

Bryophyte floras of tropical Pacific islands

H. A. Miller and H. O. Whittier

Department of Biological Sciences, University of Central Florida, Orlando, Florida 32816

Abstract: A review of the status of bryological research in each of the nations, states or governmental units of southern Melanesia, Micronesia and tropical Polynesia shows the imperfect state of knowledge about the Pacific tropical islands. Best known overall are Hawaii and Micronesia with Wallis and Futuna, the Marquesas and the high mountains of Fiji seeming to be the least known potentially species rich areas. Involvement of residents from Pacific islands in botanical study and preservation of ecosystems should be encouraged by tropical bryologists.

The decade of the seventies brought an emergence of broad interest in the biota of tropical Pacific islands and an increase in the number of investigators turning their attention to these remote specks of land. Opening of the Pacific by construction of airfields capable of receiving long range jet aircraft has created the possibility for quick access and rapid communication—both important for the holiday traveller as well as the workaday scientist. Because most research biologists sustain themselves by academic labors which limit time away from the University, the jet plane has opened the world to previously herbarium-bound scholars. At the Thirteenth Pacific Science Congress at Vancouver, British Columbia, in 1975, botanists held a symposium entitled Floristic Needs in the Pacific Basin. For three days both taxonomic groups and geographic areas were reviewed and opportunities discussed. Now, fourteen years later, many of the same promises and prospects are with us still, although much has been done.

Whether our persuasion within bryology be called monographic or floristic, we are all dedicated to learning about the plants and their identity. A new discovery of a

plant whether a new species or first collection is always of interest and value. Many such discoveries remain to be made on the islands of the Pacific.

Our efforts have been directed to Polynesia in the broadest sense embracing Micronesia, the Polynesian triangle (here excluding New Zealand and Easter), as well as southern Melanesia, including Norfolk and Lord Howe because of their vegetation, great isolation and phytogeographic interest.

Tropical Pacific political systems have undergone such great changes within recent memory as former colonial territories became independent, that national names almost unrecognizable are now on the maps. Some of these new countries correspond roughly to long familiar assemblages and others are quite different, indeed. Fortunately, the archipelagos comprising these island states for the most part have not been renamed and the individual island names have been little revised.

Even as the names and limits of sovereign lands have changed, so has the vegetation on tropical Pacific Islands. The few

remnants of the great koa forest in Hawaii are going to Japan to make paper. Micronesia was cut over after World War I and the forest had not yet regained its former composition when World War II erupted to destroy what forest had returned. Virtually all of the islands of French Polynesia have been heavily timbered at various times in the past and are in stages of secondary growth forest. Western Samoa has been visited by the timber merchants and may have little, if any, uncut forest left. The previously almost impenetrable interior of Viti Levu in Fiji has been exposed since the early 1980's and all accessible areas will be timbered soon—if it is not already done. New Caledonia has been completely exploited with a few large trees left standing as a reminder of past great forests. On Lifu in the Loyalties, the last of the great 80 meter Araucaria are being cut a few at a time despite the poor quality of the timbers they produce. The last of the great Agathis forests of Vanuatu were harvested from Aneityum about 1980. The only really large trees left in Vanuatu are those in small hanging valleys at the heads of sheer sea cliffs on Espiritu Santo.

We have not seen the Solomons, the Bismarcks or New Guinea but we have been told that the growl of the chain saw has spread across the land as it has all across Malesia. And with the forests go the habitats for the bryophytes. We are confident that glorious, grand species once common in the primeval forests have been sorely stressed and some may, indeed have become extinct.

It is easy and chic to dwell upon the ravages of mother earth's disease (man) and to bemoan opportunities no longer with us, but such lamentations gain us naught. What has impressed us in our work on these environmentally raped, pillaged and then abandoned islands is how much is still to be found. The tenacity of species and their survival under the

most alien of conditions is remarkable. For example, Mt. Togpachao on Saipan is only about 1800 feet high but was once forested and clouds do settle in a bit at night. To our surprise, more diversity of bryoflora was found than might be expected growing among the grasses and small guava bushes. *Dendroceros javanicus*, for example, grew on grass stems at the base of the clumps. Colonies of *Telaranea* grew in the shade of weeds in areas cleared less than a year before for a solar power station on Vanuatu. The case file is very long, but the point is that even as clearing the forest proceeds, microhabitats are created by the decaying slash, by the roadcuts, by the gullies and by the impacted but not eliminated steep slopes and cliffs which harbor lesser tree specimens not economical to cut.

Little is as frustrating and depressing as slashing through solid *Dicranopteris* 3-4 meters or more high or broiling in bright sun on a baked red earth with only scattered shrubby plants where forest giants once gave shelter. We cannot find in such a place the flora described by our bryological ancestors, but careful search over an island will turn up most previously found taxa as well as yet undiscovered ones. Despite the anthropogenic havoc wrought, much that is bryologically valuable remains to be done.

Let's take a look at where we are floristically today with Pacific Islands bryology by countries or archipelagoes. This ocean area is huge and the islands within it small. However, the great isolation and topographic diversity provides opportunity for perhaps the richest bryoflora in the world per unit land area at any given elevation. We have little doubt that even after the inevitable taxonomic reduction occurs this will still be true. Individual floras show strong evidence of sweepstakes dispersal from several sources at different times from different directions. Throughout the islands, however, we must

acknowledge a kind of Malesian species ground plan, or foundation, for the floras, particularly in low altitude areas at less than 600-800 meters. Persistent, somewhat drought resistant, moderately salt tolerant, species having tough propagula or spores occur on every high island and most of the low ones, but they are not the same species on all the islands. The most common strand and low altitude genera are *Calymperes*, *Leucophanes*, *Octoblepharum*, *Pelekium*, *Thuidium*, *Taxithelium* and *Ectropothecium*, among the mosses. Hepatics are *Cololejeunea*, *Cheilolejeunea*, *Drepanolejeunea*, *Lejeunea*, *Microlejeunea*, *Acrolejeunea*, *Lopholejeunea*, and also a few other holostipous Lejeuneaceous genera. It is from where the lower cloud forest begins at about 600 meters and upward that diversity increases and the individuality of the island flora becomes most apparent.

The State of Hawaii with an elevation of 13,796 feet (4,205 meters) on Mauna Kea, has the greatest topographic relief of any island east and north of New Guinea as well as being most isolated from major land masses. The high altitude flora of eastern Maui and Hawaii is comprised mainly of boreal species subject to long distance dispersal. The rainforest and lowland bryophytes, however, are of distinct Pacific and Malesian origin with numerous endemic species among genera found throughout the Pacific. The moss flora is reasonably well known with approximately, 244 species in 121 genera and 38 families recognized by Hoe (1979). Hepaticae have been somewhat less completely studied, but at least 220 species in 65 genera and 28 families are known. An illustrated guide is presently in preparation with over 400 species already drawn. No publication agreements have been reached at the time of writing. Micronesia is a mixture of several States comprised mainly of low atoll islands. High islands occur only in the Carolines and Marianas.

Kiribati is comprised of the Gilbert, Phoenix and Line Islands. All are low with land masses for the largest atoll islands reaching only a few hundred hectares. Hoe and Inoue (1973) reported Herbst's collections in the Gilbert Islands. Approximately 15 moss species, 9 genera and 8 families and 3 hepatic species in 3 genera and 1 family are been reported from Kiribati.

The Marshall Islands are today a self-governing state in free association with the United States Trust Territory of the Pacific Islands. The Marshalls are low atoll islands rather well collected by F. R. Fosberg and others and are included in the "Bryoflora of the Atolls of Micronesia" (Miller, Whittier & Bonner 1963). The number of bryophyte species can vary widely from one atoll islet to another even on the same atoll, from none to one or two species to several. Despite limited topographic relief (elevations above sea level are often reported to tops of the coconut palms—60 to 70 feet) limited rainfall (usually less than 1000 mm annually), and low habitat diversity, 18 species of mosses in 11 genera and 8 families and 14 species of hepatics in 10 genera and 2 families have been reported for the Marshall Islands.

The Caroline Islands from Yap eastward to Kosrae (formerly Kusaie) are the Federated States of Micronesia within the Trust Territory and include a mix of low coral atolls and high volcanic islands. Inoue and Miller (1965) listed hepatics from Kosrae and Smith (1976) listed mosses for the whole of the Carolines. Miller (1968) and Miller and Smith (1968) provided a guide with keys and illustrations to all bryophytes of the Truk Islands. Swanson (1969) and Swanson and Miller (1969) reported on the hepatics of the Belau (Palau) Islands, now a self-governing state within the Trust Territory extending to Helen Reef in the western Carolines. The

Carolines' moss flora includes about 25 families, 61 genera and 160 species; the hepatics 18 families, 53 genera and 155 species.

In the Marianas, Guam remains an unincorporated U.S. Territory and the Northern Mariana Islands are a U.S. Commonwealth. Bryophytes in general were treated by Miller (1960) and mosses by Smith (1969, 1976) but many hepatics remain unreported. Ninety six species of mosses in 43 genera and 18 families and 37 species in 23 genera and 9 families of Hepaticae have been cited for the Mariana Islands.

Bryophyte diversity in Micronesia is low with some 204 species, 69 genera and 29 families of mosses (Smith 1969), and 154 species, 51 genera and 17 families of hepatics reported Miller (1960) and by Swanson (1969). The mosses can be considered to be fairly well known and the hepatics less well known.

South of the equator, Papua New Guinea and the Solomon Islands are separate independent states. Schultze-Motel (1973) catalogued the mosses of Melanesia, including records for the d'Entrecasteaux, Bismarck and Solomon Islands. Our present records show approximately 21 families, 40 genera and 84 species of mosses and 21 families, 41 genera and 89 species of liverworts for the Solomon Islands, but these areas are under intensive investigation by a large team headquartered in Helsinki, led by Timo Koponen and Dan Norris. Their reports which are rapidly expanding the lists are to be found in *Annales Botanici Fennici* from volume 20 (1982) onward.

Nauru is a tiny independent island republic for which we know no bryophyte records.

Vanuatu is an independent republic which, as the New Hebrides, had a condominium government under Great Britain and

France. Recent collections by Miller and Vitt from the islands of Vanua Lava, Espiritu Santo, Malekula, Maewo, Aoba, Pentecost, Ambryum, Tongoa, Epi, Emae, Efate, Erromango, Tanna and Anatom (Aneityum) are now under study with a few new taxa already reported. The island of Futuna in Vanuatu, as distinct from Futuna in the French Overseas Territory of Wallis and Futuna, is inaccessible by air and can be reached only by an ocean-going vessel. Approximately 39 families, 83 genera and 208 species of mosses (Miller, Whittier & Whittier 1978) and 19 families, 43 genera and 136 species of hepatics are reported from Vanuatu, but these numbers will increase as the recent extensive collections by Miller and others are reported.

New Caledonia is a French Overseas Territory including the Isle of Pines and the Loyalty Islands (Ouvea, Lifu and Mare). Only the main island, sometimes called Grande Terre, reaches altitudes sufficient for development of cloud forests. Over the past ten years or so, collections have been made by Tixier, Schuster, Crosby, Iwatsuki, Hurlimann, Kitagawa and Miller. With the exception of a few genera, most of the recent collections remain unreported. A few collections by Tixier were found in the ORSTOM herbarium in Noumea from the Loyalties. McPherson and Miller were able to spend some days on Lifu and Mare and assembled a collection from several stations on each of the islands. Iwatsuki collected on the Isle of Pines. Most collections mentioned are not yet reported but it seems likely that they will contribute additional mosses to the 627 species, 151 genera and 40 families listed by Miller, Whittier & Whittier (1978) and by Pursell & Reese (1982) and the 40 families, 106 genera and 541 species of hepatics noted by Miller, Whittier & Whittier (1983).

Although south of the tropics, Norfolk Island supports a flora with tropical plants

present. A local resident of the island, Margaret Jowett, transmitted a collection to Miller. More recently, H. Streimann botanized extensively on the island and will report on the mosses. His hepatics are under study by Miller. To date, 41 species of hepatics in 16 genera and 6 families, and 21 species of mosses in 15 genera and 14 families are reported for Norfolk Island.

Lord Howe, administratively part of New South Wales, has a flora famous for its distinctive character. Vitt collected there extensively and, jointly with Helen Ramsay, is participating in preparing a bryophyte flora of the island with assistance for hepatics by Miller. Approximately 101 species, 59 genera and 34 families of mosses, 36 species, 17 genera and 12 families of liverworts are currently reported for Lord Howe Island.

Tuvalu (formerly the Ellice Islands) is an independent state comprised of low islands. With the exception of Funafuti, where 2 species, 2 genera and 2 families of mosses and no hepatics are reported, nothing is known of the bryoflora which is probably similar to that of other dry atolls.

Wallace and Futuna island groups comprise a French Overseas Territory. The possible confusion with Futuna in Vanuatu and between Ouvéa in the Loyalties and Uvea (an alternate name for Mata-Utu), the main island of the Wallace group, brings some reports into question. Futuna and Alofi (Hoorn) are high islands reaching 1310 and 2629 feet respectively and both have had extensive forest cover. The reported bryoflora includes such taxa as *Spiridens*, *Garovaglia*, *Papillaria*, *Floribundaria*, *Distichophyllum*, *Thuidium*, *Acroporium* and *Radula* — in all, 16 species, 14 genera and 8 families of mosses and 1 species, 1 genus and 1 family of hepatics. The islands are very little known and access remains difficult.

Fiji is comprised of two large islands, Viti

Levu and Vanua Levu, several considerably smaller high islands and many small low islands. Although Fiji is the crossroads of the Pacific, easily reached by air, and travel to inhabited outer islands is not difficult, penetration to the interior mountains has been limited. Only Mt. Victoria on Viti Levu has been accessible by road until recent timbering operations have opened new routes. The emerging University of the South Pacific has a small, active biology department and an affiliated herbarium but presently no one is trained in bryology. Bryophytes are reported mainly from the larger islands with a total of 306 moss species in 106 genera and 39 families (Whittier 1975), and 224 species, 72 genera and 26 families of hepatics so far reported. Among unreported or incompletely reported collections are Schuster—hepatics, Norris—mosses and hepatics, Buck—mosses and some hepatics, Iwatsuki—mostly mosses, and Miller—mosses and hepatics. Despite what has been done until now, Fiji must be considered among the least collected and least known island states per unit of rainforest land area in the Pacific. Careful study of the Fijian bryoflora can be expected to yield an increase in reported species of up to fifty percent over what is so far known.

Tokelau (formerly Union Islands), is a New Zealand territory comprised of three true atolls (Atafu, Fakaofu, Nukunono) supporting only strand vegetation typical of the relatively dry islands of Kiribati. A single bryophyte, *Trichosteleum hamatum* (Sematophyllaceae) has been reported for Tokelau, but a few more species can be expected.

Western Samoa is an independent State with two larger islands of sufficient elevation to have rainforest. Schultze-Motel assembled large collections which were reported in Schultze-Motel (1971, 1973, 1974a, 1974b) and Grolle and Schultze-Motel (1972). Reports suggest

Savaii has approximately 106 moss species in 54 genera and 26 families and Upolu, 183 species 77 genera and 32 families of mosses, 110 species, 41 genera and 17 families of hepatics.

American Samoa is an unincorporated U.S. Territory with Tutuila the principal island. The smaller land area and lower maximum elevations provide fewer bryophyte habitats than Western Samoa. Whittier's collections during the 1960 Miami University-Schooner Collegiate Rebel Expedition in the vicinity of Pago Pago remain unreported. Our records show 114 species in 57 genera and 27 families of mosses and 37 species, 29 genera and 12 families of hepatics reported for Tutuila. A few days' work in the heads of valleys and high ridges could be expected to turn up new island records.

Yuncker's (1945) collections and other records from the Manua Islands (Tau, Ofu and Olosega) of American Samoa include 33 species of mosses in 23 genera and 12 families of mosses and 4 species, 3 genera and 3 families of liverworts, but are surely not complete, as Mt. Lata on Tau reaches over 3,000 feet and must support a cloud forest, as suggested by the occurrence of *Spiridens*, *Floribundaria* and *Acroporium*. New island records surely can be expected.

Reports for Western and American Samoa combined list 248 species of mosses in 88 genera and 37 families, and for hepatics 23 families, 68 genera and 234 species. Given the area, topographic diversity and number of species reported, the flora can probably be considered about eighty per cent known.

The Kingdom of Tonga (Friendly Islands) is directly east of Fiji and comprised of many small islands including Tongatapu, Haapai and Vavau. Most are coral islands, but some are actively volcanic. Vavau is a raised coral karst terrain island about 670

feet at its highest point. Rainfall varies within the group but averages 65-90 inches a year producing rich vegetation. Recent collections of mosses and hepatics were made and reported by Yuncker (1959) and by Hurlimann (1960, 1963, 1965, 1968, 1974, 1976, 1977, 1978, 1985). The bryoflora so far reported is 46 species, 29 genera and 20 families of mosses and 19 species, 11 genera and 8 families of hepatics.

Niue is an independent State in free association with New Zealand. The single island is about 10 square miles of elevated limestone with a limited amount of soil but with a forest cover. The rock is so porous that water percolates quickly with the result that surface waters are lacking. Yuncker (1943) reported mosses determined by Edwin B. Bartram. The known bryoflora is 8 or 9 species in 8 genera and 8 families of mosses. We are unaware of any records of hepatics.

The Cook Islands are self-governing in free association with New Zealand. The seven northern islands are atolls. Rarotonga is the largest island with volcanic peaks to 2140 feet high, sufficient height to support some cloud forest. A total of 9 moss families, 11 genera and 11 species have been reported and 6 families, 8 genera and 9 species of liverworts have been tabulated (Whittier 1974; Whittier & Whittier, 1987), but W. R. Sykes' recent unreported collections contain many more taxa.

Five archipelagoes comprise French Polynesia. The best known is the Society Islands with the largest and highest island, Tahiti, having the capital at Papeete. During the past two decades H. Hurlimann, H. O. Whittier, F. R. Fosberg and M.-H. Sacht, J.-L. DeSloover, and R. Schuster collected at different times in the Society Islands, and in 1979 the Whittiers collected on several islands including Tahiti, Raiatea, Tahaa, Bora Bora, Huahine nui and Hua-

hine iti, and Maupiti which will add new records to those found in "Mosses of the Society Islands" (Whittier 1976). Neither the mosses nor the hepatics of these recent collections are yet reported. Hurlimann's papers (1960-1987) deal principally with the hepatics of the islands. Whittier & Whittier (1987) discussed in detail the several island groups of southeastern Polynesia. Despite the activity, most of the major island, Tahiti, remains under collected. Particular attention needs to be given the highest peak, Mt. Orohena, which at 2237 meters is the greatest elevation in southeastern Polynesia. The sedge genus *Oreobolus* collected there in the mid-1950's indicates the cool climate vegetation at or near the summit. Similarly, the deep valleys and ridges leading to great central volcano crater swamp and the central peaks of Tahiti nui and Tahiti iti, but not necessarily remote from Papeete, deserve attention. Middle elevation forest, long impacted by coffee and vanilla agriculture is under even heavier pressure for conifer cultivation and home construction. The habitat for *Bescherelle's Racomitrium papeetense*, found only once on Pic Rouge behind Papeete, may no longer exist. Vahiria Valley and Papenoo Valley leading to the crater swamp should yield interesting finds. Present records indicate approximately 172 species, 88 genera and 39 families of mosses (Whittier 1974), and 216 species 59 genera and 24 families of liverworts.

North and east of Tahiti are the very isolated Marquesas Islands. Ten islands comprise the group, but nearly all bryological records come from the largest, Nukuhiva, which has an area of 337 square kilometers and an elevation of 1231 meters. Hivaoa has an area of 324 square kilometers and an elevation of 1271 meters, and Uapou an area of 104 square kilometers and an elevation of 1243 meters—with extremely rugged terrain. While the higher islands are usually very wet and humid, annual rainfall may vary from 100 to 254

cm. The islands are not heavily populated today and probably never were as populous as the nearby Society Islands. Decker (1970) described in detail the Marquesan environment as it is increasingly impacted by modern residents. It is fortunate that the islands have been difficult to visit except by copra schooner or private yacht. The few collections have been made come mostly from lower elevations. The remote island interiors and the highest elevations are poorly represented. Edwin B. Bartram once observed in a letter to us he considered the Marquesas a bryological enigma. Collections by H. O. Whittier in 1960 on Nukuhiva during the Miami University-Schooner Collegiate Rebel Expedition, and by Bryce and Shirley Decker in 1963 on Nukuhiva, Hivaoa and Uapou yielded 3 families, 6 genera and 8 species of mosses new to the islands. Whittier (1973) published a checklist of 21 families, 36 genera, and 45 moss species, and Whittier and Whittier (1987) listed an hepatic flora of 10 families, 13 genera and 21 species from these rugged mountainous islands. The Marquesas remain very much understudied because of their inaccessibility and the difficulty of inland travel, but serious bryological field work should more than double the presently known number of species.

Between Tahiti and the Marquesas lie the low islands of the Tuamotu archipelago. Our current records show approximately 6 families, 9 genera and 11 species of mosses and 2 families, 2 genera and 4 species of liverworts if the raised coral island Makatea is included.

South of the Society Islands lay the Austral or Tubuai Islands. Although elevated, none of the peaks exceed 1500 feet except for Rapa which reaches 2000 feet. Some 24 families, 39 genera and 56 species of mosses and 3 families, 3 genera and 4 species of hepatics have been reported (Whittier 1974; Whittier & Whittier 1987), mostly from Rapa.

The easternmost group of French Polynesia are the Gambier Islands. Fourteen moss families, 15 genera and 18 species, and 2 families, 2 genera and 3 species of liverworts represent the entire archipelago. Mangareva, the principal island has 10 moss species and 2 hepatics reported to date.

Pitcairn Islands are a British colony including Pitcairn, Henderson (Elizabeth), Oeno and Ducie Islands. Most of our bryological knowledge is the result of limited collections by H. St. John and F. R. Fosberg, particularly on Pitcairn, reported by Bartram (1940). Pitcairn is a high volcanic island approximately 3.2 by 1.6 km, its greatest elevation, variously reported between 1,100-1,445 feet, is at the east end. We have little climatological data, but the environment supports mosses such as *Fissidens*, *Leucophanes*, *Thyridium* and *Macromitrium*, which indicate a far richer bryoflora. No hepatics have been reported for Pitcairn. The remaining islands are relatively low. Henderson's greatest elevation is about 100 feet, and the others perhaps 12-15 feet. A single liverwort, *Frullania squarrosa* was reported from Henderson Island and a single moss from Oeno (Whittier & Whittier 1987). Some 9 families, 11 genera and 13 moss species and 1 family, 1 genus and 1 species of liverworts for the Pitcairn group are known. Hepaticae seem obviously under-represented in the collections by H. St. John and F. R. Fosberg from Pitcairn. Even the moss flora should more than double if collecting is undertaken by a trained bryologist.

As this conference has made very clear, our crew for working the tropical bryophyte floras of the world is small. Our collective inadequacies in time, money and ancillary resources serve to frustrate our desire and yet forge our resolve to somehow get the job done to the best of our ability. We see the need for monographs and large floras

as the most satisfying of our intellectual endeavours. We like things in order or we would not be taxonomists and systematists. We have long held the dreams of a perfect comprehensive Pacific Island Bryoflora and it is with us now. The dream cannot be realized until the people of the Pacific Islands can be brought to participate and care about their own lands and all the plants upon them. Somehow we must involve them in our world and build their confidence and enthusiasm for so intellectual an endeavor. Therefore, even as we dream about our bryological dream of the perfect macroflora, we realize that the locally centered microflora may be the only way to get there. We need guides and keys and pictures with our catalogues if they are to help our Pacific neighbors to come to know and appreciate the richness of their lands.

Our small band must have on-site help if we are ever to understand even a part of what might be learned of tropical bryophytes. We are doing well but we must do better as we seek to bring others with us.

As we have considered the condition of the natural systems on Pacific Islands and have sought to estimate the status of strictly taxonomic knowledge on those islands, we have been driven to consider what is required to make a reasonably thorough study of the flora. We cannot escape the obvious fact that bryophytes depend heavily upon a well developed and diverse angiospermous vegetation. When that is gone, so are resident bryophytes. Despite the tenacity of individual species, some are surely lost from almost every island flora. At a time when the world community is becoming aware of the need for, and the value of, protection of natural areas, the International Association of Bryologists should consider support for the movement. Some bryophytes are rare and endangered species. They depend upon favorable habitats which are seriously threatened if

they are not already impacted. The time has come when we can no longer ignore the need to protect bryophytes and the ecosystems in which they belong. The time has come for bryologists to get involved in protection of our natural resources if we are to have the best possible representation of the plants we study. The fragile Pacific Islands are a good place to start.

Literature Cited

- Bartram, E. E. (1940).** Mosses of southeastern Polynesia. Occasional Papers of Bernice P. Bishop Museum. 15: 323-349.
- Decker, B. G. (1970)** Plants, Man and Landscape in Marquesan Valleys, French Polynesia. Ph.D. Dissertation. University of California, Berkeley. University Microfilms International. Ann Arbor. Pp. 1-324.
- Grolle, R., & W. Schultze-Motel. (1972)** Vorläufiges Verzeichnis der Lebermoose von Samoa. Journal of the Hattori Botanical Laboratory 36: 75-89.
- Hoe, W. J. (1979)** The Phytogeographical Relationships of Hawaiian Mosses. Ph.D. Dissertation. University of Hawaii. Honolulu.
- Hoe, W. J., & H. Inoue. (1973)** Bryophytes of the Gilbert Islands (Micronesia) collected by Dr. D. Herbst. Journal of Japanese Botany 48(3): 82-86.
- Hürlimann, H. (1960)** Hepaticae aus dem Gebeite des südlichen Pazifik I. Bauhinia 1(3): 251-260, pl. 15-16.
- Hürlimann, H. (1963)** Laubmoosfunde von den Fidschi- und Tonga-Inseln und von Tahiti. Bauhinia 2: 167-176.
- Hürlimann, H. (1965)** Weitere Laubmoose von den Tonga-Inseln. Bauhinia 2: 288-294.
- Hürlimann, H. (1968)** Hepaticae aus dem Gebiete des südlichen Pazifik II. Bauhinia 1(3): 251-260, pl. 15-16.
- Hürlimann, H. (1974)** Hepaticae aus dem Gebiete des südlichen Pazifik III. Bauhinia 5(2): 59-68.
- Hürlimann, H. (1976)** Hepaticae aus dem Gebiete des südlichen Pazifik IV. Bauhinia 5(4): 191-213, fig. 1-9.
- Hürlimann, H. (1977)** Hepaticae aus dem Gebiete des südlichen Pazifik V. Journal of the Hattori Botanical Laboratory. 43: 409-438.
- Hürlimann, H. (1978)** Hepaticae aus dem Gebiete des südlichen Pazifik VI. Bauhinia 6(2): 293-305, fig. 1-2.
- Hürlimann, H. (1985)** Hepaticae aus dem Gebiete des südlichen Pazifik VIII. Bauhinia 8(2): 101-118.
- Inoue, H., & H. A. Miller. (1965)** Hepaticae from Kusaie, Caroline Islands. Bulletin of the National Science Museum, Tokyo 8(2): 139-160, fig. 1-4.
- Miller, H. A. (1960)** A preliminary list of Micronesian bryophytes. Bryologist 63: 116-125.
- Miller, H. A. (1968)** Hepaticae from Truk, Caroline Islands. Micronesica 4: 239-254.
- Miller, H. A., & D. R. Smith. (1968)** Mosses from Truk, Caroline Islands. Micronesica 4: 213-237.
- Miller, H. A., H. O. Whittier & C. E. B. Bonner. (1963)** Bryoflora of the atolls of Micronesia. Beiheft zur Nova Hedwigia 11: 1- 89, tab. 1-2, pl. 1-31.
- Miller, H. A., H. O. Whittier & B. A. Whittier. (1978)** Prodromus Florae Muscorum Polynesiae. Bryophytorum Bibliotheca 16: 1- 334, map.
- Miller, H. A., H. O. Whittier & B. A. Whittier. (1983)**

