.0	2580–2600
B. marahuacae L.B.Sm., Steyerm. & H.Rob.†	J. Steyermark & F. Delascio 129196 (VEN)		lt	−25.9	2580–2600
B. marahuacae L.B.Sm., Steyerm. & H.Rob.†	J. Steyermark 129519 (VEN)		lb	−22.9	2560
B. marahuacae L.B.Sm., Steyerm. & H.Rob.†	R. Aveledo Ostos 2281 (VEN)		ll	−25.4	2700
B. reflexa (L.B.Sm.) B.Holst†	P. Berry & I. Sánchez 5053 (SEL)	1991	ia	−27.5	125
B. reflexa (L.B.Sm.) B.Holst†	O. Huber 2495 (US)		ll	−26.6	
***Cottendorfia* Schult.f.**					
C. florida Schult.f.†	E. Leme 3692 (HB)		ll	−26.5	
C. florida Schult.f.†	1996-0640A (MSBG)		ll	−27.8	
***Navia* Schult. & Schult.f.**					
N. abysmophila L.B.Sm.	B. Maguire *et al*. 42471 (K)	1957	ll	−28.6	1100
N. acaulis Mart. ex Schult. & Schult.f.	J. Idrobo & R. Schultes 644 (US)		ll	−28.1	
N. affinis L.B.Sm.	R. Liesner 25095 (SEL)		lt	−31.7	
N. aliciae L.B.Sm., Steyerm. & H.Rob.	A. Fernandez 7401 (SEL)		ll	−33.9	
N. aloifolia L.B.Sm.	B. Maguire *et al*. 37170 (US)		lb	−26.0	
N. arida L.B.Sm. & Steyerm.†	1983-0288A (MSBG)		ll	−27.1	
N. arida L.B.Sm. & Steyerm. (= *N. igneosicola* L.B.Sm., Steyerm. & H.Rob.)†	F. Michelangeli 436 (SEL)		lb	−31.5	
N. aurea L.B.Sm.	J. Steyermark 130586 & B. Holst (SEL)		lt	−27.7	
N. barbellata L.B.Sm.	B. Boom & D. Gopaul 7463 (SEL)		ll	−31.6	920–1080
N. berryana L.B.Sm., Steyerm. & H.Rob.	O. Huber 6048 (US)		ll	−29.0	
N. bicolor L.B.Sm.	R. Schultes 5444 (US)		ll	−26.9	
N. cardonae L.B.Sm.	Steyermark *et al*. 113211 (US)		ll	−25.6	
N. caricifolia L.B.Sm.	B. Holst 3336 & R. Liesner (MO)	1987	lt	−28.0	1250–1300
N. caulescens Mart. ex Schult. & Schult.f.	R. Cortés 483 (SEL)		ll	−31.6	
N. caurensis L.B.Sm.	J. Steyermark *et al*. 117978 (VEN)		ll	−27.1	1650
N. colorata L.B.Sm.	R. Cowan & J. Wurdack 31262 (US)		ll	−27.3	
N. connata L.B.Sm. & Steyerm.	Steyermark 90223 (US)		ll	−26.0	625–725
N. aff. *crassicaulis* L.B.Sm., Steyerm. & H.Rob.	B. Boom 5744 & A. Weitzman (SEL)		ll	−24.2	
N. crispa L.B.Sm.†	L. Delgado 899 (NY)		ll	−28.1	
N. crispa L.B.Sm.†	B. Maguire & C. Maguire 35375 (VEN)		ll	−24.3	1500
N. cucullata L.B.Sm.	B. Maguire 32824 (US)		ll	−24.8	1800
N. duidae L.B.Sm.	R. Liesner 24977 (SEL)		ll	−26.5	
N. ebracteata Betancur & M.V.Arbeláez	H. Garcia-Barriga & R. Schultes 14171 (US)		ll	−26.5	
N. filifera L.B.Sm., Steyerm. & H.Rob.	R. Liesner 16818 (US)		ll	−29.6	
N. fontoides L.B.Sm.	R. Schultes & I. Cabrera 15391 (US)		ll	−29.2	250
N. geaster L.B.Sm., Steyerm. & H.Rob.	Steyermark *et al*. 117978 (US)		ll	−26.5	
N. gleasonii L.B.Sm.†	B. Maguire *et al*. 29958 (NY)		ll	−30.9	800
N. gleasonii L.B.Sm.†	B. Maguire *et al*. 29958 (VEN)		ll	−31.3	800
N. heliophila L.B.Sm.	R. Schultes & I. Cabrera (US)		lb	−29.3	
N. huberiana L.B.Sm., Steyerm. & H.Rob.	G. Aymard 8348 L. Delgado (SEL)		lt	−32.8	
N. intermedia L.B.Sm. & Steyerm.	Steyermark *et al*. 108936 (US)		ll	−26.5	
N. involucrata L.B.Sm.	R. Cowan & J. Wurdack 31360 (US)		ll	−24.5	2000
N. jauana L.B.Sm., Steyerm. & H.Rob.	Steyermark *et al*. 109233A (US)		ll	−25.6	
N. lasiantha L.B.Sm. & Steyerm.	A. Fernandez 4744 (SEL)		ll	−23.6	
N. lepidota L.B.Sm.	J. Steyermark & J. Luteyn 129810 (VEN)		ll	−24.5	1880
N. liesneri L.B.Sm., Steyerm. & H.Rob.	G. Davidse 27359 & J.S. Miller (SEL)		ll	−28.6	
N. lindmanioides L.B.Sm.	Steyermark & G. Bunting 103089 (US)		ll	−31.3	
N. linearis L.B.Sm., Steyerm. & H.Rob.	R. Liesner 25146 (US)		ll	−30.7	
N. luzuloides L.B.Sm., Steyerm. & H.Rob.	J. Steyermark 124317 *et al*. (SEL)		lt	−24.9	2020
N. maguirei L.B.Sm.	B. Hoffman 3330 (NY)		lb	−31.2	700–800
N. mima L.B.Sm.	B. Maguire & L. Politi 28680 (US)		ll	−26.8	200
N. cf. *mima* L.B.Sm.	O. Huber 13598 (SEL)		lb	−26.2	
N. myriantha L.B.Sm.	H. de Lima *et al*. 3331 (SEL)		lb	−26.4	
N. navicularis L.B.Sm.	Steyermark 97817 (US)		ll	−28.9	
N. nubicola L.B.Sm.	A. Fernandez 7658 (SEL)		lt	−33.4	
N. ocellata L.B.Sm.†	B. Maguire & L. Politi 27866 (US)		ll	−29.8	1800
N. ocellata L.B.Sm.†	B. Maguire *et al*. 65706 (US)		ll	−26.2	1500
N. octopoides L.B.Sm.†	J. Steyermark *et al*. 126153 (NY)		ll	−31.9	650
N. octopoides L.B.Sm.†	J. Steyermark *et al*. 126153 (VEN)		ll	−31.8	650
N. octopoides L.B. Sm. (= *N.* cf. *octopoides* L.B.Sm.)†	R. Liesner 25892 (US)		ll	−30.9	800–1300
N. ovoidea L.B.Sm., Steyerm. & H.Rob.	O. Huber 9879 (SEL)		ll	−24.0	
N. parvula L.B.Sm. var. *parvula*	B. Maguire *et al*. 42535 (US)		ll	−27.4	1500–1600
N. patria L.B.Sm. & Steyerm.	R. Liesner & F. Delascio 22041 (MO)	1987	ll	−27.9	1550
N. phelpsiae L.B.Sm.†	B. Holst & R. Liesner 3268 (SEL)	1987	lb	−29.7	1100
N. phelpsiae L.B.Sm.†	F. Michelangeli 125 (SEL)	1995	lb	−31.6	1800
N. phelpsiae L.B.Sm.†	B. Holst & R. Liesner 3462 (US)		ll	−33.7	
N. polyglomerata L.B.Sm., Steyerm. & H.Rob.	G. Davidse & J. Miller 27234 (SEL)		ll	−29.7	
N. pulvinata L.B.Sm.	A. Fernandez 7751 (SEL)		ll	−29.6	
N. pungens L.B.Sm.	B. Maguire & C. Maguire 35215 (US)		lb	−25.5	

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	$\delta^{13}C$ (‰)	Elevation¶ (m)
N. sandwithii L.B.Sm.	T. Henkel 2396 (SEL)		lb	−31.0	
N. saxicola L.B.Sm.	C. Brewer-Carias *s.n.* (US)		ll	−26.8	1200
N. semiserrata L.B.Sm.	L. Delgado 900 (SEL)		ll	−29.4	
N. serrulata L.B.Sm.	J. Steyermark & G. Bunting 103119 (US)		ll	−26.8	
N. sp. C (Flora of the Venezuelan Guayana)	B. Holst 3101 & R. Liesner (SEL)	1987	lt	−28.8	650
N. splendens L.B.Sm.	Steyermark 94212 (US)		lb	−25.1	900
N. stenodonta L.B.Sm.	J. Hoyos & G. Morillo 56 (VEN)		ll	−27.5	
N. subpetiolata L.B.Sm.	O. Huber & L. Izquierdo 12786 (SEL)		lb	−25.0	
N. terramarae L.B.Sm. & Steyerm.	R. Liesner & G. Carnevali 22599 (SEL)	1987	ll	−27.2	1400
N. trichodonta L.B.Sm.	B. Maguire *et al.* 29798 (US)		ll	−29.7	1300
N. wurdackii L.B.Sm.	Steyermark 75159 (US)		ll	−32.0	1200–1600
***Sequencia* Givnish**					
S. serrata (L.B.Sm.) Givnish (= *Brocchinia serrata* L.B.Sm.)	J. Betancur & F. Ramírez 1265 (SEL)	1989	lb	−27.3	300–450
***Steyerbromelia* L.B.Sm.**					
S. deflexa L.B.Sm. & H.Rob.	R. Liesner 25900 (SEL)	1988	lb	−24.6	800–1300
S. discolor L.B.Sm. & H.Rob.	J. Steyermark & B. Holst 130766 (SEL)		lb	−25.6	2520–2650
S. plowmanii (L.B.Sm., Steyerm. & H.Rob.) H.Rob. & D.C.Taylor (= *S. neblinae* B.Holst; *Navia plowmanii* L.B.Sm., Steyerm. & H.Rob.)	W. Thomas & T. Plowman 3085 (US)	1984	ll	−27.7	2000
Pitcairnioideae Harms emend. Givnish					
***Deuterocohnia* Mez (including *Abromeitiella* Mez)**					
D. brevifolia (Griseb.) M.A.Spencer & L.B.Sm.	G. Varadarajan 1265 *et al.* (SEL)	1984	ll	−10.6	1825–1875
D. brevispicata Rauh & L.Hrom.	D. Cathcart B52 (SEL)	1993	ia	−13.5	1250
D. chrysantha (Phil.) Mez	P. Hutchison 396 (US)		lb	−11.3	350
D. digitata L.B.Sm.	I. Vargas C. 3185 & W. Vargas (SEL)	1994	ll	−12.2	1900
D. haumanii A.Cast.	L. Smith 4655 (US)		ia	−11.4	
D. aff. *haumanii* A.Cast.	G. Varadarajan 1250 (SEL)	1984	lb	−12.2	1400–1500
D. longipetala (Baker) Mez	J. Balcazar 100 (SEL)	1995	ll	−13.0	1660
D. lorentziana (Mez) M.A.Spencer & L.B.Sm.	G. Varadarajan 1260 *et al.* (SEL)	1984	ll	−12.2	2400–2450
D. lotteae (Rauh) M.A.Spencer & L.B.Sm.	94-142 (MSBG)		ll	−11.9	
D. meziana Kuntz ex Mez	M. Remmick 96 (SEL)	1989	ll	−12.7	
D. schreiteri A.Cast.	G. Varadarajan 1248 *et al.* (SEL)	1984	lb	−11.4	1600–1650
D. strobilifera Mez var. *inermis* L.B.Sm.	J. Krach 7488 (US)		lb	−10.3	
***Dyckia* Schult. & Schult.f.**					
D. aurea L.B.Sm.	H. Irwin *et al.* 25439 (US)		lb	−11.0	900
D. beateae E.Gross & Rauh	1997-0223B (MSBG)		ll	−13.6	
D. brachyphylla L.B.Sm.	H. Irwin *et al.* 28452 (US)		lb	−12.0	1200
D. bracteata (Wittm.) Mez	E. Pereira 2761 (US)		lb	−11.0	
D. brasiliana L.B.Sm.	W. Anderson 10266 (US)		ia	−10.4	1250–1300
D. brevifolia Baker	R. Marx 69262 (US)		lb	−11.7	
D. burchellii Baker	H. Irwin *et al* 11710 (US)		lb	−11.8	800
D. cabrerae L.B.Sm. & Reitz	L.B. Sm. *et al.* 9262 (US)	1956	ia	−15.1	700
D. choristaminea Mez	B. Rambo 48832 (US)		ll	−8.9	
D. consimilis Mez	W. Anderson *et al.* 8454 (US)		ll	−12.4	1400
D. crocea L.B.Sm.	G. Hatschbach 27105 (US)		ll	−11.1	
D. dawsonii L.B.Sm.	1994-0146A (MSBG)		ll	−12.5	
D. deltoidea (L.B.Sm.) L.B.Sm.	P. Dusen 10373 (US)		lb	−10.0	
D. densiflora Schult. & Schult.f.	H. Irwin *et al.* 22185 (US)		ll	−12.3	1370
D. dissitiflora Schult. & Schult.f.	R. Harley 26609 *et al.* (MO)		ll	−11.0	
D. aff. *dissitiflora* Schult. & Schult.f.	S. Mori *et al.* 12486 (US)		ll	−11.4	1600–1850
D. distachya Hassl.	A. Krapovickas & C. Cristobal 28760 (US)		ll	−13.1	
D. duckei L.B.Sm.	C. Sperling *et al.* 5611 (US)		ll	−12.5	700–750
D. dusenii L.B.Sm.	Reitz & Klein 5293 (US)		lb	−9.3	1200
D. elongata Mez	R. Burle Marx *s.n.* (US)		lb	−11.8	
D. eminens Mez	E. Heringer *et al.* 6381 (US)		lb	−12.0	
D. encholirioides (Gaudich.) Mez	G. Varadarajan 27 (SEL)	1983	fw	−12.2	
D. estevesii Rauh	1995-0277A (MSBG)		ll	−15.3	
D. ferox Mez	1996-0211A (MSBG)		ll	−10.5	
D. ferruginea Mez	G. Hatschbach 24566 (NY)		lb	−12.0	
D. cf. *ferruginea* Mez	P. Ibisch 93-0613 *et al.* (SEL)	1993	ll	−15.0	300
D. floribunda Griseb†	G. Varadarajan 1239 *et al.* (SEL)	1984	lb	−12.3	550–600
D. floribunda Griseb.†	W. Rauh 19222 (US)		br	−13.7	
D. fosteriana L.B.Sm.	Anon. (SEL 057707)	1987	ll	−12.0	
D. fragrans L.B.Sm. & Read ms.	E. Wurthmann *s.n.* (SEL)	1987	lb	−11.4	
D. frigida Hook.f.	M. Kuhlman 417 (US)		lb	−11.0	
D. goiana L.B.Sm.	H. Irwin 15163 *et al.* (MO)	1966	ia	−11.6	800
D. gracilis Mez	R. Seidel 3092 (SEL)	1989	lb	−13.3	700
D. hebdingii L.B.Sm.	2586798A (US)		lb	−12.0	
D. horridula Mez	A. Krapovickas *et al.* 33283 (US)		lb	−12.9	

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	δ[13]C (‰)	Elevation¶ (m)
D. irmgardiae L.B.Sm.	R. Wasum *et al*. 8657 (US)		lb	−11.9	
D. irwinii L.B.Sm.	H. Irwin *et al*. 16923 (US)	1966	lb	−13.6	400
D. lagoensis Mez	P. Duarte 3121 (US)		lb	−11.4	
D. leptostachya Baker	T. Killeen 7030 *et al*. (SEL)	1994	ll	−10.9	450
D. linearifolia Mez	G. Eiten & L. Eiten 2398 (US)		ll	−12.8	575–650
D. macedoi L.B.Sm.	G. Hatschbach & Z. Ahumada 31702 (US)		ll	−10.9	
D. machrisiana L.B.Sm.	Leme 2706 (HB)		ll	−11.8	
D. maracasensis Ule	S. Mori *et al*. 11093 (US)		ll	−12.7	900
D. maritima Baker	A. Krapovickas *et al*. 22991 (US)		ll	−10.7	0–200
D. marnier-lapostollei L.B.Sm.	1994-0143B (MSBG)		ll	−13.8	
D. microcalyx Baker	1996-0213A (MSBG)		ll	−13.2	
D. minarum Mez	E. Yale Dawson 14153 (US)		lb	−12.6	
D. monticola L.B.Sm. & Reitz	Leme 1664 (HB)		ll	−11.8	
D. niederleinii Mez	P. Jorgensen-Hansen 31012 (US)		fl	−13.6	
D. paraensis L.B.Sm.	D. Philcox & A. Fereira 4538 (US)		ll	−11.1	
D. pauciflora L.B.Sm. & Read	T. Filgueiras *et al*. 3074 (US)		ll	−12.9	
D. platyphylla L.B.Sm.	MSBG *s.n.*		ll	−13.6	
D. pseudococcinea L.B.Sm.	1993-0033A (MSBG)		ll	−13.1	
D. pulquinensis Wittm.	M. Cárdenas 6075 (US)		ll	−10.4	1600
D. pumila L.B.Sm.	H. Irwin *et al*. 17836 (US)		ll	−11.9	1000
D. racemosa Baker	Gardner 4015 (OXF)		ll	−10.9	
D. ragonesei A.Cast.	Varadarajan 1218 (?)	1984	ll	−13.2	
D. rariflora Schult. & Schult.f.	L. Smith 7065 (US)		ll	−11.8	1000
D. reitzii L.B.Sm.	Reitz & Klein 7797 (US)		lb	−9.8	
D. remotiflora Otto & A.Dietr. var. *montevidensis* (K.Koch) L.B.Sm.†	Herter 82869 (US)		lb	−13.4	
D. remotiflora Otto & A.Dietr. var. *remotiflora*†	I. Guerra *et al*. 2089 (US)		ll	−12.8	
D. saxatilis Mez	M. Fonseca *et al*. 1161 (US)		ll	−13.8	
D. sickii L.B.Sm.	M. Silva 72 (US)		lb	−13.8	
D. sordida Baker	M. Foster 623 (US)		ll	−9.4	1400
D. stenophylla L.B.Sm.	M. Fonseca *et al*. 1336 (US)		ll	−11.5	1435
D. tobatiensis Hassl.	1996-0215A (MSBG)		ll	−11.7	
D. trichostachya Baker	H. Boudet F. 1915 (NY)		lb	−12.7	
D. tuberosa (Vell.) Beer†	R. Goodland 745 (SEL)		ll	−10.7	
D. tuberosa (Vell.) Beer†	1995-0203A (MSBG)		ll	−12.8	
D. uleana Mez	P. Reitz 6797 (US)		lb	−12.2	
D. ursina L.B.Sm.	L. Smith 6697 (US)		lb	−10.8	1000
D. velascana Mez	G. Varadarajan 1267 *et al*. (SEL)	1984	lb	−12.1	1500–1550
D. vestita Hassl.	1996-0216A (MSBG)		ll	−11.9	
D. weddelliana Baker	1995069 (US)		ll	−11.8	
***Encholirium* Mart. ex Schult.f.**					
E. biflorum (Mez) Forzza (= *Dyckia biflora* Mez)	A. Macedo 2974 (MO)	1951	ll	−11.6	
E. brachypodum L.B.Sm. & Read	S. Sant' Ana *et al*. 1024 (SP)	2001	ll	−13.0	565
E. erectiflorum L.B.Sm.	A. Lima 66-4800 (US)	1966	lb	−10.2	
E. gracile L.B.Sm.	R. Forzza & K. Loyola 930 (SP)	1998	ll	−12.0	
E. heloisae (L.B.Sm.) Forzza & Wand.	G. Eiton & L. Eiton 10983 (US)		ll	−10.9	1100–1200
E. horridum L.B.Sm.	M. & R. Foster 193 (US)		ll	−11.3	
E. irwinii L.B.Sm.	E. Leme 2881 (HB)		ll	−13.7	
E. aff. *longiflorum* Leme	E. Leme 3136 (HB)		ll	−12.3	
E. luxor L.B.Sm. & Read	R. Forzza 922 (SP)	1998	ll	−11.6	
E. aff. *luxor* L.B.Sm. & Read (= *E*. aff. *piresianum* L.B.Sm. & Read)	L. Coradin *et al. s.n.* (US)		br	−11.0	
E. lymanianum E.Pereira & Martinelli	P. Hutchison 8572 *et al*. (SEL)	1983	ll	−12.9	
E. magalhaesii L.B.Sm.	W. Anderson *et al*. 35558 (US)		ll	−12.9	1250
E. reflexum Forzza & Wand. (previously *Dyckia pectinata* L.B.Sm. & Reitz)	M. Arbo *et al*. 5145 (US)		lb	−12.2	1000
E. scrutor (L.B.Sm.) Rauh (= *E. inerme* Rauh)†	1995-0113A (MSBG)		ll	−14.1	
E. scrutor (L.B.Sm.) Rauh (= *E. inerme* Rauh)†	M. Arbo *et al*. 5142 (US)		lt	−14.4	1000
E. spectabile Mart. ex Schult. & Schult.f.†	E. Leme 497 (HB)		ll	−12.5	
E. spectabile Mart. ex Schult. & Schult.f. (= *E. bahianum* L.B.Sm. & Read)†	L. Coradin *s.n.et al*. 5980 (NY)		ia	−13.3	550
E. spectabile Mart. ex Schult. & Schult.f. (= *E. densiflorum* Ule)†	M.B. Foster 2474 (US)		lb	−10.6	
E. spectabile Mart. ex Schult. & Schult.f. (= *E. hoehneanum* L.B.Sm.)†	G. Martinelli *et al*. 5155 (US)		ll	−9.8	
E. spectabile Mart. ex Schult. & Schult.f. (= *E. rupestre* Ule)†	H. Irwin *et al*. 30673 (US)		ll	−11.9	1000
E. cf. *spectabile* Mart. ex Schult. & Schult.f.	1996-0641A (MSBG)		ll	−14.4	
E. subsecundum (Baker) Mez	L. Smith 6881 (US)		lt	−11.7	
***Fosterella* L.B.Sm.**					

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	$\delta^{13}C$ (‰)	Elevation¶ (m)
F. albicans (Griseb.) L.B.Sm.	A. Gentry 71159 (SEL)	1990	ll	−25.8	1000
F. aletrioides (L.B.Sm.) L.B.Sm.	C. Vargas 17540 (US)		ll	−27.4	1200
F. beckii Read ms.	B. Krukoff 10482 (US)		ll	−30.7	750–900
F. besseae Read ms.	S. Beck 4810 (US)		ll	−29.5	850
F. caulescens Rauh	1989-0220A (MSBG)		ll	−24.8	
F. gracilis (Rusby) L.B.Sm.	G. Prance *et al*. 19368 (US)		ll	−27.6	720
F. graminea (L.B.Sm.) L.B.Sm.	M. Kessler 4100 (SEL)	1993	ll	−25.5	900
F. hatschbachii L.B.Sm. & Read	J. Pirani 1313 (NY)		lb	−31.7	
F. micrantha (Lindl.) L.B.Sm.	C. Morton & E. Makrinius 2395 (US)		ll	−30.6	400–650
F. pearcei (Baker) L.B.Sm.	B. Krukoff 10328 (MO)	1939	ll	−29.8	750–900
F. penduliflora (C.H.Wright) L.B.Sm.	M. Kessler 4214 *et al*. (SEL)	1995	ll	−30.5	1250
F. petiolata (Mez) L.B.Sm.	1995-0007A (MSBG)		ll	−28.2	
F. rojasii L.B.Sm.	F. Herrera 3316 (US)		ll	−25.2	1400
F. rusbyi (Mez) L.B.Sm.†	Varadarajan 1285 *et al*. (MO)	1984	ll	−30.6	
F. rusbyi (Mez) L.B.Sm. (= *F. elata* H.Luther)†	M. Kessler 5726 *et al*. (SEL)	1995	ll	−30.5	900
F. cf. *rusbyi* (Mez) L.B.Sm.	M. Lewis 36936 (SEL)	1989	ll	−25.6	1800
F. schidosperma (Baker) L.B.Sm.†	1978-0905A (MSBG)		ll	−25.2	
F. schidosperma (Baker) L.B.Sm.†	T. Plowman & M. Ramirez 7574 (US)		ll	−31.9	750–800
F. cf. *schidosperma* (Baker) L.B.Sm.	M. Kessler 7786 *et al*. (SEL)	1996	ll	−33.1	1300
F. spectabilis H.Luther	1995-0415A (MSBG)		ll	−27.7	
F. villosula (Harms) L.B.Sm.	M. Kessler 4109 (SEL)	1993	ll	−31.9	900
F. weddelliana (Mez) L.B.Sm.	M. Kessler 5727 *et al*. (SEL)		lb	−22.4	
***Pitcairnia* L'Hér.**					
P. abundens L.B.Sm.	S. Koch *et al*. 79444 (US)		ll	−28.8	50
P. cf. *acicularis* L.B.Sm.	C. Díaz & H. Osores 2607 (MO)	1987	ll	−28.6	2600
P. aequatorialis L.B.Sm.†	M. Kessler 2529 (SEL)	1991	br	−25.1	330
P. aequatorialis L.B.Sm. var. *bogneri* (Rauh) Manzan. & W.Till (= *P. violascens* L.B. Sm.)†	J. Boeke 965 (SEL)	1977	lb	−28.9	
P. alata var. *andreetae* (H.Luther) Manzan. & W.Till (= *P. andreetae* H.Luther)†	A. Hirtz 4427 (SEL)	1989	st	−27.3	1800
P. alata var. *andreetae* (H.Luther) Manzan. & W.Till (= *P. andreetae* H.Luther)†	A. Hirtz 2326 *et al*. (MO)	1985	ia	−31.9	
P. albiflos Herb.	A. Castellanos 5729 (US)		ll	−24.1	
P. alborubra Baker†	B. Daniel 1806 (US)		ll	−28.3	
P. alborubra Baker†	C. Luer 7309 *et al*. (SEL)	1982	ll	−29.2	1800
P. alexanderi (H.Luther) D.C.Taylor & H.Rob.	Luther 2729 *et al*. (SEL)	1989	ll	−34.2	720
P. altensteinii (Link, Klotzsch & Otto) Lem.	1987-0314A (MSBG)		ll	−27.7	
P. amblyosperma L.B.Sm.	O. van Hyning 593 (US)		ll	−27.6	305
P. andreana Linden	1975-0077-043A (MSBG)		ll	−24.6	
P. angustifolia Aiton	J. Grant 93-02268 & J. Rundell (SEL)	1993	lb	−26.1	
P. aphelandriflora Lem.†	A. Hirtz 848 (SEL)	1983	ll	−28.9	700
P. aphelandriflora Lem.†	H. von Wedel 2282 (US)		ll	−33.3	
P. archeri L.B.Sm.	A. Juncosa 2084 (SEL)	1984	lb	−24.2	300–400
P. arcuata (André) André†	1993-0449A (MSBG)		ll	−25.8	
P. arcuata (André) André†	G. Webster & L. Herbert 27498 (US)		ll	−32.2	1500–1600
P. armata Maury†	H. van der Werff 7787 & B. Holst (MO)	1985	ll	−29.2	100–250
P. armata Maury†	G. Varadarajan 1150 & Guanchez (SEL)	1983	lb	−27.6	100
P. aff. *asplundii* L.B.Sm.	J. Schunke V. 7881 (MO)		ia	−26.7	500–550
P. atrorubens (Beer) Baker	K. Barringer *et al*. 3684 (SEL)	1983	lb	−25.2	900–1000
P. attenuata L.B.Sm. & Read	J. Schunke V. 8078 (MO)	1974	ll	−33.9	700–800
P. bakeri (André) André ex Mez	J. Betancur *et al*. 2569 (SEL)	1991	lb	−31.4	1650–1800
P. barrigae L.B.Sm.	E. Forero 6065 *et al*. (MO)	1979	ll	−29.0	520–620
P. beachiae Utley & Burt-Utley†	1986-0798A (MSBG)		ll	−25.1	
P. beachiae Utley & Burt-Utley†	Beach 74/75 (SEL)	1992	lb	−29.9	300
P. bella L.B.Sm. var. *densior* L.B.Sm.	W. Palacios 5700 (SEL)	1990	lb	−35.5	650
P. beycalema Beer (= *P. muscosa* Mart. ex Schult. & Schult.f.)	(K: Brazil, det. Mez)	1867	ll	−26.5	
P. bicolor L.B.Sm. & Read	W. Kress & B. Echeverry 89-2600 (US)		lb	−27.0	2000
P. bifaria L.B.Sm.	J. Schunke-Vigo 11907 (US)		ll	−32.0	1600
P. bifrons (Lindl.) Read	P. Duss 3315 (US)		ll	−23.1	1300–1440
P. billbergioides L.B.Sm.	C. Diaz & H. Beltrán 3370 (SEL)	1989	ll	−27.1	
P. brachysperma André	S. Dalström & L. Arnby 1408 (SEL)	1990	ia	−31.9	2500
P. bradei Markgraf	H. Irwin *et al*. 8681 (US)		lb	−30.6	1175
P. breedlovei L.B.Sm.	1998-0136A (MSBG)		ll	−26.6	
P. brevicalycina Mez	R. Liesner 11870 & M. Guariglai (SEL)	1981	ll	−26.6	1200–1380
P. brittoniana Mez	Luther *et al*. 1271 (SEL)	1988	lb	−27.1	1500–1900
P. bromeliifolia L'Hér. var. *bromeliifolia*†	M. Madison 533 & Sinha (SEL)	1971	ll	−28.8	
P. bromeliifolia var. *graminifolia* Griseb.†	R. Read 1630 (US)		ll	−27.4	
P. bromeliifolia var. *wynteri* Read†	R. Read 1984 (US)		ll	−24.8	
P. brongniartiana André	M. Madison & L. Besse 7189 (SEL)	1979	lb	−28.0	800

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	δ13C (‰)	Elevation¶ (m)
P. brunnescens L.B.Sm.†	L. Besse *et al*. 100 (SEL)	1979	lb	−22.6	1200
P. brunnescens L.B.Sm.†	J. Kirkbride & H. Chamba 4083 (US)		lb	−22.4	2140
P. bulbosa L.B.Sm.†	Varadarajan & Guanchez 1144B (US)		ll	−27.8	
P. bulbosa L.B.Sm.†	A. Gröger 259 & J. Barcroft (SEL)	1992	lb	−24.8	
P. burle-marxii Braga & Sucre	1980-1647A (MSBG)		ll	−28.4	
P. calatheoides L.B.Sm.	J. Schunke V. 10469 (SEL)	1978	ll	−33.6	700–800
P. calcicola J.R.Grant & J.F.Morales	J. Grant & J. Rundell 92-02008 (SEL)	1992	ll	−27.9	
P. calderonii Standl. & L.B.Sm.	G. Davidse *et al*. 35005 (SEL)	1994	lb	−26.3	1370
P. cardenasii L.B.Sm.	Guardia *et al*. 230 (SEL)	1997	ia	−24.6	250
P. caricifolia Mart. ex Schult. & Schult.f.†	Killeen 5448 *et al*. (SEL)	1993	ll	−29.8	300
P. caricifolia Mart. ex Schult. & Schult.f.†	L. Coelho *s.n.* (US)		lb	−28.1	
P. carinata Mez	A. Glaziou 13296 (K)	1881	ll	−25.5	
P. carioana Wittm.	E. Matuda 5505 (US)		ll	−25.9	2786
P. cassapensis Mez	Mathews 2089 (OXF)	1835	ll	−20.9	
P. cataractae Manzan. & W.Till (= *P. hirtzii* H.Luther)	H. van der Werff 13296 *et al*. (MO)	1994	lb	−30.2	900
P. chiapensis Miranda	O. van Hyning *s.n.* (US)		ia	−22.8	
P. chocoensis L.B.Sm.	Gentry & Fallen 17355 (US)		ll	−29.5	500–1150
P. clarkii H.Luther	M. Bass *et al*. 110 (SEL)	1994	ll	−33.5	400–600
P. colimensis L.B.Sm.	H. Iltis *et al*. 676 (US)		ll	−27.7	600–700
P. conmixta L.B.Sm.	J. Betancur *et al*. 2593 (SEL)	1991	lb	−25.6	1100–1600
P. corallina Linden & André†	1986-0574A (MSBG)		ll	−28.9	
P. corallina Linden & André†	G. Klug 3018 (US)		ll	−31.5	220
P. corallina Linden & André†	Luther *s.n.* (SEL)	1990	ll	−27.5	1200–1500
P. corcovadensis Wawra [= *P. flammea* Lindl. var. *corcovadensis* (Wawra) L.B.Sm.]†	E. Pereira 10553 (US)		ll	−26.7	
P. corcovadensis Wawra [= *P. flammea* Lindl. var. *corcovadensis* (Wawra) L.B.Sm.]†	P. Dusén 17299 (MO)	1914	ll	−26.6	600
P. cosangaensis Gilmartin	Luther *et al*. 2709 (SEL)	1989	ll	−25.6	2100
P. crassa L.B.Sm.	M. Kessler 4222 *et al*. (SEL)	1995	br	−26.6	1200
P. crinita E.Pereira & Martinelli	C. Cid Ferreira 8057 *et al*. (MO)	1986	ll	−32.0	
P. croatii H.Luther	T. Croat 66448 (MO)	1987	ll	−28.7	1900–2000
P. ctenophylla L.B.Sm.†	T. Koyama & G. Agostini 7376 (US)		ll	−24.9	
P. ctenophylla L.B.Sm.†	G. Varadarajan 1195 (SEL)	1984	ll	−25.4	
P. cuatrecasana L.B.Sm.	A. Hirtz 4409 (SEL)	1989	lb	−30.0	900
P. cubensis (Mez) L.B.Sm.	G. Webster 4017 (NY)		lb	−25.4	520–580
P. cuzcoensis L.B.Sm.	J. Halton 83 (SEL)	1981	ll	−28.9	1100
P. cylindryostachya L.B.Sm.	J. Zabaleta 13 (US)		lb	−21.1	
P. decidua L.B.Sm.	G. Hatschbach & Z. Ahumada 31364 (US)		ll	−25.5	800–1000
P. decurvata L.B.Sm.	A. Sagástegui & S. Leiva G. 15516 (SEL)	1995	ia	−25.8	1800
P. dendroidea André	Meerow & Meerow 1081 (SEL)	1982	lb	−26.0	2000
P. densiflora Brongn. ex Lem.	H. Moore 5112 (US)		ll	−27.1	914
P. diffusa L.B.Sm.	A. Juncosa 2059 (SEL)	1984	ll	−28.4	600
P. divaricata Wittm.	S. Beck 1765 (US)		ll	−28.5	930
P. cf. *divaricata* Wittm.	M. Kessler 6225B *et al*. (SEL)	1996	ll	−31.0	10
P. dodsonii H.Luther	Luther *et al*. 2708 (SEL)	1989	ll	−29.5	2100
P. dolichopetala Harms	Dalström *et al*. 1796 (SEL)	1993	ll	−32.0	2000–2200
P. domingensis L.B.Sm.	W. Abbott 291 (US)		ll	−30.5	100–500
P. echinata Hook.	Steyermark & M. Rabe 96640 (US)		ll	−26.5	200
P. elizabethae L.B.Sm.	T. Zanoni & J. Pimentel 26386 (SEL)	1983	ll	−26.3	1350
P. elliptica Mez & Sodiro	M. Madison 4230 (SEL)	1977	lb	−30.8	1600
P. elongata L.B.Sm.	Dalström 1757 (SEL)	1993	ll	−33.2	1650
P. ensifolia Mez	H. Irwin *et al*. 11738 (US)		ll	−26.4	800
P. epiphytica L.B.Sm.	G. Davidse 27535 (US)		ll	−31.4	100
P. exserta L.B.Sm.	A. Alston 8260 (US)		ll	−29.5	2300
P. feliciana (A.Chev.) Harms & Mildbr.	French Guinea 1937/1945/1954 (K)	1954	ll	−23.8	
P. fendleri Mez	T. Croat 54524 (VEN)		ll	−27.0	500
P. filispina L.B.Sm.	B. Holst 3327 & R. Liesner (MO)	1987	ll	−28.8	1200
P. flammea Lindl.†	L. Smith 6493 (US)		ll	−26.8	500–700
P. flammea var. *floccosa* L.B.Sm.†	W. Anderson *et al*. 35851 (US)		lb	−25.9	1550
P. flammea var. *pallida* L.B.Sm.†	1995-0059A (MSBG)		ll	−27.2	
P. flammea var. *pallida* L.B.Sm.†	W. Berg *s.n.* (SEL)		pd	−29.2	800–900
P. cf. *flammea* Lindl.	1996-0697A (MSBG)		ll	−26.1	
P. flexuosa L.B.Sm.	Sandoval & Chinchilla 88 (SEL)	1991	ia	−28.8	
P. foreroi H.Luther &. Varad.	E. Forero *et al*. 7191 (MO)	1980	ll	−28.6	630–830
P. fosteriana L.B.Sm.	M. & R. Foster 1977 (US)		lb	−27.9	2256
P. fractifolia L.B.Sm.	W. Rauh 24597 (US)		ll	−25.4	800
P. fuertesii Mez	Marcano & Ariza *s.n.* (US)		ll	−25.7	
P. funkiae M.A.Spencer & L.B.Sm.	J. Grant & J. Rundell 92-01982 (SEL)	1992	lb	−25.7	
P. fusca H.Luther	J. Betancur & W. Kress 3967 (SEL)	1993	lb	−26.6	1700–1800
P. geyskesii L.B.Sm.	M. Jansen-Jacobs *et al*. 4800 (NY)		lb	−27.1	300
P. glaziovii Baker	G. Martinelli 8755 (US)		lb	−25.2	1100

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	$\delta^{13}C$ (‰)	Elevation¶ (m)
P. grafii Rauh	1993-0188A (MSBG)		ll	−30.0	
P. grubbiana L.B.Sm.	P.J. Grubb *et al*. 649 (K)	1957	ll	−25.1	2150
P. guaritermae André	M. Grant 9685 (US)		ll	−25.7	2000
P. guzmanioides L.B.Sm.	F. Javier Roldán 4407 (NY)		lb	−27.8	2460
P. halophila L.B.Sm.	J. Grant 92-01731 (SEL)	1992	lb	−30.6	
P. hammelii H.Luther	B. Hammel & G. deNevers 13599 (MO)	1985	ll	−35.4	600–800
P. harlingii L.B.Sm.	C. Ceron 4385 *et al*. (SEL)	1998	ll	−33.3	250–300
P. harrylutheri D.C.Taylor & H.Rob.	H. Beltran 1094 & R. Foster (SEL)	1994	ll	−33.2	1000–1100
P. heerdeae E.Gross & Rauh	1981-0555A (MSBG)		ll	−29.2	
P. heliophila L.B.Sm.	O. Haught 2774 (K)	1939	ll	−22.1	150
P. heterophylla (Lindl.) Beer	1996-0452A (MSBG)		ll	−23.5	
P. hintoniana L.B.Sm.	E. Matuda *et al*. 27813 (US)		ll	−27.7	1800
P. hitchcockiana L.B.Sm. emend. L.B.Sm. & Read†	R. Liesner & A. Gonzalez 10409 (US)		ll	−32.0	600–1000
P. hitchcockiana L.B.Sm. emend. L.B.Sm. & Read†	1991-0522A (MSBG)		ll	−27.2	
P. hooveri (H.Luther) D.C.Taylor & H.Rob.	P. Méndez (SEL)	1993	ll	−33.5	1000
P. imbricata (Brongn.) Regel	B. Holst *et al*. 5316 (SEL)	1996	lb	−31.6	900–1000
P. inermis (Meyer) Meyer ex Schult. & Schult.f.	K. Young 809 & G. Sullivan (SEL)	1981	ll	−26.8	
P. integrifolia Ker Gawl.	H. Luther *s.n.* (SEL)	1991	ll	−29.5	
P. irwiniana L.B.Sm.†	H.S. Irwin 11738 *et al*. (MO)	1966	lb	−25.3	800
P. irwiniana L.B.Sm.†	H.S. Irwin 11738 *et al*. (K)	1966	ll	−27.0	800
P. jimenezii L.B.Sm.	A. Liogier 12740 (NY)		ll	−26.9	
P. aff. *jimenezii* L.B.Sm.	Ariza-Julia *s.n.* (US)		ll	−24.7	
P. juncoides L.B.Sm.†	B. Maguire *et al*. 37555 (US)		lb	−26.0	100–140
P. juncoides L.B.Sm.†	P. Berry 5319 & E. Melgueiro (SEL)	1991	lt	−28.8	100
P. kalbreyeri Baker	J. Betancur & S. Churchill 2539 (SEL)	1991	lb	−26.2	2545
P. karwinskyana Schult. & Schult.f.	P. Lyonnet 3287 (US)		lb	−25.5	1800
P. killipiana L.B.Sm.	A. Juncosa 1522 (MO)		ll	−37.1	130–150
P. kniphofioides L.B.Sm.	A. Gentry 40835 *et al*. (SEL)	1983	ll	−30.2	2000
P. kressii H.Luther	Luther *s.n.* (SEL)		ia	−26.6	1200
P. lanuginoa Ruiz & Pav.	Killeen 4782 *et al*. (SEL)	1993	ll	−26.1	900
P. lechleri Baker	C. Vargas 11033 (US)		ll	−24.7	1800
P. lehmannii Baker	S. Dalstrom 1338 & L. Arnby (SEL)	1990	br	−26.6	1500
P. leprieurii Baker	Granville 8277 (MO)	1985	ll	−34.6	
P. leprosa L.B.Sm.	G. Hinton *et al*. 10653 (US)		ll	−25.4	780
P. lignose L.B.Sm.	J. Betancur & S. Churchill 2541 (SEL)	1991	lb	−28.1	1505
P. longipes Mez	M. Monsalve B. 816 (MO)	1985	ll	−35.5	100
P. lopezii L.B.Sm.	A. Lopez 226 (US)		lb	−22.4	550
P. luteyniorum L.B.Sm. & Read	J. Betancur 2560 *et al*. (SEL)	1991	ll	−30.7	2005
P. lymansmithiana H.Luther	S. Knapp 5091 (MO)	1982	ll	−27.3	1150
P. macaraensis L.B.Sm.	J. Idrobo 2106 (NY)		lb	−31.0	850
P. macranthera André	Luther *et al*. 2761 (SEL)	1989	lb	−27.7	1800
P. maidifolia (C.Morren) Decne. ex Planch.	J. Jaramillo 13187 *et al*. (SEL)	1990	ll	−29.4	1300
P. megasepala Baker	J. Betancur 519 (SEL)	1987	lb	−25.3	900
P. melanopoda L.B.Sm.	W. Rauh 24560 (US)		lb	−25.6	
P. meridensis Klotzsch ex Mez	F. Oliva E. 228 (SEL)	1992	ll	−26.7	2800
P. micheliana André	R. McVaugh 19813 (US)		lb	−24.8	500–550
P. micotrinensis Read	G. Webster 13369 (US)		lb	−23.8	1417
P. microcalyx Baker var. *microcalyx*	L. Aristeguieta 4161 (US)		ll	−25.4	
P. mituensis L.B.Sm.	R. Schultes 22711 (MO)	1960	ll	−26.0	300
P. moritziana K.Koch & C.D.Bouché	Steyermark & L. Aristeguieta 127 (US)		ll	−24.4	100–200
P. mucida L.B.Sm. & Read	S. Diaz 3561 (MO)	1983	ll	−29.8	1100
P. multiflora L.B.Sm.	W. Kress *et al*. 90-3161 (SEL)	1990	ll	−29.7	500
P. multiramosa Mez	M. Cárdenas 5732 (US)		lb	−30.0	1900
P. nematophora L.B.Sm. & Read	F. Michelangeli 400 (SEL)		lt	−28.8	
P. nigra (Carrière) André†	1973-0004-032A (MSBG)		ll	−28.6	
P. nigra var. *pulchella* (Mez) H.Luther (= *P. pulchella* Mez)†	F.C. Lehmann 4466 (K)	1906	ll	−27.7	1800–2500
P. nobilis Mez & Sodiro	J. Halton 113 (SEL)	1980	lb	−30.7	350
P. nubigena Planch.	G. Davidse & J. Steyermark 18163 (SEL)	1980	ll	−23.9	2000
P. nuda Baker	R. Determann 199 (SEL)	1981	lb	−23.8	
P. oaxacana L.B.Sm.	R. McVaugh 19972 (US)		ll	−29.9	750
P. oblongifolia L.B.Sm.	Dalstrom 1825 *et al*. (SEL)	1993	lb	−28.7	1400
P. occidentalis L.B.Sm.	J. Betancur 483 *et al*. (SEL)	1987	ll	−32.6	150
P. odontopoda Baker	M. Nee 38460 (US)		ll	−28.3	1400
P. orchidifolia Mez	H. Luther *s.n.* (SEL)		lb	−28.9	
P. palmeri S.Watson	W. Thomas *et al*. 2842 (US)		ll	−26.5	1646
P. palmoides Mez & Sodiro	1986-0675A (MSBG)		ll	−29.6	
P. paniculata (Ruiz & Pav.) Ruiz & Pav.	J. Solomon 9389 (SEL)	1983	lb	−26.6	1200–1300
P. paraguayensis L.B.Sm.	J. Fernández 6128 (MO)		ll	−27.3	
P. patentiflora L.B.Sm.†	G. Aymard 7956 & L. Delgado (SEL)	1990	ll	−29.2	280
P. patentiflora var. *macrantha* L.B.Sm.†	R. Schultes 5537 (US)		ll	−26.9	
P. patentiflora var. *subintegra* L.B.Sm.†	R. Schultes & I. Cabrera 20009 (US)		lb	−27.5	274–305

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	$\delta^{13}C$ (‰)	Elevation¶ (m)
P. pavonii Mez	X. Cornejo & C. Bonifaz 3353 (SEL)	1994	lb	−28.5	2350
P. pectinata L.B.Sm.	J. Betancur 1828 *et al*. (SEL)	1990	lb	−30.6	2100
P. petraea L.B.Sm.	M. Koie 5248 (US)		ll	−22.5	2300
P. phelpsiae (L.B.Sm.) B.Holst & L.B.Sm.	O. Huber 11915 (US)		ll	−26.9	2100
P. platypetala Mez	Steyermark 117177 (US)		ll	−25.7	
P. poeppigiana Mez	J. Halton 98 (SEL)	1981	lb	−27.9	1100
P. poortmanii André	Luther 2712 *et al*. (SEL)	1989	ll	−30.1	620
P. prolifera Rauh	X. Cornejo & C. Bonifaz 4186 (SEL)	1955	lb	−29.7	350
P. pruinosa Kunth	G. Varadarajan 1148 & Guanchez (SEL)	1983	lb	−27.1	100
P. pteropoda L.B.Sm.	G. Hinton *et al*. 10141 (US)		lb	−24.6	
P. puberula Mez & Donn.Sm.	G. Davidse & R. Pohl 2046 (US)		lb	−24.5	2100
P. pulverulenta Ruiz & Pav.	H. Luther 705 *et al*. (SEL)	1981	ll	−29.0	750
P. pungens Kunth	J. Poppleton *s.n*. (SEL)	1974	ll	−25.1	335
P. punicea Scheidw.†	1980-1590A (MSBG)		ll	−30.1	
P. punicea Scheidw.†	O. van Hyning *s.n*. (US)		ll	−29.7	
P. puyoides L.B.Sm.	G. Klug 3547 (MO)	1934	ll	−24.6	1200–1600
P. quesnelioides L.B.Sm.	Schunke 7881 (US)		ll	−27.8	
P. ramosii M.A.Spencer & L.B.Sm.	F. Silverstone-Sopkin 1341 (MO)	1982	ll	−29.2	1850–1930
P. recurvata (Scheidw.) K.Koch†	M.B.G. 5707-38 (SEL)	1961	lb	−26.8	
P. recurvata (Scheidw.) K.Koch (= *P. macrochlamys* Mez)†	D. Breedlove 6359 (US)		ll	−27.3	904
P. reflexiflora André	X. Cornejo & C. Bonifaz 4757 (SEL)	1996	lb	−25.9	1900
P. ringens Klotzsch ex Link, Klotzsch & Otto	R. King 4440 (US)		lb	−23.2	
P. riparia Mez†	L. Moore *s.n*. (SEL)	1985	lb	−28.0	
P. riparia Mez†	M. Madison *et al*. 5707 (US)		lb	−27.8	
P. roseana L.B.Sm.	J. Bauml *et al*. 1227A (US)		ll	−23.3	1966
P. rubiginosa Baker†	B. Maguire *et al*. 60293 (US)		ll	−32.2	125
P. rubiginosa Baker†	M. Silva & R. Souza 2595 (US)		ll	−28.6	
P. rubiginosa var. *amazonica* (Baker) L.B.Sm.†	C. Cid 1901 *et al*. (SEL)		ll	−36.5	
P. rubronigriflora Rauh	1989-0114A (MSBG)		ll	−28.5	
P. samuelssonii L.B.Sm.	L. Ariza-Julia 5162B (US)		ll	−27.6	
P. saxicola L.B.Sm.	J. Grant & J. Rundell 94-02301 (SEL)	1994	ll	−30.3	
P. scandens Ule	Luther *et al. S.n*. (SEL)	1981	lb	−26.0	1300
P. sceptriformis Mez	W. Palacios *et al*. 86 (SEL)	1985	ll	−26.0	1300
P. sceptrigera Mez	J. Clark *et al*. 2520 (SEL)	1986	ll	−31.3	300–600
P. schultzei Harms†	A. Gröger & W. Meier 449 (SEL)	1992	lb	−31.1	
P. schultzei Harms (= *P.* aff. *chriquensis* L.B.Sm.)†	T. Croat 37040 (MO)	1976	ll	−29.2	230
P. secundiflora L.B.Sm.	1990-0629A (MSBG)		ll	−27.2	
P. semaphora L.B.Sm.	R. Callejas & M. Arbeláez 9578 (SEL)	1990	lb	−31.9	2150
P. similis L.B.Sm.	F. Silverstone-Sopkin *et al*. 2703 (US)		ll	−31.1	2300–2400
P. simulans H.Luther	C. Aulestia & A. Grijalva 1119 (SEL)	1993	ll	−33.7	900
P. smithiorum H.Luther	1989-0004A (MSBG)		ll	−28.1	
P. sodiroi Mez	Meerow & Meerow 1094 (SEL)	1982	ll	−27.0	2500
P. sordida L.B.Sm.	G. Hinton *et al*. 14248 (US)		lb	−23.9	2250
P. spectabilis Mez	S. Dalström *et al*. 2202 (SEL)	1996	lb	−33.6	1200–1300
P. spicata (Lam.) Mez	R. Read 2033A (US)		ll	−29.7	
P. sprucei Baker†	W. Thomas *et al*. 5437 (US)		ll	−36.5	
P. sprucei Baker†	P. Mutchnick 734 & B. Allicock (SEL)		lb	−37.8	
P. squarrosa L.B.Sm.	Luther *et al*. 2775 (SEL)	1989	lb	−28.5	650
P. staminea Lodd.	H. Boudet F. 1744 (US)		ll	−29.2	
P. stenophylla André	S. Knapp 8006 (SEL)	1986	ll	−26.4	600
P. stevensonii H.Luther & Whitten	T. Croat & J. Rodríguez B. (SEL)	1986	br	−28.4	700
P. steyermarkii L.B.Sm.	1993-0183A (MSBG)		ll	−23.6	
P. suaveolens Lindl. ('*P. suaveolus*')	(K: Brazil 1867)	1867	ll	−23.3	
P. subulifera L.B.Sm.	T. Plowman & P. Rury 11160 (US)		ll	−25.6	2350–2430
P. sulphurea Andrews	R. Howard 11220 (US)		ll	−27.0	853
P. tabuliformis Linden	M. Foster 2886 (US)		ll	−30.2	
P. tarapotensis Baker	Luther *et al*. 705 (SEL)	1981	ll	−28.7	750
P. tillandsioides L.B.Sm.	G.B. Hinton *et al. s.n*. (K)	1939	ll	−26.3	1775
P. tolimensis L.B.Sm.	H. Rusby & F. Pennell 215 (US)		ll	−25.3	400–450
P. torresiana L.B.Sm.	W. Anderson 11120 (SEL)		ll	−33.3	120–150
P. trianae André	M. Kessler 11946 *et al*. (SEL)	1997	lb	−25.5	2900
P. cf. *trimorpha* L.B.Sm.	C. Luer 6689 *et al*. (SEL)	1981	ll	−24.9	1000
P. truncata L.B.Sm.	S. Leiva G. 1658 *et al*. (SEL)	1995	ll	−27.4	1780
P. tuberculata L.B.Sm.	J. Hambury-Tracy 135 (US)		ia	−23.8	1524
P. tuerckheimii Donn.Sm.	T. Macdougall 1 (US)		ll	−25.8	
P. turbinella L.B.Sm.	R. Schultes & I. Cabrera 17532 (US)		lb	−23.3	
P. uaupensis Baker†	R. Schultes & F. Lopez 8932 (US)		ll	−30.3	
P. uaupensis Baker†	M. Madison 6265 *et al*. (SEL)		ll	−30.1	
P. ulei L.B.Sm.	J. Kirkbride 4870 (NY)		lb	−29.3	870
P. undulata Scheidw.	1991-0306A (MSBG)		ll	−28.7	
P. unilateralis L.B.Sm.	X. Cornejo & C. Bonifaz 2953 (SEL)	1994	lb	−28.3	50

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	δ[13]C (‰)	Elevation¶ (m)
P. valerioi Standl.	H. Luther 1078 *et al.* (SEL)	1986	ll	−28.4	1300–1500
P. venezuelana L.B.Sm. & Steyerm.	G. Bunting *et al.* 11029 (US)		ll	−27.7	100–250
P. virginalis Utley & Burt-Utley	1991-0466A (MSBG)		ll	−25.5	
P. wendlandii Baker†	E. André 4056 (K)	1876	ll	−27.0	
P. wendlandii Baker†	1996-0529A (MSBG)		ll	−28.9	
P. wilburiana Utley	E. Martínez S. 23040 *et al.* (MO)	1988	ll	−29.4	1630
P. xanthocalyx Mart.	D. Cathcart *s.n.* (SEL)	1997	ll	−24.7	
P. yaupi-bajaensis Rauh	H. Luther *s.n.* (SEL)	1995	lb	−27.0	
Puyoideae Givnish					
***Puya* Molina**					
P. aequatorialis André	G. Varadarajan 1430 *et al.* (SEL)	1987	ll	−26.4	2390
P. alata L.B.Sm.	A. Krapovickas & A. Shinini 31374 (US)		ll	−13.6	950
P. alpestris (Poepp.) Gay var. *alpestris*	G. Zizka 8089 (FR)		ll	−25.7	
P. alpicola L.B.Sm.	S. White 574 & W. Alverson (SEL)	1977	ll	−22.4	3900
P. angelensis E.Gross & Rauh	J. Manzanares & W. Till 7970 (MO)	2003	ll	−22.4	3003
P. angulonis L.B.Sm.	D. Smith 3459 & R. Vásquez M. (SEL)	1983	lb	−22.1	3500–3800
P. angusta L.B.Sm.†	R. Ferreyra 16512 (US)		ia	−22.3	3900–4000
P. angusta L.B.Sm. (= '*P. reflexiflora* Mez')†	D. Smith 11396 (US), cf. MO	1985	ll	−21.5	4000–4400
P. araneosa L.B.Sm.	O. Tovar 4783 (US)		lb	−24.5	3400
P. argentea L.B.Sm.	J. Mostacero 596 (NY)		ia	−25.2	3350
P. aristeguietae L.B.Sm.	G. Varadarajan 1188 (SEL)		lb	−23.7	
P. assurgens L.B.Sm.	G. Varadarajan 1257 *et al.* (MO)	1984	lb	−24.8	2000–2050
P. aff. *assurgens* L.B.Sm.	G. Varadarajan 1257 *et al.* (SEL)	1984	lb	−26.3	2000–2050
P. atra L.B.Sm.	Varadarajan *et al.* 1274 (US)		lb	−22.2	3900
P. cf. *atra* L.B.Sm.	I. Vargas C. 4186 *et al.* (SEL)	1995	lb	−27.1	2500–2600
P. bermejana S.E.Gómez, Slanis & A.Grau	Grau, Gómez & Aráoz 1575 (MO)	2005	lb	−23.5	1000
P. berteroniana Mez [= *P. alpestris* (Poepp.) Gay ssp. *zoellneri* (Mez) Zizka, J.V.Schneid. & Novoa]	G. Varadarajan 1490 *et al.* (SEL)	1987	lb	−17.6	700
P. bicolor Mez	M. & R. Foster 1803 (US)		lb	−25.3	2621
P. boliviensis Baker	Rundel & Dillon (1998)		lb	−21.3	
P. brachystachya (Baker) Mez	M. Foster *et al.* 1458 (US)		ll	−24.7	2896
P. brackeana Manzan. & W.Till	J. Manzanares *et al.* 7533 (MO)	2002	ll	−24.6	3359
P. bravoi Aráoz & A.Grau	A. Grau *et al.* 1596 (MO)	2006	ll	−23.2	3200
P. brittoniana Baker	G. & U. Varadarajan 1466 (MO)		lb	−22.6	3800
P. cajasensis Manzan. & W.Till	J. Campos *et al.* 5309 (MO)	1998	ll	−24.5	3400
P. cardenasii L.B.Sm.	M. Foster 2540 (US)		br	−21.1	4333
P. cardonae L.B.Sm.	F. Oliva-Esteve 243 & B. Manare (SEL)	1993	lb	−22.4	3000
P. castellanosii L.B.Sm.	G. Varadarajan *et al.* 1476 (US)		ll	−17.3	2400–3300
P. cerrateana L.B.Sm.	W. Rauh *s.n.* (US)		lb	−14.1	2100
P. chilensis Molina†	G. Varadarajan *et al.* 1484 (MO)	1987	ll	−18.6	75
P. chilensis Molina†	G. Varadarajan *et al.* 1487 (MO)	1987	ll	−16.3	100
P. chilensis Molina†	J. West 3936 (MO)	1935	ll	−22.1	150
P. clava-herculis Mez & Sodiro	G. Varadarajan 1436 *et al.* (SEL)	1987	ll	−23.1	3890
P. coerulea Lindl. var. *intermedia* (L.B.Sm. & Looser) L.B.Sm. & Looser†	G. Varadarajan 1493 *et al.* (SEL)	1987	lb	−20.3	700
P. coerulea Lindl. var. *violacea* (Brongn.) L.B.Sm. & Looser†	O. Zöllner 8412 (MO)		ll	−23.3	
P. compacta L.B.Sm.	G. Varadarajan 1438 *et al.* (SEL)	1987	lb	−25.3	3780
P. coriacea L.B.Sm.	P. Hutchison *et al.* 6170 (MO)		br	−21.2	3640
P. cf. *coriacea* L.B.Sm.	D. Smith 3308 & R. Vásquez (SEL)	1983	br	−24.2	3700
P. cristata L.B.Sm.	M. Lewis 881103 (MO)	1988	ll	−14.1	2600–2700
P. ctenorhyncha L.B.Sm.	L. Besse 618 *et al.* (SEL)	1981	ll	−13.6	2500–2800
P. cuatrecasasii L.B.Sm.	J. Cuatrecasas *et al.* 27573 (US)		ll	−21.9	3700
P. cuevae Manzan. & W.Till	J. Campos *et al.* 5057 (MO)	1998	ll	−25.2	3200
P. cylindrica Mez	J. Solomon 3065 (MO)	1977	br	−14.7	3100
P. dasylirioides Standl.	J. Grant 91-01384 *et al.* (SEL)		lb	−25.3	2500
P. densiflora Harms	P. Núñez 9882 (SEL)	1985	ll	−17.6	2380
P. depauperata L.B.Sm.	D. Smith & J. Canne-Hilliker 5912 (MO)	1984	ll	−24.8	2400
P. dodsonii Manzan. & W.Till	C. & P. Dodson 15391 (MO)	1984	ll	−25.7	2500
P. dyckioides (Baker) Mez	J. Piccardo 50 (US)		lb	−21.8	
P. cf. *dyckioides* (Baker) Mez	P. & C. Ibisch 93-1206 (SEL)	1993	ll	−22.5	3750
P. eryngioides André	B. Øllgaard 74152 *et al.* (SEL)	1984	lt	−25.4	3000–3050
P. exigua Mez	A. Hirtz 4008 (SEL)	1989	ll	−23.2	3400
P. ferreyrae L.B.Sm.	Hutchison & Wright 6124 (US)		ll	−13.9	2290
P. ferruginea (Ruiz & Pav.) L.B.Sm.†	J. Solomon 15642 (SEL)	1986	lb	−23.2	2800
P. ferruginea (Ruiz & Pav.) L.B.Sm. (= *Pitcairnia consimilis* Baker)†	(K: La Paz 1913/1922)		ll	−20.8	
P. ferruginea (Ruiz & Pav.) L.B.Sm. (= *Pitcairnia ferruginea* Ruiz & Pav.)†	H.H. & C.M. Iltis & D. & V. Ugent (K)	1962	ll	−20.6	2900–3000
P. ferruginea (Ruiz & Pav.) L.B.Sm (= *Pitcairnia ferruginea* Ruiz & Pav.)†	(K: La Paz, Bolivia 1939, det. L.B. Smith)	1939	ll	−19.1	

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	δ13C (‰)	Elevation¶ (m)
P. ferruginea (Ruiz & Pav.) L.B.Sm (= *Pitcairnia ferruginea* Ruiz & Pav.)†	C. Vargas 11091 (K)	1939	ll	−22.8	2900
P. fiebrigii Mez	M. Kessler 4179 (SEL)	1993	ll	−24.4	1550
P. floccosa (Linden) E.Morren†	Leme 2743 (HB)		ll	−28.0	
P. floccosa (Linden) E.Morren var. *floccosa*†	J. Betancur 3975 *et al.* (SEL)	1993	br	−27.7	600
P. fosteriana L.B.Sm.	J. Solomon 18299 (SEL)	1988	lb	−22.0	4400–4500
P. furfuracea (Willd.) L.B.Sm.	J. Ewan 15906 (US)		lb	−24.0	2500
P. gargantae L.B.Sm.	J. Luteyn *et al.* 6670 (NY)		lb	−24.8	3000
P. gigas André	M. & R. Foster 2046 (US)		ll	−23.8	3333
P. glabrescens L.B.Sm.	L. Besse 502 *et al.* (SEL)	1981	lt	−24.5	3120
P. glandulosa L.B.Sm.	P. Hutchison *et al.* 6123 (MO)	1964	br	−19.8	2290
P. glaucovirens Mez	J. Wurdack 1121 (US)		lb	−23.9	2200–2400
P. glomerifera Mez & Sodiro	M. Peñafiel 918 *et al.* (SEL)	1992	ll	−25.9	3000–3100
P. goudotiana Mez	R. King *et al.* 6039 (US)		lb	−23.6	3440
P. gracilis L.B.Sm.	O. Tovar 3839 (US)		ll	−18.7	1500–1700
P. grafii Rauh	R. Liesner & B. Holst 21259 (US)		ll	−31.9	200
P. grandidens Mez	E. Cerrate 4026 (US)		ll	−21.6	3000
P. hamata L.B.Sm.	H. van der Werff & E. Gudiño 11452 (SEL)	1989	ll	−25.6	3100–3500
P. harmsii (A.Cast.) A.Cast.	L. Smith & A. Castellanos 4643 (US)		lb	−18.0	
P. aff. *harmsii* (A.Cast.) A.Cast.	G. Varadarajan 1245 & Bilos (SEL)	1984	br	−20.7	2850–2950
P. herrerae Harms	I. Sanchez *et al.* 1183 (US)		ia	−20.3	
P. herzogii Wittm.	M. Kessler 6581 *et al.* (SEL)	1996	br	−24.7	3650
P. hortensis L.B.Sm.	J. Soukup 5426 (US)		lb	−17.0	
P. humilis Mez†	1994-0269 (MSBG)		ll	−19.6	
P. humilis Mez†	G. Varadarajan 1451 *et al.* (SEL)	1987	lb	−20.5	3400
P. isabellina Mez	R. Ferreyra 19714 (US)		ll	−13.4	1300–1500
P. killipii Cuatrec.	Steyermark *et al.* 98760 (US)		lb	−22.7	3000–3200
P. kuntzeana Mez	I. Vargas C. 3452 & R. Foster (SEL)	1994	ll	−27.3	500–700
P. lanata (Kunth) Schult. & Schult.f.	M. Madison 7513 *et al.* (SEL)	1981	br	−12.4	2400
P. lasiopoda L.B.Sm.	C. Vargas 17515 (US)		ia	−23.8	2300
P. cf. *lasiopoda* L.B.Sm.	J. Solomon 10862 (SEL)	1983	ll	−25.1	1850
P. laxa L.B.Sm.†	059568 (SEL)		ll	−15.4	
P. laxa L.B.Sm.†	T. Walters *s.n.* (SEL)		lb	−14.1	
P. lehmanniana L.B.Sm.	J. Betancur 2551 & S. Churchill (SEL)	1991	br	−25.9	2555–2690
P. lilloi A.Cast.	G. Varadarajan 1236 (SEL)	1984	br	−26.3	1450–1500
P. lineata Mez	H. Barclay & P. Juajibioy 6683 (US)		lb	−23.3	3470–3510
P. longistyla Mez	H. Iltis *et al.* 962 (US)		lb	−13.8	2950
P. macbridei L.B.Sm.	R. Ferreyra 16501 (SEL)	1965	ll	−22.9	3300–3500
P. cf. *macropoda* L.B.Sm.	M. Nee & J. Solomon 30283 (MO)		ll	−28.2	850
P. macrura L.B.Sm.	R. Ferreyra 14619 (US)		lb	−16.1	2500–2600
P. maculata L.B.Sm.	J. Madsen 86118 *et al.* (SEL)	1989	ll	−24.9	3000–3400
P. mariae L.B.Sm.	J. Wurdack 602 (US)		lb	−24.0	2000–2400
P. medica L.B.Sm.	B. Becker & F. Terrones 371 (US)		ll	−25.7	2700–3700
P. membranacea L.B.Sm.	B. Peyton 1081 & S. Tilney-Peyton (SEL)	1982	ll	−21.5	3825
P. meziana Wittm.†	J. Solomon 13058 (SEL)	1985	lb	−14.3	3500
P. meziana Wittm.†	G. Varadarajan 1273 *et al.* (MO)	1984	ll	−12.6	3100
P. meziana Wittm.†	L. Besse 630 *et al.* (SEL)	1981	br	−13.4	
P. meziana Wittm. [= *P. rusbyi* (Baker) Mez]†	E. Balls 5900 (US)		lb	−12.0	4000
P. micrantha Mez	A. Schinini 10294 *et al.* (MO)	1974	lb	−24.6	
P. minima L.B.Sm.†	S. Beck 16100 & M. Liberman (SEL)	1987	ll	−25.5	2650
P. minima L.B.Sm.†	J. de Sloover 393 (US)		ll	−28.1	3000
P. mirabilis (Mez) L.B.Sm.†	G. Varadarajan 1237 (SEL)	1984	ll	−23.6	1500
P. mirabilis (Mez) L.B.Sm.†	L. Novara & C. Saravia T. 2698 (MO)		br	−26.1	1250
P. mollis Baker	M. Liberman 1013 (US)		lb	−22.9	3840
P. nana Wittm. [= *Pitcairnia nana* (Wittm.) L.B.Sm.]†	M. Cárdenas 5533 (K)	1960	ll	−23.1	1800
P. nana Wittm.†	M. Kessler 6356 *et al.* (SEL)	1996	lb	−25.5	2100
P. nitida Mez	B. Øllgaard 74722 & J. Madsen (SEL)	1984	lb	−22.5	2850–2960
P. nivalis Baker	M. Foster *et al.* 1462 (US)		lb	−22.2	
P. nutans L.B.Sm.	G. Varadarajan 1429 *et al.* (SEL)	1987	lb	−23.7	3360
P. obconica L.B.Sm.	B. Øllgaard 91068 (SEL)	1989	lb	−22.9	2750–2950
P. occidentalis L.B.Sm.	R. Fonnegra & D. Tuberquia 4644 (MO)		lb	−24.9	3130
P. olivacea Wittm.	J. Solomon & M. Nee 17936 (SEL)	1988	lb	−19.7	1950
P. oxyantha Mez	R. Ferreyra 16654 (US)		br	−23.7	2400–2500
P. parviflora L.B.Sm.	G. Harling 5724 (US)		lb	−22.8	2500
P. pearcei (Baker) Mez	P. & C. Ibisch 93-0336 (SEL)	1993	br	−29.3	800
P. pitcairnioides L.B.Sm.	P. Barbour 4224 (MO)	1978	lb	−14.7	533–767
P. ponderosa L.B.Sm.	H. Iltis *et al.* 445 (US)		br	−21.9	3800
P. pratensis L.B.Sm.	A. Lopez & A. Sagástegui 2862 (US)		ll	−23.4	3200
P. pygmaea L.B.Sm.	G. Varadarajan 1433 *et al.* (SEL)	1987	lb	−23.7	3160
P. raimondii Harms	G. & D. Schmitt 84 (SEL)	1984	lb	−22.2	3725
P. ramosissima ined. (= *P. ramosa* L.B.Sm. nom. illeg.)	J. Wurdack 1600 (US)	1962	ll	−24.4	3200–3500

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	$\delta^{13}C$ (‰)	Elevation¶ (m)
P. reflexiflora Mez (= *P.* aff. *rauhii* L.B.Sm.)	A. Sagástegui A. 9796 *et al*. (MO)	1981	ll	−17.3	1500
P. retrorsa Gilmartin	G. & U. Varadarajan 1419 (SEL)	1987	fw	−23.4	3140
P. riparia L.B.Sm.	S. Beck 4645 (US)		lb	−21.9	3750
P. robin-fosteri H.Luther	B. Boyle 4312 *et al*. (SEL)	1997	lt	−26.2	3350–3400
P. roezlii E.Morren	E. Asplund 11161 (US)		lb	−19.8	2400
P. sagasteguii L.B.Sm.	A. Lopez & A. Sagástegui 3548 (US)	1961	ll	−12.6	2500
P. sanctae-crucis (Baker) L.B.Sm.	L. Besse 1828 *et al*. (SEL)	1983	br	−25.9	2450
P. santosii Cuatrec.†	H. Garcia-Barriga 11632 (US)		lb	−23.7	3100–3300
P. santosii var. *verdensis* Cuatrec.†	A. Cleef & R. Jaramillo 3132 (US)		lb	−22.3	3500
P. silvae-baccae L.B.Sm. & Read	C. Wood & P. Berry 87 (MO)	1974	lb	−25.5	2700–3300
P. smithii A.Cast.	Schreiter 94085 (US)	1932	br	−20.9	945
P. sodiroana Mez	H. Luther 2768 *et al*. (SEL)	1989	lb	−25.5	3400
P. solomonii G.S.Varad.	J. Solomon 13395 (MO)	1985	lb	−28.6	3000
P. spathacea (Griseb.) Mez	G. Varadarajan 1268 & Bilos (SEL)	1984	lb	−25.7	1300–1350
P. stenothyrsa (Baker) Mez	G. & U. Varadarajan 1468 (US)	1987	lb	−14.8	3000
P. cf. *stenothyrsa* (Baker) L.B.Sm.	M. Nee 46669 (SEL)	1995	lb	−13.3	2150–2250
P. thomasiana André	A. Gilmartin 1130 (US)	1965	lb	−25.1	2150
P. trianae Baker	G. Varadarajan 1189 & Oliva (SEL)	1983	lt	−22.8	3200–3250
P. tristis L.B.Sm.	2542128 (US)		ll	−24.5	
P. tuberosa Mez†	M. Cárdenas 5198 (US)		ll	−26.0	1800
P. tuberosa Mez (= *P. serranoensis* Rauh)†	I. Vargas 3046 & A. Fuentes (SEL)	1993	lb	−24.5	2600
P. tuberosa Mez (= *P. vallo-grandensis* Rauh)†	P. & C. Ibisch 93-0861 (SEL)	1993	ll	−23.5	2250
P. tunariensis Mez	M. Cárdenas *et al*. 7639 (US)	1943	lb	−18.3	3600
P. ugentiana L.B.Sm.	D. Ugent 4998 (US)	1963	ll	−12.4	1950
P. ultima L.B.Sm.	Varadarajan *et al*. 1277 (MO)	1984	ll	−25.7	2940–2950
P. venezuelana L.B.Sm.	L. Aristeguieta 3538 (US)	1958	ll	−22.3	3500
P. venusta Phil.	G. Varadarajan 1483 *et al*. (SEL)	1987	lb	−17.3	75
P. vestita André	P. Peterson *et al*. 8924 (US)		lb	−22.7	2830–3100
P. volcanensis A.Cast.	S. Venturi 3383 (US)		ll	−23.7	3000
P. weberbaueri Mez	B. Peyton 1568 & S. Tilney-Peyton (SEL)	1982	br	−24.3	3810
P. weberiana E.Morren ex Mez (= *P. ushae* G.S.Varad. ms.)	G. Varadarajan *et al*. 1460 (MO)	1987	lb	−17.6	1700–1800
P. westii L.B.Sm.	C. Diaz 3018 & R. Vásquez (SEL)	1988	ll	−24.3	3000
P. wrightii L.B.Sm.	P. Hutchison & J. Wright 3786 (US)	1964	ll	−13.1	380
P. yakespala A.Cast.	G. Varadarajan *et al*. 1478 (US)		ll	−24.0	3900
Tillandsioideae Burnett					
***Alcantarea* Harms**					
A. brasiliana (L.B.Sm.) J.R.Grant	R. Read 77-1 (SEL)		ll	−26.1	
A. duarteana (L.B.Sm.) J.R.Grant	G. Hatschbach *et al*. 28977 (US)		lb	−21.5	1450
A. cf. *edmundoi* (Leme) J.R.Grant	H. Luther *s.n.* (SEL)	1992	ll	−26.1	
A. extensa (L.B.Sm.) J.R.Grant	G. Hatschbach 48595 & J. Silva (MO)	1984	ll	−25.0	
A. farneyi (Martinelli & Costa) J.R.Grant	H. Luther *s.n.* (SEL)	1998	ia	−24.4	
A. glaziouana (Lem.) Leme†	W. Berg *s.n.* (SEL)	1998	br	−23.4	
A. glaziouana (Lem.) Leme [= *Vriesea geniculata* (Wawra) Wawra]†	A. Gentry 49496 & E. Zardini (MO)	1985	ll	−23.0	10
A. imperialis (Carrière) Harms†	L. Smith & A. Brade 5653 (US)		ll	−24.3	
A. imperialis (Carrière) Harms†	J. Steyermark 107579 (VEN)		ll	−24.6	950
A. nahoumii (Leme) J.R.Grant	W. Berg *s.n.* (SEL)	1988	ll	−26.2	800
A. odorata (Leme) J.R.Grant	G. & M. Hatschbach 61610 (NY)		lb	−22.8	
A. regina (Vell.) Harms	L. Smith 6829 (US)		ll	−25.9	0
***Catopsis* Griseb.**					
C. berteroniana (Schult. & Schult.f.) Mez	G. Davidse & D. Holland 37052 (MO)	1997	lb	−24.7	20
C. delicatula L.B.Sm. (= *C.* cf. *minimiflora* Matuda)	T. Croat 43759 (MO)	1977	ll	−26.0	300–500
C. floribunda L.B.Sm.	M. Mejía & T. Zanoni 7923 (MO)		ll	−24.5	500
C. juncifolia Mez & Wercklé	P. Moreno 10324 (MO)	1981	ll	−24.3	740–760
C. micrantha L.B.Sm.	T. Croat 40885 (MO)	1977	ll	−24.6	1100–1250
C. morreniana Mez	P. Moreno 6468 (MO)	1981	ll	−24.4	800–1000
C. nitida (Hook.) Griseb.	J. Morales 1866 (MO)	1993	ll	−26.5	1850
C. nutans (Sw.) Griseb.	T. Croat 78476 (MO)	1996	ll	−24.9	900–1050
C. oerstediana Mez (= *C. hahnii* Baker)	W. Stevens & B. Krukoff 11687 (MO)	1979	ll	−23.8	1200–1400
C. paniculata E.Morren	P. Moreno 9528 (MO)	1981	ll	−26.4	1100–1200
C. sessiliflora (Ruiz & Pav.) Mez	G. Herrera 8221 (MO)	1995	ll	−26.8	1100
C. subulata L.B.Sm.	G. Davidse 35157 *et al*. (MO)	1994	lb	−29.0	1320
C. wangerinii Mez & Wercklé	P. Tenorío L. 14691 *et al*. (MO)	1988	ll	−25.2	
***Glomeropitcairnia* Mez**					
G. erectiflora Mez	W. Broadway *s.n.* (MO)	1931	ll	−27.5	
G. penduliflora (Griseb.) Mez	S. Hill 22037 (MO)	1991	ll	−28.2	667
***Guzmania* Ruiz & Pav.**					
G. acorifolia (Griseb.) Mez	H. Luther *s.n.* (SEL)	1992	ll	−24.7	
G. acuminata L.B.Sm.	C. Cerón M. 1233 (MO)	1987	ll	−32.0	450

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	$\delta^{13}C$ (‰)	Elevation¶ (m)
G. acutispica E.Gross†	Luther 2719 *et al*. (SEL)	1989	ll	−28.0	650
G. acutispica E.Gross (previously *G. tarapotina* Ule)†	Luther 2719 *et al*. (MO)		ll	−26.4	650
G. aequatorialis L.B.Sm.	Teuscher 2022-56 (US)		lb	−23.3	
G. albescens H.Luther & Determann	H. Luther *s.n.* (SEL)	1995	ll	−25.5	
G. alborosea H.Luther	G. Tipaz 231 *et al*. (MO)		ll	−28.5	1600
G. alcantarioides H.Luther	C. Skotak *s.n.* (SEL)	1992	lb	−24.3	
G. altsonii L.B.Sm.	R. Liesner & B. Holst 20803 (MO)		ll	−30.7	950–1100
G. amplectens L.B.Sm.	G. Tipaz 2243 *et al*. (MO)		ll	−28.1	300
G. andreana (E.Morren) Mez	A. Gentry 35075 *et al*. (MO)		ll	−26.3	1750
G. andreettae Rauh	J. Raack 930816.9 (SEL)	1993	ll	−28.0	1800
G. angustifolia (Baker) Wittm.	S. Ingram & K. Ferrell-Ingram 1473 (MO)		lt	−29.6	1500–1550
G. asplundii L.B.Sm.	F. Hurtado & A. Alvarado 940 (MO)		lb	−25.2	
G. attenuata L.B.Sm. & Read	A. Gentry 16866 *et al*. (MO)		ll	−31.3	1400–1600
G. bakeri (Wittm.) Mez	C. Dodson *et al*. 13989 (MO)		lb	−23.9	2700
G. barbiei Rauh	H. Luther *s.n.* (SEL)	1992	ll	−25.7	
G. berteroniana (Schult. & Schult.f.) Mez	T. Croat 60935 (SEL)	1985	lb	−26.5	800
G. besseae H.Luther†	A. Gentry 79952 (MO)		ll	−26.2	2210
G. besseae H.Luther [= *G. osyana* (E.Morren) Mez]†	J. Madsen 86064 (MO)	1989	ll	−31.8	2500
G. bicolor L.B.Sm.	Luther 1226 *et al*. (SEL)	1988	ll	−27.6	850
G. bipartita L.B.Sm.	J. Solomon 9539 (MO)	1983	ll	−26.7	1500
G. bismarckii Rauh	H. Luther *s.n.* (SEL)	1992	ll	−26.0	
G. blassii Rauh	J. Morales 2516 (MO)	1994	ll	−30.7	1500
G. bracteosa (André) André ex Mez	A. Hirtz 1826 (MO)		ll	−27.9	2300
G. brasiliensis Ule	R. Liesner 3559 (MO)		ll	−29.8	120
G. breviscapa H.Luther	H. Luther *s.n.* (SEL)	1995	lb	−23.9	
G. butcheri Rauh	H. Herrera 850 (MO)	1991	ll	−30.6	600–750
G. cabrerae Gilmartin	A. Gentry 40834 *et al*. (MO)	1983	ll	−28.7	2000
G. calamifolia André ex Mez	B. Hammel 3585 (MO)	1978	ll	−25.0	733
G. calothyrsus Mez	R. Vásquez & N. Jaramillo 3814 (MO)	1983	lb	−31.5	130
G. candelabrum (André) André ex Mez	J. Giraldo & L. Olver 592 (MO)	1995	ll	−27.1	1900
G. caricifolia (André ex Baker) L.B.Sm.	F. Silverstone-Sopkin 2727 (MO)	1986	ll	−29.0	2300–2425
G. circinnata Rauh	C. Skotak *s.n.* (SEL)	1991	ll	−23.7	1250
G. claviformis H.Luther	Luther *et al*. 2717B (SEL)	1989	lb	−25.9	600
G. compacta Mez	S. Ingram 1533 *et al*. (SEL)	1992	ll	−30.2	1500–1550
G. condensata Mez & Wercklé	R. Liesner & E. Judziewicz 14527 (MO)	1983	ll	−24.6	1450
G. condorensis H.Luther	A. Gentry 80503 (SEL)	1993	ll	−31.7	930
G. confinis L.B.Sm.	R. Foster *et al*. 7651 (SEL)	1983	lb	−26.6	2500–3000
G. confusa L.B.Sm.	J. Manzanares 5135 (SEL)	1993	br	−23.1	
G. conifera (André) André ex Mez	H. Beltran & R. Foster 874 (SEL)	1998	ll	−27.9	1500–1800
G. coriostachya (Griseb.) Mez	J. Morales & G. Carnevali 2898 (MO)		ll	−25.9	1000
G. cuatrecasasii L.B.Sm. (= *G.* cf. *goudotiana* Mez)	J. Betancur 717 *et al*. (MO)	1988	ll	−26.2	1300–1700
G. cuzcoensis L.B.Sm.	I. Sanchez Vega 6009 *et al*. (SEL)	1991	ll	−22.8	2400
G. cylindrica L.B.Sm.	B. Trujillo & M. Ponce 18274 (MO)		ll	−27.5	1500–1700
G. danielii L.B.Sm.	W. Palacios 9805 *et al*. (MO)		ll	−27.0	2000–2200
G. delicatula L.B.Sm.	J. Betancur 570 *et al*. (MO)		ll	−30.9	1350–1450
G. densiflora Mez	W. Palacios & E. Freire 4985 (MO)		ll	−28.5	2200–2300
G. desautelsii L.B.Sm. & Read	R. Liesner & E. Judziewicz 14945 (MO)		ll	−28.9	1100
G. devansayana E.Morren	A. Hirtz 2415 *et al*. (MO)		ll	−29.6	1500
G. diffusa L.B.Sm.	J. MacDougal & F. Roldán 3521 (MO)		ll	−24.9	2550–2700
G. dissitiflora (André) L.B.Sm.	M. Grayum 7844 & G. Herrera (MO)		ll	−30.7	1200–1400
G. donnellsmithii Mez ex Donn.Sm.	J. Morales 2550 *et al*. (MO)		ll	−30.7	850–950
G. aff. *dudleyi* L.B.Sm.	E. Forero & R. Jaramillo 2483 (MO)	1976	ll	−31.5	1370
G. dussii Mez	T. Aitken *et al*. 493 (US)		ll	−29.5	1000
G. ecuadorensis Gilmartin	A. Alvarez 1144 *et al*. (MO)		ll	−26.0	2150–2650
G. eduardi André ex Mez	A. Gentry 15832 *et al*. (MO)		ll	−31.9	150
G. ekmanii (Harms) Harms ex Mez	H. Luther *s.n.* (SEL)	1989	ll	−22.3	
G. erythrolepis Brongn. ex Planch.	K. Sytsma and T. Antonio 3023 (MO)		ll	−25.5	933–1000
G. farciminiformis H.Luther (= *G.* cf. *foetida* Rauh)	W. Palacios 8326 *et al*. (MO)		ll	−30.7	1000–1100
G. fawcettii Mez	W. Harris & N. Britton 10534 (US)		ll	−24.1	
G. filiorum L.B.Sm.	S. Mori 3743a *et al*. (MO)		ll	−28.4	333
G. flagellata S.Pierce & J.R.Grant [= *G. virescens* (Hook.) Mez var. *laxior* L.B.Sm.]†	G. McPherson 10621 (MO)		ll	−29.1	950
G. flagellata S.Pierce & J.R.Grant [= *G. virescens* (Hook.) Mez var. *laxior* L.B.Sm.]†	H. Kennedy 3370 (US)		lb	−26.4	800
G. fosteriana L.B.Sm.	B. Hansen 7856 *et al*. (MO)		ll	−24.9	
G. fuerstenbergiana (Kirchoff & Wittm.) Wittm.	H. Luther *s.n.* (SEL)	1989	lb	−23.9	600–700
G. fuquae H.Luther & Determann	R. Determan *s.n.* (SEL)		ll	−26.5	ca. 700
G. garciaensis Rauh	A. Gentry 80439 (MO)		ll	−24.7	2100
G. globosa L.B.Sm.	D. Smith 2040 (MO)		ll	−30.7	910
G. glomerata Mez & Wercklé	M. Grayum & R. Warner 5428 (MO)		ll	−28.9	1350
G. gloriosa (André) André ex Mez	G. Tipaz & E. Gudiño 1175 (MO)		ll	−28.1	3000

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	δ13C (‰)	Elevation¶ (m)
G. gracilior (André) Mez	A. Gentry 80473 (MO)		ll	−26.4	
G. graminifolia (André ex Baker) L.B.Sm.	M. Grayum 7015 (MO)		ll	−29.8	
G. harlingii H.Luther	B. Girko E91D 028 (SEL)	1991	ll	−23.7	600–700
G. hedychioides L.B.Sm.	M. Foster 2740 (US)		br	−26.3	1700
G. herrerae H.Luther & Kress	H. Luther *s.n.* (SEL)		ll	−24.1	
G. hirtzii H.Luther	C. Dodson 14009 *et al.* (MO)	1983	ll	−23.6	1850
G. hitchcockiana L.B.Sm.	C. Dodson 8494 *et al.* (MO)	1979	ll	−23.9	600
G. hollinensis H.Luther	E. Freire & J. Cerda 262 (MO)	1996	ll	−32.5	500
G. jaramilloi H.Luther†	S. Espinoza 723 (MO)	1991	ll	−29.5	1200
G. jaramilloi H.Luther (= *G. fusispica* Mez & Sodiro)†	V. Zak 1523 (MO)	1986	ll	−28.7	1300–1500
G. kalbreyeri (Baker) L.B.Sm.	R. Callejas 2898 *et al.* (MO)		ll	−33.0	2100
G. killipiana L.B.Sm.	R. Foster & D. Smith 7562 (MO)	1983	lb	−25.3	2100
G. kraenzliniana Wittm.	W. Kress *et al.* 90-3071 (US)		ll	−28.3	1000
G. laeta H.Luther (= *G. pacifica* Betancur ms.]	J. Betancur *et al.* 431 (US)		lb	−26.0	1750
G. lehmanniana (Wittm.) Mez	S. Espinoza 730 (MO)	1991	ll	−26.3	1200
G. cf. *lepidota* (André) André ex Mez	A. Gentry 80286 (SEL)	1993	lb	−22.1	2090
G. lindenii (André) André ex Mez	S. Knapp & P. Alcorn 7346A (MO)		ll	−28.3	
G. lingulata (L.) Mez†	R. Liesner 14097 (MO)	1983	ll	−28.0	
G. lingulata var. *flammea* (L.B.Sm.) L.B.Sm.†	C. Dodson 8922 *et al.* (MO)	1979	ll	−24.0	
G. longipetala (Baker) Mez	C. Aulestia *et al.* 807 (MO)		ll	−29.4	900
G. lychnis L.B.Sm.	R. Liesner *et al.* 12962 (MO)		ll	−22.9	1600–1900
G. macropoda L.B.Sm.	S. Mori 7993 (MO)		ll	−29.8	1000
G. madisonii H.Luther†	D. Neill & W. Palacios 9543 (MO)	1990	ll	−26.3	1000–1200
G. madisonii H.Luther (= *G. condorensis* H.Luther)†	H. van der Werff *et al.* 13228 (MO)	1994	ll	−34.9	900–1200
G. marantoidea (Rusby) H.Luther	P. Barbour 2808 (US)		ll	−30.9	2187
G. megastachya (Baker) Mez	D. Nicholson 4078 (US)		ll	−29.3	1060
G. melinonis Regel†	D. Neill 6113 *et al.* (MO)	1985	ll	−26.0	1100
G. melinonis Regel†	M. Tirado 96 *et al.* (SEL)	1993	ll	−28.9	350
G. membranacea L.B.Sm. & Steyerm.	G. McPherson 10625 (MO)		ll	−30.8	950
G. mitis L.B.Sm.	R. Liesner *et al.* 8128 (MO)		ll	−27.0	2285–3290
G. monostachia (L.) Rusby ex Mez	R. Liesner 15282 *et al.* (MO)	1983	ll	−25.1	525–600
G. morreniana Mez	D. Smith 4461 (MO)	1983	ll	−28.4	1750
G. mosquerae (Wittm.) Mez	A. Gentry 80484 (MO)		ll	−27.0	2500
G. mucronata (Griseb.) Mez	R. Liesner & A. González 9863 (MO)		ll	−24.8	1200–1800
G. multiflora (André) André ex Mez	A. Hirtz 1787 (MO)		ll	−22.4	2800
G. musaica (Linden & André) Mez	A. Chacón 278 (MO)		ll	−24.7	810
G. nicaraguensis Mez & Baker ex Mez	B. Holst 5663 (MO)		ll	−31.2	700
G. nidularioides L.B.Sm.	J. Betancur *et al.* 5965 (MO)		ll	−25.3	1420–1610
G. nubicola L.B.Sm.	J. Betancur *et al.* 447 (US)		ll	−25.6	1910
G. nubigena L.B.Sm.	R. Liesner & J. Steyermark 12395 (MO)		ll	−27.1	1200–1300
G. obtusiloba L.B.Sm.	L. Gómez 18735 (MO)	1982	ll	−30.7	1300–1800
G. pallida L.B.Sm.	R. Romero Castañeda 6949 (US)		lb	−21.8	1300
G. panamensis L.B.Sm. & Read ms.	A. Gentry & E. Renteria 24035 (MO)	1979	ll	−25.8	250
G. paniculata Mez	W. Palacios & M. Tirado 13061 (MO)	1995	ll	−30.9	2300
G. patula Mez & Wercklé	J. Morales 2107 *et al.* (MO)		ll	−28.7	1050
G. pearcei (Baker) L.B.Sm.	B. Øllgaard 35917 *et al.* (MO)		ll	−29.8	2000
G. pennellii L.B.Sm.	B. Øllgaard & H. Balslev 9469 (MO)		ll	−25.9	2800–2950
G. plicatifolia L.B.Sm.†	S. Ingram & K. Ferrell-Ingram 1340 (MO)	1992	ll	−27.8	1500–1550
G. plicatifolia L.B.Sm.†	J. Morales 2868 & G. Carnevali (SEL)	1994	br	−31.4	1250
G. plumieri (Griseb.) Mez†	K. Chambers 2760 (VEN)		ll	−23.8	1400
G. plumieri (Griseb.) Mez†	T. Aitken *et al.* 475 (US)		br	−27.2	933
G. polycephala Mez & Wercklé ex Mez	T. Croat 36033 (MO)		ll	−29.3	1270–1350
G. pungens L.B.Sm.	M. & R. Foster 2076 (US)		ll	−27.2	1167
G. puyoensis Rauh	H. Beltran 765 & R. Foster (SEL)	1994	ll	−31.2	1200
G. cf. *radiata* L.B.Sm.	J. Kent *s.n.* (SEL)		ll	−26.7	ca. 1300
G. rauhiana H.Luther	W. Berg *s.n.* (SEL)	1991	lb	−22.1	
G. regalis H.Luther	Luther 2779 *et al.* (MO)	1989	ll	−26.6	600
G. remyi L.B.Sm.	J. Clark 1585 *et al.* (MO)		ll	−27.7	350
G. retusa L.B.Sm.	J. Clark *et al.* 3122 (MO)		ll	−27.3	1100
G. rhonhofiana Harms	J. Clark 3020 (MO)		ll	−28.1	500
G. roezlii (E.Morren) Mez	D. Smith *et al.* 13296 (MO)		lb	−27.3	700–800
G. rosea L.B.Sm.	H. Herrera 1094 *et al.* (MO)		ll	−30.4	50–150
G. roseiflora Rauh	A. Gentry & G. Shupp 26620 (SEL)	1979	lb	−27.5	2230
G. rubrolutea Rauh	W. Berg *s.n.* (SEL)	1993	ll	−28.8	1280
G. rugosa L.B.Sm. & Read	W. Kress & B. Echeverry 89-2608 (SEL)	1989	lb	−28.0	2000
G. sanguinea (André) André ex Mez	L. Gómez 3272 (MO)	1970	ll	−26.7	
G. scandens H.Luther & Kress	J. Morales 2518 (MO)	1994	ll	−34.5	1500
G. scherzeriana Mez	B. Hammel & J. Trainer 13167 (MO)	1982	ll	−29.5	100
G. septata L.B.Sm.	E. Asplund 19679 (US)		lb	−24.7	900
G. sibundoyorum L.B.Sm.	J. Folsom 5941 & R. Page (MO)	1977	ll	−32.7	1000
G. skotakii H.Luther	J. Grant 91-01510 & C. Skotak (SEL)	1991	ll	−26.0	

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	δ13C (‰)	Elevation¶ (m)
G. sneidernii L.B.Sm.	J. Betancur & F. Roldán 2570 (SEL)	1991	ll	−26.7	1650–1800
G. spectabilis (Mez & Wercklé) Utley	Berg & Anderson 124 (SEL)	1995	ll	−28.4	575
G. sphaeroidea (André) André ex Mez	T. Croat 68655 (MO)	1988	ll	−26.5	700–750
G. sprucei (André) L.B.Sm.	J. Solomon 19255 (MO)	1990	ll	−27.5	1200
G. squarrosa (Mez & Sodiro) L.B.Sm. & Pittendr.	R. Liesner 12754 *et al.* (MO)	1982	ll	−24.1	1300–1500
G. stenostachya L.B.Sm.	T. Croat 36178 (MO)	1976	ll	−30.5	1500–1600
G. steyermarkii L.B.Sm.†	J. Steyermark & S. Nilsson 71 (US)		lb	−29.7	1060
G. steyermarkii L.B.Sm.†	J. Steyermark *et al.* 92326 (VEN)		ll	−29.1	950–1400
G. cf. *stricta* L.B.Sm.	P. Tristram *s.n.* (SEL)	1995	ll	−28.2	
G. strobilantha (Ruiz & Pav.) Mez	D. Smith 3850 (MO)	1983	ll	−28.5	300
G. subcorymbosa L.B.Sm.	J. Grant 90-00800 *et al.* (MO)		ll	−27.1	
G. terrestris L.B.Sm. & Steyerm.	J. Steyermark & B. Holst 130823 (MO)		ll	−26.2	2520–2650
G. testudinis L.B.Sm. & Read†	D. Rubio 1554 *et al.* (SEL)	1991	ll	−28.2	1800
G. testudinis var. *splendida* H.Luther†	H. van der Werff 11884 *et al.* (MO)	1991	ll	−29.7	700
G. teuscheri L.B.Sm.	M. Kessler 2647 (SEL)	1991	ll	−27.2	900
G. triangularis L.B.Sm.	J. Betancur 550 *et al.* (MO)		ll	−26.3	2650
G. undulatobracteata (Rauh) Rauh	H. Balslev & E. Madsen 10388 (MO)		ll	−25.0	1900–2000
G. van-volxemii (André) André ex Mez	W. Hoover & S. Wormley 1442 (MO)		ll	−28.8	1700
G. variegata L.B.Sm.	Luther *et al.* 2763 (MO)		ll	−26.4	2000
G. ventricos (Griseb.) Mez	J. Steyermark *et al.* 127854 (MO)		ll	−27.0	2100–2240
G. verecunda L.B.Sm.	W. Kress & B. Echeverry 89-2607 (SEL)	1989	lb	−25.5	2000
G. vittata (Mart. ex Schult. & Schult.f.) Mez	J. Ruíz 1318 (MO)	1988	ll	−31.1	122
G. weberbaueri Mez	D. Neill 5797 *et al.* (MO)	1985	lb	−25.9	1100
G. wittmackii (André) André ex Mez	G. Tipaz *et al.* 1048 (MO)	1992	ll	−29.1	3200
G. xanthobractea Gilmartin	T. Croat 72078 (MO)	1992	ll	−27.3	1850–1950
G. xipholepis L.B.Sm.	D. Smith *et al.* 7832 (MO)	1984	ll	−25.8	2500
G. zahnii (Hook.f.) Mez	Anon. (MO 209308)		ll	−24.0	
G. zakii H.Luther	V. Zak 4017 (MO)	1989	ll	−28.5	320
***Mezobromelia* L.B.Sm.**					
M. bicolor L.B.Sm.	C. & P. Dodson 14050 *et al.* (MO)	1983	br	−23.5	2150
M. capituligera (Griseb.) J.R.Grant	A. Alvarez 866 *et al.* (MO)	1993	ll	−24.1	2200–2400
M. fulgens L.B.Sm.	C. Dodson *et al.* 10516 (SEL)	1980	ll	−23.9	2800
M. hospitalis (L.B.Sm.) J.R.Grant	R. Romero 7757 (MO)	1959	ll	−22.9	2600–2800
M. lyman-smithii Rauh & Barthlott	H. van der Werff 12520 *et al.* (MO)	1991	ll	−25.5	2300
M. magdalenae (L.B.Sm.) J.R.Grant	R. Romero C. 8253 (MO)	1960	ll	−21.1	1300–1400
M. pleiosticha (Griseb.) Utley & H.Luther†	J. Dwyer 8748 & B. Lallathin (MO)	1968	ll	−22.1	1500–1833
M. pleiosticha (Griseb.) Utley & H.Luther†	J. Morales & E. Lépiz 3072 (MO)	1994	ll	−25.5	1200
***Racinaea* M.A.Spencer & L.B.Sm.**					
R. adpressa (André) J.R.Grant	C. Dodson & L. Bermeo 15721 (MO)	1985	ll	−26.1	1050–1300
R. aeris-incola (Mez) M.A.Spencer & L.B.Sm.	G. Hatschbach 19239 (US)		lb	−26.8	
R. blasii (L.B.Sm.) M.A.Spencer & L.B.Sm.	Cathcart & Berg *s.n.* (SEL)	1990	ll	−26.3	2000
R. commixa (Mez) M.A.Spencer & L.B.Sm.	W. Rauh 20469 (US)		lb	−22.4	
R. contorta (Mez & Pittier) M.A.Spencer & L.B.Sm.	L. Gómez *et al.* 21195 (MO)	1984	ll	−26.5	700
R. crispa (Baker) M.A.Spencer & L.B.Sm.	J. Duke & T. Elias 13786 (MO)	1967	ll	−26.5	830–1500
R. cuspidata (L.B.Sm.) M.A.Spencer & L.B.Sm.	Rauh & Hirsch P2257 (US)		lb	−22.0	3100
R. dielsii (Harms) H.Luther	A. Gentry *et al.* 30905 (MO)	1981	ll	−27.0	1540–1600
R. diffusa (L.B.Sm.) M.A.Spencer & L.B.Sm.	A. López *et al.* 7395 (US)		lb	−20.0	2100
R. elegans (L.B.Sm.) M.A.Spencer & L.B.Sm.	J. Manzanares 5253 (MO)	1994	lb	−26.3	2400
R. euryelytra J.R.Grant	J. Raack 3 (SEL)	1997	ll	−22.3	3533
R. flexuosa (Baker) M.A.Spencer & L.B.Sm.	M. Kessler 12495 (SEL)	1997	lb	−23.8	2600
R. fraseri (Baker) M.A.Spencer & L.B.Sm.	M. & R. Foster 2201 (US)		ll	−20.1	3333
R. ghiesbreghtii (Baker) M.A.Spencer & L.B.Sm.	J. Rzedowski 19611 (US)		ia	−23.6	
R. gilmartiniae (L.B.Sm.) M.A.Spencer & L.B.Sm.	C. Dodson *et al.* 10682 (SEL)	1981	ll	−24.1	3110
R. homostachya (André) M.A.Spencer & L.B.Sm.	C. Cerón M. & C. Iguago 5644 (SEL)	1988	ll	−21.8	1800–2250
R. insularis (Mez) M.A.Spencer & L.B.Sm.	H. Schimpff *s.n.* (MO)		ll	−25.3	250
R. jenmanii (Baker) M.A.Spencer & L.B.Sm.	B. Holst & F. Oliva-Esteve 3811 (MO)	1987	lb	−24.7	1700–1800
R. kessleri H.Luther	M. Kessler *et al.* 7254 (SEL)		ll	−24.0	2200
R. michelii (Mez) M.A.Spencer & L.B.Sm.	M. de F. & Alvarez & Gallego 444 (US)		lb	−28.1	2250
R. miniata (Rauh) J.R.Grant	H. Beltran 879 & R. Foster (SEL)	1994	ll	−27.8	1500–1800
R. monticola (Mez & Sodiro) M.A.Spencer & L.B.Sm.	H. van der Weff *et al.* 12217 (SEL)	1991	lb	−24.5	1850
R. multiflora (Benth.) M.A.Spencer & L.B.Sm. var. *decipiens* (André) M.A.Spencer & L.B.Sm.	J. Manzanares 5297 (MO)	1989	br	−26.5	150
R. nervibracteata (Gilmartin & H.Luther) J.R.Grant	P. Ibisch & C. Ibisch (SEL)	1993	ll	−22.7	2100
R. pallidoflavens (Mez) M.A.Spencer & L.B.Sm.	R. Foster 9043 (MO)		ll	−24.9	2700–2800
R. pardina (L.B.Sm.) M.A.Spencer & L.B.Sm.	M. Kessler *et al.* 9871 (SEL)	1997	ll	−26.9	1450
R. parviflora (Ruiz & Pav.) M.A.Spencer & L.B.Sm.	P. Barbour 2658 (US)		ll	−26.8	1900
R. pectinata (André) M.A.Spencer & L.B.Sm.	M. Peñafiel *et al.* 345 (MO)	1991	lb	−21.3	3100–3400
R. penduliflora Gouda & Manzan.	S.J. Heathcote *s.n.* (OXF)		ll.	−29.7	2739
R. pendulispica (Mez) M.A.Spencer & L.B.Sm.	J. Boeke 2107 (US)		lb	−21.9	
R. penlandii (L.B.Sm.) M.A.Spencer & L.B.Sm.	D. Smith 2714 (MO)	1982	ll	−26.3	2080

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	δ13C (‰)	Elevation¶ (m)
R. pseudotetrantha (Gilmartin & H.Luther) J.R.Grant	X. Cornejo & C. Bonifaz 87 (SEL)	1993	ll	−24.8	500
R. pugiformis (L.B.Sm.) M.A.Spencer & L.B.Sm.	A. Gilmartin 1152 (US)		ll	−21.2	2300
R. quadripinnata (Mez & Sodiro) M.A.Spencer & L.B.Sm.	X. Cornejo & C. Bonifaz 3290 (SEL)	1994	ll	−21.8	1800–1900
R. riocreuxii (André) M.A.Spencer & L.B.Sm.	J. Hawkes & H. Garcia B. 32 (US)		ll	−23.9	2950
R. ropalocarpa (André) M.A.Spencer & L.B.Sm.	D. Rubio & C. Quelal 600 (MO)	1990	lb	−24.0	3000
R. rothschuhiana (Mez) M.A.Spencer & L.B.Sm.†	E. Martínez 18683 & M. Soto (MO)	1986	ll	−25.1	
R. rothschuhiana Mez [= *R. adscendens* (L.B.Sm.) M.A.Spencer & L.B.Sm.]†	W. Harmon & J. Fuentes 2171 (MO)	1970	lb	−23.8	1200–1350
R. sanctae-martae (L.B.Sm.) M.A.Spencer & L.B.Sm.	J. Kirkbride 2396 (US)		lb	−26.1	1700–1900
R. schumanniana (Wittm.) J.R.Grant	W. Palacios 11396 (MO)	1993	lb	−30.5	900
R. seemannii (Baker) M.A.Spencer & L.B.Sm.	W. Palacios 12476 (MO)	1994	ll	−30.2	2800
R. sinuosa (L.B.Sm.) M.A.Spencer & L.B.Sm.	J. Manzanares & K. Broeke 5298 (MO)	1989	br	−22.2	2400
R. spiculosa (Griseb.) M.A.Spencer & L.B.Sm.	J. Morales & E. Lépiz 2653 (MO)	1994	ll	−25.9	900–1200
R. subalata (André) M.A.Spencer & L.B.Sm.	F. Pennell 7564 (US)		lb	−24.6	2400–2700
R. tandapiana (H.Luther) M.A.Spencer & L.B.Sm.	C. Dodson & A. Gentry 9590 (MO)	1980	ll	−26.5	1400
R. tenuispica (André) M.A.Spencer & L.B.Sm.	Steyermark *et al*. 126928 (US)		ll	−24.1	1170
R. tetrantha (Ruiz & Pav.) M.A.Spencer & L.B.Sm.	W. Palacios & G. Tipaz 9905 (MO)	1992	lb	−25.4	3400
R. trapeziformis (Mez) M.A.Spencer & L.B.Sm.	J. Luteyn & R. Callejas 12505 (NY)		ll	−28.6	1800–1850
R. tripinnata (Baker) M.A.Spencer & L.B.Sm.	J. Manzanares 5433 (MO)	1992	lb	−23.6	2200
R. undulifolia (Mez) H.Luther	M. Madison 3549 *et al*. (SEL)	1976	lb	−26.2	2000
***Tillandsia* L.**					
T. abbreviata H.Luther	H. Luther *s.n.* (SEL)	1979	lb	−24.3	
T. achyrostachys E.Morren ex Baker	R. Torres C. & J. Villaseñor 5059 (MO)		lb	−14.7	1050
T. acosta-solisii Gilmartin	T. Croat 57092 (MO)		ll	−28.6	900
T. acuminata L.B.Sm.	M. Kessler *et al*. 12524 (SEL)	1997	lb	−22.6	2750
T. adamsii Read	G. Proctor 21334 (US)		lt	−26.3	667–733
T. adpressiflora Mez	W. Anderson 12299 (US)		ll	−26.2	220
T. aeranthos (Loisel.) L.B.Sm.	D. Seigler & B. Soraru DS-10102 (MO)		lt	−16.1	
T. aizoides Mez	A. Grauitfelsin 253 (MO)		ll	−13.4	
T. albida Mez & Purpus	D. Barry Jr. 68 (US)		lt	−21.9	
T. amicorum I.Ramírez & Bevil.	G. Davidse *et al*. 20827 (VEN)		ll	−28.7	1200–1300
T. anceps Lodd.	B. Holst 4046 (MO)		lb	−28.0	700–750
T. andicola Gillies ex Baker	Schreiter 6415 (US)		ll	−12.0	1500
T. andreana E.Morren ex André	A. Alston 5716 (US)		ll	−13.7	200
T. andrieuxii (Mez) L.B.Sm.	D. Cathcart *s.n.* (SEL)		ll	−23.4	
T. antillana L.B.Sm.	G. Proctor 9269 (US)		br	−11.4	667
T. appenii (Rauh) J.R.Grant (= *Vriesea appenii* Rauh)	Cathcart & Berg *s.n.* (SEL)	1998	ll	−23.9	ca. 2000
T. araujei Mez	H. Luther *s.n.* (SEL)	1991	lb	−13.9	
T. argentea Griseb.	D. Cathcart *s.n.* (SEL)	1991	ll	−13.3	
T. argentina C.H.Wright	W. Till 10260 (MO)		ll	−13.2	1280
T. arhiza Mez	G. Brown *s.n.*, SEL 83-112 (SEL)		ll	−18.4	
T. ariza-juliae L.B.Sm. & Jiménez	T. Zanoni 19580 *et al*. (SEL)	1982	lb	−15.4	600
T. asplundii L.B.Sm.	J. Betancur *et al*. 478 (MO)		ll	−14.2	30
T. atroviridipetala Matuda	D. Cathcart *s.n.* (SEL)	1993	ll	−15.2	
T. aurea Mez	C. Luer *et al*. 5375 (SEL)	1980	ll	−18.2	2600
T. australis Mez	J. Solomon 11032 (MO)		ll	−24.4	1600
T. baileyi Rose ex Small	B. Tharp *s.n.* (MO)		ll	−13.3	
T. balbisiana Schult. & Schult.f.	T. Croat 12309 (MO)		ll	−14.1	
T. baliophylla Harms	B. Holst 6294 *et al*. (SEL)	1997	ll	−23.1	1200
T. bandensis Baker	A. Schinini 13849 (US)		lt	−12.8	
T. barbeyana Wittm.	Anon. (US 2483768)		lb	−21.3	1900
T. barclayana Baker [= *Vriesea barclayana* (Baker) L.B.Sm.]	C. & P. Dodson 12950 (MO)		ll	−18.5	50
T. barthlottii Rauh	Luther *et al*. 696 (SEL)	1981	lb	−22.6	600
T. bartramii Elliott	A. Gentry & E. Zardini 51676 (MO)		ll	−14.0	
T. belloensis W.Weber	M. Nee 32850 (SEL)	1986	lb	−13.4	1200
T. bergeri Mez	H. Luther *s.n.* (SEL)		ll	−13.5	
T. bermejoensis H.Hrom.	D. Cathcart B16 (SEL)		ll	−13.8	ca. 1450
T. biflora Ruiz & Pav.	W. Stevens 18164 (MO)		ll	−25.1	2250–2400
T. boliviana Mez	M. Baug 2202 (MO)		lb	−22.1	
T. cf. *boliviensis* Baker	D. Cathcart B1 (SEL)		ll	−14.2	3000
T. cf. *bongarana* L.B.Sm.	A. Hirtz 4009 (SEL)	1989	lb	−28.6	2700
T. bourgaei Baker	P. Tenorio L. 5386 & C. Romero (MO)		lb	−13.5	2120
T. brachycaulos Schltdl.†	M. Grayum 7603 *et al*. (MO)		lb	−15.1	35–40
T. brachycaulos Schltdl. (= *T. cryptantha* Baker)†	D. Cathcart *s.n.* (SEL)		lb	−12.6	
T. brachyphylla Baker	H. Luther *s.n.* (SEL)		br	−14.3	
T. bradeana Mez & Tonduz (= *T. abdita* L.B.Sm.)	J. Morales & R. Abarca 2692 (MO)		ll	−13.4	1600–1800
T. brevilingua Mez	R. Foster & T. Wachter 7363 (MO)		ll	−28.2	700–1050
T. bryoides Griseb. ex Baker†	H. Iltis *et al*. 829 (US)		ll	−13.3	2300–2500
T. bryoides Griseb. ex Baker [= *T. pedicellata* (Mez) A.Cast.]†	W. Till 10333 (MO)		ll	−14.6	1750
T. bulbosa Hook.	G. Davidse & A. Brant 32091 (MO)		lb	−12.4	300–620

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	δ13C (‰)	Elevation¶ (m)
T. buseri Mez	Luther *et al.* 2738 (US)		ll	−24.0	1500
T. butzii Mez	J. Morales 1683 (MO)		lb	−13.1	1550
T. cacticola L.B.Sm.	I. Sánchez V. 26 (US)		ll	−17.2	2000
T. caerulea Kunth	J. Odom 34 (US)		lt	−19.1	0
T. calcicola L.B.Sm. & Proctor	G. Proctor 34951 (MO)		lb	−12.9	430
T. califani Rauh	W. Rauh 15447 (US)		lb	−14.7	
T. caliginosa W.Till	W. Till 10092 (MO)		ll	−12.9	2040
T. calothyrsus Mez†	R. McVaugh 14216 (US)		lb	−12.5	1300–1600
T. calothyrsus Mez†	T. MacDougall 4B (US)		lb	−13.1	
T. caloura Harms	R. Romero C. 7685 (MO)		ll	−24.6	2600–2800
T. camargoensis L.Hrom.	P. & C. Ibisch 93.1202 (SEL)		ll	−14.4	3000
T. canescens Sw.	G. Proctor 38039 (MO)		ll	−13.4	1030
T. capillaris Ruiz & Pav.†	J. Solomon 5880 (MO)		ll	−13.8	ca. 3100
T. capillaris forma *virescens* (Ruiz & Pav.) L.B.Sm. (= *T. virescens* Ruiz & Pav.)†	G. Sullivan *et al.* 1097 (MO)		ll	−12.6	1000–3000
T. capitata Griseb.	O. Téllez 9114 (MO)		ll	−13.6	
T. caput-medusae E.Morren	W. Stevens 2617 (MO)		ll	−15.4	
T. cardenasii L.B.Sm.	M. Kessler *et al.* 4832 (SEL)	1995	ll	−14.4	2100
T. carlos-hankii Matuda	G. Martin 511 (MO)		ll	−20.8	2100
T. carlsoniae L.B.Sm.	D. Cathcart *s.n.* (SEL)	1997	ll	−19.1	2000
T. carminea W.Till	R. Ehlers *s.n.* (SEL)		lb	−16.5	1800
T. carnosa L.B.Sm.	M. Kessler 9630 *et al.* (SEL)	1997	ll	−16.9	2100
T. castellanii L.B.Sm.	A. Schinini & R. Vanni 22524 (MO)		ll	−12.9	3000
T. caulescens Brongn. ex Baker	M. Kessler 5808 *et al.* (SEL)		ll	−14.8	850
T. cauliflora Mez & Wercklé ex Mez	P. Tristram *s.n.* (SEL)	1990	br	−26.4	1000
T. cauligera Mez	E. Killip & A. Smith 21803 (US)		ll	−12.3	3000–3200
T. cereicola Mez [= *Vriesea cereicola* (Mez) L.B.Sm.]	A. Sagástegui 9792 (MO)		ll	−13.5	1000
T. cernua L.B.Sm.	M. Foster 2621 (US)		lb	−21.6	4000
T. cerrateana L.B.Sm.	D. Smith 11982 *et al.* (MO)		ll	−20.0	3800–3900
T. chaetophylla Mez	A. Campos V. & R. Torres 1565 (MO)		ll	−24.4	2020
T. chiapensis C.S.Gardner	D. Breedlove 27395 (MO)		ll	−12.2	800–1000
T. chlorophylla L.B.Sm.	P. Valdivia Q. 1588 (MO)		ll	−17.6	156
T. chontalensis (Baker) L.B.Sm. [= *Vriesea chontalensis* (Baker) L.B.Sm.]	R. Liesner 248 (MO)		lb	−26.0	1150
T. circinnatoides Matuda	D. Lorence 3374 *et al.* (MO)		lb	−14.3	2200
T. clavigera Mez†	J. Raack 2 (SEL)		ll	−31.2	
T. clavigera Mez var. *clavigera* (= *T. brevicapsula* Gilmartin)†	A. Gentry 80358 (MO)		ll	−26.8	
T. cochabambae E.Gross & Rauh	M. Kessler *et al.* 4676 (SEL)	1995	lb	−15.0	2900
T. coinaensis Ehlers	D. Smith & R. Vásquez M. 3260 (MO)		ll	−23.1	2550
T. comarapaensis H.Luther	M. Kessler 4605 *et al.* (SEL)		ll	−13.1	2500
T. compacta Griseb.†	D. Luz Echeverry & J. Pineda 24 (US)		ll	−22.6	3000
T. compacta Griseb.†	Steyermark & M. Rabe 95973 (US)		ll	−21.9	1750
T. complanata Benth.	D. Wasshausen & F. Encarnación 874 (US)		lb	−23.9	1200
T. compressa Bertero ex Schult. & Schult.f. (= *T. jaliscomonticola* Matuda)	P. Magaña 42 & E. Lott (MO)		lb	−12.4	
T. concolor L.B.Sm.	B. Hansen & M. Nee 7461 (MO)		lb	−18.6	250
T. confertiflora André	A. Sagástegui & J. Cabanillas 8692 (US)		ll	−25.0	2650
T. confinis L.B.Sm.	T. Croat 73436 (MO)		lb	−26.9	1180
T. copanensis Rauh & Rutschm.	H. Luther *s.n.* (SEL)	1992	lb	−14.1	
T. cornuta Mez & Sodiro	J. Clark 429 (MO)		ll	−33.2	400–600
T. cossonii Baker	H. Beltz *s.n.* (SEL)	1984	lb	−22.7	2300
T. cretacea L.B.Sm.	M. Dimmitt 1981-060-02 *et al.* (MO)		lb	−20.6	
T. crocata (E.Morren) N.E.Br.	G. Hatschbach 9796 (US)		ll	−12.1	1000
T. cryptopoda L.B.Sm.	O. Rohweder 134 (MO)		ll	−27.6	2350
T. cuatrecasasii L.B.Sm.	J. Cuatrecasas 20599 (US)		lb	−23.7	3400–3550
T. cucullata L.B.Sm.	A. Alvarez 459 *et al.* (MO)		lb	−21.7	2250
T. cyanea Linden ex K.Koch†	Berendsohn 288 (MO)	1985	lb	−20.1	805
T. cyanea Linden ex K.Koch (= *T. lindenii* Regel)†	C. Díaz & S. Baldeón 2453 (SEL)	1987	ll	−26.5	1500–1900
T. dasyliriifolia Baker	G. Davidse & A. Brant 32672 (MO)		ll	−11.1	1
T. deflexa L.B.Sm.	T. Yuncker *et al.* 5932 (MO)		ll	−26.5	1350
T. delicatula L.B.Sm.	W. Kress & B. Echeverry 89-2620 (US)		lb	−26.5	2000
T. demissa L.B.Sm.	A.J.G. 1154 (US)		lb	−19.3	2300
T. denudata André	J. Steyermark & R. Liesner 118278 (MO)		ll	−25.5	2150–2300
T. deppeana Steud.	F. Ventura 1145 (MO)		lb	−24.6	
T. dexteri H.Luther	C. Skotak *s.n.* (SEL)	1988	ll	−14.2	800
T. dichrophylla L.B.Sm.	L. Albert *et al.* 7295 (US)		ll	−25.2	2850
T. didisticha (E.Morren) Baker	A. Gentry *et al.* 75215 (MO)		ll	−16.7	350
T. didistichoides Mez [= *Vriesea didistichoides* (Mez) L.B.Sm.]	R. Liesner & A. González 9871 (MO)		ll	−25.9	1200–1800
T. diguetii Mez & Rol.-Goss.	Mooney, Bullock & Ehleringer (1989)		ll	−14.2	

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	δ13C (‰)	Elevation¶ (m)
T. disticha Kunth	M. Foster 2614 (US)		ll	−17.8	1000
T. dodsonii L.B.Sm.	G. Tipaz & C. Quelal 689 (MO)		ll	−23.1	650
T. dugesii Baker	E. Matuda 38538 (US)		ll	−12.7	1900
T. dura Baker	D. Cathcart *s.n.* (SEL)	1991	ll	−12.0	
T. durangensis Rauh & Ehlers	W. Berg *s.n.* (SEL)		br	−14.5	
T. duratii Vis.	M. Lewis 37187 (MO)		ll	−12.8	1300–1500
T. dyeriana André	C. Dodson & A. Embree 13098 (SEL)	1982	lb	−24.6	1
T. edithae Rauh	M. Kessler *et al*. 12314 (SEL)	1987	ll	−13.8	1150
T. eistetteri Ehlers	E. Lott 1625 & J. Wendt (MO)		ll	−15.9	
T. eizii L.B.Sm.	R. Thorne & E. Lathrop 46712 (SEL)	1971	lb	−27.8	1800
T. elizabethae Rauh	R. Felger 687 (MO)		ll	−13.5	
T. elongata Kunth†	W. Stevens 22895 (MO)		ll	−13.9	100
T. elongata var. *subimbricata* (Baker) L.B.Sm.†	R. Liesner *et al*. 12047 (US)		ll	−16.9	200–250
T. elvirae-grossiae Rauh	H. Beltrán & R. Foster 1312 (SEL)	1994	ll	−25.8	1200–1400
T. emergens Mez & Sodiro	W. Drew E-142 (US)		ll	−25.1	3600
T. engleriana Wittm.	St. G. Beck 3138 (US)		lb	−23.2	2410
T. erecta Gillies ex Baker	B. Adolfo M. 265 (US)		ll	−12.3	2610
T. erubescens Schltdl.	R. Felger 94-244 *et al*. (MO)		lb	−15.3	1600
T. espinosae L.B.Sm. [= *Vriesea espinosae* (L.B.Sm.) Gilmartin]	P. Barbour 2158 (MO)		ll	−15.2	500
T. excelsa Griseb.	J. Folsom 8705 (MO)		ll	−29.0	100
T. exserta Fernald	Y. Mexia 337.5 (MO)		ll	−13.7	267
T. extensa Mez	P. Koide *s.n.* (SEL)	1988	lb	−18.8	500–700
T. fasciculata Sw.†	A. Curtiss 5489 (MO)		lb	−11.9	
T. fasciculata Sw. var. *fasciculata* (= *T. beutelspacheri* Matuda)†	H. Luther *s.n.* (SEL)	1994	lb	−19.9	
T. fassettii L.B.Sm.	N. Fassett 25434 (US)		lb	−26.0	2067
T. fendleri Griseb.	T. Zanoni & M. Mejía 12390 (MO)		ll	−23.0	1590
T. ferreyrae L.B.Sm.	D. Smith & S. Vásquez S. 4969 (SEL)	1983	ll	−19.8	2220–2380
T. ferrisiana L.B.Sm.	A. Carter & F. Chisaki 3608 (US)		lb	−12.9	630
T. festucoides Brongn. ex Mez	G. Davidse 36890 (MO)		ll	−14.6	400
T. filifolia Schltdl. & Cham.	G. Davidse 35804 (MO)		ll	−27.2	260
T. flabellata Baker	D. Breedlove 33779 (MO)		ll	−15.1	1000
T. flagellata L.B.Sm.	M. Kessler 2276 (SEL)	1991	ll	−19.4	1000
T. flexuosa Sw.	R. Schmalzel 684 (MO)		ll	−13.2	
T. floribunda Kunth	L. Moore *s.n.* (MO)		ll	−17.2	
T. × *floridana* (L.B.Sm.) H.Luther	C. Evans 4 (SEL)	1989	ll	−14.7	
T. foliosa M.Martens & Galeotti	C. Purpus 8879 (MO)		ll	−12.4	
T. fragrans André [= *Vriesea fragrans* (André) L.B.Sm.]	R. Romero 7887 (MO)		lb	−22.4	1800–2300
T. frank-hasei J.R.Grant (= *Vriesea hasei* Ehlers)	F. Oliva 220 (SEL)	1992	ll	−23.3	1800
T. fuchsii W.Till var. *fuchsii* forma *gracilis* W.Till	A. Molina R. 30230 *et al*. (MO)		ll	−21.1	2000
T. funckiana Baker	D. Cathcart *s.n.* (SEL)	1991	ll	−11.0	
T. funebris A.Cast.	G. Navarro 1604B (MO)		ll	−16.2	400
T. fusiformis L.B.Sm.	A. Hirtz 139 *et al*. (SEL)	1981	ll	−25.2	3100
T. gardneri Lindl.	J. Steyermark 115517 *et al*. (MO)		ll	−12.0	1160
T. geissei Phil.†	Rundel & Dillon (1998)		ll	−13.2	
T. geissei Phil.†	G. Zizka 8160 (FR)		ll	−15.8	
T. geminiflora Brongn.	E. Zardini 7777 (MO)		ll	−14.5	
T. gilliesii Baker	G. Lorentz *s.n.* (US)		ll	−12.9	
T. glauca L.B.Sm.	H. Luther *s.n.* (SEL)	1994	lb	−26.5	1750
T. globosa Wawra	R. Liesner 7815 *et al*. (MO)		ll	−16.8	600–900
T. grandis Schltdl.	D. Breedlove 34445 (MO)		ll	−25.8	2100–2500
T. grao-mogolensis Silveira	D. Cathcart *s.n.* (SEL)	1992	ll	−13.8	
T. guatemalensis L.B.Sm.	M. Huft 2166 *et al*. (MO)		ll	−25.3	2400
T. guelzii Rauh	H. Luther *s.n.* (SEL)		lb	−14.2	
T. guerreroensis Rauh	P. Isley *s.n.* (SEL)	1986	ll	−14.7	
T. gymnobotrya Baker	A. García & R. Torres 2036 (MO)		lb	−23.9	2360
T. hamaleana E.Morren	M. Kessler 2432 (SEL)	1991	ll	−24.1	1450
T. harrisii Ehlers	M. Prince *s.n.* (SEL)	1991	lb	−13.7	
T. hemkeri Rauh	Tristram 5 (SEL)		ll	−27.7	
T. heterandra André [= *Vriesea heterandra* (André) L.B.Sm.]	J. Steyermark & R. Liesner 118626 (MO)		lb	−25.3	2150–2300
T. heteromorpha Mez	Rauh 35344/73 (US)		ll	−13.3	600–800
T. heterophylla E.Morren	T. Croat 39543 (MO)		lb	−28.1	1260–1400
T. heubergeri Ehlers	R. Ehlers *s.n.* (SEL)		br	−14.8	1000
T. hintoniana L.B.Sm.	E. Matuda 30516 (US)		ll	−24.5	1500
T. hirta W.Till & H.Hrom.	G. Tate 1196 (NY)		ll	−13.1	2533
T. hirtzii Rauh	C. & P. Dodson 14010 *et al*. (SEL)	1983	ll	−23.2	1850
T. hondurensis Rauh	H. Luther *s.n.* (SEL)	1996	lb	−16.3	1200
T. hotteana Urban	M. Mejía & T. Zanoni 8401 (MO)		ll	−21.2	1600
T. huarazensis Ehlers & W.Till	J. Mezas *s.n.* (SEL)	1993	ll	−15.0	
T. humilis Presl†	D. Smith *et al*. 11710 (US)		ll	−18.1	3800

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	δ[13]C (‰)	Elevation¶ (m)
T. humilis Presl†	W. Rauh 20568 (US)		lb	−16.0	3400
T. ignesiae Mez	E. Matuda 38504 (MO)		ll	−21.6	
T. imperialis E.Morren ex Roezl†	R. Torres 4983 & C. Martínez (MO)		lb	−24.5	
T. imperialis E.Morren ex Roezl (= *T. candelifera* Rohweder)†	P. Koide *s.n.* (SEL)	1993	ll	−19.8	
T. incarnata Kunth	C. Cerón & M. Cerón 5895 (MO)		ll	−12.9	2400–2550
T. indigofera Mez & Sodiro	A. Hirtz 1105 (SEL)		ll	−16.1	3000
T. intermedia Mez	B. Hansen *et al*. 1431 (SEL)	1973	ll	−15.9	100
T. interrupta Mez	A. Sagástegui *et al*. 14762 (SEL)	1992	lb	−19.5	2600
T. ionantha Planch.	J. Miller & F. Neill 397 (MO)		ll	−13.9	50–120
T. ionochroma André ex Mez	J. Solomon 14401 (MO)		ll	−25.4	2700
T. ixioides Griseb.	A. Gentry 51727 (MO)		ll	−14.2	1240
T. jucunda A.Cast.	S. Venturi 9479 (MO)		ll	−12.2	900
T. juncea (Ruiz & Pav.) Poir.†	J. Morales 1794 & R. Abarca (MO)		ll	−14.5	
T. juncea (Ruiz & Pav.) Poir. (= *T.* cf. *hammeri* Rauh & Ehlers)†	T. Croat & D. Hannon 65815 (MO)		ll	−13.3	1950
T. kalmbacheri Matuda	H. Luther *s.n.* (SEL)	1983	ll	−24.5	
T. kammii Rauh	H. Luther *s.n.* (SEL)	1994	lt	−15.2	
T. karwinskyana Schult. & Schult.f.	S. Gardner 301.1 (US)		lb	−14.4	600
T. kautskyi E.Pereira	H. Luther *s.n.* (SEL)		ll	−11.9	
T. kegeliana Mez	W. Stern *et al*. 896 (MO)		ll	−14.3	
T. kirchhoffiana Wittm.	A. Campos 3591 & R. Torres (MO)		ll	−22.9	1300
T. kolbii W.Till & Schatzl	C. Dodson 9500 *et al*. (SEL)	1980	ll	−13.2	1300
T. krukoffiana L.B.Sm.	M. Lewis 35108 (MO)		ll	−19.4	2680
T. cf. *kuntzeana* Mez	P. Ibisch *et al*. 93.1027 (SEL)	1993	ll	−26.5	2100
T. lajensis André	C. Cerón *et al*. 1817 (MO)		br	−22.6	1800–3356
T. laminata L.B.Sm.	C. Luer 9663 *et al*. (SEL)	1984	ll	−23.8	2750
T. lampropoda L.B.Sm.	E. Martínez 20010 *et al*. (MO)		ll	−26.3	
T. landbeckii Phil. ssp. *andina* W.Till var. *andina*	A. Tupayachi & W. Galiano 1200 (MO)		ll	−12.9	2900–4600
T. langlasseana Mez	P. Koide *s.n.* (SEL)	1993	br	−14.7	
T. latifolia Meyen var. *divaricata* (Benth.) Mez	H. Iltis *et al*. 828 (US)		lb	−14.3	2300–2500
T. lautneri Ehlers	Bush & Burch *s.n.* (SEL)	1980	lb	−22.8	ca. 2300
T. laxissima Mez	M. Rothenberg *s.n.* (SEL)	1981	ia	−27.7	
T. leiboldiana Schltdl.	B. Holst 5659 (MO)		ll	−28.0	700–750
T. leonamiana E.Pereira	H. Luther *s.n.* (SEL)		lb	−15.5	
T. lepidosepala L.B.Sm.	E. Matuda 38433 (MO)		lt	−13.3	2300
T. leucolepis L.B.Sm.	T. MacDougall 280 (US)		pd	−12.0	1667
T. limbata Schltdl.	G. Davidse 20112 *et al*. (MO)		ll	−13.3	10
T. linearis Vell.	G. Hatschbach 47848 (MO)		ll	−12.2	
T. × *lineatispica* Mez	P. Acevedo & A. Siaca 4170 (MO)		br	−12.1	
T. loliacea Mart. ex Schult. & Schult.f.	G. & L. Eiten 4935 (US)		ll	−14.5	
T. longifolia Baker	J. Wurdack 563 (US)		ll	−20.7	1800
T. lopezii L.B.Sm.	A. Lopez M. *et al*. 7563 (US)		lb	−21.5	3800
T. lorentziana Griseb.	W. Till 10119 (MO)		lb	−15.0	1300
T. lotteae H.Hrom. ex Rauh	J. Balcazar 40 (MO)		lb	−12.4	1600
T. lucida E.Morren ex Baker	D. Cathcart *s.n.* (SEL)	1991	ll	−23.0	
T. lymanii Rauh	H. & L. Hromadnik 2183 (SEL)	1976	lb	−18.5	1200
T. macdougallii L.B.Sm.	R. Torres C. 3959 *et al*. (MO)		lt	−20.8	2030
T. macrochlamys Baker	Luther *et al*. 2955 (SEL)	1993	ll	−23.4	2035
T. maculata Ruiz & Pav.	J. MacBride 5094 (US)		ll	−24.8	1167
T. magnusiana Wittm.	O. Rohweder 211 (MO)		lt	−18.1	1400
T. makoyana Baker	A. Gentry 63981 (MO)		ll	−13.9	50
T. mallemontii Glaz. ex Mez	G. Hatschbach 1201 (US)		lt	−11.9	
T. marabascoensis Ehlers & J.Lautner	H. Luther *s.n.* (SEL)		lb	−13.5	
T. marconae W.Till & Vitek	G. Zizka 8186 (FR)		ll	−15.3	
T. marnieri-apostollei L.B.Sm.	P. Peterson *et al*. 8911 (US)		lb	−14.6	1880
T. matudae L.B.Sm.†	D. Cathcart *s.n.* (SEL)	1991	ll	−16.8	
T. matudae L.B.Sm. (= *T. velickiana* L.B.Sm.)†	Cathcart *s.n.* (SEL)	1983	ll	−21.3	
T. mauryana L.B.Sm.	H. Luther *s.n.* (SEL)	1993	ll	−15.8	
T. micans L.B.Sm.	W. Galiano 2013 (SEL)	1990	ll	−14.3	2900–3700
T. mima L.B.Sm.	A. Silverstone-Sopkin *et al*. 2265 (MO)		lb	−15.0	975
T. monadelpha (E.Morren) Baker	P. Moreno & J. Sandino 14662 (MO)		ll	−28.6	10
T. montana Reitz	Reitz & Klein 7189 (US)		ll	−12.6	300
T. mooreana L.B.Sm.	R. Hernández 5242 *et al*. (MO)		lb	−18.1	1790
T. moscosoi L.B.Sm.	T. Zanoni 17365 *et al*. (MO)		lb	−19.6	1150
T. multicaulis Steudel	B. Holst & M. Meadows 5745 (MO)		ll	−27.1	800–900
T. myosura Griseb. ex Baker	E. García 2521 (SEL)	1991	ll	−11.6	3200
T. myriantha Baker	Steyermark *et al*. 110086 (US)		ll	−22.1	1600–1800
T. nana Baker	A. Tupayachi & W. Galiano 1150 (MO)		br	−16.7	2900–4600
T. narthecioides Presl	J. Clark & Y. Troya 638 (MO)		ll	−23.5	400–600
T. neglecta E.Pereira	Luther 2904 *et al*. (SEL)		ll	−11.9	250

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	δ13C (‰)	Elevation¶ (m)
T. nervata L.B.Sm.	P. Isley *s.n.* (SEL)	1983	br	−22.0	
T. nervisepala (Gilmartin) L.B.Sm.	B. Girko E90-191J (SEL)	1990	br	−25.6	1700
T. nolleriana Ehlers ex Rauh	D. Cathcart *s.n.* (SEL)	1995	ll	−24.6	1500
T. novakii H.Luther	R. Ehlers *s.n.* (SEL)	1990	ia	−16.4	
T. nuyooensis Ehlers	D. Cathcart *s.n.* (SEL)		ll	−22.9	
T. oaxacana L.B.Sm.	P. Koide 3 (SEL)	1983	lb	−26.7	ca. 2000
T. oerstediana L.B.Sm.	J. Utley & K. Utley 600 (MO)		lb	−24.2	
T. orbicularis L.B.Sm.	J. Cuatrecasas 18831 (MO)		lb	−22.8	3300–3350
T. orogenes Standl. & L.O.Williams	T. Hawkins 882 (MO)		lb	−28.8	1100–1600
T. ortgiesiana E.Morren ex Mez	C. Conzatti 1743 (US)		lb	−13.2	
T. pachyaxon L.B.Sm.	S. Dalstrom & L. Arnby 1324 (SEL)	1990	ll	−26.8	2800
T. pacifica Ehlers	R. Ehlers *s.n.* (SEL)		lb	−16.0	
T. paleacea Presl	W. Rauh 20727 (US)		ll	−12.5	3000
T. pamelae Rauh	P. Koide *s.n.* (MO)		br	−22.9	
T. paniculata (L.) L.	T. Zanoni 24472 *et al.* (MO)		ll	−15.4	280
T. paraensis Mez	J. Steyermark *et al.* 117304 (MO)		ll	−14.2	730–900
T. parryi Baker†	J. Anderson *s.n.* (SEL)	1991	ll	−19.2	ca. 1970
T. parryi Baker (= *T. sueae* Ehlers)†	P. Tristram 1 (SEL)	1988	ll	−24.2	
T. pastensis André	C. Cerón M. & M. Macías 1895 (MO)		ll	−25.5	1800–3356
T. paucifolia Baker	A. Curtiss 2845 (MO)		ll	−12.6	
T. peiranoi A.Cast.	L.B. Sm. 4654 (US)		lt	−13.0	
T. pinnata Mez & Sodiro	B. Bennett & P. Gómez 3413 (US)		ll	−25.8	
T. pinnatodigitata Mez	D. Smith & M. Buddensiek 10949 (MO)	1985	ll	−23.3	2870
T. plagiotropica Rohweder	H. Luther *s.n.* (SEL)	1994	ll	−15.2	
T. platyphylla Mez	P. Hutchison & J. Wright 3516 (MO)	1964	br	−13.8	
T. platyrhachis Mez	Schimpff 714 (MO)		ll	−23.7	
T. plumosa Baker	D. Lorence 3373 & A. García (MO)		ll	−15.0	2450
T. pohliana Mez	P. Núñez 8156 (MO)		ll	−13.3	1100–1550
T. polita L.B.Sm.	M. Foster & O. Van Hyning 2951 (US)		lb	−11.9	
T. polyantha Mez & Sodiro	G. Tipaz 993 *et al.* (MO)		ll	−27.1	2300–3000
T. polystachia (L.) L.	W. Harmon 2213 (MO)		ll	−12.8	
T. polzii Ehlers	H. Luther *s.n.* (SEL)		ll	−13.5	
T. ponderosa L.B.Sm.	E. Martínez S. 22437 *et al.* (MO)		ll	−22.0	2850–3000
T. pretiosa Mez	D. Neill & M. Asanza 10340 (MO)		ll	−27.9	1200
T. prodigiosa (Lem.) Baker†	M. Cházaro B. 42 (MO)		ll	−29.4	2300–2400
T. prodigiosa (Lem.) Baker (= *T. hromadnikiana* Ehlers)†	K. & R. Ehlers 90.1001 (SEL)	1990	ll	−23.0	1700
T. propagulifera Rauh	R. Ferreyra 19430 (SEL)	1981	lb	−17.7	1300–1400
T. pruinosa Sw.	R. Vagner *s.n.* (MO)		ll	−16.5	
T. pseudobaileyi C.S.Gardner	W. Stevens 5694 (MO)		lb	−14.5	540
T. cf. *pseudomicans* Rauh	T.I.P. 02 (SEL)	1982	lb	−13.4	
T. cf. *pseudomontana* W.Weber & Ehlers	H. Plever *s.n.* (SEL)		br	−12.5	
T. pseudosetacea Ehlers & Rauh	A. Sanders 10624 *et al.* (MO)		ll	−16.5	1180
T. pucaraensis Ehlers	P. Koide *s.n.* (SEL)		br	−18.0	
T. pueblensis L.B.Sm.	Anon. (MO 3265037)		lt	−12.6	
T. punctulata Schltdl. & Cham.	T. Croat 15749 (US)		ll	−24.5	
T. purpurea Ruiz & Pav.	A. Gentry *et al.* 22518 (US)		lt	−11.5	
T. pyramidata André	C. Dodson & A. Embree 13176 (MO)	1982	ll	−25.5	1250–1400
T. quaquaflorifera Matuda	E. Matuda 38701 (MO)		lb	−21.7	700
T. queroensis Gilmartin	K. Young & M. Eisenberg 910 (SEL)	1981	ll	−12.2	3000–3200
T. rauhii L.B.Sm.	A. Sagástegui A. 12420 *et al.* (MO)		ll	−20.8	700
T. rectangula Baker	A. Grauifelsen 190 (MO)		ll	−12.3	
T. recurvata (L.) L.	R. Thomas & D. Bell 127091 (MO)		ll	−15.9	
T. recurvifolia Hook.	B. Holst 4957 *et al.* (SEL)		ll	−14.6	1000–1100
T. recurvispica L.Hrom. & P.Schneid.	P. Isley *s.n.* (SEL)		br	−12.6	
T. reducta L.B.Sm.	A. Lopez & A. Sagástegui 2785 (US)		ll	−13.9	2600
T. reichenbachii Baker	A. Gentry 75217 *et al.* (MO)		ll	−15.6	350
T. remota Wittm.	R. Villacorta 784 (MO)		ll	−14.5	800
T. restrepoana André	M.& R. Foster *et al.* 1909 (US)		lb	−23.4	2333
T. retorta Griseb. ex Baker	W. Till 10257 (MO)		lt	−13.4	1280
T. reuteri Rauh	J. Raack 930816.1 (SEL)	1993	ll	−25.4	800
T. rhodosticta L.B.Sm.	A. Hirtz 2030 (MO)		ll	−28.0	1350
T. rhomboidea André	E. Gudiño 265 (MO)		ll	−29.7	400
T. rodrigueziana Mez	P. Moreno 12741 (MO)		lb	−15.2	1400–1450
T. roezlii E.Morren	J. Meza 6 (SEL)	1991	ll	−13.5	
T. roland-gosselinii Mez	R. King 4191 (US)		ll	−11.7	
T. romeroi L.B.Sm.	R. Romero C. 7307 (MO)		ia	−22.3	2800
T. cf. *roseiflora* Ehlers & W.Weber	P. Tristram 24 (SEL)		lb	−12.4	
T. roseoscapa Matuda	R. & K. Ehlers EM 911803 (SEL)	1991	lb	−13.4	
T. rothii Rauh	H. Luther *s.n.* (SEL)	1998	br	−16.5	
T. rotundata (L.B.Sm.) C.S.Gardner	J. Boeke 120A (MO)		ll	−13.0	
T. rubella Baker	J. Boeke & S. Boeke 3198 (MO)		ll	−26.0	

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	δ13C (‰)	Elevation¶ (m)
T. cf. *rubroviolacea* Rauh	D. Cathcart *s.n.* (SEL)	1994	ia	−16.2	2000
T. rusbyi Baker	J. Solomon & M. Uehling 12182 (MO)		ll	−25.9	2100
T. sagasteguii L.B.Sm.	A. Sagástegui 3752 (US)		lb	−18.3	2500
T. cf. *salmonea* Ehlers	R. Guess 2 (SEL)	1998	lb	−11.5	2312
T. samaipatensis W.Till	M. Kessler 7452 (SEL)	1996	ll	−25.1	1150
T. scaligera Mez & Sodiro	A. Juncosa 804 (MO)		ll	−26.9	120
T. sceptriformis Mez & Sodiro ex Mez	M. Peñafiel 344 *et al.* (MO)		ll	−21.6	3100–3400
T. schiedeana Steud.	P. Moreno 160 (MO)		ll	−12.1	
T. schimperiana Wittm.	E. Asplund 18261 (US)		lb	−21.3	3000
T. schultzei Harms	J. Steyermark *et al.* 120048 (MO)		ll	−22.7	1150–1250
T. secunda Kunth	Luther *et al.* 2769 (US)		ll	−16.1	1500
T. seleriana Mez	E. Martinez S. 22347 *et al.* (MO)		lb	−13.4	1500
T. selleana Harms	T. Zanoni *et al.* 19243 (SEL)	1982	ll	−24.2	1667
T. setacea Sw.	T. Plowman 14126 (MO)		ll	−14.0	
T. sierrajuarezensis Matuda	D. Cathcart *s.n.* (SEL)	1996	ll	−24.9	
T. sigmoidea L.B.Sm.	J. Cuatrecasas & R. Romero C. 24741 (US)		lb	−21.7	2400–2650
T. simulata Small	W. Judd 3215 *et al.* (MO)		lb	−14.4	
T. singularis Mez & Wercklé	E. Bello 2083 (MO)		ll	−26.9	900
T. socialis L.B.Sm.	D. Cathcart *s.n.* (SEL)	1995	lb	−18.5	ca. 467
T. sodiroi Mez	A. Hitchcock 21597 (US)		lb	−18.0	2700–3300
T. somnians L.B.Sm.	D. Cathcart & W. Berg *s.n.* (SEL)	1989	ll	−26.0	1900
T. spathacea Mez & Sodiro	Luther 1283A *et al.* (SEL)	1988	ll	−21.2	2750
T. sphaerocephala Baker	M. Cárdenas 6167 (US)		lb	−14.9	2700
T. spiralipetala Gouda	J. Solomon 8906 (MO)		lt	−15.2	1200
T. sprengeliana Klotzsch ex Mez	Restinga I-712 (US)		ll	−12.2	
T. standleyi L.B.Sm.	A. Gilmartin 983 (US)		ll	−29.6	1600
T. stenoura Harms	A. Gentry 80491 (MO)		ll	−23.5	2500
T. cf. *stipitata* L.B.Sm.	G. Davidse & A. González 22257 (SEL)	1982	ll	−24.4	2000
T. straminea Kunth	H. Iltis *et al.* 23 (US)		lt	−19.1	
T. streptocarpa Baker	E. Zardini & R. Velázquez 18316 (MO)		ll	−12.8	
T. streptophylla Scheidw. ex E.Morren	R. Ortega 507 (MO)		ll	−13.5	350
T. stricta Sol.	G. Grazziotin *et al.* 3677 (MO)		ll	−14.9	800
T. subconcolor L.B.Sm.	J. Solomon 3114 (MO)		lb	−14.1	ca. 1100
T. subulifera Mez	G. Herrera 4755 (MO)		ll	−13.0	200
T. suescana L.B.Sm.	J. Betancur *et al.* 4027 (SEL)	1993	ll	−25.8	2740
T. superba Mez & Sodiro	C. Cerón & G. Hernández 1961 (MO)		ll	−24.9	1800–3356
T. supermexicana Matuda	R. & K. Ehlers EM90-2505 (SEL)	1991	lb	−15.2	
T. tectorum E.Morren	D. Smith *et al.* 12127 (MO)		ll	−14.2	3400
T. tenuifolia L.	M. Lewis 881142 (MO)		ll	−14.6	1500
T. teres L.B.Sm.	A. López & A. Sagástegui 5192 (US)		lb	−13.0	800
T. thyrsigera E.Morren ex Baker	E. Matuda 30587 *et al.* (MO)		ll	−19.4	1700
T. tortilis Klotzsch ex Baker	C. Gardner 1321 (SEL)		ll	−13.9	2130
T. tovarensis Mez	P. Jørgensen *et al.* 430 (MO)		lb	−23.0	2610
T. tragophoba M.O.Dillon	Rundel & Dillon (1998)		ll	−19.2	
T. tricholepis Baker	M. Nee 34245 (US)		ll	−12.9	375
T. tricolor Schltdl. & Cham.	G. Davidse & G. Herrera 26251 (MO)		ll	−15.2	1100–1200
T. triglochinoides Presl	J. Clark & T. Núñez 1561 (MO)		ll	−13.9	200–300
T. truncata L.B.Sm.	Luther *et al.* 2764 (US)		lb	−24.4	2100
T. turneri Baker	F. Roldan *et al.* 2358 (MO)		lb	−23.7	2350
T. turquinensis Willinger & Michálik	K. Willinger *s.n.* (SEL)	1990	ll	−14.6	300
T. umbellata André	M. Kessler 2412 (SEL)	1991	ll	−28.6	1500
T. usneoides (L.) L.	Smith & Epstein (1971)		ll	−18.6	
T. utriculata L. var. *utriculata*	F. Rugel 345 (MO)		ll	−11.4	
T. variabilis Schltdl.	P. Moreno 6679 (MO)		ll	−12.7	
T. velutina Ehlers	H. Luther *s.n.* (SEL)	1994	ll	−17.4	
T. ventanaensis Ehlers & P.Koide	P. Koide *s.n.* (SEL)	1993	br	−14.0	1800–2000
T. venusta Mez & Wercklé	J. Clark *et al.* 1692 (MO)		ll	−27.2	500
T. vernicosa Baker	M. Lewis 37213 (MO)		ll	−13.9	1400
T. vicentina Standl.	W. Stevens 21865 (MO)		ll	−19.4	ca. 1400
T. violacea Baker	T. Croat & D. Hannon 65656 (MO)		lb	−23.9	1000
T. violascens Mez	D. Smith *et al.* 13377 (MO)		lb	−24.0	2000
T. viridiflora (Beer) Baker	T. Croat 42919 (MO)		ll	−24.8	
T. wagneriana L.B.Sm.	M. Dimmit & P. Isley 1169 (SEL)	1982	ll	−30.9	
T. walteri Mez	J. Wurdack 1459 (US)		ll	−23.6	2850–2900
T. welzii Ehlers	R. & K. Ehlers EG 92-1101 (SEL)	1992	lb	−13.9	2000
T. werdermannii Harms	Rundel & Dillon (1998)		ll	−11.5	
T. werneriana J.R.Grant (= *Vriesea rauhii* L.B.Sm.)	A. Sagástegui *et al.* 15383 (SEL)		ll	−19.7	2400
T. wuelfinghoffii Ehlers	R. & K. Ehlers EM 881601 (SEL)	1991	lb	−16.3	1800–1900
T. wurdackii L.B.Sm.	M. Kessler 2470 (SEL)	1991	ll	−24.6	3000
T. xerographica Rohweder	H. Luther *s.n.* (SEL)	1993	ll	−12.5	700
T. xiphioides Ker Gawl. ssp. *xiphioides* var. *minor* L.Hrom.†	W. & S. Till 5018 (MO)		lb	−14.3	1220

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	δ13C (‰)	Elevation¶ (m)
T. xiphioides Ker Gawl. ssp. *xiphioides* var. *xiphioides*†	W. Till 10261 (MO)		ll	−12.4	1100
T. yunckeri L.B.Sm.	G. Davidse *et al.* 35338 (MO)		ll	−31.7	1890
T. zecheri W.Till var. *zecheri* forma *brealitoensis* C.A.Palací & G.K.Br.	W. Till 10197 (MO)		lb	−15.2	2500
Vriesea **Lindl.**					
V. agostiniana E.Pereira	H. Luther *s.n.* (SEL)		ll	−25.8	
V. alta (Baker) E.Morren ex Mez	N. Britton 3208 (NY)		lb	−23.4	
V. altimontana E.Pereira & Martinelli	Martinelli 8747 (US)		lb	−26.3	
V. altodaserrae L.B.Sm.	G. Hatschbach 58521 (MO)	1993	lb	−25.3	800
V. cf. *andreettae* Rauh	D. Cathcart & W. Berg *s.n.* (SEL)	1986	lb	−20.2	1733
V. arpocalyx (André) L.B.Sm.	A. Hirtz 1556 (MO)	1984	ll	−22.3	3000
V. atra Mez	M. & R. Foster 993 (US)		ll	−23.7	
V. atropurpurea Silveira	H. Irwin *et al.* 30248 (US)		lb	−22.8	1800–2000
V. barilletii E.Morren	H. Luther *s.n.* (SEL)	1998	lb	−23.8	
V. bi-beatricis Morillo	A. Gröger 678 (MO)	1993	ll	−25.6	
V. biguassuensis Reitz	Seidel 943 (US)		lb	−26.7	40
V. billbergioides E.Morren var. *ampla* L.B.Sm.	Segadas-Vianna 3121 (US)		lb	−23.0	
V. bituminosa Wawra	H. Luther *s.n.* (SEL)		ll	−27.3	
V. bleheri Röth & Weber	H. Luther *s.n.* (SEL)	1990	ll	−24.7	
V. brassicoides (Baker) Mez	H. Luther *s.n.* (SEL)	1998	lb	−23.1	
V. capixabae Leme	B. Whitman 1 (SEL)	1985	ll	−27.9	
V. carinata Wawra†	R. Harley 18194 (MO)	1977	lb	−26.9	100
V. carinata var. *mangaratibensis* Leme & A.S.Costa†	R. Silva 852 & J. Pirani (SEL)	1993	lb	−28.0	
V. castaneobulbosa (Mez & Wercklé) J.R.Grant	J. Grant 91-01363 *et al.* (MO)	1991	lb	−25.9	2150
V. chrysostachys E.Morren var. *chrysostachys*	J. Betancur *et al.* 4154 (MO)	1993	ll	−22.3	1150
V. clausseniana (Baker) Mez	M. Arbo *et al.* 5257 (US)		lb	−21.6	1200
V. corcovadensis (Britten) Mez	J. Raack 930816.15 (SEL)		lb	−30.3	
V. correia-araujoi E.Pereira & Penna	W. Berg *s.n.* (SEL)	1995	ia	−24.6	
V. crassa Mez	H. Irwin *et al.* 28252 (US)		lb	−21.8	1200
V. crenulipetala (Mez) L.B.Sm.	R. Romero-Castañeda 6919 (US)		lb	−25.8	1300
V. cylindrica L.B.Sm.	Luther *et al.* 643 (MO)	1981	ll	−26.0	1350
V. densiflora Mez	W. Anderson *et al.* 35757 (US)		lb	−23.8	2250
V. dissitiflora (C.Wright) Mez	B. Alain & J. Acuña 3017 (US)		ll	−21.0	
V. drepanocarpa (Baker) Mez	J. Raack *s.n.* (SEL)		ll	−26.8	
V. dubia (L.B.Sm.) L.B.Sm.	F. Coello 305 (MO)	1988	lb	−29.4	240
V. duidae (L.B.Sm.) Gouda (= *Tillandsia duidae* L.B.Sm.)	B. Stein 1650 *et al.* (MO)	1984	ll	−29.2	1600
V. duvaliana E.Morren	C. & W. Waggoner 115B-10-85 (SEL)	1985	ll	−23.9	
V. elata (Baker) L.B.Sm.	J. MacDougal *et al.* 4002 (MO)	1988	lb	−28.4	1480–1560
V. ensiformis (Vell.) Beer†	P. Dusén 18008A (MO)		ll	−29.4	
V. ensiformis (Vell.) Beer (= *V. warmingii* E.Morren)†	H. Luther *s.n.* (SEL)	1990	ll	−24.7	
V. erythrodactylon E.Morren	A. Krapovickas & C. Cristóbal 40362 (MO)		ll	−28.1	
V. fenestralis Linden & André	H. Luther *s.n.* (SEL)	1994	ll	−24.0	
V. fibrosa L.B.Sm.	B. Maguire & L. Politi 28108 (US)		ll	−23.4	1400
V. flammea L.B.Sm.	C. Roderjan 250 & Y. Kuniyoshi (MO)		ll	−26.1	
V. friburgensis Mez†	R. Harley 27434 & M. Arrais (MO)	1988	lb	−26.3	1500
V. friburgensis var. *tucumanensis* (Mez) L.B.Sm.†	E. Zardini 7453 (MO)		ll	−29.0	
V. gigantea Gaudich.	P. Worley *s.n.* (SEL)	1995	ll	−26.6	
V. glutinosa Lindl.	T. Aitken *et al.* 465E (US)		lb	−26.8	
V. goniorachis (Baker) Mez	E. Pereira *et al. s.n.* (US)		lb	−22.7	
V. gradata Baker	W. Berg *s.n.* (SEL)		lb	−23.5	
V. guttata Linden & André	P. Dusén *s.n.* (MO)	1914	lb	−25.6	700
V. harmsiana (L.B.Sm.) L.B.Sm.†	A. Sagástegui *et al.* 11938 (MO)	1984	lb	−21.0	2800
V. harmsiana (L.B.Sm.) L.B.Sm. [= *T.* aff. *tillandsioides* (L.B.Sm.) J.R.Grant = *Vriesea* aff. *tillandsioides* L.B.Sm.]†	A. Sagástegui *et al.* 11938 (US)		lb	−21.0	2800
V. heliconioides (Kunth) Hook. ex Walp.	W. Stevens 8212 (MO)	1978	ll	−25.3	8–10
V. heterostachys (Baker) L.B.Sm.	Luther 2905 *et al.* (SEL)	1992	br	−25.1	ca. 1000
V. hieroglyphica (Carrière) E.Morren	M. & R. Foster 300 (US)		lb	−23.3	850
V. hitchcockiana (L.B.Sm.) L.B.Sm.	M. Dimmitt & P. Isley 1190b (SEL)		lb	−32.9	
V. hoehneana L.B.Sm.	Reitz & Klein 6135 (US)		lb	−25.1	1300
V. hydrophora Ule	A. Brade 9849 (US)		lb	−28.3	1400
V. incurva (Griseb.) Read	J. Morales & V. Ramírez 2489 (MO)	1994	lb	−24.9	1500
V. incurvata Gaudich.	A. Krapovickas & C. Cristóbal 42148 (MO)	1988	ll	−28.6	
V. inflata (Wawra) Wawra	H. Luther *s.n.* (SEL)	1998	lb	−25.7	
V. itatiaiae Wawra	L. Smith 1703 (US)		br	−24.3	2000–2300
V. jonghei (K.Koch) E.Morren [= *V. johnstonii* (Mez) L.B.Sm. & Pittendr.]	G. Hatschbach & A. Campos 55720 (MO)	1991	ll	−25.0	10–20
V. cf. *joyae* E.Pereira & I.A.Penna	H. Luther *s.n.* (SEL)	1990	br	−24.3	
V. koideae Rauh	P. Koide *s.n.* (SEL)		br	−23.3	
V. lancifolia (Baker) L.B.Sm.	A. Amorim *et al.* 1776 (SEL)	1995	ll	−23.9	
V. languida L.B.Sm.	H. Luther *s.n.* (SEL)	1985	lb	−25.7	

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	δ13C (‰)	Elevation¶ (m)
V. laxa Mez	R. Liesner & A. González 9979 (MO)	1980	ll	–23.8	1000
V. leptantha Harms	Santos Lima & Brade 14179 (US)		ll	–24.4	1600
V. limae L.B.Sm.	Andrade-Lima *s.n.* (US)		lb	–20.6	
V. limonensis Rauh	B. Girko E90-145J (SEL)	1990	ll	–23.1	1250
V. longicaulis (Baker) Mez	T. Plowman & G. Martinelli 10132 (US)		lb	–26.6	1180
V. longiscapa Ule	G. Martinelli & C. Farney 8731 (US)		lb	–26.9	1100–1200
V. lubbersii (Baker) E.Morren	G. Martinelli 10923 *et al.* (MO)	1985	ll	–25.1	800–1000
V. lutheriana J.R.Grant	J. Hall *s.n.* (SEL)	1988	ll	–30.0	
V. macrostachya (Bello) Mez	J. Grant 93-02294 & J. Rundell (SEL)	1993	lb	–25.3	
V. maguirei L.B.Sm.	M. Nee 30669 (MO)	1985	ll	–22.8	1730–1850
V. malzinei E.Morren	A. Villalobos C. 16 *et al.* (MO)	1983	ll	–33.5	120
V. maxoniana (L.B.Sm.) L.B.Sm.	J. Solomon & M. Uehling 12229 (MO)	1984	ll	–27.5	1700
V. modesta Mez	H. Boudet F. 1070 (US)		lb	–28.4	
V. monstrum (Mez) L.B.Sm.	J. Morales 2554 *et al.* (MO)	1994	ll	–26.3	850–950
V. morrenii Wawra	M. & R. Foster 280 (US)		lb	–26.7	850
V. muelleri Mez	H. Luther *s.n.* (SEL)	1998	lb	–25.6	
V. neoglutinosa Mez†	P. Dusén 17040B (MO)		ll	–23.0	
V. neoglutinosa Mez†	G. Morillo & A. Braun 9293 (VEN)		ll	–22.8	
V. oligantha (Baker) Mez	H. Irwin 20471 *et al.* (MO)	1968	ll	–24.1	1250
V. olmosana L.B.Sm. var. *pachamamae* Rauh	D. Cathcart & W. Berg *s.n.* (SEL)	1988	ll	–23.7	1730
V. ospinae var. *gruberi* H.Luther	W. Berg *s.n.* (SEL)	1993	br	–23.6	
V. paraibica Wawra	Luther 2906 (SEL)	1993	ll	–25.9	ca. 1200
V. aff. *paraibica* Wawra (= *V.* aff. *pallidiflora* E.Pereira)	R. Read & G. Daniels 3432 (US)		lb	–25.8	
V. paratiensis E.Pereira	J. Silva & G. Hatschbach 1881 (NY)		lb	–27.2	
V. pardalina Mez	Apparicio *et al.* 2233 (US)		lb	–22.2	1330
V. parviflora L.B.Sm.	G. Martinelli *et al.* 8085 (US)		lb	–24.4	1000
V. cf. *pastuchoffiana* Glaz. ex Mez	E. Wurthmann *s.n.* (SEL)	1981	br	–21.7	
V. patula (Mez) L.B.Sm.	M. Madison *et al.* 7449 (SEL)	1981	lb	–24.0	2480
V. pereziana (André) L.B.Sm.	M. Foster *et al.* 1907 (US)		lb	–22.9	2333
V. petraea (L.B.Sm.) L.B.Sm.	Anon. (US 2571247A)		lb	–22.5	
V. philippocoburgii Wawra	B. Rambo 31566 (MO)		ll	–29.1	
V. platynema Gaudich.	R. Liesner 8409 *et al.* (MO)	1979	br	–26.7	1400–1560
V. platzmannii E.Morren	L. Smith & P. Reitz 5744 (US)		lb	–26.2	2
V. poenulata (Baker) E.Morren ex Mez	G. Waggoner *s.n.* (SEL)	1983	ll	–23.5	
V. procera (Mart. ex Schult. & Schult.f.) Wittm.	J. Steyermark 114740 *et al.* (MO)	1977	ll	–27.9	50
V. pseudoatra Leme	G. Martinelli & C. Farney 8711 (US)		ll	–24.7	1100–1200
V. psittacina (Hook.) Lindl.	J. Jardim 832 *et al.* (SEL)	1996	ll	–31.2	510
V. racinae L.B.Sm.	H. Boudet Fernandes 2163 (US)		lb	–25.7	
V. recurvata Gaudich.	T. Santos 3200 (US)		lb	–26.6	
V. regnellii Mez	A. Regnell *s.n.* (US)		br	–23.8	
V. reitzii Leme & A.S.Costa	G. Hatschbach & E. Barbosa 58218 (MO)	1992	lb	–26.2	1100
V. rhodostachys L.B.Sm.	W. Boone 1014 (US)		lb	–27.7	
V. robusta (Griseb.) L.B.Sm.†	J. Steyermark & M. Rabe 96840 (US)		lb	–23.2	3000
V. robusta (Griseb.) L.B.Sm.†	F. Oliva E. & B. Manara 98-6 (VEN)		ll	–24.6	2900
V. rodigasiana E.Morren	J. Anderson BAB 72 (SEL)		br	–25.6	
V. rubra (Ruiz & Pav.) Beer	T. Croat 74668 (MO)	1993	ll	–26.6	1600
V. rubrobracteata Rauh	J. Betancur *et al.* 5377 (SEL)	1994	lb	–28.2	1500–1670
V. ruschii vel aff. L.B.Sm.	D. Folli 2401 (SEL)	1994	lb	–25.9	
V. sagasteguii L.B.Sm.	H. Luther *s.n.* (SEL)	1995	lb	–20.0	
V. saundersii (Carrière) E.Morren ex Mez	H. Luther *s.n.* (SEL)	1997	lb	–25.2	
V. scalaris E.Morren	W. Berg *s.n.* (SEL)	1991	ll	–22.3	
V. sceptrum Mez	G. Eiten & L. Eiten 7584 (MO)	1966	ll	–24.3	1900
V. schultesiana L.B.Sm.	R. Schultes & I. Cabrera 14967 (US)		ll	–29.1	300
V. schwackeana Mez	H. Luther *s.n.* (SEL)	1998	lb	–26.4	
V. simplex (Vell.) Beer	J. Steyermark & G. Davidse 116525 (MO)	1978	ll	–30.1	20–700
V. socialis L.B.Sm.	M. Yanez 50 (MO)	1989	ll	–29.9	95
V. soderstromii L.B.Sm.	R. Cowan & T. Soderstrom 1862 (US)	1962	lb	–24.1	467
V. sparsiflora L.B.Sm.	G. Martinelli & C. Farney 8733 (US)		lb	–28.2	1000–1100
V. splendens (Brongn.) Lem.	A. González & F. Ortega 1303 (MO)		ll	–30.1	
V. strobeliae Rauh	B. Girko E90-055J (SEL)	1990	ll	–25.8	1500
V. sucrei L.B.Sm. & Read	P. Magana *s.n.* (SEL)	1986	lb	–25.8	
V. sulcata L.B.Sm.	F. Michelangeli 138 (SEL)	1995	lb	–26.1	1800
V. swartzii (Baker) Mez	H. Luther *s.n.* (SEL)	1992	lb	–26.1	
V. taritubensis E.Pereira & Penna	W. Berg *s.n.* (SEL)	1998	ll	–22.2	
V. tequendamae (André) L.B.Sm.	C. Cerón M. & C. Iguago 5660 (MO)	1988	ll	–22.7	1800–2250
V. thyrsoidea Mez	G. Martinelli & E. Simonis 9083 (US)		ll	–25.4	1500
V. triligulata Mez	A. Abendroth 9 (US)		ll	–24.9	
V. tuerckheimii (Mez) L.B.Sm.	B. Holst 6262 *et al.* (SEL)	1997	ll	–25.0	650
V. unilateralis (Baker) Mez	H. Luther *s.n.* (SEL)	1998	lb	–21.6	
V. cf. *vagans* (L.B.Sm.) L.B.Sm.	P. Tristram 21 (SEL)	1989	br	–30.2	
V. vidalii L.B.Sm. & Handro	J. Vidal 3267 (US)		lb	–22.6	

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	$\delta^{13}C$ (‰)	Elevation¶ (m)
V. wuelfinghoffii Rauh & E.Gross	J. Manzanares 5295 (MO)	1989	lb	−21.2	2400
V. wurdackii L.B.Sm.	R. Liesner 18728 (US)		ll	−26.1	350
V. zamorensis (L.B.Sm.) L.B.Sm.	A. Gentry 80499 (MO)	1993	ll	−27.7	930
***Werauhia* J.R.Grant**					
W. ampla (L.B.Sm.) J.R.Grant	M. Grayum & B. Jacobs 3735 (MO)	1984	ll	−26.2	1210
W. apiculata (L.B.Sm.) J.R.Grant†	J. Morales *et al.* 2418 (US)		ll	−26.5	290–320
W. apiculata (L.B.Sm.) J.R.Grant†	L. Smith & C. Dodson 15306 (US)		lb	−25.8	
W. attenuata (L.B.Sm. & Pittendr.) J.R.Grant	L. Gómez 19311 (MO)	1982	lb	−24.3	1400–1700
W. balanophora (Mez) J.R.Grant	A. & B. Haines 679 (MO)	1962	ll	−24.9	1833
W. bicolor (L.B.Sm.) J.R.Grant	J. Grant *et al.* 91-01403 (US)		lb	−24.2	
W. broadwayi (L.B.Sm.) J.R.Grant	N. Britton *et al.* 1258 (US)		lb	−26.7	
W. brunei (Mez & Wercklé) J.R.Grant	J. Grant & J. Rundell 92-02173B (US)		ll	−30.0	2150
W. burgeri (L.B.Sm.) J.R.Grant	J. Morales 2115 *et al.* (MO)	1993	ll	−22.4	2100
W. capitata (Mez & Wercklé) J.R.Grant	J. Folsom 6333 *et al.* (MO)	1977	ll	−28.3	1200–1400
W. comata (Mez & Wercklé) J.R.Grant	Luther 1119 *et al.* (SEL)	1986	lb	−27.7	ca. 1200
W. cowellii (Mez & Britton) J.R.Grant	R. Liesner & A. Gonzàlez 9924A (MO)	1980	lb	−25.3	1200–1800
W. gibba (L.B.Sm.) J.R.Grant	R. Howard & G. Proctor 14293 (US)		lb	−20.6	750
W. gigantea (Mart. ex Schult. & Schult.f.) J.R.Grant	J. Solomon 3381 (MO)	1977	ll	−28.1	700
W. gladioliflora (H.Wendl.) J.R.Grant	G. Davidse & D. Holland 36639 (MO)	1997	ll	−28.5	420
W. graminifolia (Mez & Wercklé) J.R.Grant	J. Morales & G. Carnevali 2877 (MO)	1994	lb	−28.1	1250
W. guadelupensis (Baker) J.R.Grant	H. Luther *s.n.* (SEL)	1979	lb	−27.3	500
W. hainesiorum (L.B.Sm.) J.R.Grant†	J. & K. Utley 3865 (MO)	1976	ll	−26.6	1800–1900
W. hainesiorum (L.B.Sm.) J.R.Grant†	J. & K. Utley 3063 (US)		lt	−26.7	
W. haltonii (H.Luther) J.R.Grant	Luther *et al.* 998 (MO)	1985	ll	−27.0	2000
W. hygrometrica (André) J.R.Grant	J. & K. Utley 2907c (MO)	1975	lb	−26.4	1500
W. insignis (Mez) W.Till, Barfuss & M.R.Samuel [= *Tillandsia insignis* (Mez) L.B.Sm. & Pittendr.]	J. Morales 2637 & E. Lépiz (MO)	1994	ll	−28.9	1550
W. jenii S.Pierce	Pierce *et al.* (2002a)	2000	ll	−29.1	
W. kathyae (Utley) J.R.Grant	J. Morales 2526 (MO)	1994	ll	−29.5	1500
W. kupperiana (Suess.) J.R.Grant	R. Liesner 15362 *et al.* (MO)	1983	ll	−22.0	450–525
W. latissima (Mez & Wercklé) J.R.Grant	H. Luther 309 (SEL)	1980	lb	−26.3	
W. laxa (Mez & Wercklé) J.R.Grant†	J. & K. Utley 1857 (MO)	1975	ll	−27.7	1000
W. laxa (Mez & Wercklé) J.R.Grant†	A. Gentry *et al.* 16930 (US)		ll	−29.7	1650–1800
W. leucophylla (L.B.Sm.) J.R.Grant	M. Grayum 3619 (MO)	1984	lb	−25.8	1350
W. lutheri S.Pierce & Aranda	Pierce *et al.* (2002a)	2000	ll	−28.4	
W. lyman-smithii (Utley) J.R.Grant	J. & K. Utley 4960 (US)		lb	−23.5	
W. marnier-lapostollei (L.B.Sm.) J.R.Grant	J. Morales 2418 *et al.* (MO)	1994	ll	−32.0	290–320
W. millennia J.R.Grant	Pierce *et al.* (2002a)	2000	ll	−28.1	
W. nephrolepis (L.B.Sm. & Pittendr.) J.R.Grant [= *W. montana* (L.B.Sm.) J.F.Morales & Cerén]	M. Grayum 8097 *et al.* (MO)	1987	ll	−26.5	1700–1800
W. aff. *notata* (L.B.Sm. & Pittendr.) J.R.Grant	S. Ingram & K. Ferrell-Ingram 1305 (SEL)	1992	ll	−24.7	1500–1550
W. orjuelae (L.B.Sm.) J.R.Grant	Orjuela 290 (US)		lb	−26.0	
W. ororiensis (Mez) J.R.Grant	J. Morales & V. Ureña 2339 (MO)	1994	ll	−25.6	2150
W. panamaensis (E.Gross & Rauh) J.R.Grant	Pierce *et al.* (2002a)	2000	ll	−27.6	
W. paniculata (Mez & Wercklé) J.R.Grant	J. & K. Utley 5162 (US)		lb	−25.7	1400–1700
W. patzeltii (Rauh) J.R.Grant [= *W. greenbergii* (Utley) J.R.Grant]	J. Morales & E. Lépiz 2699 (MO)	1994	ll	−28.1	1000
W. paupera (Mez & Sodiro) J.R.Grant	J. Clark 1662 (SEL)	1995	ll	−28.2	500
W. pectinata (L.B.Sm.) J.R.Grant	L. Williams *et al.* 40585 (US)		lb	−25.5	1200–1600
W. pedicellata (Mez & Wercklé) J.R.Grant	S. Ingram & K. Ferrell-Ingram 1325 (MO)	1992	ll	−29.6	1500–1550
W. picta (Mez & Wercklé) J.R.Grant	T. Croat 37107 (MO)	1976	ll	−25.3	1610–1670
W. pittieri (Mez) J.R.Grant	J. Morales 2195 & V. Ureña (MO)	1993	ll	−25.3	2150
W. pycnantha (L.B.Sm.) J.R.Grant†	T. Croat 78615 (MO)	1996	lb	−24.5	1860
W. pycnantha (L.B.Sm.) J.R.Grant†	J. MacDougall 136 (US)		lb	−26.1	
W. ringens (Griseb.) J.R.Grant	R. Hartman 12370 (MO)	1980	ll	−27.6	800–900
W. rubra (Mez & Wercklé) J.R.Grant†	J. Morales & V. Ureña 2179 (MO)	1993	ll	−28.1	2150
W. rubra (Mez & Wercklé) J.R.Grant†	P. Standley 42179 (US)		ll	−25.9	2000–2100
W. sanguinolenta (Linden ex Cogn. & Marchal) J.R.Grant	J. Morales 2383 *et al.* (MO)	1994	lb	−25.3	350
W. sintenisii (Baker) J.R.Grant	P. Rivero 2157 (SEL)	1992	ll	−27.9	1338
W. stenophylla (Mez & Wercklé) J.R.Grant	S. Ingram & K. Ferrell-Ingram 1323 (SEL)	1992	ll	−28.3	1500–1550
W. subsecunda (Wittm.) J.R.Grant	G. Rivera 206 (MO)	1990	ll	−30.5	2500
W. tonduziana (L.B.Sm.) J.R.Grant	S. Ingram 215 (SEL)	1988	lb	−25.4	1530
W. umbrosa (L.B.Sm.) J.R.Grant	T. Croat 66665 (MO)	1987	ll	−27.0	1170
W. urbaniana (Mez) J.R.Grant	J. Schafer 301 (NY)		lb	−27.1	
W. uxoris (Utley) J.R.Grant	J. & K. Utley 812 (MO)	1974	ll	−22.5	
W. vanhyningii (L.B.Sm.) J.R.Grant	F. Ventura 1045 (MO)	1970	ll	−26.6	1500
W. vietoris (Utley) J.R.Grant	A. Meerow *et al.* 1117 (US)		lb	−23.1	2330
W. viridiflora (Regel) J.R.Grant†	J. Morales & G. Carnevali 2888 (MO)	1994	lb	−29.3	1250
W. viridiflora (Regel) J.R.Grant†	P. Biolley f. 17370 (US)		ll	−25.2	1500
W. viridis (Mez & Wercklé) J.R.Grant	M. Grayum 7147 *et al.* (MO)	1986	ll	−26.1	2060–2080

Table 1. *Continued*

Taxon	Accession/voucher details‡ or reference	Date of collection	Tissue§	$\delta^{13}C$ (‰)	Elevation¶ (m)
W. vittata (Mez & Wercklé) J.R.Grant	J. Morales & E. Lépiz 2701 (MO)	1994	lb	−30.8	1000
W. werckleana (Mez) J.R.Grant	G. Davidse & D. Holland 36719 (MO)	1997	ll	−29.7	920
W. williamsii (L.B.Sm.) J.R.Grant	Luther & Bak 2811 (SEL)	1990	ll	−24.3	1650
W. woodsoniana (L.B.Sm.) J.R.Grant	C. Skotak *s.n.* (SEL)		lb	−27.0	1000

This table contains $\delta^{13}C$ values for 1893 accepted species of Bromeliaceae including new determinations for 1879 species. Previously published values for 15 species, 14 of which were not sampled in the present study, are included. Among the included determinations, 138 species are represented by more than one specimen (for 120 species more than one independently collected vouchered specimen was analysed, and for 18 species more than one infraspecific taxon was analysed, representing a total of 160 replicate specimens), whereas 69 specimens were only provisionally identified (designated by aff., cf., vel aff. or ms. to indicate that the name has not been validly published), and therefore were also not included in the total species count. Names are listed by subfamily (arranged alphabetically) according to the phylogenetic classification of Givnish *et al.* (2007). Genus concepts are those of Luther (2012), except for the monotypic *Pseudananas* Hassl. ex Harms, which is included in *Ananas* (Coppens d'Eeckenbrugge & Leal, 2003; Govaerts *et al.*, 2013), and *Pepinia* Brongn. ex André, which is included in *Pitcairnia* (Holst, 1997; Taylor & Robinson, 1999; Govaerts *et al.*, 2013). Species concepts are those of Govaerts *et al.* (2013) except where noted. Synonyms are indicated in parentheses only where these are the names under which the herbarium specimens were originally recorded. Abbreviations for authorities follow The International Plant Names Index (2013).

†Denotes species duplicates for which the mean $\delta^{13}C$ value was calculated.

‡Herbaria are denoted by their acronyms (Holmgren, Holmgren & Barnett, 1990): FR, Senckenberg Forschungsinstitut und Naturmuseum, Frankfurt, Germany; HB, Herbarium Bradeanum, Rio de Janeiro, Brazil; K, Herbarium, Royal Botanic Gardens, Kew, UK; MO, Missouri Botanical Garden, St. Louis, MO, USA; OXF, Herbaria, University of Oxford, UK; SEL, Herbarium, Marie Selby Botanical Gardens, Sarasota, FL, USA; SP, Herbário, Instituto de Botânica, São Paulo, Brazil; US, United States National Herbarium, Smithsonian Institution, Washington DC, USA; VEN, Fundación Instituto Botánico de Venezuela, Caracas, Venezuela. MSBG refers to plants accessioned in the living collection at Marie Selby Botanical Gardens, which are, in most cases, not vouchered in a herbarium (total 46 species).

§Material analysed was taken from the bract (br), flower (fl), fruit wall (fw), inflorescence axis (ia), leaf base (lb), leaf lamina (ll), leaf tip (lt), pedicel (pd) or stem (st).

¶Elevation refers to the site at which the specimen was collected, where known.

RESULTS AND DISCUSSION

Sampling strategy and data interpretation

Table 1 presents $\delta^{13}C$ values for 1893 species of Bromeliaceae, with taxonomic authorities, voucher information and details of specimen collection locality. This represents the results of 2124 stable isotope determinations conducted for this study. Data for 14 other species not covered in this survey, but for which values were available in the literature, have been incorporated into Table 1 for completeness. In total, this survey covers data for 57% of the currently accepted 3350 species in the family.

For the majority of species investigated, only a single isotope determination was made, partly on the grounds of cost and often limited sample availability, but also because of the high measurement precision of the mass spectrometer (± 0.02‰) and because of evidence that the $\delta^{13}C$ value tends to be a relatively conservative trait within species, even across broad environmental gradients (e.g. Smith, Griffiths & Lüttge, 1986). Nevertheless, there may be individual instances of polymorphic behaviour in photosynthetic performance, such as that seen in the *Puya chilensis* Molina complex (Schulte *et al.*, 2010; Jabaily & Sytsma, 2013; Zizka *et al.*, 2013), in which $\delta^{13}C$ values have been recorded ranging between −16.3‰ (this study) and −24.8‰ (Quezada, Zotz & Gianoli, 2014; cf. Medina *et al.*, 1977; Griffiths, 1984); such material would clearly be worthy of further investigation at both the taxonomic and ecophysiological levels. For 138 species for which more than one individual or infraspecific taxon was analysed in this study, the median difference in value between individuals was 1.9‰. In only five cases did the difference in $\delta^{13}C$ value observed between individuals introduce ambiguity into the assignment of a taxon to the CAM vs. C_3 category with respect to the threshold of −20.0‰ [*Aechmea aculeatosepala* (Rauh & Barthlott) Leme: −14.0 and −20.5‰; *Puya chilensis* Molina: −16.3, −18.6 and −22.1‰; *Puya ferruginea* (Ruiz & Pav.) L.B.Sm.: −19.1, −20.6, −20.8, −22.8 and −23.2‰; *Puya humilis* Mez: −19.6 and −20.5‰; and *Tillandsia imperialis* E.Morren ex Roezl: −19.8 and −24.5‰]; in these cases, the photosynthetic pathway was assigned based on the arithmetic mean of the $\delta^{13}C$ values. (Nine instances of conflicting information are considered in Supporting Information Table S2, with suggested explanations for these discrepancies.) These results imply that, in general, individual taxa tend to exhibit only a limited degree of plasticity in carbon fixation mechanism under field conditions.

According to linear regression analysis of the entire dataset, there was no significant relationship between year of collection (where noted) and $\delta^{13}C$ value ($y = -37.77 - 0.008x$; $r^2 = 7.3 \times 10^{-5}$; $P > 0.5$; $N = 1214$; data not shown). This suggests that no significant bias was introduced through possible variations in ^{13}C composition of the source (atmospheric) CO_2 over the time period of several decades over which the original specimens were collected in the field (we believe the oldest specimen sampled to have been *Pitcairnia cassapensis* Mez, collected in 1835).

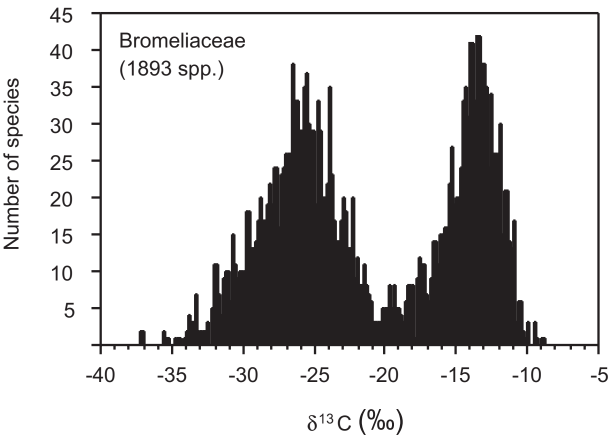

Figure 1. Frequency histogram of $\delta^{13}C$ values of 1893 species of Bromeliaceae plotted in class intervals of 0.2‰.

Bimodal distribution of $\delta^{13}C$ values

The $\delta^{13}C$ values obtained for Bromeliaceae in this study ranged from −37.8‰ (*Pitcairnia sprucei* Baker) to −8.9‰ (*Dyckia choristaminea* Mez). Only ten species had $\delta^{13}C$ values more negative than −34.0‰, and 12 species had values less negative than −10.0‰. In sum, 1074 species (57% of the total sampled) possessed values of −20‰ or more negative, typical of predominantly daytime carbon fixation via the C_3 pathway, whereas 819 species (43%) showed values less negative than −20‰, indicative of predominantly nocturnal fixation of carbon via the CAM pathway, as shown in the summary by genera in Table 2. This is the most extensive study of $\delta^{13}C$ values ever undertaken on a monophyletic group of plants and demonstrates unequivocally that $\delta^{13}C$ values are distributed bimodally (Fig. 1). The C_3 cluster had a mode of −26.7‰ and the CAM cluster a mode of −13.3‰, with the minimum frequency of species occurring in the class interval −21 to −20‰. This bimodality has been noted in some previous studies of C_3 vs. CAM plants (e.g. Medina *et al*., 1977; Griffiths & Smith, 1983; Pierce *et al*., 2002a; Winter & Holtum, 2002; Silvera, Santiago & Winter, 2005; Silvera *et al*., 2010), although these were based on many fewer species or on values derived from highly divergent groups of plants.

Studies of 24-h CO_2 exchange of various CAM plants under controlled conditions in the laboratory have demonstrated a linear relationship between $\delta^{13}C$ value and the proportion of CO_2 fixed via the CAM pathway (Winter & Holtum, 2002). From this cross-species calibration, it can be predicted that 100% diurnal or 100% nocturnal CO_2 uptake would yield a $\delta^{13}C$ value of about −26.9‰ or −8.7‰, respectively, under such conditions. Hence, for those species capable of showing some net nocturnal CO_2 fixation, the $\delta^{13}C$ value of −20.0‰ in the $\delta^{13}C$ frequency distribution for Bromeliaceae corresponds to an estimated 38% of carbon fixation occurring via the CAM pathway. However, among C_3 species, a number of environmental factors are known to cause variation around the estimated global average value of −28.5‰ (Kohn, 2010). Species growing in wet, humid, low-light environments tend to have $\delta^{13}C$ values more negative than the mean (typically more negative than −31.5‰, as has been found for bromeliads growing in the forest understorey: Griffiths & Smith, 1983); under these conditions, the diffusional limitation to CO_2 fixation presented by stomata and internal resistances within the leaf tissue is relatively low, and the $\delta^{13}C$ of the source CO_2 may also be slightly more negative on account of ^{13}C depletion via leaf litter decomposition and soil respiration (Kohn, 2010). Conversely, C_3 species growing in arid, high-light environments tend to have less negative $\delta^{13}C$ values, approaching −20‰ in hyper-arid deserts (Kohn, 2010), as the diffusional (primarily stomatal) limitation to the rate of CO_2 fixation becomes progressively more important. Ultimately, therefore, the possibility that species with $\delta^{13}C$ values in the range −27‰ to −20‰ may be fixing some CO_2 at night must be investigated empirically for individual taxa on a case by case basis.

To test for the extent of 'cryptic CAM' in Bromeliaceae with C_3-like $\delta^{13}C$ values, Pierce *et al*. (2002a) investigated 31 species with $\delta^{13}C$ values more negative than −20‰, but found only two species [*Guzmania monostachia* (L.) Rusby ex Mez (confirming previous studies) and *Ronnbergia explodens* L.B.Sm.] that were able to exhibit small amounts of net nocturnal CO_2 uptake, and an additional two species [*Tillandsia cretacea* L.B.Sm. and *Werauhia sanguinolenta* (Linden ex Cogn. & Marchal) J.R.Grant] that displayed significant nocturnal acidification indicative of recycling of respired CO_2. Although notable for revealing the existence of additional species capable of a limited degree of nocturnal CO_2 fixation, the study of Pierce *et al*. (2002a) also suggests such species will be in a small minority among taxa displaying C_3-like $\delta^{13}C$ values. Thus, although recognizing that this may represent a slight oversimplification, we use the strong bimodal distribution of $\delta^{13}C$ values in Figure 1 as the basis for referring to species with values more negative or less negative than −20‰ as C_3 species and CAM species, respectively.

Phylogenetic distribution of C_3 and CAM photosynthesis

As shown in Table 1 and summarized in Table 2 and Figure 2, the $\delta^{13}C$ values for the two earliest diverging subfamilies, Brocchinioideae and Lindmanioideae, were indicative of C_3 photosynthesis for all species sampled (Brocchinioideae is monogeneric: *Brocchinia*, $N = 16$ species sampled; Lindmanioideae comprises

Table 2. Summary of number of species of Bromeliaceae sampled for determination of the photosynthetic pathway, listed by genus

Taxon	Number of species sampled/total†	C_3 species ($\delta^{13}C$ more negative than −20‰)	CAM species ($\delta^{13}C$ less negative than −20‰)	CAM species as proportion of total sampled (%)
BROMELIACEAE	**1893/3350**	**1074**	**819**	**43**
Brocchinioideae	**16/20**	**16**	**0**	**0**
□ *Brocchinia*	16‡/20	16‡	0	0
Bromelioideae	**499/930**	**49**	**450**	**90**
❖ *Acanthostachys*	2/2	1	1	50
■ *Aechmea*	170§/281	2	168§	99
■ *Ananas*	6/6	0	6	100
■ *Androlepis*	1/2	0	1	100
■ *Araeococcus*	5/9	0	5	100
■ *Billbergia*	45/64	1	44	98
■ *Bromelia*	33/61	0	33	100
■ *Canistropsis*	7/10	1	6	86
■ *Canistrum*	6/13	0	6	100
❖ *Cryptanthus*	24/68	7	17	71
■ *Deinacanthon*	1/1	0	1	100
■ *Disteganthus*	2/3	0	2	100
■ *Edmundoa*	3/3	0	3	100
■ *Eduandrea*	1/1	0	1	100
□ *Fascicularia*	1/1	1	0	0
□ *Fernseea*	2/2	2	0	0
□ *Greigia*	13/35	13	0	0
■ *Hohenbergia*	33/62	0	33	100
■ *Hohenbergiopsis*	1/1	0	1	100
□ *Lapanthus*	1/3	1	0	0
■ *Lymania*	5/9	0	5	100
■ *Neoglaziovia*	2/3	0	2	100
■ *Neoregelia*	53/121	0	53	100
❖ *Nidularium*	23/46	8	15	65
□ *Ochagavia*	4/4	4	0	0
■ *Orthophytum*	23/67	1	22	96
■ *Portea*	7/9	0	7	100
■ *Quesnelia*	12/23	0	12	100
❖ *Ronnbergia*	7/11	6	1	14
■ *Ursulaea*	2/2	0	2	100
❖ *Wittrockia*	4/7	1	3	75
Hechtioideae	**25/66**	**0**	**25**	**100**
■ *Hechtia*	25/66	0	25	100
Lindmanioideae	**28/42**	**28**	**0**	**0**
□ *Connellia*	5/6	5	0	0
□ *Lindmania*	23/36	23	0	0
Navioideae	**70/105**	**70**	**0**	**0**
□ *Brewcaria*	6/6	6	0	0
□ *Cottendorfia*	1/1	1	0	0
□ *Navia*	59/91	59	0	0
□ *Sequencia*	1/1	1	0	0
□ *Steyerbromelia*	3/6	3	0	0
Pitcairnioideae	**331/632**	**238**	**93**	**28**
■ *Deuterocohnia*	11/19	0	11	100
■ *Dyckia*	68¶/159	0	68¶	100

Table 2. *Continued*

Taxon	Number of species sampled/total†	C_3 species ($\delta^{13}C$ more negative than −20‰)	CAM species ($\delta^{13}C$ less negative than −20‰)	CAM species as proportion of total sampled (%)
■ *Encholirium*	14/27	0	14	100
□ *Fosterella*	16/31	16	0	0
□ *Pitcairnia*	222/396	222	0	0
Puyoideae	**132/220**	**104**	**28††**	**21**
❖ *Puya*	132††/220	104	28††	21
Tillandsioideae	**792/1335**	**569**	**223**	**28**
□ *Alcantarea*	9/32	9	0	0
□ *Catopsis*	13/20	13	0	0
□ *Glomeropitcairnia*	2/2	2	0	0
□ *Guzmania*	154/213	154	0	0
□ *Mezobromelia*	7/9	7	0	0
□ *Racinaea*	49/76	49	0	0
❖ *Tillandsia*	373‡‡/624	150	223‡‡	60
□ *Vriesea*	125/264	125	0	0
□ *Werauhia*	60/95	60	0	0

Taxa are listed according to their subfamilial placement in Givnish *et al*. (2007). Taxonomic concepts follow Luther (2012) for genera, except that the monotypic *Pseudaechmea* L.B.Sm. & Read is included in *Billbergia* Thunb., the monotypic *Pseudananas* Hassl. ex Harms is included in *Ananas* L., and *Pepinia* Brongn. ex André is included in *Pitcairnia* L'Hér. Total species numbers for each taxon are based on Govaerts *et al*. (2013), but following the synonymy identified by Luther (2012). Taxa are assigned to one of two categories on the basis of carbon isotope ratios ($\delta^{13}C$ values) of either −20‰ or more negative (indicative of carbon fixation principally via C_3 photosynthesis) or less negative than −20‰ [indicative of carbon fixation occurring predominantly by crassulacean acid metabolism (CAM) photosynthesis]. The totals include information from 14 additional species obtained from previous studies, as detailed in Table 1. Genera are designated as follows: □, exclusively or overwhelmingly comprised of C_3 species; ■, exclusively or overwhelmingly comprised of CAM species; ❖, containing a substantial proportion of both C_3 and CAM species, or a substantial proportion of species with $\delta^{13}C$ values between −23‰ and −20‰.

†Based on the most recent catalogue of accepted names (Govaerts *et al*., 2013).

‡The $\delta^{13}C$ value of −19.6‰ for *Brocchinia maguirei* has been rounded to −20‰ and assigned to the category of values of −20‰ or more negative on the grounds that this taxon is unlikely to represent a *bona fide* CAM species, for the reasons discussed in the text.

§The $\delta^{13}C$ value of −20.2‰ for *Aechmea podonantha* has been rounded to −20‰ and assigned to the category of values of −20‰ or less negative on the grounds that the overwhelming majority (99%) of *Aechmea* species show CAM-like $\delta^{13}C$ values, and that this species does not differ significantly in its morphology from other species in the genus (Smith & Downs, 1979).

¶The $\delta^{13}C$ value of −26.8‰ for *Dyckia selloa* listed in Table S2 has been excluded on the grounds that it was obtained from material in cultivation and conflicts both with the results obtained for the remainder of the genus and with the expectation of CAM photosynthesis in this species based on its strongly xeromorphic features (Smith & Downs, 1974), which are characteristic of the whole genus. A number of CAM plants have been reported to switch to predominantly C_3 photosynthesis under the influence of persistently high soil water availability, e.g. *Agave deserti* (Hartsock & Nobel, 1976) and *Mesembryanthemum crystallinum* (Winter *et al*., 1978), and so the photosynthetic pathway likely to be shown by *D. selloa* in its natural habitat is best regarded as undetermined.

††The two independent samples of *Puya humilis* showed $\delta^{13}C$ values of −19.6 and −20.5‰, suggesting different photosynthetic pathways. Because both of these values fall near the −20.0‰ cut-off and thus are not strongly indicative of a particular pathway, the photosynthetic pathway in this species is best regarded as undetermined. For the sake of accounting, we assigned this species to the C_3 group on the basis that the average of the two values (−20.1‰) falls just within the C_3 range. *Puya ferruginea* was classified as a C_3 plant because four of the five independent samples analysed showed $\delta^{13}C$ values indicative of predominantly C_3 photosynthesis (−23.2, −22.8, −20.8, −20.6‰), whereas the fifth (−19.1‰) was at the high end of the range typical of CAM plants.

‡‡*Tillandsia imperialis* was classified as a C_3 plant even though one of the two independent samples showed a $\delta^{13}C$ value which weakly suggests CAM photosynthesis (−19.8‰). The other value of −24.5‰ is indicative of predominantly C_3 photosynthesis, as is the average of the two samples (−22.2‰).

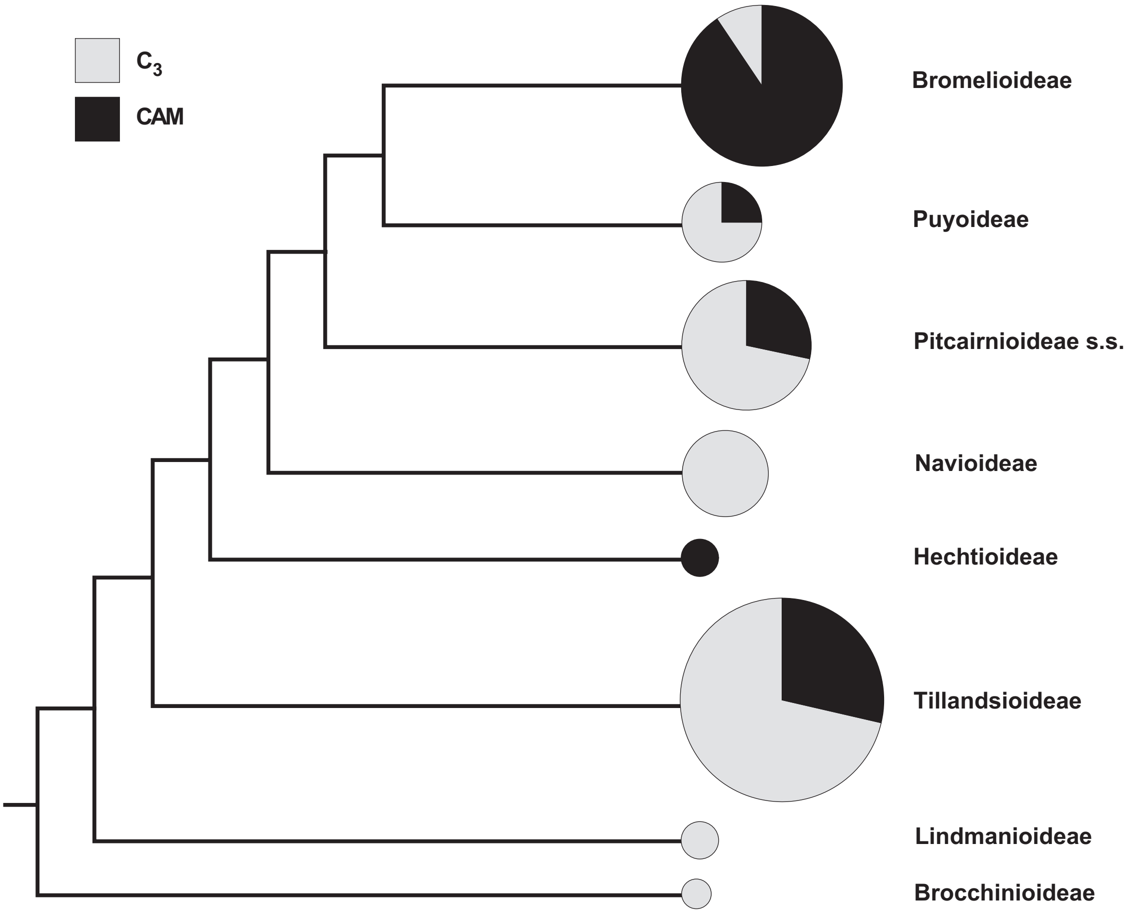

Figure 2. Phylogenetic distribution of photosynthetic pathways among subfamilies of Bromeliaceae. The consensus cladogram is based on Givnish *et al*. (2011). The pie graphs represent the proportion of species showing crassulacean acid metabolism (CAM)-like (black) and C_3-like (grey) $\delta^{13}C$ values, with the areas being proportional to the number of species sampled.

two genera: *Connellia* N.E.Br., $N = 5$, *Lindmania* Mez, $N = 23$). Both subfamilies are endemic to the wet, nutrient-poor tepuis and surrounding habitats of the Guiana Shield (Givnish *et al*., 1997; Holst, 1997; Benzing, 2000). Brocchinioideae is sister to the remainder of the family and diverged at approximately 23 Ma (Givnish *et al*., 2014). The exclusive occurrence of C_3 photosynthesis in these genera, and in the closely related Typhaceae and Rapateaceae (Crayn, Smith & Winter, 2001) and other early-diverging families of Poales (Bouchenak-Khelladi *et al*., 2014), suggests that this photosynthetic pathway represents the ancestral character state in Bromeliaceae.

In the third diverging subfamily, Tillandsioideae, 28% of the 792 sampled species showed $\delta^{13}C$ values indicative of CAM photosynthesis; indeed, all the early-diverging lineages in this subfamily are C_3, and the CAM species are entirely restricted to the more derived genus *Tillandsia*, 60% of which show CAM photosynthesis (Fig. 3; Table 2). The next diverging subfamily, Hechtioideae, is the only subfamily in which all sampled species ($N = 26$) exhibited a carbon isotope signature indicative of CAM photosynthesis. In contrast, Navioideae, sister to the remaining three subfamilies, is comprised entirely of species with a C_3-like carbon isotope signature ($N = 70$). In Pitcairnioideae *s.s.* and Puyoideae, approximately one-quarter of sampled species showed $\delta^{13}C$ values indicative of CAM photosynthesis, i.e. 28% of 331 sampled species in Pitcairnioideae, and 21% of 132 sampled species in Puyoideae. In subfamily Pitcairnioideae, CAM photosynthesis was restricted to a derived clade comprising *Deuterocohnia* Mez (including the former *Abromeitiella* Mez), *Dyckia* Schult.f. and *Encholirium* Mart. ex Schult.f., all species of which were found to be CAM plants. Phylogenetic relationships in Puyoideae are currently less well resolved (Jabaily & Sytsma, 2010, 2013), and further work incorporating increased taxon sampling and next-generation DNA sequencing will be needed to determine whether C_3 or CAM

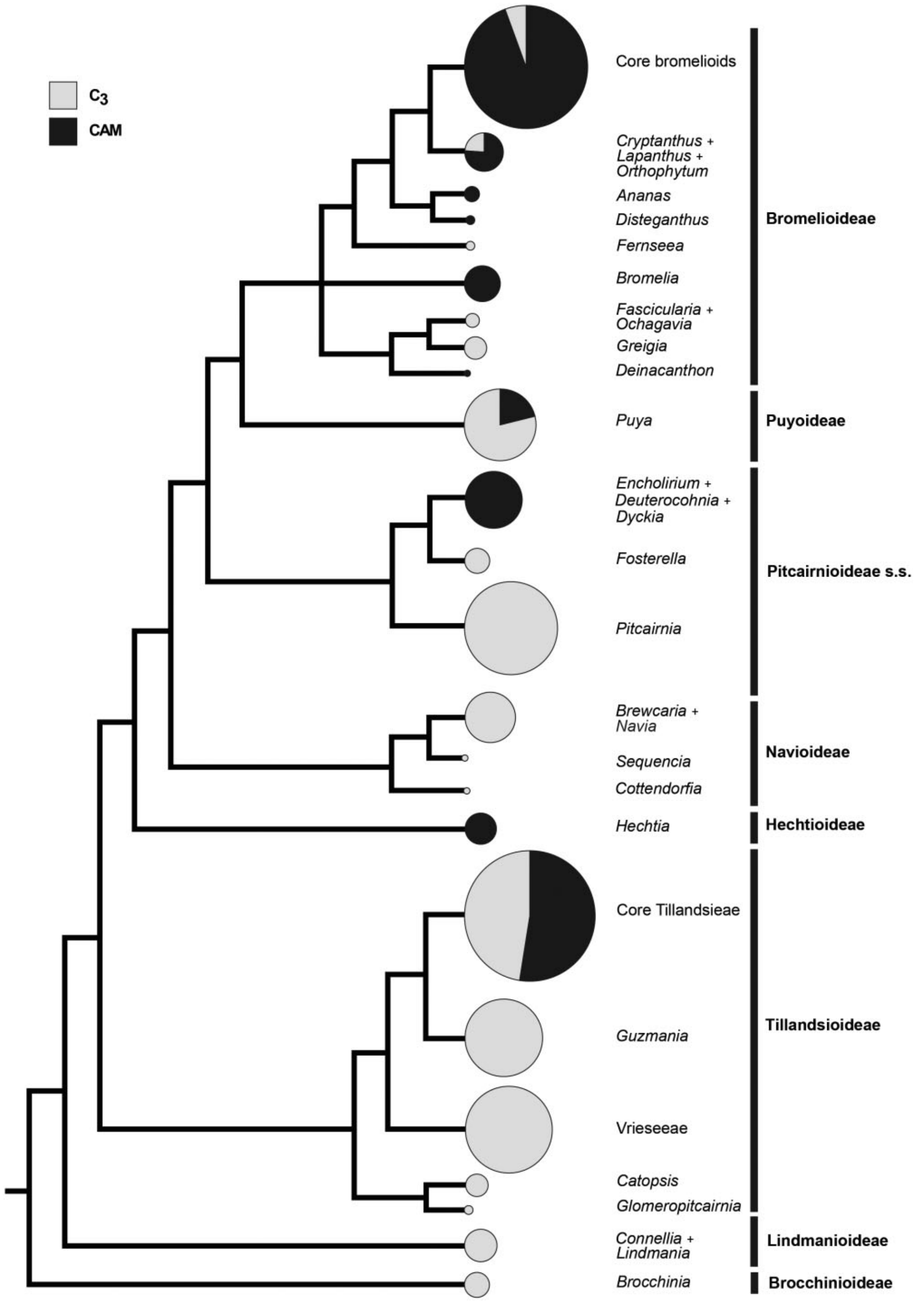

Figure 3. Phylogenetic distribution of photosynthetic pathways among genera of Bromeliaceae. The tree is a simplified consensus cladogram derived from published molecular phylogenetic trees (Barfuss *et al.*, 2005; Givnish *et al.*, 2011; Silvestro *et al.*, 2014). The pie graphs represent the proportion of species showing crassulacean acid metabolism (CAM)-like (black) and C_3-like (grey) $\delta^{13}C$ values, with the areas being proportional to the number of species sampled. Relationships among many genera in Bromelioideae are uncertain and these are aggregated on the cladogram as 'core bromelioids': *Acanthostachys*, *Aechmea*, *Androlepis*, *Araeococcus*, *Billbergia*, *Canistropsis*, *Canistrum*, *Edmundoa*, *Eduandrea*, *Hohenbergia*, *Hohenbergiopsis*, *Lymania*, *Neoglaziovia*, *Neoregelia*, *Nidularium*, *Portea*, *Quesnelia*, *Ronnbergia*, *Ursulaea*, *Wittrockia*. Likewise, in Tillandsioideae, the genera *Alcantarea, Mezobromelia, Vriesea* and *Werauhia* have been aggregated as tribe Vrieseeae, and *Racinaea* and *Tillandsia* as core Tillandsieae.

photosynthesis is the ancestral character state in this clade. Similarly, in subfamily Bromelioideae, although the large majority of species (90% of 499 taxa sampled) exhibited CAM photosynthesis, several of the earliest diverging genera exhibited C_3 photosynthesis, namely *Fascicularia* Mez, *Ochagavia* Phil. and *Greigia* Regel (Tables 1, 2, Fig. 3), and it remains to be inferred whether the last common ancestor of *Puya* Molina and Bromelioideae possessed C_3 or CAM photosynthesis.

Evolutionary ecology of C_3 and CAM photosynthesis

One conclusion to emerge from this large taxonomic survey of photosynthetic pathways in Bromeliaceae is that the majority of genera in the family tend to be either overwhelmingly C_3 or CAM, with relatively few possessing substantial numbers of both photosynthetic types. Of the 12 largest genera in the family, only *Puya* (21% CAM) and *Tillandsia* (60% CAM) contain substantial numbers of both CAM- and C_3-type $\delta^{13}C$ values (Table 2, Fig. 3). These results imply a high degree of phylogenetic niche conservatism, the tendency of lineages to retain their niche-related traits through speciation events (Wiens & Donoghue, 2004; Crisp & Cook, 2012), in the majority of genera. Given that the understanding of bromeliad phylogeny has advanced substantially in recent years, it is now possible to identify with greater confidence the principal lineages in which CAM photosynthesis has arisen, at least at higher taxonomic levels, and to draw some conclusions about the ecological characteristics of these distinct lineages.

On the basis of the phylogenetic reconstructions of Givnish *et al*. (2011, 2014), CAM can be inferred to have arisen at least four, and probably five, times independently at the taxonomic level of genus or above. Deriving estimates of timing from the molecular chronogram in Givnish *et al*. (2014), it is likely that CAM photosynthesis made its earliest appearance in the family in the genus *Hechtia* Klotzsch in the mid- to late Miocene (stem node, 16.2 Ma; crown node, 9.9 Ma). *Hechtia* is a rather isolated lineage of 66 species, centred in its distribution on the semi-arid habitats of Mexico, and extending from the Chihuahuan Desert and Sonoran Desert regions in the north to Honduras and Nicaragua in the south (Smith & Downs, 1974; Benzing, 2000). Based on our sampling of nearly 40% of the genus, the clade appears to be entirely CAM and to represent a prime example of phylogenetic and ecological niche conservatism at this taxonomic level. The diversification of *Hechtia* would have been broadly contemporaneous with that of other distinctive arid zone taxa, such as *Leucaena* Benth. and *Prosopis* L. (Lavin *et al*., 2004; Catalano *et al*., 2008), *Bursera* Jacq. ex L. (Becerra, 2005), *Tiquilia* Pers. (Moore & Jansen, 2006), *Ephedra* L. (Loera, Sosa & Ickert-Bond, 2012) and *Milla* Cav. (Gándara, Specht & Sosa, 2014), which is viewed as a response to progressive late Miocene aridification. Regionally, this would have been associated with the spread of more arid habitats in central Mexico and formation of the North American deserts (Graham, 1999), creating suitable conditions for diversification of two of the archetypical families of terrestrial CAM plants: Agavaceae and Cactaceae (Good-Avila *et al*., 2006; Pellmyr *et al*., 2007; Smith *et al*., 2008; Arakaki *et al*., 2011).

The second distinct origin of CAM photosynthesis in Bromeliaceae occurred in Tillandsioideae, which also arose as a subfamily in the mid-Miocene (stem node, 17 Ma; crown node, 15 Ma: Givnish *et al*., 2014). Essentially all members of Tillandsioideae are epiphytic, although they may be found growing as lithophytes or epiarenically, but CAM taxa are wholly restricted to the derived genus *Tillandsia*. The early-diverging lineages in Tillandsioideae are notably species poor [*Glomeropitcairnia* Mez (two species); *Catopsis* Griseb. (20 species)] and it is possible that *Catopsis*, in particular, despite containing characteristically light-demanding species that occupy relatively exposed epiphytic niches (Smith & Downs, 1977; Benzing, 2000), has remained a relatively small lineage on account of the absence of CAM photosynthesis. The great species diversification (~1300 species) seen in six genera making up core Tillandsioideae evidently began in the late Miocene and has been associated with the occupation of an enormous variety of epiphytic niches, especially in the montane forests of the northern Andes and Mesoamerican cordilleras and across the Caribbean. These range from shade-tolerant forms in rain forests, through light-demanding species occupying more exposed niches in the forest canopy, to xeromorphic drought-tolerant species found in semi-deciduous forests and thorn woodland (Pittendrigh, 1948; Benzing, 2000). In *Tillandsia*, the largest (> 600 species) and most widely distributed genus in the entire family, CAM photosynthesis is closely associated with this trend towards more extreme xeromorphy (Medina, 1974; Medina *et al*., 1977; Griffiths & Smith, 1983; Smith, 1989), and essentially all of the species with the specialized 'atmospheric' life-form sampled here were found to be CAM plants (Table 1). Further work is needed to understand the phylogenetic relationships in the core tillandsioids (Barfuss *et al*., 2005), and it is possible that CAM photosynthesis will be found to have evolved on more than one occasion in this lineage.

After Navioideae, an exclusively C_3 clade of about 100 terrestrial species restricted, like Brocchinioideae and Lindmanioideae, to wet, nutrient-poor habitats in the Guiana Shield (Givnish *et al*., 1997, 2004), the third distinct origin of CAM photosynthesis at a higher taxonomic level was in the terrestrial subfamily Pitcairnioideae in a monophyletic 'xeric' clade comprising the genera *Deuterocohnia*, *Dyckia* and *Encholirium* (Crayn *et al*., 2004; Givnish *et al*., 2007, 2011, 2014). The earliest diverging lineage in Pitcairnioideae was *Pitcairnia*, a large (~400 species), widely distributed genus of predominantly understorey species (but including some moderately drought-tolerant members) which, however, has remained exclusively C_3. The later diverging xeric clade (stem node, 11.3 Ma; crown node, 8.0 Ma) is sister to *Fosterella* L.B.Sm., a small genus of relatively mesomorphic C_3 species centred on the Andean slopes of southern Peru, Bolivia and northern Argentina (Smith & Downs, 1974; Rex *et al*., 2009; Wagner *et al*., 2013). The genera *Deuterocohnia*, *Dyckia* and *Encholirium* making up the xeric clade of approximately 200 species are spiny, xeromorphic plants distributed across arid parts of the southern Andes, northern Argentina, Paraguay, and southern and eastern Brazil (Smith & Downs, 1974; Benzing, 2000; Santos-Silva *et al*., 2013; Krapp *et al*., 2014). This clade appears to be made up solely of CAM species and presents another striking example of ecological niche conservatism in these water-limited habitats. *Dyckia* and *Encholirium* are particularly characteristic elements of the more arid parts of the cerrado and caatinga formations in eastern Brazil, where these CAM species are often found in a succulent biome in association with cacti (Pennington, Lavin & Oliveira-Filho, 2009). *Dyckia*, the largest of the three genera with ~160 species, appears to have diversified particularly in the Pliocene and Pleistocene (Krapp *et al*., 2014).

The last two lineages containing CAM species are *Puya* (now raised to the status of subfamily Puyoideae: Givnish *et al*., 2007, 2011) and its sister group Bromelioideae. Phylogenetic relationships among the early-diverging lineages of both of these lineages are currently not well resolved, and so it cannot yet be inferred whether the last common ancestor of these two subfamilies was C_3 or CAM (Crayn *et al*., 2004; Schulte *et al*., 2009; Escobedo-Sarti *et al*., 2013; Givnish *et al*., 2014; Silvestro *et al*., 2014). In *Puya* (stem node, 10.7 Ma; crown node, 9.4 Ma), the earliest diverging lineages are found in the southern part of the present-day range of the genus in Chile, but the majority of the 220 species are Andean, and indeed the genus may have diversified in a northerly direction in the late Miocene and Pliocene, coincident with the final uplift of the Andes (Jabaily & Sytsma, 2010, 2013; Schulte *et al*., 2010). Approximately 20% of the genus is estimated to possess CAM photosynthesis (Table 2), including many species found at high elevations in the Andes, presumably occupying drier microhabitats, such as arid intermontane valleys and exposed slopes (Smith & Downs, 1974; Varadarajan, 1990; Benzing, 2000; Jabaily & Sytsma, 2010, 2013).

Finally, in subfamily Bromelioideae (stem node, 10.7 Ma; crown node, 9.4 Ma), 90% of the sampled species possess CAM photosynthesis, and most individual genera consist largely or entirely of CAM species (Table 2). In the subfamily, there has been a clear evolutionary trend from the terrestrial habit to epiphytism (Crayn *et al*., 2004; Silvestro *et al*., 2014), and four of the early-diverging terrestrial genera were notable for being exclusively C_3: these are typically found either in cooler climates in montane habitats (*Fernseea* Baker, *Greigia*) or towards the southerly latitudinal limit of the range of the family (*Fascicularia*, *Ochagavia*: Zizka *et al*., 2009). The phylogenetic relationships of these C_3 taxa to the early-diverging CAM lineages *Deinacanthon* Mez and *Bromelia* L. need to be resolved to be able to infer the evolution of the photosynthetic pathway (including any biogeographical or environmental influences) in the early radiation of Bromelioideae (Crayn *et al*., 2004; Schulte *et al*., 2009; Givnish *et al*., 2014; Silvestro *et al*., 2014). A number of other bromelioid genera that include representatives tolerant of relatively shaded or moist habitats were found to contain a number of C_3 species [*Aechmea* Ruiz & Pav., *Cryptanthus* Otto & A.Dietr., *Lapanthus* Louzada & Versieux (2010), *Nidularium* Lem., *Ronnbergia* E.Morren & André, *Wittrockia* Lindm.], and these may represent examples of reversion to C_3 photosynthesis from within ancestrally CAM lineages (Crayn *et al*., 2004).

Elevational distribution and photosynthetic pathway

Although the geographical range sizes of bromeliad taxa vary widely, several environmental variables change with increasing elevation, and many bromeliads exhibit distinctive altitudinal zonation. To investigate the relationship between photosynthetic pathway and elevation, $\delta^{13}C$ values were plotted against elevation for 1264 samples (including replicates) for which reasonably precise collection locality elevation was available (Fig. 4). For the C_3 group of species ($\delta^{13}C$ values of −20.0‰ or more negative, $N = 854$), there was a significant ($P < 0.001$) effect of elevation on $\delta^{13}C$, which increased by 1.47‰ per 1000 m, or by 6.54‰ over the full elevational range of these taxa from sea level to 4450 m. In contrast, there was no statistically significant trend with elevation in the CAM group of species ($\delta^{13}C$ values less negative than −20.0‰, $N = 410$).

The magnitude of the elevational increase in $\delta^{13}C$ value of C_3 bromeliads is similar to the average change of 1.2‰ per 1000 m observed in 100 C_3 species

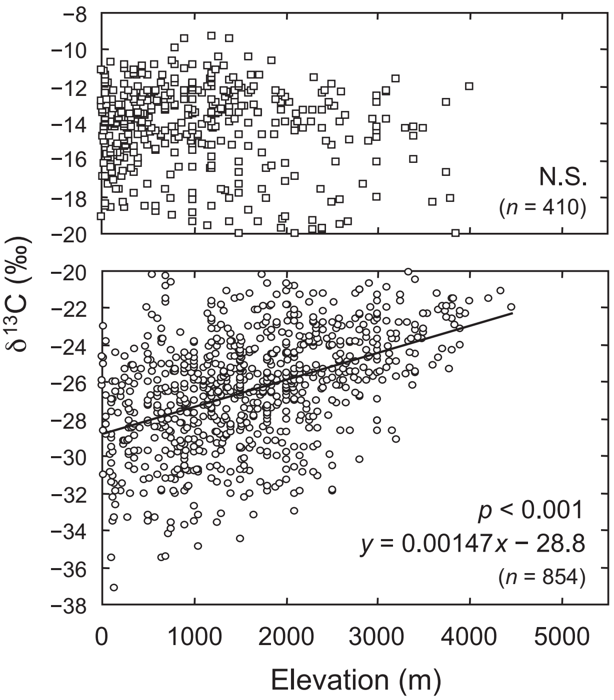

Figure 4. Elevation versus $\delta^{13}C$ values for 1264 samples (including replicates). Where an elevational range was recorded for a species, the mid-point value was used. Data were analysed by least-squares regression in two groups: samples ($N = 854$) with $\delta^{13}C$ values of −20.0‰ or more negative ($y = 0.00147x - 28.8$, $r^2 = 0.214$, $P < 0.001$) and samples ($N = 410$) with $\delta^{13}C$ values less negative than −20.0‰ ($y = -0.00023x - 14.0$; $r^2 = 0.0084$, $P = 0.071$; N.S., not significant).

collected across a range of taxa from several elevational gradients around the globe (Körner, Farquhar & Roksandic, 1988; Körner, Farquhar & Wong, 1991), although less than the increase of 3.3‰ per 1000 m observed for 85 species of Rapateaceae (Crayn *et al.*, 2001). Intraspecific changes have been found to be of comparable extent, i.e. 1.6‰ per 1000 m as the mean increase for four evergreen conifers in the Rocky Mountains, USA (Hultine & Marshall, 2000), and 2.4‰ per 1000 m in the tree species *Metrosideros polymorpha* Gaudich. from Hawaii (Cordell *et al.*, 1999). Less negative $\delta^{13}C$ values with increasing elevation are usually associated with increased leaf nitrogen contents and increased leaf mass/area ratios, although this has not yet been verified for bromeliads. The elevational response of $\delta^{13}C$ may be linked to lower c_i/c_a ratios during photosynthesis at higher elevations, in particular owing to increased carboxylation efficiency of Rubisco at decreasing oxygen partial pressure (Farquhar & Wong, 1984), and possibly to temperature-related changes in the viscosity of water, slowing the transport of water to the evaporative sites in leaves (Cernusak *et al.*, 2013). Anatomical changes affecting the diffusion of CO_2 to carboxylation sites may also be involved (Hultine & Marshall, 2000; Cernusak *et al.*, 2013).

The observed absence of an elevational effect on $\delta^{13}C$ of CAM bromeliads probably results from a complex compensatory interplay of processes that increase $\delta^{13}C$ with increasing elevation (increased diffusional limitation of daytime CO_2 uptake) or decrease $\delta^{13}C$ (increased diurnal vs. nocturnal CO_2 fixation owing to decreases in ambient temperature; increased diffusional limitation of dark CO_2 fixation). Theory predicts that, in contrast with C_3 photosynthetic CO_2 uptake in the light, increased diffusional limitation of PEPC-mediated CO_2 uptake in the dark should lead to more negative, not less negative $\delta^{13}C$ values, a conclusion supported by online carbon isotope discrimination measurements on species of *Clusia* L. (Roberts, Borland & Griffiths, 1997) and on C_4 plants photosynthesizing at different c_i/c_a ratios (Farquhar *et al.*, 1989). Moreover, a wealth of literature on diel patterns of net CO_2 exchange in constitutive CAM species, such as species of *Kalanchoë* Adans., indicates that low daytime temperatures promote C_3 photosynthetic daytime CO_2 fixation at the expense of nocturnal CO_2 fixation (Kluge & Ting, 1978; Winter, 1985).

In absolute terms, the species richness of the bromeliad flora declined with elevation above 1500 m, but this was the net result of different trends in the two photosynthetic types (Fig. 5). CAM species richness declined gradually with increasing elevation, as has been noted in other studies of CAM plant abundance along elevational gradients (Griffiths & Smith, 1983; Griffiths *et al.*, 1986; Earnshaw *et al.*, 1987; Smith, 1989; Hietz, Wanek & Popp, 1999), but C_3 species showed a richness peak between about 1000 and 2000 m, consistent with previous considerations of a general mid-elevation maximum in species richness (Whittaker & Niering, 1975; Cardelús, Colwell & Watkins, 2006). As a proportion of the total bromeliad flora, CAM species richness was highest (61% of total) at the lowest elevations, but, above 1500 m, despite declining absolute numbers, they still represented a relatively constant proportion (approximately 20%) of the total (Fig. 5, inset). The persistence of a small number of epiphytic CAM species in high-rainfall upper montane rain forest and even ridge-top cloud forest has been noted previously (Griffiths & Smith, 1983; Griffiths *et al.*, 1986; Smith *et al.*, 1986; Pierce, Winter & Griffiths, 2002b), and may be related to local topographical factors, such as exposure and wind speed. At any rate, interactions between temperature and water gradients caused by increased elevation evidently have contrasting effects on the abundance of C_3 and CAM bromeliads. More detailed

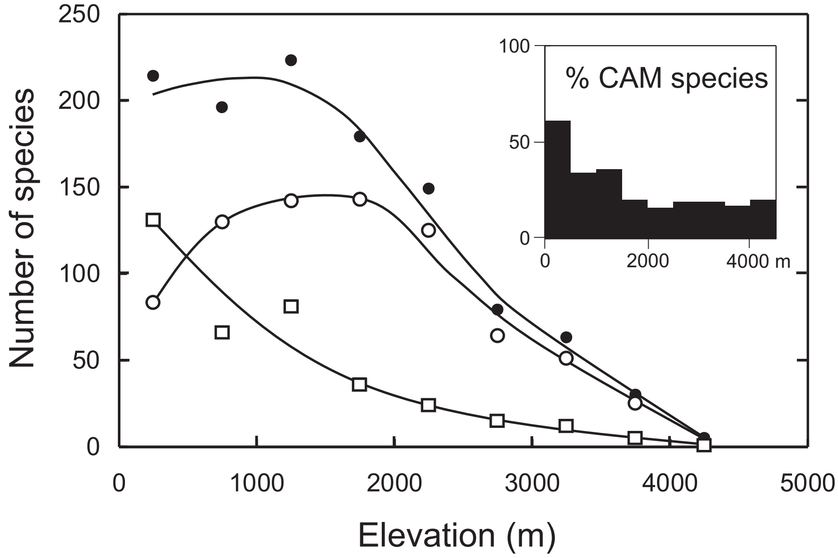

Figure 5. Relationship between elevation and the number of bromeliad species showing crassulacean acid metabolism (CAM)-like (white squares) and C_3-like (white circles) $\delta^{13}C$ values (the black circles are the combined total). Data were separated into 500-m bins. The inset shows the percentage of species exhibiting CAM in each elevational class.

analysis of the linkage between environmental factors and bromeliad distribution along elevational gradients may help to refine our knowledge of the ecological niches occupied by C_3 and CAM species, and thereby allow more accurate predictions of the possible effects of future climate change on species distribution patterns and relative abundance (Feeley *et al*., 2011; Tovar *et al*., 2013).

The high elevations attained by some species of bromeliad are a notable feature of the family, and especially of the predominantly Andean genus *Puya*. More than 20 *Puya* spp. have been recorded at elevations of > 4000 m (Smith & Downs, 1974; Tropicos.org), with the highest documented occurrence appearing to be that of *P. hamata* L.B.Sm. vel sp. aff. at 4970 m (D.N. Smith & M. Buddensiek 11222; MO). Although the relative abundance of CAM taxa was found to decrease gradually with increasing elevation (Fig. 5), it is evident that CAM photosynthesis is not incompatible with the extreme conditions (notably the subzero night-time temperatures) that characterize these high-elevation sites. Four *Puya* spp. that show clear CAM-type $\delta^{13}C$ values [*P. cerrateana* L.B.Sm. (−14.1‰), *P. longistyla* Mez (−13.8‰), *P. meziana* Wittm. (−13.1‰, average of four independent specimens) and *P. reflexiflora* Mez (−17.3‰)] have elevational ranges that extend above 4000 m, and ten of the CAM *Puya* spp. identified in the present survey (covering 60% of the genus) occur above 3000 m (Tropicos.org). Although not frequent, there have been a number of other notable examples of high-elevation CAM. Two species of cacti, *Oroya peruviana* (K.Schum.) Britton & Rose and *Tephrocactus floccosus* (Salm-Dyck) Backeb. [= *Austrocylindropuntia floccosa* (Salm-Dyck) F.Ritter], have been observed showing nocturnal acidification typical of CAM and $\delta^{13}C$ values between −13.9‰ and −14.6‰ at two sites at 4270 and 4190 m in the Peruvian Andes by Keeley & Keeley, (1989); the former species was noted to extend to elevations above 4700 m. In addition, in a study of several species of *Calandrinia* Kunth and *Philippiamra* Kuntze in the Chilean Andes, Arroyo, Medina & Ziegler (1990) observed a CAM-type $\delta^{13}C$ value of −16.2‰ for *C. spicata* Phil., a species reported to occur up to 3400 m, and intermediate values in the range −19 to −22‰ were observed for five other species, possibly indicating some degree of CAM activity in these taxa (and/or an effect of high elevation on the $\delta^{13}C$ value in C_3 species).

CONCLUSIONS

In summary, our extensive survey of $\delta^{13}C$ values among species of Bromeliaceae shows that CAM photosynthesis is the principal pathway of carbon assimilation in nearly half of the members of this large and ecologically diverse family. The strong bimodal partitioning of $\delta^{13}C$ values into a C_3 cluster and a CAM cluster in this single species-rich clade suggests that CAM is a discrete physiological trait and that a carbon acquisition strategy involving equal contributions of C_3 and CAM photosynthesis is apparently not favoured. Although bromeliads extend over a wide range of elevations from 0 to > 4000 m, the greatest numbers of CAM bromeliads occur in the lowlands. The relative contributions of temperature and rainfall to this distributional pattern are not yet known. Although the C_3-type carbon isotopic signature varies strongly with elevation, the CAM-type isotopic signature does not, pointing to differential sensitivities of Rubisco- and PEPC-mediated CO_2 fixation to changes in CO_2 and O_2 pressure.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article at the publisher's website:

Table S1. Names of bromeliad taxa cited in previous investigations of the photosynthetic pathway that are now placed in synonymy, or for which citations in these references are identified as transcription errors. All of these taxa were sampled as part of the present study and are listed in Table 1 under their accepted names.
Table S2. List of taxa showing apparent discrepancies between the consensus on their likely photosynthetic pathway (based on carbon isotope ratios measured in the present study and other evidence where available) and conflicting individual reports in the earlier literature.

