

Thomas R. Soderstrom*: **Bamboo Systematics: Yesterday, Today and Tomorrow †**

The use of bamboo in Asia certainly must date back to man's earliest times, for wherever man has come into contact with this plant, he has found a use for it. According to Marden (1980), an ancient dictionary of the Chinese called the *Erh Ya* mentions bamboo by the name of "ts'ao," and doubtless many references to tree grasses under other names are to be found in other early accounts.



Alexander the Great

But while the earliest bamboo technology and artistry belong to the Chinese, who have always lived among it, an understanding of bamboo systematic and the earliest scientific classifications belong to the Europeans. According to Ruprecht (1839), the first mention of bamboo in Western literature was made in a letter from Alexander the Great to Aristotle and referred to by Pliny (23-79 AD) in his encyclopedic *Natural History* of 37 books.

I have attempted to search out the earliest references to bamboo that played a role in the ultimate establishment of the name in scientific literature. We are first drawn to a learned man known in later times as the "Prince of Physicians". Ibn Sina, or Avicenna, who was born in Bokhara, Persia (now Iran) in 980 A.D. and who became educated in all branches of science known at the time. This was during the flowering of the intellectual Arabic world. Avicenna travelled from court to court in Central Asia looking for a place for his talents and eventually settled down as physician to one of the rulers. His *Canon* of medicine was a "codification" of the whole of ancient and Muslim knowledge and is considered to be one of the highest achievements in Arabic culture. It became the textbook of medicinal study in European universities and as recently as 1650 was still used at Montpellier. In this book, Avicenna refers to a medication known as "Tabaxir", which in Arabic means milk or juice or a liquid which is condensed. In the same book, Avicenna also referred to "Mambu," which later authors took to be a reference to bamboo.



Avicenna

During the sixteenth century, the southwestern flank of India, known as the Malabar coast, was conquered by the Portuguese, who established their colony of Goa, here lived its most famous early citizen, Garcia da Orta, a physician who tended a garden of native plants, learned everything here was to know about their uses and wrote an important treatise called the *Coloquios dos Simples e Drogas da India*. This book, which appeared in 1563, was the first to be published on Indian plants. In it, Garcia da Orta talks of "tabaxir" and refers to the earlier references by Avicenna. Garcia da Orta states that the indigenous peoples



Garcia da Orta
 ESTADO DA INDIA

(of Goa) called this "Saccar Mambu," derived from the words "açucar de bamboo", which in turn came from the Portuguese word "açucar" for sugar and "mambu", a local Indian word for cane or the branch of a tree. Da Orta stated that the merchants called this "tabaxir mambu" and that it was exported as a medication from India by the Arabs, Persians and Turks. The illustration he gave of the plant from which this tabaxir was derived and the accompanying description must certainly have been some plant other than a bamboo, perhaps sugarcane. Thus while later authors referred to Avicenna plant as bamboo, I believe this was in error.

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We shall leave Avicenna of eleventh-century Persia and Garcia da Orta of sixteenth-century India and travel to the city of Basel, Switzerland, where we find Caspar Bauhin (1560-1624), a physician and botanist at the University of Basel. Bauhin studied at Basel, Padua, Bologna, Montpellier, Tübingen and Paris, taking his doctorate at Basel where he became professor of botany and anatomy. During his extensive travels, he had made botanical collections and formed acquaintances throughout Europe, building up an herbarium of several thousand plants, not only from Europe but from far-away countries as well.



Bauhin spent some 40 years in assembling data on all plants known at the time and listing all references under each name. His book, commonly known as the *Pinax*, appeared in 1623. He used the name "Arundo" for reed grasses and devoted several pages to plants in this category. Under the different kinds of "Arundo" from India, his first is "Arundo arbor," i.e., a woody or treelike reed. He stated that the substance derived from this plant was called Tabaxir by Avicenna and the Arabs and that the plant was known as "Mambu" by the Indians. He also listed Garcia da Orta's reference to "Tabaxir" or "Saccar Mambu." Later in this list of references to this plant, Bauhin gives the following (in translation): "Cana Tabaxir and Arundo, which the Indians call "Bambus." For the source of information on "Bambus" he cites a reference to part 4 of "India Orient. (*Indiae Orientalis*), cap. 3", a compilation of natural history articles edited by Johann DeBry. In his description of the plants, Bauhin states that they are reeds of very pleasing aspect, are very tall, black round, thick, and grow spontaneously all over the Malabar Coast and especially near Coromandel (the eastern coast of India). He goes on to mention their presence in Pegu (Burma) and in Bantam (Java), and talks of their use in India for making houses and their use by barbarians in Brazil to produce arrows. While Bauhin certainly referred at least in part to bamboo under his "Arundo arbor", he included other elements such as "Tabaxir." While Bauhin had several elements in his "Arundo arbor" it is his use of the word "Bambus" that is important, for it was utilized by Linnaeus in 1753 as the basis of his "*Arundo bambos*," from which the genus name *Bambusa* was later adapted.

We must remember that up until the time of Bauhin, only four thousand or so plants were known, but many names were used for these. Bauhin brought great order out of chaos and gave us our first nomenclatural tag, albeit inexact, for bamboos "Arundo arbor."

The famous Malabar coast, where Garcia da Orta lived in the 1500's, came under Dutch rule in the following century, and from 1669-1677 the Dutch Commander of Malabar was Hendrik Adriaan van Rhee de tot Draakestein. Rhee de was born in Amsterdam in 1636 of a distinguished family but was orphaned at four and went abroad at the early age of 14. He entered the service of the Dutch East India Company as a soldier and rose to the rank of lieutenant and fought to wrest control of the Malabar Coast from the Portuguese, subsequently developing good relations with the King of Cochin. At the time, medicines had to be transported from Holland to the colonies, a costly trip that took many months. Rhee de was aware of the great medicinal use made by the natives of the plants of the richly vegetated Malabar Coast and sought to bring knowledge of these plants together in an organized fashion. He employed several Brahmins who knew the plants well to gather information for his *Hortus Malabaricus*, a work that eventually consisted of 12 volumes, the first of which appeared in Amsterdam in 1678. While no specimens were made of the plants illustrated in this book, the plate (number 16) of bamboo, known in the local language of Malayalam as -Illy-, is possibly the first published illustration of a bamboo of scientific value. He worked with several scientific collaborators in producing his *Hortus Malabaricus*, among them Jan Commelin, who wrote the remarks on "Illy". Commelin (1626-1692), who was a druggist and a member of the town council of Amsterdam, studied botany in his spare time and helped



Rheede on the second and later volumes. He also founded the Amsterdam Botanic Garden and mentioned many of the plants cultivated in that garden.

Even though the illustration in *Hortus Malabaricus* is poor, the name “Illy” which identifies the plant, is used to this day for the common thorny bamboo of southern India. Commelin commented at length upon the bamboo and called it “Arundo arbor”, citing Avicenna and Bauhin’s *Pinax*. Thus, while various names were again employed, *Hortus Malabaricus* was the first to provide an illustration of the plant in addition to a local name.



At the time that Commelin was preparing the comments on the bamboo for the text, he had the drawing of the bamboo from the Malabar Coast, which included flowering branches. He also received some specimens that had recently been collected in Ceylon by Paul Hermann, a Dutch botanist who had been to that island between 1670 and 1677. If plants of the Malabar Coast and Ceylon flowered at the same time, Hermann and Rheede must have seen them between 1674 and April of 1675. At the top of page 25 in *Hortus Malabaricus*, Commelin comments that this plant flowers every 60 years and dies, the first reference to my knowledge of a flowering cycle in bamboos.

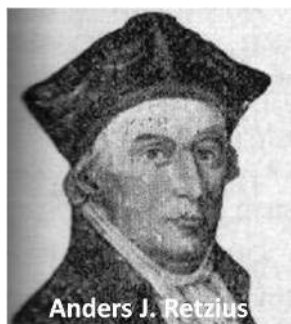
Hermann return to Holland came just before the birth in 1681 of George Clifford, who became a wealthy banker and proprietor of large estate in central Holland called “de Hartecamp.” The young Swedish physician and botanist, Carolus Linnaeus, went to Holland in 1735, where he spent the next few years. Part of this time was at de Hartecamp, where he was hired as Clifford’s personal physician with duties to catalog the plants on the estate, acquire new ones and publish manuscripts on these. In 1737 appeared the results of Linnaeus efforts in the form of the now-famous book, *Hortus Cliffortianus*. Linnaeus listed here an - “Arundo arbor,” so we know at least that Clifford had a bamboo in cultivation at his estate at the time.

While Linnaeus was working for Clifford, the Dutch botanist, Adriaan van Royen, prepared an account of the plants cultivated in the botanic garden at Leiden, the *Flora Leydensis Prodromus* of 1740. In this listing, van Royen also included an “Arundo arbor”. It is interesting to note that Bauhin in his *Pinax* of 1623 had cited a fragment of a plant from this botanic garden under his “Arundo arbor”, so whatever the bamboo in cultivation in Holland in 1740, it had probably been there at least since the first part of the seventeenth century.

These earlier publications of Linnaeus were leading up to the work for which he is most known, the *Species Plantarum* of 1753, on page 81 of which he used the binomial, *Arundo bambos*. Linnaeus did not give a description but cited previous works and authorities whose concepts were unclear: Caspar Bauhins *Pinax* (page 18), his own *Hortus Cliffortianus* (page 25) and *Flora Zeylanica* (page 47), and the *Flora Leydensis Prodromus* of Royen (cited as -Roy.lugdb., page 67). “Tabaxir & Mombu (sic)Arbor” of the *Historia Plantarum Universalis* by Jean Bauhin and Johann Heinrich Cherler, volume 1, page 222, were also listed. Linnaeus also cited -Illy- (sic) from Rheede’s *Hortus Malabaricus* volume 1, page 25, table 16. Certainly the “species” of Linnaeus included all bamboos up to his time and while the circumscription was confusing it is important to note that all formal botanical nomenclature commences with this publication of 1753. In other words, *Arundo bambos* of Linnaeus, 1753, is the first validly published name of a bamboo in scientific literature.



The next bamboo to be described is *Arundo gigantea*, the “large cane” of southern United States, which appeared in Walter’s *Flora Caroliniana* of 1788. By this time, the binomial system of nomenclature of Linnaeus was becoming widely adopted, and as more and more plants were described, it became apparent that many species represented distinct genera. And so it became clear that the myriad species included under *Arundo* represented in fact a number of distinct genera. In 1789, two botanists, Retzius and Schreber, decided that what had been called *Arundo bambos* represented a distinct genus from *Arundo*. Retzius called it *Bambos*, employing the specific name as the new genus name as was the custom, while Schreber did the same thing but used the Latin form, *Bambusa*. This latter name has since been the accepted form. The herbarium sheet from which Retzius, a professor at the Swedish University in Lund, made his description consisted of two elements, a thorny bamboo and a non-thorny one. He had received



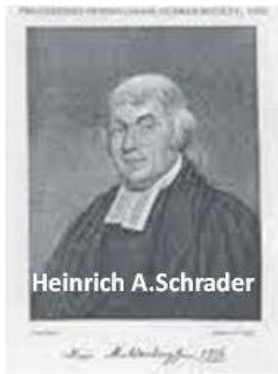
earlier imperfect specimens from travelers and supplemented this material with good flowering material sent by Koenig. In making *Arundo bambos* a genus, Retzius chose *-arundinaceae-* as the specific name and described the species on the basis of the two different bamboos which he had mounted on one sheet. The sheet with these two elements is to this day in the Lund Herbarium. Although we cannot be sure from the Lund sheet which material came from Koenig, we may conjecture that it is the non-thorny one. A specimen of Koenig’s bamboo, probably a duplicate of the Lund material, is at the British Museum and is a non thorny bamboo, which we now know as *Bambusa vulgaris*.

Johan Gerhard Koenig (1728-1789) was a missionary-surgeon, born in the Duchy of Courland (between Poland and Russia), who went to Uppsala to learn medicine. When he was middle-aged, he joined the Tranquebar Mission as a surgeon and naturalist and studied the flora of the Madras Coast. He sent specimens to Retzius between 1768 and 1778 before leaving for Siam and the Malay Peninsula.

In 1790, another well-known bamboo was described, this one by João de Loureiro (1717-1791), a Portuguese missionary and naturalist who worked in Mocambique, Goa and Cophinchina (now South Vietnam). The bamboo was called *Arundo multiplex* (later recognized as a species of *Bambusa*), a common hedge bamboo of the region. Many botanists have felt that the short description given by Loureiro was insufficient to know which species the author had in mind, especially since the author made no herbarium specimen for future reference. Most botanist and horticulturist have therefore taken up a later name, *Bambusa glaucescens*. In my opinion, however, there is enough information in the original description to leave no doubt as to the bamboo Loureiro was describing. For one, he gave the common name as “Cay hóp”, and there are only three bamboos from the region with “hóp” in the name: Loureiro’s bamboo and two named later by Munro as *Bambusa tuldooides* and *Bambusa flexuosa*. The latter is thorny and not used in hedges so can be ruled out, and the former has culms larger than one inch in diameter as described by Loureiro for his species. This leaves only the one hedge bamboo. A further point, overlooked by other authorities as far as I know, is that Loureiro describes the flower as having three stigmas that are sessile on the ovary. This is indeed true of “*multiplex*” but not of *B. tuldooides* in which there is a style that precedes the three stigmas. It is clear that Loureiro was describing the common hedge bamboo known since as *Bambusa multiplex* of *B. glaucescens*. Since *B. multiplex* is the earlier name, and the identification is not in doubt, it must be used.

While we cannot review the description of each new species, it is interesting to see what these early entities were. In 1791 *Nastus borbonicus* was described by Gmelin from the island of Reunion, and in 1803 Michaux elevated *Arundo gigantea* to the genus *Arundinaria*. So at this time, we have the three earliest described genera of bamboos: *Bambusa*, *Arundinaria* and *Nastus*.

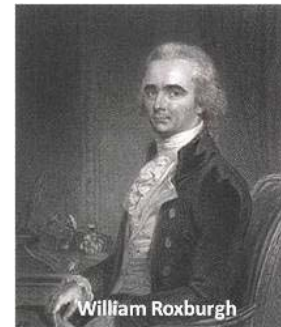
Our most common bamboo, *Bambusa vulgaris*, was cultivated in Europe by the early 1800s, and how long before that I do not know. J.C. Wendland, a horticulturist at Hannover, Germany, was working on a



book, *Sertum Hannoveranum*, with his colleague, Professor Heinrich Adolph Schrader of Gottingen. When Wendlands bamboo came into flower in Hannover he sent a specimen to Schrader. Schrader suggested *-vulgaris-* as a good name for this species new to science, which in fact Wendland used when he described it. That the name was suggested by Schrader and the actual description written by Wendland is reflected in the formal taxonomic name of this most common bamboo: *Bambusa vulgaris* Schrader ex Wendland.

In the early 1800s, the East India Company was flourishing, and headquarters of the enterprise had been established at Calcutta.

Across the Hoogly river was the Company Garden, of which Dr. William Roxburgh was the director. In 1814 appeared his listing of the plants in cultivation at the Garden under the title of Hortus Bengalensis. In the list were seven bamboos, all of which are to this day important cultivated bamboos. I have added the current names in brackets: *Bambusa arundinacea* (bambos), *B. tulda*, *B. balcooa*, *B. (Dendrocalamus) stricta*, *B. nana* (actually multiplex or a different species ?), *B. spinosa* -(bambos) and *B. (Melocanna) baccifera*.

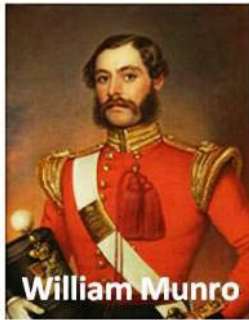


By now the number of genera and species of bamboos was increasing at a rapid pace, and in the first really good natural system of classification of grasses, Kunth recognized bamboos as one of his ten natural groups of genera. In his paper, published when the young German of twenty-seven was working in Paris, Kunth referred to the group as *-Gramina Bambusacea-*. This excellent botanist was followed by another of equal stature, the great Nees von Esenbeck (1776-1858), who was a naturalist, physician and professor of botany at universities in Erlangen, Bonn and Breslau. In 1835, he published a book on the bamboos of Brazil (*Bambuseae Brasilienses*), in which he included *Streptochaeta* as one of the bamboo groups and was thus the first to recognize a relationship between woody and herbaceous species. Nees divided the bamboos into three groups: a, *Bambuseae* (with *Bambusa*); b, *Arundinariae* (with *Arundinaria*); and c, *Streptochaeta* (by itself and not in a tribe). In his treatment of *Bambuseae*, he recognized 2 subgenera, *Bambusa* and *Guadua*.



By 1839, Ruprecht, working in St. Petersburg (now Leningrad), published his *Bambuseas Monographic* and included 67 taxa, is representing the first worldwide treatment of bamboos. Franz Joseph Ruprecht (1814-1870), who had been born in Freiburg, Germany, spent 31 years in St. Petersburg and for part of the time was director of the Botanical Museum there. He had studied under the great agrostologist, Trinius, and completed his bamboo monograph when he was only twenty-five.

The next monograph of bamboos to appear was that of Colonel William Munro. Since this world monograph of 1868, there has been none other, and it remains a classic, to this day one of the most useful original references on bamboos. Munro was born in 1818, and at the age of 16 joined the English army, eventually rising to the rank of general in the 39th Regiment. He saw much active service in India and was severely wounded in the Battle of Maharajpore. In the various places where he was stationed, among them India, Canada and the West Indies he established gardens for the recreation and comfort of his soldiers. His beautifully written introduction is a must for all to read. In it he speaks of Ruprecht who had described nine genera and 69 species, of which he had seen 55 in flower. Munro states that he has reduced the number of species to 50 and has in his monograph described upwards of 170 species in 20 genera, (showing how largely our knowledge of this family has increased in the last twenty-five years). Munro's system was based on the foundation that Nees had laid down earlier but expanded to include many new taxa. All of the groups and subgroups that Munro recognized have remained in systems to this day, even though we may use other



William Munro

names or place them at other ranks. Munro, like Nees before him, had a keen perception of natural relationships, and the two must be counted among the best in bamboo systematic.

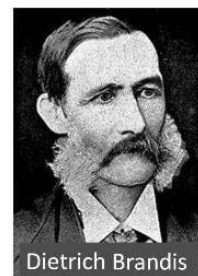
At about the time Munro was preparing his monograph, a young German, Wilhelm Sulpis Kurz, born in 1833 in Munich and a pupil of the famous Martius, was curator of the herbarium in Calcutta but left for Indonesia where he learned all he could of bamboos. His long paper on "*Bamboo and its Use*", which appeared in 1876, is full of original information. He was the first to make observations on the special nature of the proliferating bamboo spikelet, the type later to be studied in more detail by McClure (1934), who called it "pseudospikelet". Kurz's plan to write an account of the bamboos of India ended with his premature death at Penang (Malaysia) in December of 1877. His notes and specimens, however, were later used by Gamble in his treatment.

I think it is interesting here to note that in 1887 Adrien Franchet, a botanist at the Museum National d'Histoire Naturelle in Paris, wrote a small paper in which he described new genera of bamboos from French Congo: *Atractocarpa*, *Guadeuella*, *Microcalamus* and *Puelia*. He referred to these as miniature bamboos and is, to my knowledge, the first botanist to recognize herbaceous bamboo since Nees, who had included the American genus, *Streptochaeta*. Franchet, it may be recalled, described some interesting woody bamboos as well --the curious *Glaziophyton* from Brazil, which he named in honor of the French landscaper and botanist in Rio de Janeiro, M Glaziou -1889-, and *Fargesia*, which he named for the French missionary in Sichuan province of China, Abbe Farges (1893). (We now know that *Microcalamus* is not a bamboo and that *Atractocarpa* is congeneric with *Puelia*, buy apart from that, all of his other genera are recognized to this day).



Adrien Franchet

Little research has been done on the bamboos of Africa since the time of Franchet, but the same cannot be said of India and Burma, and here the town of Dehra Dun in northern India plays a big role. Sir Dietrich Brandis, who like Beethoven before him, was born in Bonn, was called upon by the British to help them in matters of forestry, in which the Germans had much more experience. Brandis was in Burma between 1856 and 1862 where he was the superintendent of Forests in Pegu, which is the large area of forest in the southern part of that country, in 1878, he founded the forestry school at Dehra Dun, which to this day remains a strong force in forestry in Asia. While Brandis did not work principally on bamboos, he published a remarkable paper in 1907 on the structure of bamboos leaves and noted the great similarity in features of the leaf anatomy and epidermis of different bamboos. Interestingly, he also looked at leaves of *Olyra*, *Diandrolyra*, *Leptaspis* and *Pharus* and remarked on the similarity of these leaves to those of the bamboos. The anatomical figures that accompany this paper are superior.

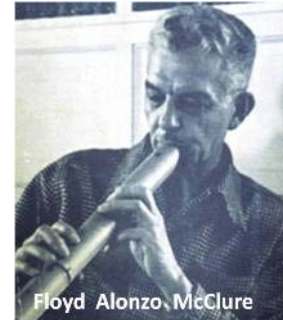


Dietrich Brandis

James Sykes Gamble, who had been born in London in 1847, had his practical training at the Ecole National des Eaux et Forest at Nancy, France, and then went to India in 1871, where he spent many years in the Indian Forest Service. In 1890, he was appointed Director of the Imperial Forest School at Dehra Dun where he remained until 1899. He wrote several important works on the forests of India and Burma, among them a monograph on the bamboos of British India, which appeared in 1896 in the *Annals of the Royal Botanic Garden, Calcutta*. Gambles first-hand knowledge of bamboos can be felt throughout his excellent work, accompanied by illustrations made in India from fresh material. This treatise covers 15 genera and 115 species and contains 119 plates, certainly the most exhaustive work to its time. The publication was prepared at the herbarium of the Royal Botanic Gardens, Kew, which had earlier been consulted by Munro and contained at the time the best bamboo herbarium in the world.

By the beginning of this century, the study of bamboos had progressed rapidly with major emphasis on those of India. No further world monographs of bamboos have appeared in this century except for that of E.-G. Camus of the same museum where Franchet had worked. His book, *Les Bambusées - Monographie, Biologie, Culture, Principaux Usages*, appears to be most useful since it is a compilation of all previous works, but it was poorly done and cannot be relied upon.

During the early years in this century, a young American from Ohio, Floyd Alonzo McClure, went to Lingnan University in Canton, China to teach biology, there he became interested in economic plants, particularly bamboos, which he saw all about him. So intrigued by these plants was he that he worked on the morphology of the spikelet and published a paper on the pseudospikelet as found in *Schizostachyum* (1934). In later years he returned to the United States and worked at the Smithsonian Institution where his plans were to revise all of the bamboo genera for *Die Natürlichen Pflanzenfamilien*. By the time of his death in 1971, he had mostly completed the manuscript for just the New World bamboos.



I must introduce McClure in this discussion for two facts: one, in 1946, he chose the 1678 illustration of Rheede as the type species of the genus *Bambusa*. The correct name for this bamboo is thus *Bambusa bambos*, which combination had first been made by Voss in 1896. This name takes precedence over *Bambusa arundinacea*, which has most generally been used for the thorny bamboo of India. Two, in 1961 McClure published a description of the subfamily Bambusoideae, which was thorough and detailed but included only the woody members.

In this same year, 1961, Professor Lorenzo R. Parodi, an eminent agrostologist from Argentina, defined the subfamily Bambusoideae as it applied to representatives from his country. In the subfamily he included all of the woody bamboos under the tribe Bambuseae, but placed the herbaceous members in three tribes - Olyreae, Phareae and Streptochaeteae.



During my discussions with McClure toward the end of the 1960s and just before his death in 1971, we talked of the herbaceous grasses that so resemble the woody bamboos, and he agreed that all should be treated in the same subfamily. McClure (in McClure and Smith, 1967:3) mentioned how Parodi had brought into sharper focus the "long-recognized bambusoid affinities of certain other gramineous genera toward the bamboos."

In summary, we find that the principal steps in the history of bamboo classification are the following:

1623. Caspar Bauhin in his *Pinax* lists bamboo under "Arundo arbor".
1753. Linnaeus, in *Species Plantarum*, gives bamboos their first formal name in botanical nomenclature, *Arundo bambos*, a name that embraced more than one taxon.
1789. Retzius in Sweden and Schreber in Germany recognize bamboo as a distinct genus, the former calling it *Bambos* and the latter *Bambusa*.
1815. Kunth recognizes bamboos as one of his ten natural groups of grasses and thus conceptualized what we know today as the subfamily Bambusoideae.
1835. Nees von Esenbeck establishes the first system of classification for bamboos in his treatment of Brazilian bamboos, recognizing three groups - two of which were woody, Bambuseae (with *Bambusa*), and Arundinariae (with *Arundinaria*) and one of which was herbaceous, Streptochaeteae (with *Streptochaeta*).
1961. Parodi formalizes the subfamily Bambusoideae in establishing a system of classification for the grasses of Argentina. In this system he included all of the woody bamboos in a single tribe, Bambuseae, and allocated the herbaceous members to three tribes Olyreae, Phareae and Streptochaetea.

Since Parodi's publication there have been numerous papers on all subjects of bamboo and this is not the place to comment upon them. While many new genera and species have been described and further work on morphology and anatomy confirms the validity of the system developed up to the time of Parodi, no basic new concepts in the classification of bamboos have really been introduced.

Presently there is a great deal of interest in bamboo systematic, and many new taxa are being described, especially from tropical America and The Peoples Republic of China. Research is also being made in silviculture and utilization, particularly in the Peoples Re. of China. A good idea of bamboo activities in Asia may be found in Lessard and Chouinard (1980) *Bamboo Research in Asia* (the proceedings of a workshop held in Singapore May 28-30 1980). I commend the horticultural efforts of the American Bamboo Society, which is introducing new taxa for cultivation as ornamentals. There are so many beautiful species worthy of cultivation in this country, especially temperate genera like *Drepanostachyum* of the Himalayas and *Chusquea* of the Andes and tropical genera like *Schizostachyum* and *Thyrsostachys*. Because of the economic value of bamboo, most research will continue to focus upon practical problems, but I would like to point out the kinds of scientific studies that I feel should be pursued as well.

1. Fieldwork

Highest on my agenda would be extensive fieldwork and field observations. While new laboratory techniques and methods of analysis are useful in studying species we already know, there is nothing to compare with completely new material. Each collecting trip that we have made to eastern Brazil, for example, has yielded new taxa, the study of which helps us to understand other genera to which they are related. One example is a new genus from Bahía, which is related to *Guadua*. A study of it has helped us define the genus *Guadua* itself and recognize its distinctiveness from *Bambusa*, with which genus McClure 1973 and others had merged it. New genera are not always in out of the way places. *Olmeca*, a genus that I recently described 1981, grows abundantly on both sides of road in Veracruz that leads to the Biological Station of the University of Mexico. For years students and professors of botany have driven by this bamboo, little realizing that it was a genus unknown to science.



The area of most interest for collecting is the Malagasy Republic where almost all of the bamboos are endemic and of which we have little well-collected material. There are more different kinds of bamboo on the island of Madagascar than there are on the whole continent of Africa. Other areas most likely to yield new taxa of bamboos are the eastern coastal of Brazil and other regions of lowland tropical America, particularly the Guiana's and low hill regions between the Amazon basin and the Andes. The mountains of eastern India and border in Burma and China are extremely rich in bamboos and should continue to yield novelties to science. The forest of tropical West Africa must also be explored and I hope they will provide us with further species of herbaceous bamboos.

2. Morphological and anatomical studies

Characters from leaf anatomy are useful in classifying grasses in general, and the similarity in basic structure among woody and herbaceous bamboos has been a strong factor in maintain the groups within the same subfamily. A survey of leaf anatomy of bamboos, which I have made with Dr. Roger Ellis of Pretoria, has allowed us to discern the major lines of evolution in the subfamily.

Once we have studied the anatomy, the next most important organ to survey is the flower, particularly the gynecium and resulting fruit, including the embryo and seedling. Holttum, in his important paper of

1956 on bamboo classification, stressed the importance of the ovary. Few studies have been made to date on the gynecium but we are presently sectioning ovaries of all bamboos for which we have material. Careful analyses should also be made of rhizomes for only the general nature of the sympodial, amphipodial and monopodial systems is known.

3. Biological studies

This is the area in which we have the least amount of information. Perhaps because scientists have found bamboos difficult to collect and name, they have left them alone. The unusual cyclic flowering behavior of bamboos is well known, and while anecdotal information is plentiful, few scientific studies of an experimental nature have ever been made on the subject. We are trying to rectify this situation in a bamboo flowering research program at the Tropical Agriculture Research Station at Mayaguez, Puerto Rico, while one objective of this program is to induce flowering outside of the normal cycle, we are interested in a number of related problems. For example, are bamboos self-crossing, out crossing or both?. We need more information on seed-set and data on seed germination. Chromosome counts, although known for some bamboo taxa, are few, mostly because flowers are seldom available. For this reason efforts should be directed toward processing of root tips for chromosome counts.

Fruit dispersal in the Bambusoideae is also a subject worthy of further investigation. In many taxa the fruits fall to the ground and grow near the parent plant, the situation we find in most bamboos. Herbaceous bamboos, however, have evolved various adaptations to enhance their dispersal. The infructescence of *Pharus* clings to the fur of passing animals, a phenomenon known as epizoochory, A specialized movement of the glumes of *Raddia* at spikelet maturity causes the fruits to be ejected, a phenomenon known as ballistochoory.

4. Physiological and biochemical studies

The study of enzyme system in plants has received much attention in recent years and may prove useful in bamboos, although few papers on the subject, such as that of Chou et al. (1984), have yet been published. In many plant groups, differences in isozymes have been used to distinguish clones, and we are hopeful that this technique may work to distinguish bamboo clones as well. New techniques, such as DNA hybridization, will doubtless prove to be an important means of measuring relationships between taxa of the Bambusoideae.

Many of the bambusoid grasses exhibit leaf movements at night. While Brongniart (1860) commented on sleep movements in *Raddia* (as *Strephium*) *guianensis*, the general extent of this phenomenon in herbaceous bambusoid grasses was not reported in the literature until recently (Soderstrom, 1980). In all of the taxa that we have observed, the leaves fold upward at night, but in *Lithachne* they fold downward. Here is a phenomenon we have observed only because we have cultivated these bambusoid grasses and been able to observe them at night.

Studies presently being undertaken by Dr. Gerald Deitzer of the Smithsonian Environmental Research Center in Rockville, Maryland, and by David Edelman in Puerto Rico show that the seeds of *Lithachne* do not germinate immediately but do so only after several months. There are few published studies on seed germination in bamboos and none to my knowledge in the herbaceous species.

The successful tissue-culturing of bamboo would be most desirable, not only to produce material for experimental purposes but to provide new plants for cultivation. I do not know of any case in which mature plants have yet been produced by this method. Some success has been made at the early stages of growth in a few bamboos by Huang and Murashige (1983).

5. Taxonomy

Revisions must be made of all genera, with keys to the species and descriptions of them, and should include all studies on the plants that are practicable, from anatomical and morphological to biological and chemical. The data can now be analyzed in new ways with the aid of computer programs.

Primitive and advanced -derived- characters in the species can be compared in a relatively new method called "cladistics" (see Humphries and Funk, 1984). In collaboration with Dr. H.S. Blommestein of the Netherlands I have completed a cladistic analysis of the genus *Olyra* and the tribe Olyreae and anticipate making similar analyses of the remaining tribes of the Bambusoideae.

The ultimate aim in the systematic of the Bambusoideae is to have an understanding of all bambusoid taxa that occur on the surface of the earth and to know their distribution, how to recognize them, how they are related to one another and how they got to where they are. Each new study helps to confirm or disprove what we have previously believed.

Of all the grasses the Bambusoideae are still the most poorly known. Apart from their beauty and utility, bamboos offer unlimited opportunities for scientific investigation.

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