

INTRODUCTION

The objective of this list is to provide an estimate of the moss diversity found in the tropical Andes. This includes the countries of Bolivia, Colombia, Ecuador, Peru and Venezuela. We include here species recorded from both the lowlands and highlands (Andes) from each of the five countries. There are two benefits in this, first it provides a record of all known species for a particular country, and second, by recording the elevational range for individual species from each country, one can obtain an estimate of what life zone a particular species is associated with and also a general impression of where diversity is concentrated for a particular family or genus. It will be demonstrated that the great majority of species and higher taxa are from the Andes, the lowlands (1000 meter or lower) probably contribute about only 10% of the moss diversity.

This catalogue includes 2089 taxa distributed among 362 genera and 76 families. We provide no direct reference to document the presence of a species in a particular country, listed are the floristic studies that can be consulted, more importantly collections can be viewed directly on the TROPICOS W3 database: <http://mobot.mobot.org/Pick/Search/most.html>. At present more than 16000 Andean collections held at MO have been entered in the database; in addition selected collections from other herbaria, particular types, have also been incorporated. In the near future it is hoped to enter additional collections from other herbaria holding significant Andean collections.

The following sections provide reference sources to the Andes in general and countries in particular with regard to the vegetation, exploration, and moss floristics.

GEOGRAPHY AND VEGETATION

The tropical Andes forms a natural geographical unit both in terms of the physical setting and the organisms that occur there. This region can further be divided into two subregions: a) northern Andes, consisting of Venezuela, Colombia, Ecuador, and northern Peru; and b) the central Andes, consisting of Peru (excluding the extreme northern part) and Bolivia (and extreme northern Argentina, not treated here). Both subregions readily fall within the boundary referred to as the Neotropics. The southern Andean region that includes Argentina and Chile, generally classified as temperate, is not treated here.

Geographical setting

There are several general publications covering the biogeography of the area treated in this checklist. One of the most useful overviews of the tropical Andes is

DUELLMAN (1979). Montane forests biodiversity and related topics were reviewed by CHURCHILL & *al.* (1995a) and WEBSTER (1995), and "páramo" is covered in VUILLEUMIER & MONASTERIO (1986), CHURCHILL & GRIFFIN (1999), and BALSLEV & LUTEYN (1992). Guayana Highland tepuis were surveyed in MAGUIRE (1979), and STEYERMARK (1986). Finally, ECKHOLM (1975) describes the fragile nature of mountain landscapes.

Vegetational history

HAMMEN (1974) presented a general overview of the changes in biomes composition and distribution during time in tropical South America. Other studies have since then focused in particular areas of tropical South America: lowlands, including Amazonia, were studied by COLINVAUX (1989) and BUSH & *al.* (1990); montane biomes by HAMMEN (1989); and the "páramo" by HAMMEN & CLEEF (1986). Recently, a monographic volume on the relationships between former Gondwanaland has rendered useful data on past vegetation and relationships of current neotropical areas (GOLDBLATT, 1993).

Diversity

General phytodiversity in the neotropical region was summarized by GENTRY (1982), and HENDERSON & *al.* (1991). Tropical bryophytes have been described in general terms by GRADSTEIN (1993), LUTEYN & CHURCHILL (2000), PÓCS (1982), RICHARDS (1984b), and GRADSTEIN & PÓCS (1989). Liverwort diversity in the Andes has been reviewed by GRADSTEIN (1995). A general overview of the diversity of Andean mosses is given in CHURCHILL (1996), and CHURCHILL & *al.* (1995b, 1996).

Exploration

A general overview of botanical exploration in Latin America was provided by PENNELL (1945). Focused on bryology, several reviews have been published in recent times (DELGADILLO, 1982; GRIFFIN & GRADSTEIN, 1982; MATTERI, 1985; BUCK & THIERS, 1989). Despite those comprehensive works, our knowledge of the tropical Andes, regarding mosses, is at present still relatively poor, yet it is obvious that these organisms contribute significantly to the overall biodiversity of this region. Although not yet documented, mosses together with hepatics play a significant role, if not the major role, in the formation and maintenance of the Andean ecosystem. This is not unlike that documented for the boreal and tundra region of the Northern Hemisphere, although in the Andean region the functional role is of a different nature related to mountain systems.

FLORISTIC LITERATURE

Checklists for the mosses exist for all of the tropical Andean countries: Bolivia (HERMANN, 1976), Colombia (FLORSCHÜTZ-DE WAARD & FLORSCHÜTZ, 1979; CHURCHILL, 1989), Ecuador (STEERE, 1948; CHURCHILL, 1994a), Peru (HEGEWALD & HEGEWALD, 1985; MENZEL, 1992), and Venezuela (PITTIER, 1936; PURSELL, 1973). Several of the checklists, however, are now seriously outdated. Increased field work and resulting published floristic studies in the last two decades have added many new additions to the individual countries. Revisionary treatments, a rather recent event in bryology, have significantly increased and added to our knowledge, cir-

cumscribing species concepts and reducing the glut of names. The recent publication of LATMOSS by DELGADILLO & *al.* (1995) has provided the first catalogue of neotropical mosses. While there are constraints with regard to synonyms and cross-references to alternate taxon concepts and names, this single volume provides a much needed reference.

There are now several standard references employed by those attempting to learn neotropical mosses. Two monumental works, and even at this time indispensable, include the treatment by MITTEN (1869), enumerating all mosses of Latin America up to that time and describing numerous new taxa. The second is the world treatment of all families and genera by BROTHÉRUS (1924-1925). Peripheral floras include the treatment of the Guatemalan mosses by BARTRAM (1949), which served all beginning students. Nevertheless, it has been superseded by the recent treatment of the mosses of Central America by ALLEN (1994) of which the first of four planned volumes has been completed and another is now in press. A landmark is the multi-authored flora of Mexico edited by SHARP & *al.* (1994). Both the Mexican and Central American moss floras are particularly useful for the northern Andean countries. The lowland moss diversity, while not particularly rich, contains many common and widespread species that are covered in large part by the Surinam flora (FLORSCHÜTZ, 1964; FLORSCHÜTZ-DE WAARD, 1986; VELIG & *al.*, 1996), the flora of the Manaus region (GRIFFIN, 1979a), or the flora of eastern Ecuador by CHURCHILL (1994a). The treatment of eastern North American mosses by CRUM & ANDERSON (1981) is particularly useful for a number of temperate taxa, e.g., the Amblystegiaceae, that often occur at mid to more commonly high elevations in the “páramo” and wet puna. Finally, a guide to neotropical mosses will be published soon (CHURCHILL & SALAZAR ALLEN, in press). A key to the genera of Costa Rica covers many of those also found in the Andes (GRIFFIN, 1983).

While few, there are several floras and florulas available for Andean countries. For the northern Andes exist the keys to the genera of the Mérida region of Venezuela (GRIFFIN, 1982), the abbreviated moss flora of Colombia (CHURCHILL & LINARES, 1995), and the florula derived from the BRYOTROP transect of eastern Peru (SCHULTZE-MOTEL & MENZEL, 1987). For Bolivia is still useful the treatment by HERZOG (1916), which includes detailed discussions and illustrations of the collections made by the author, and also the florula by LEWIS (1991) for an inventory study in the region near La Paz. Monographic and related taxonomic studies, although few, are still the primary source of information on many species.

Recent regional checklists have been published for the “páramos” by CHURCHILL & GRIFFIN (1999), and for the Amazon by CHURCHILL (1998), which includes portions of the five Andean countries.

Bolivia

Introduction to the general vegetation and flora can be found in HERZOG (1923) and SOLOMON (1989). Useful information on collecting and previous collectors can be found in LEWIS (1983, 1990a, b); DORR (1991) has detailed the itinerary of R. S. Williams, and general, primarily vascular plant collectors, are enumerated by FUNCK & MORI (1989).

Floristic literature related to mosses includes: BRITTON (1896), BROTHÉRUS

(1913), CRUM (1990a), HERMANN (1976), HERMANN & ROBINSON (1974), HERZOG (1910a, b, 1916, 1920, 1949), LEWIS (1981a, b, 1991, unpubl.), LEWIS & ALLEN (1992), MCQUEEN (1997), MONTAGNE (1839), MÜLLER (1878, 1897a), REESE (1979b), THÉRIOT (1929), WILLIAMS (1903, 1910).

Colombia

The now classic paper by CUATRECASAS (1958) provides a good introduction to vegetation and zonations in Colombia. Further information is provided by FORERO (1989) and GENTRY (1989). Numerous vegetation studies now exist for Colombia. A number concern the “páramo” life zone and bryophytes are often discussed in detail (BEKKER & CLEEF, 1989; CLEEF, 1981; SANCHEZ-M. & *al.*, 1989; STURM & RANGEL-CH., 1985). Paleoeological studies by KUHRY (1988a, b) have included bryophytes. The ECOANDES transect studies by Colombian and Dutch collaborators have produced significant information related to vegetation analyses and inventories, e.g., HAMMEN & RUIZ (1984). Bryophyte diversity and communities have also been studied through the ECOANDES project by REENEN & GRADSTEIN (1983, 1984) and REENEN & *al.* (1984). Additional ecological studies include LEERDAM & *al.* (1990), LINARES (1988), and RUDAS & AGUIRRE CH. (1990). History of Colombian botany and exploration can be found in PATIÑO (1985), and LÓPEZ L. (1989) has provided an interesting history of the Brothers who were the leading naturalists in the early part of this century. A short history of Colombian bryology and enumeration of moss collectors is given by CHURCHILL & LINARES (1995).

Floristic literature related to mosses includes: ALBERT DE ESCOBAR (1989), BARTRAM (1953), BESCHERELLE (1894), BROTHERUS (1906), CASTILLO L. & *al.* (1994a, b), CHURCHILL (1988a, b, 1989, 1991a, b, 1993, 1994b), CHURCHILL & HOLLAENDER (1988), CHURCHILL & LINARES (1995), CHURCHILL & SASTRE-DE JESÚS (1987), FLEISCHER (1918), FLORSCHÜTZ-DE WAARD & FLORSCHÜTZ (1979), FRAHM (1994), GRADSTEIN & *al.* (1989), GRIFFIN & WEBER (1982), HAMPE (1862, 1862-1863, 1865-1866, 1869a), HERZOG (1934, 1949, 1951), HOOKER (1818-1820), IRMSCHER (1914), KINDBERG (1901), KUNTH (1822), LINARES (1986), LINARES & *al.* (1996), LOZANO C. & RANGEL CH. (1989), MÄGDEFRAU (1983), MÜLLER (1847a,b, 1848, 1857, 1875), MUTIS (1985), PARIS (1906), PURSELL (1985), PURSELL & AGUIRRE C. (1991), ROBINSON (1967a), RUDAS & AGUIRRE CH. (1990), SASTRE-DE JESÚS & CHURCHILL (1986), SASTRE-DE JESÚS & *al.* (1986), SILVERSTONE-SOPKIN & RAMOS-PÉREZ (1995), STEERE (1936, 1982), THÉRIOT (1906, 1937), WILLIAMS (1925, 1930), WILSON (1847), and ZANDER (1977a).

Ecuador

Overviews of the vegetation, diversity and geographical distributions, particularly informative with regard to diversity patterns of vascular plants, have been provided by HARLING (1979) and JØRGENSEN & LEÓN-YÁNEZ (1999). Vegetation studies that included bryophytes are by BALSLEV & VRIES (1982, 1991), GRUBB & *al.* (1963), GRUBB & WHITMORE (1966, 1967), LØJTNANT & MOLAU (1982), and MUÑOZ & *al.* (1985). MÜLLER & FRAHM (1998) examined the bryophytes on trunks, branches and twigs of a montane forest at 2000 m. RENNER (1993) has enumerated the plant collectors, including bryologists, for the Ecuadorian Amazon region.

Floristic literature related to mosses includes: ARTS & SOLLMAN (1998), BA-

RAHONA (1997), BARTRAM (1934, 1953, 1955, 1964), BESCHERELLE (1894), BROTERUS (1920), CHURCHILL (1990, 1994a, 1994b), CHURCHILL & *al.* (1992), CRUM (1957, 1987c), DE NOTARIS (1859), GRADSTEIN & WEBER (1982), HAMPE (1869b), HERZOG (1951), HOOKER (1818-1820), KUNTH (1822), LORENTZ (1868), MITTEN (1851), ROBINSON & *al.* (1971, 1977), STEERE (1936, 1948, 1982, 1986, 1988), TAYLOR (1846, 1847, 1848a, b), THÉRIOT (1936), WEBER (1993), WILLIAMS (1924a).

Peru

The classical treatment on the vegetation of Peru is WEBERBAUER (1945); brief summaries can be found in GENTRY (1982, 1993). Various aspects of plants and animals of the montane forest are provided by YOUNG & VALENCIA (1992).

Floristic literature related to mosses includes: ALLEN (1988), AYALA (1970), BUCHLOH (1961), CARRILLO & CHANCO (1971), CRUM (1967), DEGUCHI (1984), FRAHM (1984b), FRAHM & HEGEWALD (1979), FREY (1987), GRIFFIN & HEGEWALD (1986), HAMPE (1865), HEGEWALD (1975a,b), HEGEWALD & HEGEWALD (1975, 1977a,b, 1985), HERZOG (1938, 1939), MENZEL (1985b, 1986b, 1992), MENZEL & SCHULTZE-MOTEL (1987a,b), PURSELL (1979), REIMERS (1926), ROBINSON (1971), ROIVAINEN (1936), SALAZAR ALLEN & GRADSTEIN (1996), SCHULTZE-MOTEL & MENZEL (1987), SOUKUP (1951, 1955), SULLIVANT (1859), TIMME (1985), VARGAS (1974), WEBERBAUER (1945), WILLIAMS (1916, 1926, 1927, 1928), YOUNG & LEÓN (1990), ZANDER (1986b), ZANDER & CRUM (1977), ZANDER & HEGEWALD (1976).

Venezuela

A general overview of the vegetation of this country has been provided by HUBER & FRAME (1989). VARESCHI (1970) reviewed the aspects of the "páramo" vegetation and flora, and MAGUIRE (1979) and STEYERMARK (1986) have given excellent summary of the Guayana Highland tepuis. Venezuela had not only the first (PITTIER, 1936), but also the second (PURSELL, 1973) checklist of mosses before all the other Andean countries. Since 1973, however, many additional records have been reported for the country, particularly by Griffin and collaborators.

Floristic literature related to mosses includes: BARTRAM (1951, 1953, 1957a,b, 1960, 1963, 1966), BERMÚDEZ R. (1978), BERMÚDEZ R. & BHAT (1974), DOZY & MOLKENBOER (1854), GRIFFIN (1975a,b, 1976, 1977a,b, 1978, 1979b, 1982, 1987a,b, 1990a,b), GRIFFIN & *al.* (1973), HAMPE (1847), HOOKER (1818-1820), IRELAND (1990), KUNTH (1822), LEÓN V. & *al.* (1998), LEWINSKY & GRIFFIN (1986), LÓPEZ FIGUEIRAS (1976), MÄGDEFRAU (1983), MITTEN (1887), MORENO (1992a,b), MÜLLER (1852, 1879, 1897b), PITTIER (1936), PURSELL (1973, 1977), PURSELL & CRUSCO DE DALL'AGLIO (1978), PURSELL & CURRY (1969), RAMÍREZ REYES & BOWERS (1975), RAMÍREZ REYES & CRUSCO DE DALL'AGLIO (1981), REESE & BERMÚDEZ R. (1980), ROBINSON (1965, 1967b, 1972, 1976, 1986), SIPMAN (1992), VARESCHI (1970), WILLIAMS (1924b, 1931, 1934).

FORMAT OF THE CHECKLIST

This catalogue lists all taxa in alphabetical order by family, genus and species. Each country is listed in which a particular species has been reported from the literature, either floristic and revisionary studies, and from various herbaria, particularly MO and NY. All available revisionary studies have been consulted and followed in

most cases regarding taxonomic concepts. Monographic studies supersede "checklist" reports in terms of distribution records unless we have knowledge otherwise to include or exclude a particular species or report. The countries are ordered from north to south (Venezuela, Colombia, Ecuador, Peru, and Bolivia). The elevational range for each country is given if known, based likewise on the aforementioned sources for species. The world range for each species is given following the list of Andean countries; we have used the system employed by WILK & *al.* (1959-1969). While not an exact reflection of the phytogeographic regions, it is a useful means of ascertaining world ranges that is familiar to many bryologists. We have attempted to update the initial ranges given in Index Muscorum to a limited extent with emphasis on the Neotropics, but have not consulted all floristic literature outside that region.

An alphabetized list of current generic family affiliations accepted in this checklist is provided. This is deemed useful, if not absolutely necessary, since many genera and even families have been newly recognized in the last 20 years, to say nothing of the various emended familial or generic concepts, and finally the fair number of additional genera and a few families now recorded for the Andean region that were previously unknown. Recognition of synonyms provided in this list places emphasis on those related to the Andes and literature from that region. Literature combines both floristic and taxonomic studies, however we have listed separately the floristic work for each individual country given above. Index Muscorum (WILK & *al.* 1959-1969), and preceding major supplements to that work (CROSBY & *al.*, 1992; CROSBY & MAGILL, 1994, 1997) have been consulted in the preparation of this work. Abbreviations for authors of species names follows BRUMMITT & POWELL (1992), and for the citation of literature following LAWRENCE & *al.* (1968) and BRIDSON & SMITH (1991).

Although it may not be necessary, a cautionary note is made related to species and elevational ranges. A certain degree of subjective judgment has been employed for the recording of species; taxa readily known and easily recognized or those determined by specialists were accepted without question, in a few cases we have chosen not to record a particular species if there was reason to question the determination, particularly with regard to herbarium specimens. The same may be said regarding elevation if a record appeared questionable. For example, a collection recording a species from the "páramo" where in fact that species is generally known from the tropical lowlands may be deleted. Elevational range presented a further problem, label information may state a single elevation but it is not uncommon for a range to be given, e.g., 2550-3000 m. In general we have taken a conservative approach particularly when that record represented an extreme range, thus a species found at 3000 meters or above, and the label states 2000-2850, we record only 2850.

ACKNOWLEDGMENTS

The following specialists are gratefully acknowledged for providing comments or information on their particular group(s): William R. Buck, Ronald Pursell, William Reese, and Richard Zander. A portion of this work was supported by grants from the National Science Foundation (DEB-88-18051, DEB-92-01281, DEB-9626747) to the first author.