**Supplementary file 1: Methods**

This file contains detailed examples on how the coding was done (reported in supplementary file 2). A number of examples were chosen to represent each of the four tropical regions with alpine-like environments. References to literature are given (details included in supplementary file 2) and a denotation of certainty included.

(data s) = data supported by phylogenetic evidence.

(data p) = data only partially supported.

(data u) = data not supported by phylogenetic evidence, coding based on taxonomic/morphological work in combination with species, lineage and/or generic distribution data.

**Afroalpine coding examples:**

*Afroligusticum* (Apiaceae) genus of 13 species all in sub-Saharan Africa, 9 in Tropical Africa in montane and temperate regions,1 Afroalpine species. Phylogenetic evidence Winter et al. 2008 TAXON, 57 (2): 347-364. 1 **biome change (data s)**

*Haplosciadium* (Apiaceae) monotypic genus most likely related to other genera from the temperate regions in sub-Saharan Africa, i.e. other member of the African Tordylieae group. No phlyogenetic evidence but see Winter et al. 2008 TAXON, 57 (2): 347-364 **biome change (data u)**

*Pimpinella* (Apiaceae) genus of around 200 species mostly Eurasia and Africa, 48 in sub-Saharan Africa of which 42 in Tropical Africa in montane and temperate regions,2 Afroalpine species, *P. pimpinelloides* (Hochst.) H.Wolff. restricted to upper Afroalpine above 4200m in Simien Mts. in Ethiopia, the other widely distribution on mountain tops in tropical Africa from 2300-4200m. Phylogenetic evidence Magee et al. 2010 Plant Systematics and Evolution 288(3-4): 201-211. *P. oreophila* (incl. var. *kilimandscharica* (Engl.) C. C. Towns.) is sister to *P. hirtella* from temperate highlands in the same area imbedded in a clade of African mountain species. *P. pimpinelloides* is very similar to *P. oreophila* and perhaps only a high level form of that species (Fl. Eth. & Eritrea 4/1: 28 2003). **1 biome change 1 in situ speciation (data s)**

*Primula* (Primulaceae), genus of about 430 species Europe 34, Eastern Himalaya 225, Americas as well as tropical mountains in Africa to Java and New Guinea 1 in sub-Saharan Africa (Afroalpine from 2000-4200 m). No phylogenetic evidence. **1 alpine dispersal (data u)**

*Oreophyton falcatum* (Hochst. ex A.Rich.) O.E.Schulz (Brassicaceae),. Monotypic genus restricted to Afroalpine regions between 4000-4600 m. Phylogenetic evidence Coveur et al. 2010 Mol Biol Evol. 27(1):55–71. Sister to *Murbeckiella* (5 species with subalpine-alpine distribution) and together sister to *Erysmium* (150 species in the Northern temperate Hemisphere). **1 alpine dispersal (data u)**

*Alchemilla* (Rosaceae), genus of more than 1000 (micro-)species mostly Eurasian, 40 in sub-Saharan Africa of which 18 occur in Tropical Africa in montane and temperate regions,13 Afroalpine species. Phylogenetic evidence see Gehrke at al. (2016). **4** **biome change, 9 in situ speciation (data s)**

*Euryops* (Asteraceae), genus of 97 species restricted to Africa (+ 1 sp. on the Arabian Peninsula), the greatest species number and diversity occurs in Southern Africa, eight species are confined to the high mountains of Eastern Africa, 3 strict Afroalpine and one subalpine species. Phylogenetic evidence. Devos et al. 2010 Taxon 59(1): 57-67. East African Afromontane form a clade with *E. prostratus* sister to the rest. “The Afromontane species of tropical Africa could thus have originated from a northward migration of an ancient high-altitude ancestral species related to the extant [Drakensberg ] alpine endemics”. *E. elgonensis* Mattf. potentially only a subsp. of *E. brownie* S. Moore (same areas but subalpine-alpine 3000-3900m) according to Hedberg 1957). **1 alpine dispersal 1** **biome change 1 in situ speciation (data p)**

*Helichrysum* (Asteraceae) more than 500 species mostly Southern African, 300 species in sub-Saharan Africa of which 151 occur in Tropical Africa in montane and temperate regions, 9 strictly Afroalpine species, 7 more occur there occasionally. Galbany-Carals et al 2014 Taxon **5** **biome change, 4 in situ speciation (data p)**

*Lobelia* (Campanulaceae), genus of about 300 species most species rich in the Americas and Africa 142 species in sub-Saharan Africa of which 91 occur in Tropical Africa in montane and temperate regions, 6 strictly Afroalpine species. Often reported to be typical for Afroalpine regions. Phylogenetic evidence Antonelli et al. 2009 BMC Biol 7 and Knox & Palmer 1998 Syst Bot 23(2): 109-149. 4 **biome change 2 in situ speciation (data p)**

*Arabis* (Brassicaceae), genus of about 100 species from the temperate northern Hemisphere 2 spp. in sub-Saharan Africa**. *Arabis alpina*** widespread species with an amphiatlantic distribution in Europe, western Eurasia, Greenland and Northeast America, in East Africa high moutains widespread and common. Phylogenetic evidence Assefa et al. 2007 HEREDITY 99(2): 133-142 and Koch et al. 2006 MOL. ECOL. 15(3): 825-839. At least two independent colonisation events of the Afroalpine from Eurasia one with an accession from the Lebanon as sister to the African material and one from a Haplotype group also present on the Arabian Peninsula. *Arabis elgonensis* is similar to *A. alpina* but restricted to Mt. Elgon. **2** **biome change 1 in situ speciation (data p)**

**Mt. Kinabalu coding examples:**

*Carex* (Cyperaceae) genus of nearly 1000 species, 58 species all in Malesia and 17 on Borneo, 4 species at higher elevation on Mt. Kinabalu, 3 widespread species of subgenus Vignea occurring from Asia to New Zealand in montane grasslands and 1 species of subgenus *Carex* (*C. verticillata)*. **4** **biome changes (data u)**

*Gaultheria* (Ericaceae) genus of nearly 120 species 28 species in Malesia. Only *G. borneensis* Stapf in Malaysia (Mt. Kinabalu), the Philippines (Luzon), and Taiwan. Phylogenetic evidence Fritsch (2011) Novon 21(3):338-342, Lu et al. (2010) Mol Phyl Evol 57(1): 364-379. **1 alpine dispersal (data p)**

*Rhododendron* (Ericaceae) genus of about 1000 species from the temperate Northern Hemisphere 155 species endemic in New Guinea, 30 species on Borneo 2 species on alpine Mt. Kinabalu. Phylogenetic evidence Goetsch et al (2011) Taxon 60(4):1015-1028. *Rhododendron* *buxifolium* Low ex Hook.f. is part of the Malaysian sect. *Schistanthe* (= sect. *Vireya*), sister to *R. edanoi* and *R. suaveolens* and *Rhododendron ericoides* H. Low ex Hook.f. is part of sect. *Discovirey* from lower, montane regions*.* **2** **biome change (data s)**

*Dendrochilum* (Orchidaceae) genus of about 300 species from Southeast Asia and Malaysia, distributed at mostly at higher elevations in the humid rainforests. 276 species in Malesia, 83 species on Borneo 5 species in alpine Mt. Kinabalu. Phylogenetic evidence Barkman and Simpson (2001) Syst Bot 26(3):658-669. **1** **biome change, 4 in situ speciation (data p)**

**Páramo coding examples:**

*Aragoa* (Plantaginaceae) genus of 19 species endemic to Páramos of Colombia and Venezuela, although some species may also occur in upper montane forest (Cleef 1979, Fernández-Alonso 1995, Luteyn 1999). Only 4 species occur in the alpine-like part of the Páramo of which all also occur below 3800m. The genus is sister to *Plantago*. Phylogenetic evidence Bello et al 2002 Kew Bulletin, 57(3): 585-59. **1-4** **biome change, 0-3 in situ speciation (data u)**

***Espeletia*** s.l. / subtribe Espeletiinae Cuatrec. (Asteraceae) is a complex of ca. 140 species endemic to the northern Andes. The Espeletiinae also includes *Carramboa*, *Coespeletia*, *Espeletiopsis*, *Libanothamnus*, *Paramiflos*, *Ruilopezia* and *Tamania.* Major species richness is found in the Venezuelan Andes and the Colombian Eastern Cordillera with more than 120 species described as confined to Páramo habitats (Moran and Funk 2006). However only five species are restricted to alpine-like Páramo regions above 3800m and 17 additional are likely to occur mainly in this area. The majority of Espeletiinae seem to occur in open grassland below 3800m as 80 of the 126 investigated species are recorded in Luteyn (1999) as not reaching elevations of 3800m and higher. Phylogenetic evidence Moran and Funk 2006 Syst. Bot. 31(3): 597-609 ***Espeletia*** 15 strict alpine-like Páramo species with **5-10** **biome change, 8-13 in situ speciation events** **(data u) *Espeletia*** including *Coespeletia*, *Espeletiopsis* 22 strict alpine-like Páramo species with **7-14** **biome change 11-18 in situ speciation events** **(data u)**

***Chuquiraga***  (Asteraceae) genus of 23 species from the Andean of Chile and Argentina to Colombia, probably 13 species in the tropical part of the Andes, 3 Paramo species. According to Skelnar et al. 2011 a southern South America origin of *Chuquiraga* is suggested by phylogenetic studies, which imply a south to north migration into Páramo. He coded this genus as a Neotropical lineage. Phylogenetic evidence Ezcurra 2002 Bot Rev 68(1): 153-70. **2** **biome change 1 in situ speciation**

***Paspalum*** (Poaceae) genus of nearly 350 species widespread across much of Asia, Africa, Australia, and the Americas, most diverse in subtropical and tropical regions. Seven species above 3000m, only *P. penicillatum* coded as a true alpine Páramo species. Phylogenetic evidence Scataglini et al. 2014 suggest that this species is nested in a Andean high altitude clade. **1** **biome change**

***Sisyrinchium*** (Iridaceae) genus of ~140 species on the American continent. *Sisyrinchium* is an herbaceous genus mainly characterized by the lanceolate to linear or eventually terete leaves and the presence of either a rhizomatous rootstock or a fibrous root system (Goldblatt & Manning 2008). Eleven species recorded in the Páramo s.l. of which four are commonly found in the alpine-like Páramo s.str. of which S. brevipes is exclusively confined to the alpine parts. Phylogenetic evidence Chauveau et al. 2011 suggest that paraphyletic *S. jamesonii* with *S. pusillum* and *S. brevipes* are part of clade 0, while paraphyletic *S. tinctorum* is part of clade I. Sister to the clade of *S. tinctorum* and other species is *S. palustre* present in Peru and Ecuador at high altitudes, often above 3000m. Sister to this clade is *S. longipes* from North America. Clade 0 also includes *S. praealtum* from Peru and *S. laxinervum*. Sister to *Sisyrinchium* is *Olsynium* native to sunny hillsides in South America and western North America. This is possibly one of the few examples of a reversal to non-alpine environments. *Sisyrinchium trinervis* is not included in the study. **2** **biome change 2 in situ speciation (data s)**

***Puya*** (Bromeliaceae) genus of >200 species described species of terrestrial rosette-forming bromeliads, is a striking example of recent rapid species diversification in the Andes . Five species commonly present in high alpine regions, nine additional ones occasionally. *P. nutansand P. trianae* reconstructed as independently evolved at high elevations (>3000m) in the Northern Andes. Phylogenetic evidence Jabaily and Sytsma 2013 Historical biogeography and life-history evolution of Andean Puya (Bromeliaceae) Bot J Lin Soc 171(1): 201-224. **5-2** **biome change, 0-3 in situ speciation (data s)**

**Out of the alpine examples:**

***Diplostephium*** (Asteraceae) “we hypothesize that the ancestor of the genus [*Diplostephium*] was more likely a paramo-puna-shrub morphotype that originated along the high Andes, with subsequent colonizations to the Andean forest” Vargas and Madriňán 2012 Lundellia 15:1–15.

“Evolution of forest tree species derived from paramo ancestors has not been previously described (see van der Hammen and Cleef 1986).” Vargas and Madriňán 2012 Lundellia 15:1–15.

***Azorella*** (Apiaceae, a genus of about 70 species native to South America, New Zealand and the islands of the Southern Ocean. The genus comprises cushion forming or low-growing dwarf mat-forming plants. Nine species are recorded in Luteyn (1999) as occurring in the Páramo s.l. of which eight occur between (3250-)3500-4600m with one, *A. cuatrecasasii* recorded as being confined to elevations between 3000-3800m.