PLANT TAXONOMY
IN THE HAWAIIAN ISLANDS

The Hawaiian flora contains many taxonomically complex and poorly understood groups that require further study in the field.

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Taxonomy, or systematics, is an attempt to catalog and study elements of the living world, both present and past, and to understand the processes that have led to the remarkable diversity of living organisms. At least 5 million kinds of living things have been described and share our biosphere. Plant taxonomy (systematic botany) conveys our best understanding of patterns of natural biological diversity in plants. Since taxonomy is a very functional science, it must be flexible enough to reflect changes as we obtain new information that helps us better understand the organisms we are studying and the relationships among them.

It is useful to review the evolution of plant taxonomy, which has resulted in our modern systems of classification. More than 2,000 years ago the Greek philosopher Theophrastus, a pupil of Aristotle, recognized the differences between trees, shrubs, and annual, biennial, and perennial herbs. Known as the "father of botany," Theophrastus also understood the seed, stem, and leaf differences between monocotyledons and dicotyledons as well as many other morphological differences in vegetative and floral features; many of these formed the basis for later systems of classification.

The practice of referring to organisms by descriptive Latin phrase names known as polynomials (many names) began in medieval times. The concept of genus, a group of closely related species to which an organism belongs, dates back to the end of the 17th century, when it was used in herbalists, highly illustrated works about plants considered to have medicinal value.

The system of naming living things was simplified considerably in 1753 when Carolus Linnaeus published his Species Plantarum (Species of Plants), a landmark work that contained brief analytical descriptions of every known species of plant as well as references to earlier works. For convenience, Linnaeus introduced a binomial (two-name) system using both a generic and a specific name for each plant. In addition to providing the first consistent use of the binomial system, Linnaeus instituted two systems of plant classification, an artificial classification system for the rapid cataloging and identifying of plants based primarily on the number of floral parts, and the basis for a natural classification system, that is, one reflecting the actual evolutionary relationships of plants to each other.

During the 18th and 19th centuries a number of classification systems, primarily descriptive in scope, were developed. The publication of Darwin's Origin of Species in 1859 had a great impact on plant systematics, and the
The concept of evolution began to be reflected in classification systems of the 20th century. For the first time it was recognized that species and higher taxa were derived from progenitors (ancestral forms) through evolution by natural selection. The concept of phylogeny, or evolutionary relationships of organisms to each other, was thus formed. It was to be a most important characteristic of all later systems of classification. Many other systems were subsequently developed to reconcile the morphological features of plants with an evolutionary interpretation of these features.

Although in the past much systematic research was based almost entirely upon "classical" morphological and anatomical similarities and differences, modern biosystematics (biological systematics) now has at its disposal a whole spectrum of new tools and techniques for phylogenetic interpretation and solution of taxonomic problems. Biochemical data from quantification of DNA (genome analysis) and studies of protein molecules can be used to understand relationships of species to one another. Chemical taxonomy (chemotaxonomy) provides additional data for the systematist and is useful in determining the parental species in cases of suspected hybridization. Both scanning and transmission electron microscopy (SEM and TEM) are powerful tools now widely used in systematic studies, for example, examination of trichomes (hairs), pollen, and sieve tube plastids (storage organelles or little organs found in vascular plant tissue). In addition, chromosome number and pairing behavior, karyotype analysis, hybridization, cytogenetics, and breeding systems are aspects of biosystematic studies that provide important data for understanding plants taxonomically and phylogenetically. Interdisciplinary collaboration between biologists is also becoming increasingly important.

The most modern and widely accepted systems of plant classification today are essentially based on a synthesis of all available data.

A HISTORY OF BOTANY IN THE HAWAIIAN ISLANDS

Early Explorers

Because of their isolation, the Hawaiian Islands harbor a unique and astonishing flora with a higher degree of endemism than any comparable area of the world. About 91% of Hawai‘i’s flowering plants are endemic (found nowhere else) (Carlquist 1980; Sohmer and Gustafson 1987; see also Kaneshiro, this volume). The first Western botanist to explore and collect specimens in the Hawaiian Archipelago was David Nelson in 1779, on Captain James Cook’s third voyage. Many others followed, most notably Archibald Menzies, Adelbert Charrière, Charles Gaudichaud-Beaupré, and James Macrae. Finally, a team of scientists with the U.S. Exploring Expedition commanded by Charles Wilkes in 1840-1841 spent six months in the Hawaiian Islands making extensive natural history collections that resulted in the published descriptions of many new species. During the same period, the Islands were also visited by a number of independent travelers and naturalists, some of whom collected plants (Kay 1972).

Early Resident Botanists

The great exploring expeditions finally came to an end in the late 19th century. Descendants of the early missionary families subsequently became
interested in natural history and made biological collections which they sent to scientists in America or Europe.

An important phase began when botanists such as Hillebrand, Mann, Brigham, Rock, and Forbes went to the Hawaiian Islands and made significant collections while residing there. William Hillebrand, a German physician and accomplished botanist, lived in Honolulu for 20 years and was one of Hawai'i's most renowned doctors. During his stay in Hawai'i (1851-1871), Hillebrand explored all the larger Islands and collected numerous herbarium specimens, sets of which were deposited in the B.P. Bishop Museum in Honolulu, Melbourne, Berlin, and Zurich herbaria. His extensive living collections now form part of Honolulu's Foster Botanic Garden. Charles Forbes, the first full-time botanist at the B.P. Bishop Museum, was appointed in 1908. His many herbarium specimens became the nucleus of the rich Hawaiian collections housed there today. Joseph F. Rock, who came to Hawai'i in 1907 from Austria, spent about 12 years studying the flora of Hawai'i and collected numerous herbarium specimens. Among the other early resident naturalists, Jules Rémy, Theo Balbue, Valdemar Knudson, and John M. Lydgate all deserve mention for their contributions.

Recent Resident Botanists

Two great students of the Hawaiian flora have lived and worked in the Islands for many years. Otto Degener (recently deceased) came to Hawai'i in 1922 and collected extensively. He distributed a large series of duplicate plant specimens to a number of herbaria worldwide. Harold St. John came to teach at the University of Hawaii in 1929 and has pursued his studies of Hawaiian plants since then, making extensive collections.

PUBLICATIONS ON HAWAIIAN BOTANY

Existing publications on the flora of the Hawaiian Islands fall into two main categories: systematic studies, including monographs and revisions, and floristic treatments (floras). An early example of the first category is Rock's monograph of the Hawaiian species of the tribe Lobeloideae of Campanulaceae ('lobelioids'), published in 1919. Although many taxonomic studies on Hawaiian plants exist, a large number were published by botanists such as E.E. Sherff, who worked exclusively with dried herbarium specimens and never visited Hawai'i. On the other hand, several excellent examples of modern biosystematic treatments incorporating field observation with morphological, anatomical, cytological, and hybridization data exist. More work of this type is badly needed for many Hawaiian groups.

The first comprehensive account of the Hawaiian flora as a whole is Hillebrand's *Flora of the Hawaiian Islands* (1888, republished in 1981), based on extensive collections and field observations. Although now dated, it has been used by generations of students of the Hawaiian flora. Rock's (1913, reprinted in 1974) *Indigenous Trees of the Hawaiian Islands* also falls into the floristic category. Degener's *Flora Hawaiensis*, begun in 1932, is an ongoing series comprising some seven volumes consisting of treatments with taxonomic keys, descriptions, synonymy, and line drawings (see Mill et al. 1985 for details). Although quite useful, it is unfortunately not complete. A number of popular works on Hawaiian plants also exist, including Marie Neal's *In Gardens of Hawaii* (1965) and the recently published *Plants and Flowers*
of Hawaii (Sohmer and Gustafson 1987), the last replete with excellent color photographs. The forthcoming Manual of the Flowering Plants of Hawaii, coauthored by W. Wagner, D. Herbst, and S. Sohmer, is in press. The Manual will not only offer consistent, synoptic treatments with a biological basis for flowering plant families in Hawaii, but will also highlight and discuss problematic and taxonomically complex genera and species groups. However, the resolution of some problems is beyond the scope of a floristic treatment, as plants need to be studied through a combination of field observations, biosystematics, and other modern techniques as well as a classical taxonomic approach. By calling attention to these problems, the authors hope to stimulate new interest and research by others.

MAJOR PROBLEMS

The Hawaiian flora contains many taxonomically complex and poorly understood groups that require further study in the field. Although a large number of botanical specimens have been collected in Hawaii, there has been relatively little study of natural populations in the field and few attempts to correlate field results with data from biosystematic studies. One major problem is that many previous taxonomic studies were based entirely on dried herbarium specimens. Therefore, taxonomic entities such as species or varieties were often described, with no biological understanding of the plants, on the basis of one or a few specimens. In reality, the specimens may merely represent stages in a continuous range of variation and not biological entities. Field studies are therefore necessary to understand what is represented in a biological sense. Habitat disturbances by feral animals, human activity, and invasion by alien species are all becoming increasingly severe. Studies of plant and animal populations in the field and application of modern techniques are contingent on protection of their habitats.

In addition, a large influx of collections made over the recent years is yielding specimens which are critical to an understanding of problem groups. Other collections represent new distributional records for islands and even include new undescribed taxa. Since the existing taxonomic and floristic literature is scattered and varies greatly in scope, quality, and consistency, it is obvious that a changing, modern flora is required to incorporate and synthesize all the information.

Another major problem in plant taxonomy in Hawaii today is that more trained taxonomists and students, both at the graduate and undergraduate levels, are needed. Funding for personnel, as well as for research equipment, herbarium supplies, and field work, is a major constraint. Many of the existing facilities and infrastructures are generally adequate (for example, those at the B.P. Bishop Museum and Pacific Tropical Botanical Garden), but an active research program always requires some expansion.

RECOMMENDATIONS

It is suggested that available time and resources be focused on field studies and analyses of plants with specific taxonomic problems. The results will not only contribute to conservation, but also will provide essential data on the biology, evolution, and relationships of plant taxa. Modern
biosystematic revisions and monographs dealing with Hawaiian plants are few, and further efforts should be of this type. More funding for plant taxonomy, both research and personnel, should be sought.

Important References: Herbaria

The herbarium is an extremely important reference for conservationists as well as taxonomists. It is a permanent data base and repository for voucher specimens of the plants being studied and is important as a reference collection for determining and verifying plant identity, thus serving as the basis for scientific studies and publications. The herbarium is also an important reference at the State level (for example, the herbaria of the B.P. Bishop Museum, Pacific Tropical Botanical Garden, University of Hawaii, and National Park Service), as the specimens yield information on the plants' distribution (past and present), habitat, range, phenology (flowering and fruiting times), and morphology.

Important References: Literature


