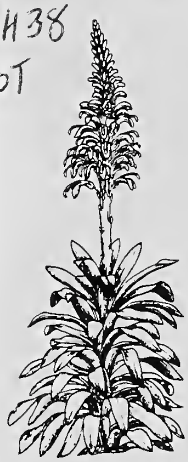
NEWSLETTER

of the

Hawaiian Botanical Society



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c/o DEPARTMENT OF BOTANY
UNIVERSITY OF HAWAII
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DEPARTMENTS

PRINCIPAL PAPER

SOME BOTANICAL OBSERVATIONS ON KOA 1/

Charles H. Lamoureux 2/

Introduction Koa, in the broadest sense, includes a number of closely related species and varieties of the genus Acacia native to the Hawaiian Islands and apparently endemic to these islands.

The genus Acacia is one of the largest genera of higher plants, including perhaps 500 species native to the tropical and subtropical areas of the world. Of these 500 about 300 are native to Australia, perhaps 50 to Africa, and most of the rest to tropical America and Asia. The African species all possess bipinnate leaves on mature branches, as do most of the American and Asian ones, and need not concern us further as potential close relatives of koa. However, about 250 of the 300 Australian acacias are phyllodineous -- the leaves on mature plants are reduced to flattened petioles -- phyllodes -- as is the case with the native Hawaiian acacias.

Origin and Dispersal Phyllodineous acacias are also known from New Caledonia, Tahiti, Samoa, Tonga, Fiji, the New Hebrides, New Guinea, the Philippines and Taiwan (Acacia confusa). From our point of view the most interesting species is Acacia heterophylla native to Mauritius and Reunion Islands of the Mascarene group in the Indian Ocean. This species is so similar to Acacia koa that some of the earliest botanists concerned with the Hawaiian flora considered koa to belong to the species Acacia heterophylla. In fact, Asa Gray, when he described Acacia koa as a species new to science in 1854 stated: "In distinguishing the two trees, peculiar to these most widely separated stations, perhaps I incur the charge of being influenced by geographical considerations rather than botanical characters." However, since we still have

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1/ Paper presented at Koa Seminar, sponsored by Institute of Pacific Islands Forestry, U. S. Forest Service, October 9, 1970.
2/ Department of Botany, University of Hawaii.

no complete comparisons of Hawaiian koa with the plants from Mauritius and Reunion [3/], it is probably more in accord with modern biogeographic theory to consider that the two groups are different species, perhaps descended from a common ancestor.

This ancestral type, at least for koa, was probably a species such as Acacia melanoxylon, the blackwood of Australia. All but one of the botanists who have considered the origin of koa in any depth have suggested that its closest relatives are species from Australia or some of the islands in the South Pacific (in addition to the Mauritius species). The only exception was Forrest Brown, who attributed the origin of the bulk of the Hawaiian flora to Tropical America while essentially all other workers have considered that most Hawaiian plants have their closest relatives in the Australasian regions. Brown (1921) wrote: "a cusp-pointed phyllode of the same size and outline as the Hawaiian Acacia koa var. lanaiensis has been found in the American Lower Eocene." Despite Brown's comments, I think we must look toward the south and west for the original immigrant which, once established in Hawaii, developed into our native acacias.

How did the first seeds get here from Australia or the Australasian region? Acacia seeds are obviously too heavy to be carried by wind currents. Rock (1919) suggested that they were carried here by birds which "do not exist today" (in Hawaii), "but were in all probability the now extinct columbae and their relatives." On the other hand, Carlquist (1966) has suggested that rafting was responsible for the seeds which reached Hawaii from elsewhere. Although seeds of Hawaiian koas will not float, Carlquist suggested that perhaps a branch bearing unopened but mature seed pods could have drifted here. In Acacia simplicifolia, from Samoa and Tonga, each seed is contained in a loment-like segment which contains an air space sufficient to float the seed for at least a few days. This is not a very efficient means of dispersal but one which might have been successful at least once during the past 20 million years or so. Carlquist further suggested that koa could have been distributed among the islands, once it reached here, by seed-eating birds such as Psittacirostra.

All we really know, then, is that koa got here, by some natural means, from some other area - the rest is all speculation at this stage. But, while we're speculating, let's go one step further and suggest that the immigration of the ancestors of koa to Hawaii probably occurred only once, and that this one occurrence was some time ago (on the order of perhaps a few million years). The arguments in favor of a single introduction rather than repeated introductions are twofold - first, the chances of the occurrence of a successful natural introduction to Hawaii are fairly small when the dispersal mechanisms available are no more efficient that they are in these acacias, and thus the probability of two successful introductions at different times from the same source is extremely small; second, the Hawaiian acacias seem to be fairly closely related, and it is probable that they have developed from a single ancestral type. The evidence in favor of a relatively long time since the ancestors

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3/ After this paper was delivered, Mr. Craig Whitesell called to my attention a recent paper by Vassal (A propos de Acacias heterophylla et koa. Bull. Soc. d'Hist. Nat. de Toulouse 105:443-447. 1969) who demonstrates that on the basis of corolla structure, fruit and seed size, and morphology of the first two leaves on the seedlings, Acacia heterophylla from the Mascarene Islands differs significantly from A. koa of Hawaii. Vassal therefore considers the two species to be distinct. He also reports that in A. heterophylla, as in A. koa, the chromosome number is 2N = 52.

of koa became established in the islands is also of at least two types - first, the fact that local populations have become established to the extent that taxonomists have recognized at least three species, one of which has three varieties; second, a large number of endemic insects restricted to koa have also had time to evolve (Swezey, 1954; Gressitt & Davis, 1969).

Taxonomy There are five taxa of Hawaiian acacias which are more or less generally recognized. These are:

1. *Acacia koa* (Gray, Bot. U. S. Expl. Exped. 480. 1854, variety koa (*A. heterophylla* Willd. according to Gaudichaud and according to Hooker and Arnott).

2. *Acacia koa* Gray var. *lanaiensis* Rock, T. H. Bd. Agr. For., Bot. Bull. 5:21. 1919. (*A. koa* B var. Hillebrand, Flora Haw, Isl. 113. 1888).

3. *Acacia koa* Gray var. *hawaiiensis* Rock, T. H. Bd. Agr. For., Bot. Bull. 5:23. 1919. This is the type with broad phyllodes from Hawaii. It is of special interest as it is the type most likely to be used as a source of timber. It should be noted that Gray (1854), Hillebrand (1888), and Skottsberg (1944) did not consider this taxon to be distinct from var. *koa*.

4. *Acacia koaia* Hillebrand, Flora Haw. Isl. 113. 1888.

5. *Acacia kauaiensis* Hillebrand, Flora Haw. Isl. 113. 1888.

Table I gives the distribution of these taxa and a list of their distinguishing features as indicated by Rock (1919; 1920) and Judd (1920). This summarizes our knowledge of the systematics of Hawaiian acacias, which is not in a very satisfactory state. We really need to make careful and complete collections from throughout the islands, and to study them using modern techniques. For example, there is only one recorded chromosome count for "*Acacia koa*" (2N = 52, Atchison, 1948). This is of interest as the other phyllodineous species reported by Atchison had 2N = 26, suggesting that the Hawaiian material he studied was tetraploid. A complete cytological study would be most helpful in interpreting the evolutionary history of Hawaiian acacias. Little attention has been paid to characters exhibited by the juvenile foliage. While the wood anatomy of *A. koa* and *A. koaia* has been described (Brown, 1922; Lamberton, 1955), there have been no other anatomical studies. Newer methods of comparisons of bio-chemical constituents using electrophoretic and chromatographic techniques might provide useful systematic information.

We know that koa varies morphologically from place to place, but we really don't have any idea how much of this variation is genetically controlled and how much is environmentally controlled. For example, both Rock (1919) and Judd (1920) suggested that the broad phyllodes of var. *hawaiiensis* are a response to high altitude with consequent fog and mist. Rock even cited an example of var. *hawaiiensis* grown from seed in San Francisco which had wider phyllodes than any observed in Hawaii. Yet, on Hawaii, although there is considerable variation in phyllode width, not all the plants with very broad phyllodes are restricted to higher, moister areas. In Kipahulu Valley on Maui,on the other hand, koa grows in areas which seem to be wetter than most other areas in the islands where it is found, yet the phyllodes are quite narrow. I suspect that we are dealing with both genetic and environmental factors here.

TABLE I.

	Acacia koa var. *koa*	var. *lanaiensis*	var. *hawaiiensis*	*Acacia koaia*	*Acacia kauaiensis*
DISTRIBUTION	Kauai(eastern?) Oahu, Molokai, Maui	Lanai	Hawaii	Molokai, Maui, Hawaii	Kauai (western)
STATURE	Tree, medium to large-sized.	Tree, medium-sized	Tree, large (to 100 ft+)	Tree, small, gnarled	Tree, large
PHYLLODES	10-15 cm X 6-24 mm. Falcate, apex acute or obtuse.	3.5-8 cm X 8-15 mm. Almost straight, apex obtuse, mucronate.	12.5-16 cm X 25-50 mm. Broad obovate to ovate to linear-oblong slightly curved, apex acute to obtuse, uncinate.	6-12 cm X 8-10 mm. Falcate, linear, apex acute with recurved mucro.	10-16 cm X 12 mm. Falciform, narrow linear, apex somewhat obtuse mucronate, uncinate.
INFLORESCENCE	Peduncles ± 12 mm, solitary or fascicled in upper axils.	As in var. *koa*.	Peduncles ± 1.5 mm, with 1-3 flower heads each on 3 mm pedicel.	As in var. *koa*, axillary racemes with generally 1, sometimes 2-3 heads.	Peduncles ± 10 mm, each bearing several 4-6 mm single-headed pedicels, forming a terminal foliose paniculate receme.
FLOWERS	Sepals fused nearly to tips; petals fused in lower half.	Unknown	As in var. *koa*.	As in var. *koa*.	Petals and sepals free nearly to base.
PODS	7.5-15 cm X 16-18 mm. Straight, about 12-seeded.	Unknown	11 cm X 25 mm. Straight, or slightly wavy margins.	10-15 cm X 8-10 mm. Somewhat curved, with slight constrictions between seeds.	15 cm X 20 mm. Straight, about 15 seeded.
SEEDS	Flat, dark brn. to black, "size of apple seed" (Judd).	Unknown	"Twice size of Oahu seeds", darker (Judd).	Oblong, 6 mm in long diameter.	Round, flat, black.

Data from Rock (1919; 1920) and Judd (1920).

Ecology Let us take a brief look at some environmental parameters. Whitesell (1964) indicated that koa will grow in areas with 25-75 inches average annual rainfall, but that it does best in areas of from 75 to more than 200 inches. It has been suggested that koa grows in all forest areas of the state except the very wettest and the very dryest. On the lower islands (those less than about 6000 feet altitude) this means that koa forests are generally located at lower elevations, in somewhat less wet areas than the ohia (Metrosideros) forests which extend to the summits of the mountains. On the other hand, where mountains are higher, and where the maximum rainfall is in a belt along the windward slopes, there was apparently, at least originally, a band of koa forest below and another band above the ohia forest. Some evidence of this still exists in places on the island of Hawaii, but the original situation on the slopes of Haleakala, Maui is not clear.

We know little of the role of edaphic factors in koa distribution. Forbes (1912) indicated that, in the Kona district of Hawaii, koa forests tended to occupy weathered pahoehoe lava flows while aa flows supported ohia forests. However, Forbes himself suggested and later workers have tended to support the hypothesis that the phenomenon described may merely have reflected different stages in succession. Observations have generally confirmed the fact that koa is not a pioneer species on new volcanic surfaces - rather, it becomes established at later stages of succession. Thus, Forbes' suggestion that koa forests tended to occupy pahoehoe flows may merely have reflected differences in the rates of succession on pahoehoe and aa lava flows of comparable ages.

The altitudinal limits of distribution of koa have been mentioned by many workers. Whitesell (1964) indicated that koa occurred between 600 and 7000 feet. MacCaughey (1917a) gave the distribution of A. koaia as 1000 to 3000 feet. MacCaughey (1917b), in describing the phytogeography of Manoa Valley stated that "koa thrives in Manoa at elevations as low as 50 feet and was at one time fairly plentiful in the valley floor", but he cited no evidence for this. I have seen koa, probably planted, growing well at 100-150 feet elevation in Manoa Valley in recent years, and at elevations of perhaps 300 feet in the upper part of the valley it still grows naturally. MacCaughey (1917b) further stated that in Manoa the upper limits of koa averaged 1200 feet, sometimes rising to 1800 feet. This is approximately the maximum altitude to which koa can be found commonly in the Koolau Mountains. At Salt Lake on Oahu there are fossils of koa, about 400,000 years of age, found in an area not more than ten feet above current sea level, but we do not know where sea level was at the time the fossils were formed. Hartt and Neal (1940) gave the altitudinal range of A. koa var. hawaiiensis as 3000 to 6000 feet, then indicated that they found it on Mauna Kea at 5800 to 7000 feet. Mueller-Dombois and Krajina (1968) reported koa growing up to elevations of 6600 to 7000 feet on the east flanks of both Mauna Loa and Mauna Kea. Yet on the southeast slopes of Haleakala, in Kipahulu Valley, koa was not present above 4000 feet (Warner, 1968) (koa may extend a bit higher on the northern slopes of Haleakala). On Mauna Loa and Mauna Kea there is an extensive koa forest above the ohia forest -- in Kipahulu Valley this is not the case.

From this somewhat disjointed series of observations, about all we can conclude is that we don't know nearly as much as we should about the factors that influence the distribution of koa. However, the facts do suggest that the koa on Mauna Kea behaves differently from that in Kipahulu Valley which behaves differently from that in the Koolau Mountains. I suspect that we may be dealing with a series of ecotypes here, but the necessary work to verify this hypothesis still remains to be done. The evidence that we do have, meager as it is, suggests that if we are to exploit as many areas as possible for koa production on a sustained-yield basis we are going to have to take such possibilities into account.

Reproduction As a final point, I would like to discuss some aspects of koa reproduction. The evidence seems to indicate that koa reproduction is notably scarce in the undisturbed forest (Scowcroft, 1970). Certainly after land clearing, exposure of mineral soil, or fire, in appropriate areas one finds impressive crops of koa seedlings, while in mature koa forests few seedlings can be found. Yet reproduction must be occurring in those areas which have healthy koa forests today. Such reproduction need not be especially frequent to maintain the forest -- perhaps the establishment of one or two seedlings or root sprouts in an opening created when a mature tree dies or blows over is sufficient to maintain the population at a uniform level. Of course the picture has been greatly complicated by disturbance -- but some natural balance must have existed in the past in maintaining extensive koa forests. The Kipahulu forest, for example, seems to be perpetuating itself. We must be careful to distinguish between a natural koa ecosystem, which may be able to maintain itself with a very low rate of koa reproduction, and a greatly disturbed or managed or recently burned koa forest in which, at an early stage of secondary succession, many thousands of koa seedlings per acre can be observed.

Foresters have shown me areas on the Hamakua Coast of Hawaii where there is an ohia-tree fern forest with an occasional mature koa tree. It has been suggested that in such areas koa forest is being replaced by ohia forest. This may be the case, but I am not yet convinced by the evidence. While these areas could represent a successional stage on the way to an ohia climax forest, I think it is more likely that this is merely the transition zone between koa and ohia forest types, and that at very infrequent intervals a koa may manage to become established in an opening in this forest. Although it is possible that, as a natural stage of succession on a new lava flow, ohia forest could replace koa forest, I think that the information we do have (summarized in Doty and Mueller-Dombois, 1966) suggests that the opposite is more likely to occur -- i.e., in areas where climatic, edaphic, and other factors are optimal to support a koa forest, koa may well replace a pioneer ohia forest and become a climax forest type. Another possible interpretation is that after disturbance, by cattle or fire, for instance, an area in which factors are optimal to support an ohia forest or a mixed ohia-koa forest may pass through an early stage of secondary succession dominated by koa. However, I have not yet been convinced that in any area in which environmental factors favor a koa forest climax, there is evidence of replacement of koa by ohia. Perhaps in some of these areas koa may be replaced by such exotic species as strawberry guava or banana poka, and in many areas affected by cattle koa is replaced by grassland, but there is no evidence that ohia is replacing koa in such areas. If replacement of koa by ohia is occurring in some areas, this would suggest that there is probably some related climatic or edaphic change which is basically responsible.

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EVENTS

First Steps to Rehabilitate Kahoolawe

During the period January 11 to 14, the Division of Forestry planted small plots of around 35 species of trees and shrubs, as well as sisal and several grasses in Kahoolawe. The plantings were made within six "goat-proof" fenced areas each 100 x 200 feet in size. The fences were installed in October, 1970. These fenced areas sampled a variety of conditions from sandy beach to some of the windiest and most severely eroded part of the central mesa.

Species included several indigenous Hawaiian plants such as coconut, beach naupaka, milo, koaia and wiliwili. These and non-indigenous plants such as eucalypts and casuarinas were planted in units where they were believed to be suited to the habitat. High mortality is expected because, at best, growing conditions on this dry, windy island are severe. Hopefully a few of the hardiest species and individuals will survive to show which are more promising. At the time of planting the soil contained abundant moisture.

Half of each fenced area was left unplanted for observation of the development of existing vegetation.

The Navy transported the work crew from Maui with helicopters, and assisted in checking unexploded ordnance, and in construction of the fences. William Sager, Assistant District Forester, Maui supervised the forestry work.

Letter to the Editor

Dear Sir:

I read with interest the paper on Kahoolawe in the last issue of the Newsletter, but noticed that it did not mention any Hibiscus from that island. In Sister Margaret James Roe's article on Hawaiian Hibiscus (Pacific Science 15:11, 1961) she mentions (without reference to her source of information) that H. brackenridgei Gray was reportedly collected by Jules Rémy on Kahoolawe but that the plants are unavailable.

I am happy to be able to report to the Society, as well as to Pacific botanists in general, that they are available again. For decades, many Old World unmounted collections in the Paris herbarium, especially Pacific collections, have been accumulating in a hopeless backlog, piled up in recent years in an attic. Mr. N. Hallé, Sous-Directeur of the Laboratoire de Phanerogamie has undertaken the immense task of sorting these out by family and large geographical region, so they can be accessible, at least. I recently worked my way through the Pacific and Asiatic Malvaceae and found a Hibiscus collection from Kahoolawe, very likely the missing Rémy 559. I put it on a pile of collections of special interest or value which Mr. Hallé assured me he would have mounted and inserted in the Herbier Général right away, for safety's sake.

I might add here that Mr. Hallé is prepared to have mounted and made available material in any family, provided that botanists intending to visit the Paris herbarium and interested in this treasure trove take the trouble to notify the Laboratoire of their planned visit and interests sufficiently ahead of time. Pacific botanists should by all means take advantage of this offer and will be richly rewarded. We owe Mr. Hallé a great deal for tackling this huge "hay stack" and bringing to light rare and long-lost collections.

/s/ Marie-Hélène Sachet
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Schiedea and Pleomele -- Comments by Otto and Isa Degener

Dr. St. John's interesting observations regarding Schiedea in Pac. Sci. 24:245-254. 1970, prompt us to draw to the attention of local botanists an obscure publication by Franz Buxbaum, appearing in Egle & Troll's "Beitrage zur Biologie der Pflanzen." In Dr. Buxbaum's reprint, appearing Jan. 1, 1961, he writes, among a few other paragraphs of special interest:

> "Kraft has already (1917) expressed the view that the origin of the Caryophyllaceae doubtless should be looked for in these Alsinoideae which are closely related in their flower structure to the Stellaria. This point of view can be definitely represented morphologically. Nevertheless it appears to be difficult from the 'Stellaria-Typus' to establish a connection to any other family of the Centrospermea because Stellaria typically is so much like a Caryophyllaceae. In the last analysis, the species of the Alsinoideae, Schidea (incl. Alsinodendron), which as woody plants typically deviate from the other Caryophyllaceae, would offer a connection. As an endemic species of the Sandwich Islands it does represent without question a very old relic. It is especially striking that the 'Staminodien' which correspond to the petals of other Alsinoideae superpose the sepalous sections of the perianth (the calyx of other Alsinoideae). The origin of the stamens from a'tender discus ring' however, is homologous to the growing together of the primary stamens in Phytolacca; this association is also noticeable in the obviously similar very old species Drymaria."

Buxbaum's reference to the herbarium specimen No. 25,047 should not read "Otto Degener, Isa Degener et Ward Hening," but ".... et Ward Fleming."

The Lanai endemic Pleomele is presently burdened with the two following binomials:

> Pleomele lanaiensis Degener, Fl. Haw. fam. 68: Aug. 10, 1932.
> Pleomele fernaldii St. John in Contrib. Gray Herb. 65:39-42. 1947.

If we follow the reasoning expressed in Taxon 12:202. 1963, the correct name for this halapepe appears to be the more appropriate P. lanaiensis Deg.

Editors Note: The above quoted text was translated by a friend of the editor for the convenience of non-German-speakers.

Research Review

The Department of Land and Natural Resources has sent invitations to approximately 100 persons including the scientific community and representatives of business and the public to participate in updating its forestry research program. The revised plan will be called "Forest Conservation Research Plan for the Seventies". Institute of Pacific Islands Forestry of the U. S. Forest Service is assisting in the planning.

Study and Survey of Ohia Decline.

Plans are underway to study the extent of the decline of ohia on the island of Hawaii, as well as the rate of spread and the cause. Dr. Franklin F. Laemmlen, Plant Pathology at the University, Clifton Davis of the Hawaii Dept. of Agriculture, State Forester Tom K. Tagawa, and Robert E. Nelson of the U. S. Forest Service are among those who will take part.

PROCEEDINGS OF THE SOCIETY

(Highlights only; not the complete minutes)

January 4, 1971

1. A very favorable report was heard on the Botanical Society's handling of the Smoker during the Annual Meeting of the Society of Western Naturalists with special thanks to Beatrice Krauss who had charge and Gladys Baker, Mrs. Max Doty, Ron Hurov, and Steve Montgomery who assisted.

2. After extended discussion of the desirability of inventorying and labeling arboreta and plant collections in Hawaii, Robert Osgood, H.S.P.A., was appointed interim chairman.

3. Speaker of the evening. Dr. Theodor Philip Haas, retired Plant Taxonomist, Philadelphia College of Pharmacy, formerly Assistant Curator, Botanical Gardens, Munich. The biology of flowers. Presented with many beautiful color transparency photographs to illustrate the great range in morphology of flowers and the many specialized adaptations of the various organs and parts.

PUBLICATIONS

Abstract. Zepernick, Bernhard. Pflanzennamen als Hinweis auf kulturelle Beziehungen innerhalb Polynesiens. Festschr. 100 jahr. Fest. Berl. Ges. Anthrop. Ethnol. Urg. Pt. 2:202-206. 1970. Comparing the names used in various Polynesian (and Micronesian) dialects for seven common plant species, the author concludes that the vernacular names were brought from the western archipelagoes to the eastern without touching the Tahiti-Tubuai area. Otto & Isa Degener.

Recent Literature

Degener, Otto and Isa 1970
Flora Hawaiiensis Eight new insert leaves dated June 10, 1970; 1 leaf, Crotalaria anagyroides; 1 leaf, Vicia menziesii; 2 leaves, Key to Genus Pelea; 2 leaves, Key to Family Umbelliferae; 1 leaf, Bidens awaluana; 1 leaf, Gnaphalium peregrinum.

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OFFICERS

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Editor Russell K. LeBarron
(Hawaii Division of Forestry)

THE HAWAIIAN BOTANICAL SOCIETY was founded in 1924 to "advance the science of Botany in all its applications, encourage research in Botany in all its phases," and "promote the welfare of its members and to develop the spirit of good fellowship and cooperation among them." Any person interested in the plant life of the Hawaiian Islands is eligible for membership in this Society. Dues, regular, $3.00 per year; college students, $2.00; students below college level, $1.00.

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