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*Lobelia gloria-montis*

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# Inter- and Intra-Island Genetic Variation in *wiliwili* (*Erythrina sandwicensis*)

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**ABSTRACT. Three populations of *wiliwili* from the island of O'ahu and individuals from populations from five islands were genetically analyzed using random amplified polymorphic DNA (RAPD) to determine the extent of genetic variation within and among distinct geographically separated populations. Among O'ahu populations, Five RAPD primers were used to amplify DNA and a total of 40 markers were scored, 10 being fixed in all populations. Variation within and among populations were seen for all three populations. Koko Crater was the most genetically distinctive population and the Ka'ena individuals showed the most intrapopulation variation. Eight primers were used to amplify DNA of representative populations from different islands, and 76 markers were scored. The Kaua'i population was found to be most genetically distinctive of all populations examined. Kaho'olawe samples were most closely associated with, but genetically distinct from the Maui population. Restoration efforts on Kaho'olawe should include wiliwili trees grown from seeds obtained from existing trees on that islands interspersed sith individuals from Maui germplasm.**

*Wiliwili* (*Erythrina sandwicensis* Degener; Fabaceae) is an endemic dryland tree species found on all of the main Hawaiian Islands. *Wiliwili* occurs in dry forests up to 600 m elevation, mostly on the leeward slopes of the islands. Trees can reach 15 m in height and are readily distinguished by prickly, reddish-orange bark and bright flowers that

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can be reddish-orange, yellow, white, or pale green (Wagner et al. 1990). Plants are deciduous and drop leaves late in summer and throughout fall, and flowers and fruits during the fall and winter months. The light, soft wood of the *wiliwili* was used for making the *'ama* (float) for Hawaiian canoes and *papa he'enaulu* (surfboards). The bright red or orange seeds were commonly made into *lei wiliwili* by stringing the seeds together (Abbott 1992)

St. John (1973) previously recognized three morphological entities of *wiliwili* that are endemic to different island groups: *E. s.* f. *alba* (O'ahu), *E. s.* f. *lutea* (Maui Nui), and *E. s.* var. *luteosperma* (Ni'ihau). Plants on Kaua'i, Kaho'olawe, and Hawai'i were treated as *E. s.* var. *sandwicensis*, f. *sandwicensis*. Although this striking native tree is not yet rare, its range is declining due to impacts of urbanization as well as alien plant introduction and naturalization (Cuddihy and Stone 1990). In the Kona area of the Big Island, the invasive grass *Pennisetum setaceum* (fountain grass) grows in dense clumps forming thick mats under *wiliwili* trees impeding seeds from reaching the soil and germinating (D'Antonio and Vitousek 1992).

The management of this tree is potentially very important for reforestation efforts of dryland areas where native vegetation is utilized for outplanting. The Kaho'olawe reforestation project is working to revegetate the island with native plants that may slow the effects of erosion. *Wiliwili*, being adapted to dry forest conditions and previously existing on the island, is a good choice for the reforestation effort. It is important for this project to utilize germplasm from individuals adapted to conditions similar to those that are present on the island. Kaho'olawe's soil is deficient in nitrogen, phosphorous, sulfur, and soil organisms, and the lack of rainfall or a fresh water source add to the degeneration of the soil conditions (KIRC 1997). There are a few extant *wiliwili* on Kaho'olawe from which potential outplantings could be generated. For example, the plant illustrated in Rock (1919) is still extant. However, the limited genetic resources that might be present in these individuals may limit the capacity of the reestablished population to adapt to changing environmental conditions. Therefore, it may be most optimal for outplanted individuals to come from a genetically similar, though more variable population.

The purpose of this study is to examine the interpopulation genetic variation present in *wiliwili* to gain a better understanding of relationships among of different islands and to assess the extent of intra- and inter-population variation present on one island (O'ahu). Randomly Amplified Polymorphic DNA (RAPD) was used to genetically sample individuals from all islands except Hawai'i, Lana'i, and Ni'ihau, and three geographically isolated populations on O'ahu. The RAPD process has the capability of screening many individuals at once and detecting high levels of polymorphism (Williams e. al. 1990; Welsh and McClelland 1990). RAPD markers have since been used extensively to generate genetic chromosome maps (Riesberg et al. 1993, 1995; Sobral and Honeycutt 1993), genetic fingerprinting (Ho and Quiros 1991; Wilde et al. 1992; Bhat et al. 1995), assessing genetic variation of relationships among cultivars (Williams and St. Clair 1993; Stiles et al. 1993; Liu et al. 1994; Hilu and Stalker 1995) and natural populations (Chalmers et al. 1992; Adams et al. 1993; Swenson et al. 1995; Nesbitt et al. 1995; Oxelman 1996; Lifante and Aguinagalde 1996), and analyzing hybrid populations (Marsolais et al. 1993; Crawford et al. 1993; Orozco-Castillo et al. 1994; Riesberg 1996; Riesberg and Gerber 1995; Smith et al. 1996; Caraway 1997).

## MATERIALS AND METHODS

### *Plant material and DNA extraction*

Plant material was obtained by either the collection of fresh leaf material from individual trees in a population or, because leaves were not available at the time of collection, by collecting seeds, germinating them and extracting fresh leaf material from saplings (Table 1). Seeds may have potentially come from the same or a very few individuals. Fresh leaf material was collected from individuals dispersed throughout the population.

Approximately 1 g of leaf material was sliced and ground in hot (65°C) buffer (2% CTAB, 100 mM Tris-HCL (pH 8), 1.4 NaCl, 20 mM EDTA, 0.2% _-mercaptoethanol, and dH20) in a preheated mortar with a small amount of sterile sand. Slurry was poured into plastic tubes and incubated in 60-65°C water for 15-60 min. Material was extracted once with SEVAG (24:1 chloroform: isoamyl alcohol) and mixed gently, then

**Table 1.** Germplasm for wiliwili samples used in RAPD analysis. Source of germplasm is either germinated from seed or collected from leaves in populations. HPDL are accessions in the Hawaiian plant DNA library (Morden et al. 1996, Randell and Morden 1999).

| Location | Number of Individuals | Source | Voucher | HPDL |
|---|---|---|---|---|
| Kaho'olawe | 3 | seed | LeGrande sn. | 1587-1589 |
| Kaua'i | 1 | leaves | K. R. Wood 7278 | 1668 |
| Pukalani, Maui | 8 | seed | Morden sn. | 1590-1597 |
| East Moloka'i | 2 | seed | LeGrande sn. | 1598, 1599 |
| O'ahu | | | | |
| Kaena , O'ahu | 16 | leaves | LeGrande 1001-1016 | 2115-2130 |
| Koko Crater, O'ahu | 8 | seed | LeGrande sn. | 1600-1607 |
| Koko Crater, O'ahu | 19 | leaves | LeGrande 1017-1035 | 2174-2192 |
| Makakilo, O'ahu | 11 | leaves | Morden 1548 | 1657-1667 |

centrifuged at 3000 RPMs for 10 min. The top aqueous phase was transferred into a 15 ml tube and 2/3 volume of isopropanol was added to each tube to precipitate DNA. Tubes were then centrifuged at 3000 RPMs for 5 min to collect precipitate. Liquid was poured off and the pellet drained, washed with 5 ml of wash buffer (76% ethanol, 10 mM ammonium acetate, and $dH_20$), and centrifuged again at 3000 RPMs for 5 min. Pellets were resuspended in 4.0 ml of TE, then combined with 3.9 g of cesium chloride (CsCl) and 50 ml of ethidium bromide (EtBr). Samples were ultracentrifuged in a VTi 65.2 rotor (Beckman Instruments) for 6 hours at 55K. DNA bands were pulled and EtBr was extracted with water saturated isobutanol. CsCl was removed by precipitating DNA with an equal volume of TE and 4 volumes of 100% EtOH, gently mixing and centrifuging to collect the pellet followed by washing the pellet with 70% EtOH, centrifugation, and air drying. DNA was resuspended in TE and stored at 4°C. All DNA samples were accessioned into the Hawaiian Plant DNA Library (Morden et. al., 1996, Randell and Morden 1999).

### *RAPD and PCR amplification*

A subset of four samples were screened with primers series OPA and OPB. From these, nine primers were chosed for RAPD amplification for interisland comparisons, six of which were further used for comparison of O'ahu poplations. PCR amplifications were made up in 25 μl reactions using 14.3 μl dH20, 1x Taq Polymerase buffer, 2.0 mM $MgCl_2$, 8.0 mM primer, 0.1 mM each of dATP, dCTP, dGTP, and dTTP, 1 unit of Taq Polymerase (Promega, Madison, WI.), and approximately 25 ng of DNA. Two drops of mineral oil were laid over the solution and then put into the Hybaid Omni Gene thermocycler to carry out amplification. The program used ran for one cycle at 94°C for 3 min, 35°C for 30 sec, and 72°C for 2 min, followed by 43 cycles at 95°C for 45 sec, 35°C for 30 sec, and 72°C for 2 min, and a final cycle at 94°C for 45 sec, 35°C for 30 sec, and 72°C for 6 min. After amplification, loading dye was added to each sample and 10 μl were run out on 1.5% agarose gels. Restriction digested pBS plasmid (Stratagene, La Jolla, CA.) was used as a marker to estimate size of amplified products. Photographs were taken of each gel using a UV transilluminator and Polaroid MP4 camera (film type 667). Genetic markers were identified for each primer based on their size, i.e., OPA3-1.5 is the 1.5 kb marker amplified with primer OPA3.

## RESULTS

### *Interisland comparison*

Eight of the nine primers chosen to amplify the genomic DNA of *wiliwili* gave consistent results for all individuals and were used to score individuals. For each primer, individuals were scored for absence or presence of markers by indicating "0" or "1", respectively. A total of 76 markers were scored, bands that were questionable due to intensity were not scored as markers. Of the total markers scored 25 were fixed in all individuals, and 36 markers were present in all populations, but perhaps being variable in some.

The Makakilo, O'ahu population represents a sampling of 11 separate individuals. Other populations were sampled from germinated seeds that had been bulk collected, and as such may not fully represent the potential genetic variation of that population. Therefore, the Makakilo, O'ahu population was used as a standard to assess the level of genetic variation in a naturally occuring population and to determine if the markers amplified in the other populations are adequately representative.

The Makakilo population showed little variation within the population. The number of fixed markers for the population was 100% in two primers. Of the 59 markers amplified for this population, only 20 were variable (33%). Rare markers (markers in only one individual) accounted for 6% of the total markers scored for all primers. Markers specific to the Makakilo population are OPA7-1.255 and OPA12-1.11. In contrast, the other O'ahu population from Koko Head only had 24 fixed markers with 12 being variable (50%). There were only 3 rare markers for this population (12%).

Maui, Moloka'i, and Kaho'olawe, three islands representing Maui Nui, were observed to have similar banding patterns. Four markers showed distinct bands only associated with two or all three of the above islands: OPA3-1.5 banded for Maui and Kaho'olawe only; OPA7-0.448 was absent in both Maui and Moloka'i populations; both Kaho'olawe and Maui show absence of marker OPA10-0.5; and OPB15-0.62 was present in two Maui individuals, two Kaho'olawe individuals, and one Moloka'i individual.

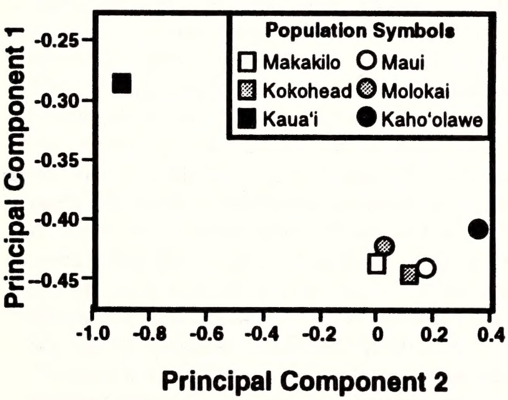


**Fig. 1.** Principal components analysis of wiliwili individuals from populations on different islands. Frequency of markers was averaged for each population prior to analysis.

Although most populations of wiliwili tested showed little interpopulation variation, there was one exception. Kaho'olawe showed polymorphisms between individuals at 6 markers (OPA1-0.692, OPA5-1.153, OPA7-0.64, OPA10-0.932, OPA10-0.448 and OPB12-1.7). This relatively high occurance of polymorphism within this population could be accounted for due to the small gene pool available on the island, or the population may also be showing high levels of heterozygosity among individuals since the 3 individuals tested were germinated from seed from the same tree.

The most distinct variablility among populations occured in the Kaua'i individual. The Kaua'i individual showed markers unique only to that island in 8 markers for 7 primer systems. These markers were: OPA1-1.2, OPA3-0.867, OPA5-0.83, OPA7-0.37, OPA10-1.05, OPA10-0.9, OPA13-0.64, and OPB12-1.6.

Data was summarized for each population and the data analyzed with Principal components analysis (Minitab, 1996). PCA arranged the island populations by genetic similarity. Principal component 1 and principal component 2 accounted for 85% of the variation of RAPD data. As illustrated in Fig. 1, the Kaua'i individual is distanced from the other generally grouped populations. The analysis groups the Makakilo population with the Moloka'i population and the Koko Head with the Maui population. Kaho'olawe is close but distinct from these two sets of groupings.

### *O'ahu population comparison*

Five of the six primers chosen to amplify the genomic DNA of *wiliwili* were used to score individuals. For each primer, individuals were scored for absence or presence of markers by indicating "0" or "1" respectively. A total of 40 markers were scored, bands that were questionable due to intensity were not scored as markers. Of the total markers scored 10 were fixed in all individuals, and 23 markers were present in all populations, but perhaps being variable in some.

The Koko Crater population had the least genetic variability within the population compared to the two other O'ahu populations. The total number of fixed markers for the population was 55%. Koko Crater also showed the greatest variation among populations with three population specific markers, OPA3-560, OPA5-448, and OPB12-490.

The Makakilo population had one specific marker OPB12-2.4 that distinguished it from the other populations. 40% of the total markers scored were fixed in every individual from the Makakilo population. Although intrapopulation variation was evident, there were no rare markers in the Makakilo population. The remaining population from Ka'ena showed the most intra-population variation with only 37.5% of the total number of markers being fixed in the population. The population specific marker OPB15-795 distinguished the Ka'ena population from the other two O'ahu populations.

Data was summarized for each population and the data analyzed with Principal components analysis (Minitab 1996). PCA arranged the island populations by genetic similarity. Principal component 1 and principal component 2 accounted

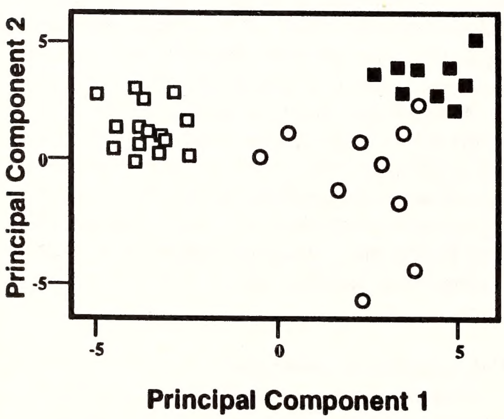


Fig. 2. Principal components analysis of individuals from three O'ahu populations. Populations identified by: ■ = Ka'ena; ○ = Makakilo; ❑ = Koko Crater.

for 70% of the variation of RAPD data. As illustrated in Fig. 2, the Koko Crater population forms a cohesive cluster while the Ka'ena and Makakilo populations show considerable levels of variation that appears to be continuous among the two populations.

## Discussion

The results of this study show that genetic variation does exist among populations of wiliwili. The most dramatic interisland differences were between Kaua'i and the other islands studied. This may be associated with differences between var. *luteosperma* (restricted to Ni'ihau) and var. *sandwicensis* (all other islands), with a close affiliation of the Kaua'i population to the Ni'ihau variety. Future studies are being directed to investigate these relationships.

It is curious to note that the PCA grouped the Makakilo population from west O'ahu more closely to the Moloka'i population than to the Koko Head population from east O'ahu. Similarly, the Koko Head population is more closely associated with the Maui population than the Makakilo population. Kaho'olawe appears to be distinct from these two groupings, but is most closely related to the Maui population.

In comparing population level variation in O'ahu populations, the Koko Crater population may have had the least intrapopulation variation due to the isolated area in which it grows and the low frequency of gene flow into the population. The Makakilo and Ka'ena population shared marker OPA3-1.7, grouping them closer to eachother than to the Koko Crater population.

The high level of genetic variablility in the Ka'ena population may be explained by the physical distribution of the individuals within this broadly distributed population. Both the Koko Crater and Makakilo populations are geographical confined to a relatively small geographic range (i.e., within the crater and along a small stream drainage) while the Ka'ena population is scattered over a several kilometer distance along the northern slopes of the Wai'anae Mountain range.

The germplasm source for revegetating Kaho'olawe would most optimally be from the island itself. Saplings planted from seeds germinated from Kaho'olawe trees could be outplanted and mixed with saplings from a Maui source. Interspersing trees from the two islands adds to the genetic resources of the population and may increase the fitness of this islands population. Some experimental plantings of wiliwili have been carried out on the island with seeds from Maui (Nishimura, pers. comm.), but because Maui germplasm was fairly different than Kaho'olawe germplasm, Maui plants should not be planted out to the exclusion of Kaho'olawe plants.

Further work on this endemic Hawaiian tree species would be informative for conservation efforts on all the main islands. The work here was a preliminary analysis to test whether these approaches will be beneficial in evaluating the genetic variability within and among populations of this important native dry forest species. Future studies will consist of analyzing the population genetics of the species throughout all of the main Hawaiian Islands and evaluating the possible taxomomic and biogeographical relationships among them.

## ACKNOWLEDGEMENTS

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# Comparative Study of Leaf Sap Osmolarity: Native Hawaiian Coastal Species Grown in their Native Habitat and a Common Garden

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**Abstract. Leaf cell sap osmolarity was determined for three native perennial herbs, *Lipochaeta intefrigolia*, *Tribulus cistoides*, and *Heliotropium curassavicum*. Plants collected from the native coastal environment exhibited significantly higher sap osmolarity than those collected from a common garden. The difference suggests that cell sap osmolarity is an environmentally determined trait.**

Coastal plants of Hawai'i grow in harsh environments. They are subjected to prolonged periods of intense sunlight, low-water availability, inhabit soils of high salinity, and some species are exposed to intermittent sea spray. To deal with water, one mechanism is to increase osmotically active solutes in cell sap. Increasing osmolarity in turn increases plant water potential helping the plant retain water.

A study done on the relationship between salinity and osmotic potential in Mangrove species demonstrated that increased levels of soil salinity correlated to decreases in osmotic potential (Rada et al., 1989). This trend was also observed in a study of a native Hawaiian species, *Scaevola sericea*. Alpha et al. (1996) grew *Scaevola* seedlings in substrates of different salinity. These seedlings were also exposed to different levels of salt spray. The results showed that increasing both substrate salinity and exposure to salt spray increased cell sap osmolarity.

In measuring cell sap osmolarity significant errors can occur due to dilution of samples by apoplastic water (Meinzer et al. 1986). Recorded osmolarity would be much lower than the actual osmolarity. The dilution effect may exaggerate the osmolarity difference between plants from a water-limited environment and a well-watered environment. Walker and Gessel (1991) removed the leaf mid-rib to minimize any dilution due to apoplastic water.

A common garden experiment of *Metrosideros polymorpha* demonstrated that some physiological and anatomical variations were due to specific environmental conditions (plastic response/acclimation) while particular morphological traits were genetically determined (adaptation) (Cordell et al., 1998). We hoped to determine if cell sap osmolarity of native Hawaiian coastal plants is environmentally determined. A comparison was made between the osmolarity of native Hawaiian plants grown in their native coastal environment and of those grown in a common garden.

## Hypothesis

Leaf cell sap osmolarity of native Hawaiian coastal plants is higher in their native habitat than in a cultivated garden indicating that osmolarity is an environmentally determined characteristic.

## Materials and Methods

Three species of native coastal perennial herbs, nehe (*Lipochaeta integrifolia*), nohu (*Tribulus cistoides*), and nena (*Heliotropium curassavicum*), found in their natural habitat and in a common garden were used in this experiment. Study sites were located on the island of O'ahu. Leaves of field plants were collected from Ka'ena Point. Leaves of the common garden plants were obtained from a cultivated garden in Waipahu.

Leaves collected were similar in size, from healthy plants, and growing under similar local

**Table 1.** Cell leaf sap osmolarity (mmol/kg) measured with the vapor pressure osmometer. Five plants selected per species with five replicates of osmometer readings per sample. Mean and standard error values for five replicates of each plant are given. Two to ten leaves removed from each plant = one sample Cell sap expressed for each sample.

| Plant Species | Plant | Ka'ena Point Mean (mmol/kg) | Ka'ena Point SE | Waipahu Mean (mmol/kg) | Waipahu SE |
|---|---|---|---|---|---|
| *Lipochaeta integrifolia* | 1 | 1278.2 | 26.4 | 460.2 | 28.0 |
| | 2 | 1310.8 | 8.5 | 539.8 | 10.3 |
| | 3 | 1091.6 | 6.4 | 468.6 | 12.1 |
| | 4 | 841.2 | 6.8 | 398.0 | 37.2 |
| | 5 | 949.8 | 8.6 | 449.8 | 24.1 |
| | **Mean** | **1094.3** | **160.1** | **463.3** | **32.7** |
| *Tribulus cistoides* | 1 | 1107.2 | 5.3 | 568.8 | 12.2 |
| | 2 | 1367.2 | 12.9 | 551.4 | 13.2 |
| | 3 | 1532.8 | 29.6 | 900.2 | 16.1 |
| | 4 | 1365.0 | 46.9 | * | * |
| | 5 | 1356.8 | 29.41 | 806.6 | 21.2 |
| | **Mean** | **1345.8** | **95.4** | **706.8** | **146.7** |
| *Heliotropium curassavicum* | 1 | 1438.0 | 13.2 | 509.2 | 61.3 |
| | 2 | 1403.6 | 25.1 | 479.6 | 18.3 |
| | 3 | 1435.6 | 10.2 | 445.4 | 8.4 |
| | 4 | 1797.0 | 3.6 | 459.8 | 16.3 |
| | 5 | 1796.6 | 12.8 | 464.2 | 3.0 |
| | **Mean** | **1574.2** | **178.1** | **471.6** | **18.2** |

* Unable to extract cell sap from the sample.

conditions. Five different plants per species were sampled. Two to ten leaves were collected per plant. After removal from plant, the leaves were cleaned with cotton pads saturated with distilled water. The midrib of the leaves were removed with a scalpel and discarded. Leaves were placed in plastic bags and stored in an ice filled cooler and then transferred to a freezer within several hours after collection. All samples from Ka'ena Point and the Waipahu garden were collected at the same time of day under similar light conditions.

Cell sap from each sample were expressed from frozen leaves. Five replicates per sample were measured using the vapor pressure osmometer. Five microliters of cell sap were micropipetted onto filter discs for each reading.

## Results

Osmotic solute concentrations were significantly higher in field plant samples from Ka'ena Point than in the common garden samples from Waipahu (Table 1). The leaf sap osmolarity of *Lipochaeta integrifolia* and *Tribulus cistoides* was twice as high in the field plants than in the common garden plants. The osmolarity of *Heliotropium curassavicum* was three times greater in the field plants than in the garden plants. (Fig. 1).

## Discussion

The consistently higher leaf cell sap osmolarity values of Lipochaeta integrifolia, *Tribulus cistoides*, and *Heliotropium curassavium* specimens from the native coastal habitat suggests that cell sap osmolarity is environmentally determined. Plants growing along the coast were

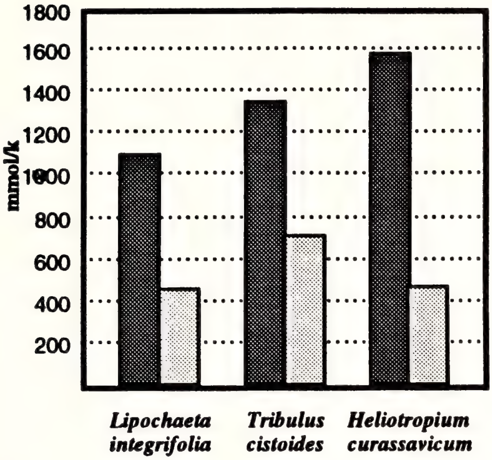


**Fig. 1.** Mean values of cell leaf sap osmolarity (mmol/kg) of three native perennial herb species from the native coastal habitat at Ka'ena Point (dark boxes), and a common garden in Waipahu (light boxes).

subjected to low water availability and exposure to high salinity conditions while plants cultivated in the garden were well-watered and exposure to high salinity conditions were absent. The acclimation of these plants to an area of high water availability appears to include the reduction of osmotically active solutes in cells as expected. Other coastal plants such as *Scaevola sericea* and mangrove species have also demonstrated similar fluctuations in osmolarity correlating to changes in salinity exposure (Rada et al., 1989; Alpha et al., 1996).

Plasticity in osmotic potentials in response to drought may be advantageous to these coastal plants. Exposed to various fluctuations in water potential due to tide changes, salt spray, and occasional flooding, a physiological mechanism to adjust to and tolerate various environmental conditions would enable survival and wide spread distribution. Most widespread species maintain higher levels of genetic variation than their endemic relatives (Soltis et al, 1991). Island plant groups, typically restricted in distribution and of relatively small population size, also tend to be less variable genetically than mainland counterparts (Witter et al., 1988). Most coastal plants, however, such as *Scaevola sericea* are widely distributed throughout the Hawaiian Islands and the Pacific. Coastal plant population frequencies appear to be higher than in other island plant groups in part due to certain flexibility to adjust to various environmental conditions. Fluctuation in osmolarity is perhaps an example of that flexibility.

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# The Hawaiian Uses of *Kukui*

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**Editors Note: Mr. Duvauchelle received the Isabella A. Abbott undergraduate award from the Department of Botany, University of Hawai'i for the work presented here.**

As I scan the Ko'olau mountains, I cannot help but notice the groves of *kukui* that trace the many gulches. With their bright silverish color, the trees stand out magnificently against the darker foliage of the rest of the forest. The *kukui* seems to light up the mountains with its beautiful display. The *kukui* lit up the lives of the Hawaiians in more ways than this. Mary Kawena Pukui (1957) defines *kukui* as a lamp, light, torch, guide, or leader. Not only did *kukui* serve as a practical light it also represented a sy bolic light. It represented enlighten ent and knowledge.

*"There was a lazy person named Moemoe. All he did was sleep all day. He would go into the cool forest to escape the heat of the day and to avoid doing any work. He would find a large, shady tree to sleep under.*

*One day, this sleeping habit came over him and he decided to have a long nap by the side of a flowing stream underneath a large* **kukui** *tree. As Moemoe was sleeping, the stream flowed more strongly and gradually, it became very full.*

*overflowed its banks and Moemoe was covered with leaves, small branches oe was so lazy the he kept on sleeping. A* **kukui** *nut came to rest on his nose. It began to grow and tickled his nose.*

*Moemoe finally woke up and realized he could no longer sleep his life away. The* **kukui** *nut was telling him to wake up and make himself useful. Now, when Moemoe sleeps, it is at night after enjoying a busy and productive day." (Pukui 1951)*

The Hawaiians had many uses for this extraordinary tree. Believed to have brought this valuable resource with them, the Hawaiians were able to utilize every aspect of this plant. First and foremost, the *kukui* was a source of light. It's luminescence intrigued many of the haole who were lucky enough to stumble upon these isolated islands. *Kukui* also served medical purposes by curing some of the diseases that the haole had brought with them. But, with its many other uses, there is no wonder why Hawai'i proclaimed *Kukui* as the State Tree.

### *Kukui*: A Botanical Description

The *kukui*, or candle nut, is also identified as *Aleu tes moluccana* (L.) Wild. of the Euphorbiaceae, or Spurge family. It produces a white, milky sap. The leaves are covered with a whitish pubescence that gives them a pale green, silvery appearance. In a Hawaiian *mo'olelo*, or story, *kukui* is located among Hawai'i's most beautiful places:

*He strayed away from the others to look into the canyon for he loved its grandeur and its beauty. He sat on a rock close to the rim and watched the white birds circling. As his eyes followed the lines of the silvery* **kukui** *he found a slender waterfall. (Pukui 1960)*

These long-stalked leaves have blades that measure about seven to eight inches in length and are very often three lobed. A *kukui* that grows in ideal conditions is more than capable of reaching heights in excess of eighty feet. I have personally seen a number of very large trees in the valley of

Pelekunu, on the island of Moloka'i, which were at least sixty to seventy feet tall.

The *kukui* produces a large cluster of small whitish flowers which are functionally unisexual defining it as monoecious, or having both male and female flowers appearing on the same tree. The common cyatheum inflorescence is usually one female flower surrounded by many male flowers. The male flowers, or staminates, bear about eighteen stamens with a non-functional ovary. The female flower, or pistillate, bears a two-celled ovary with no functional stamens (Degener 1929). It is from these female flowers that the fruit, or nut, is borne.

A single *kukui* is able to produce a seed crop of as much as seventy-five to one-hundred pounds of nuts in a years time. Because the kernels contain at least 50% oil, they are fairly oily in texture. The oil is considered to be a drying oil, not unlike that of linseed oil (Coryell 1986). The Applied Biological Sciences Laboratory of Glendale California (Coryell 1986) found that the oil from these nuts to be a non-toxic substance. Degener (1929) describes these nuts in great detail as being:

> *. . . more or less spherical fruits about one and a half inches in diameter, each containing one or, rarely, two seeds. The outer part of the fruit consists of a hard green covering about one-fourth of an inch in thickness. WIthin this is found a thin crust-like shell most easily visible after the fruit has partly decayed. This surrounds the seed. The latter, in turn, consists of a thick, wrinkled, woody seed-coat which protects a large quantity of oily tissue called endosperm. This is not part of the embryo which later develops into the seedling, but food stored up for it by the parent plant. The embryo, composed largely of a minute stem and two flat leaves, termed cotyledons, lies between the two halves of the endosperm. When conditions are favorable for germination, the cotyledons exude a slippery excretion which actually softens and liquefies the endosperm. This is then gradually absorbed by the seedling, thus filrnished with nourishment until it had the opportunity to become established in the soil and to begin the manufacture of food for its own life process.*

## *KUKUI*: ITS ORIGINS

In old Hawai'i, since there was no written language, information and stories alike were handed down from generation to generation orally to ensure their preservation. Thanks to European and Tahitian missionaries, the Hawaiians were able to learn how to put important information down on paper. Here is an exert from one of Mary Pukui's collections, told by a young Hawaiian boy, suggesting the origin of the *kukui* nut tree (1960):

> *Long, long ago our islands came up from the sea and lay barren—mountains and plains and beaches. The sun god had not yet come from the ocean. Only moon and stars gave light. The tree god came and sat upon the sandy shore where a stream entered the sea. He took white sand, moistened with water from the stream, and made seeds of many kinds. When these were dry he planted them, some he planted near the beach, some on the level plain, others in gulches or on black lava slopes.*
>
> *Tiny trees sprang up with many-colored leaves. For a little time these trees grew, but the dim light of the moon and stars was not enough. They sickened and withered away. The tree god searched on shore, plain, and mountain slope. "My trees are dead," he said. "They need the sun." But still he searched and in small gulches found growing trees. Lighted only by moon and stars these little trees had flourished, and their leaves were like moonlight seen through floating clouds or reflected on still water.*
>
> **Kukui** *trees still grow in gulches and on mountain slopes. Lighted now by the sun their small new leaves are green. As the leaves grow they turn a silvery color so that a* **kukui** *grove looks as if lighted by the moon. The trees seem to remember it was the moon which gave light to their ancestors.*

This story suggests that the *kukui* is a native to the Hawaiian islands. It is possible that a *kukui* nut, which is capable of floating across vast ocean distances, could have migrated to the Hawaiian islands on its own as it is thought to have traveled to many of the other Pacific islands. The *kukui* was known throughout the Pacific Islands to be used in similar ways to that of the Hawaiians uses. It is speculated that the Polynesians who migrated to the Hawaiian islands brought the *kukui* nut, along with a number of other life sustaining plants, with them. It is also very possible that the *kukui* could have been distributed naturally . The only evidence suggesting otherwise is that some scientists feel that "exposure to salt water for the amount of time required to reach Hawai'i would render it incapable of successful germination" (Coryell 1986). How long does it take a *kukui* nut to travel to Hawai'i? How long can a *kukui* nut survive in the ocean and still be able to germinate successfully? It is believed that a plant colonated Hawai'i every th its many tropical storms and occasional hurricane, the Pacif ng objects enormous distances at an unbelievable rate. With the million possibilities that *kukui* nuts could have reached the Hawaiian Islands, it is probable that, by chance, at least one *kukui* nut could have successfully crossed the vast Pacific.

The fact that *kukui* is one of the most common trees that are found in the Hawaiian Islands also supports my theory that it was probably here before migratory people came. These trees can be found in the lowlands and in very isolated, high elevation localities. Ripperton and Hosaka (1942) discovered that *kukui* was most commonly found in "closed forest areas under 7,000 feet" where sixty or more inches of rain had fallen per year. Handy ( 1972) said that *kukui* were more often found in the wao "...the wild—a place distant and not often penetrated by man..." Charles Gaudichaud (St. John 1983) noted that "this tree grew all the way up to the dry forests close to the clouds." I think that the *kukui* was here long before the Hawaiians were.

### *Kukui*: Light

*Native flowers bordered the paths and crowned the plateau, as if man's worst nature could never wither the appeal of things beautiful. A magnificent koa tree spread its protecting branches by the spot chosen by Kokoa for his grass house.* **Kukui** *trees furnished their oily nuts for his torches. (Westervelt 1963)*

The *kukui* eat importance for it served as a means of illumination. But, only certain nuts were chosen to light the ways of the ancient people. Rotten nuts were not usable, rather, only the *kukui* nuts that had just dropped from the trees, usually during the months of September to November, were collected. The nuts would then be baked in an imu or placed in the open sun to dry. The *imu*, or underground oven, was primarily used to cook food. *Kukui* nuts were probably placed off to the side to bake. After baking, the flammabl m the hard shell and could be stored for later use. Whole kernels were desired so, special care had to be taken when cracking the hard shells. If not, the kernels had a tendency of crumbling to pieces when hit too hard. It was these *kukui* kernels, which had been prepared correctly, that the Hawaiians used for light.

The torch was the basic means of light. Torches had many uses, some were used for night fishing, hunting for wild pigs at night, lighting a *heiau* during ceremonies, lighting the area around the *hale*, used for night searches, or lighting a path traveled at night. When I was little, my *Tutu* use to tell me about the night marchers. They would only be seen on *po kane*, or the night when the moon was almost new. There were only certain places where these night marchers marched, he said. But, no matter what, they could not be mistaken because of the rows of torches, the drumming, the chanting, and sometimes the glowing of their eyes. My *Tutu* said that if I ever came across these night marchers, or they came across me, I should take off all of my clothes and lie face down on the ground until they passed. If not, the night marchers would make me a member of their band:

> *...In the march of the* **aumakua** *of each district there was music and chanting. The marchers carried candle nut torches which burned brightly even on a rainy night. They might be seen even in broad daylight and were followed by whirlwinds such as come one after another in columns... (Beckwith 1978)*

There were two kinds of torches made by the Hawaiians. The easiest to make of the two was the *lama*. A person would cut an *'ohe* stalk, preferably two to three inches in diameter, to a length of about eighteen inches or longer. The stalk of *'ohe* trees have nodes running up and down its length. These nodes were usually at least twelve inches apart. When the length of *'ohe* was cut above a node, a cup was formed at the top of the stalk. This "cup" could vary in depth depending on the amount of kernels needed to produce sufficient light:

> *At last the boy reached the rock where his sister still sat weeping and praying. "Na'ilima" he whispered. She threw her arms about him. "Pueo saved you!" she whispered back. Then they both heard distant shouting. "It may be those who search for you," she said. "Quick! Slip into the hollow below this rock." Two searchers came with* **kukui** *torches and found Na'ilima seated on the rock as she had been before. "Did you see a man go by this way?" they asked. (Pukui 1951)*

The other type of torch was the *aulama* This type could be made by wrapping six or more *kalikukui* "candles" together with dried *mai'a* (*Musa* spp.) leaves. This type of torch was usually three to six inches in diameter and of varying lengths, depending on the purpose. The *aulama* torch was usually seen during ceremonies at *heiau*. Because the *aulama* torch gave off a significant amount of smoke it was not used indoors.

The *kalikukui*, the Hawaiian candle, was used for illuminating the inside of the house. This was a number of *kukui* kernels strung on a skinny stick of varying lengths. The longer the stick the longer the *kalikukui* would last. Usually a *niu* (*Coco nusifera*) leaf midrib or a thin split of *'ohe* was used to string the *kukui* kernels, but any long, thin stick would suffice. When lit, the *kalikukui* was stuck in a *pohokukui*, small stone bowl, filled with sand to hold the stick upright. Sometimes there were small holes at the bottom of the *pohokukui* to aid in holding the *kalikukui* upright. The *kalikukui* could also be held if so desired:

> *The high chief of Kailua carried a string of* **kukui** *nuts whose light was sheltered by a half shell of a gourd. With this dim light he found a trail and led Kawelu, helping her as they climbed. (Pukui 1951)*

Though the dim light of the *kalikukui* was used mostly indoors, at times it was also used outside if necessary. One of the younger children was usually in charge of tending to the *kalikukui*. When the top nut was lit it could burn anywhere from three to five minutes depending on the size of the *kukui* el. As the first nut began to burn out, the child would invert the stick to light the next *kukui* kernel and knock off the kernel that was through burning. How long the candle lasted depended on the amount of *kukui* kernels that were strung. One or, maybe up to three candles were lit and put into a *pohokukui*, depending on the amount of light needed. Though the candles did give off some smoke, it was not as much as the *lama* or the *aulama*, and its smell is similar to that of roasting peanuts:

> *The old nurse trembled so she could hardly stand and Ka'ili put out an arm to steady her. Though it was late* **kukui** *candles were burning in the house. By their smoky light the two could see an old wrinkled woman printing kapa. This was Waha, the most powerful kahuna of Kaua'i, feared by all. She did not lift her head but asked in a terrible voice, Why have you come? (Pukui 1951)*

> *At last Mano stopped. The night was dark but Kawelu knew they must be high on the mountainside. A great rock barred their way. She saw Mano grasp a strong root, swing around the rock and disappear. A moment later his arm caught her and swung her too around the rock. They stood together on a ledge and there the father joined them. Then Mano lifted vines and led them into a cave."*
>
> *By the dim light of the* **kukui** *candle the girl saw that the cave was small and furnished with a mat and a few gourd bowls. Mano spread the mat. "Rest here," he said. The chief lay down. Mano put out his kukui light and stretched himself beside the older man. (Pukui 1951 )*

"The highest type of Hawaiian illumination" was the *pohokano*, a stone oil lamp. A stone bowl very similar to the *pohokukui* was filled with *kukui* oil. *Kamani* (*Callophyllum inophyllum*) oil, *niu* oil, or fish oil were suitable substitutes (Degener 1929). To extract the oil from the *kukui* endosperm, the selected nuts first had to be crushed or pounded into small pieces by means of an *'ala* stone or a block of wood. After the kernels were crushed they were strained to remove the solid pieces so only the oil remained. *Kukui* oil could also be collected by catching the excess oil that would drip down from a burning *kalikukui* into the stone bowl. To carry the flame, a kapa wick was draped over the edge of the stone bowl. If a brighter light was desired, one only had to add another wick or two.

Malo states that these *pohokano* were used only during late nights "...merely to talk by, there was no eating done at that time" (Malo 1971). Here is an example of this from the "Legend of Kalelealuaka and Keinohoomanawanui:

> *Usually after partaking of their evening meal they would light their **kukui** nut lamp and then lie down with their heads on their pillows, look up at the roof, Kaleleaiuaka at one gable of the house and Keinohoomanawanui at the other, when Kalelealuaka would call out to Keinohoomanawanui: let us name our wishes... (Fornander 1974)*

### *Kukui*: Medicine

A "Genealogical" Chant of Diseases and Illnesses

I

Hina was born from heaven,
Hina was born from the earth,
Called Hinamaikalani,
Hinamaikahonua
Questioned was the illness of the chief,
How are you doing within him?
Very peacefully,
Called Hinahoowilialau,
The twisting inside of the chief due to the severe disease,
The breath was truly expelled,
Called Aikanakaahi,
When the disease ate at the flesh of the chief,
The presence of the royal disease, Waikanaka, appeared,
The presence of the disease, Waikanaka, appeared,
The tearing of the royal disease,
Going to the clouds above,
Cramping at man's evening (?)
When red-hot like fire, they listened,
The patient is still like a beam,
Here is Nuua, it is below (?)
Rested, awaken, striving
Observe, the discharge of yellow,
Those who come to clean appear,
What area are you from?
From the disturbing
Disturbing, perturbing, overcoming, massaged until limp,
Completed.

II

Arriving at Kahiki, the land,
The land of glowing heat,
The cloak is a full cloak,
The pig is one that runs to the cry,
The disease is the sickness and the weakness of the child, the cure is the lance,
The payment is pain for Haumanu (?)

III

Arriving on Ni'ihau, the land,
The land is a moving land,
The pig is a sickly pig,
The disease is dizziness, the cure is the *popolo* berry

IV

Arriving on Kaua'i, the land,
The land is white,
The cloak is white,
The pig is a tasteless pig,
The disease is a hard lump on the flesh, the cure is the *pauku*.

V

Arriving on O'ahu, the land,
The land in reddish brown,
The cloak is reddish brown,
The pig is a pale red,
The disease is a rash, the cure is ashes.

VI

Arriving on Moloka'i, the land,
The land is the shell,
The cloak is a net mesh,
The pig is a wild pig,
The disease is rage, the cure is the *nonolau* gourd.

VII

Arriving on Lana'i, the land,
The land is the cape julting out,
The cloak is the ma cloak,
The pig is the one with the reddish-colored hams,
The disease is painful breathing, the cure is the poppy seed.

VIII

Arriving on Kanaloaho'olawe, the land,
The land is very desolate,
The cloak is the Kanaloa cloak,
The pig is a spotted pig,
The disease is the flowing of blood, the cure is an astringent.

IX

Arriving on Maui, the land,
The land is red,
The cloak is red,
The pig is a brown pig with darker stripes,
The disease is severe constipation, the cure is the ***kukui*** nut enema.

X

Arriving on Hawai'i, the land,
The land is black,
The pig is black,
The disease is an ulcerous sore, the cure is the ***kukui***
The payment is pain for Haumanu,
Kukuialii was born, warmed in the breast of Papa,
The fish of the ***kukui*** enclosure was born,
Turned over to the sea, guards the ***kukui***, in the uplands,
The fish of the ***kukui*** nut cowry was born,
Turned over to the sea, the ***kukui*** guards in the uplands,
The fish of the ***kukui*** nut was born,
Turned over to the sea, we populated the uplands here. (Chun 1986)

The Hawaiians discovered that *kukui* could be used as a remedy for a number of bodily problems. Constipation was probably the most well known problem curable by *kukui*. The entire tree was useful, but *kukui* was seldom administered alone, it was usually mixed with other herbs to be effective. What follows are specific troubles and the recipes for their cure.

**Weakness of the body due to bowel or stomach disorder: children 6 months to 1-2 yrs**

4 clusters of *kukui* flowers
2 handful of 'ala'alawai nui (*Peperomia* sp.) stems without leaves
2 pieces of 'ohi'a'ai (*Syzigium* .sp.) bark (palm size) –
1 thoroughly baked *kukui* nut
1 onion (*Allium* sp.) bulb
1 *noni* (*Morinda citrifolia*) fruit (fully matured)
2 segments of *ko* (sugar cane)

Mix these ingredients together. Pound the mixture thoroughly and have the juice strained from it with the fibers of *makaloa* (*Cyperus laevigata*). 1 teaspoon = 1 dose. Take one dose of the liquid 3 times a day—morning, noon, night, for as long as the supply of liquid lasts. "Five preparations of like amount may be made without causing any injury to the patient" (Akana 1922).

**Severe Asthma (produces foul breath)**

4 pieces of *kukui* bark (palm size)
a like amount of *'ohi'a'ai* and *koa* (*Acacia koa*) bark
1 hatful of *'ala'alawainui* stems and buds (no leaves)
a similar amount of *Campylotheca*
2 handful of *kohekohe* ( ) found growing in taro patches.
4 *noni* fruits (fully matured)
4 *noni* fruits (half-ripe)
the bark from 4 *'uhaloa* (*Waltheria americana*) roots
a similar amount of the bark from *popolo* (*Solanum americanum*) roots
4 segments of *ko*

Mix these ingredients together. Pound the mixture thoroughly and have the juice strained from it with the fibers of *makaloa*. Cook the liquid with 4 red-hot stones. After cooked liquid is cooled, "the patient, lying down on his stomach with a cushion supporting his abdomen, drinks the whole of it. " (= 1 dose) Patient must take 1 dose in the morning and 1 dose at night for 5 consecutive days. Prepare a fresh supply for each dose. Drink *Campylotheca* tea regularly and at the end of the 5days, take a good dose of a *kukui* laxative. Avoid eating sour *poi* and salty foods (Akana 1922).

**Scrofulous sores, bad cases of ulcers, other bad sores where flesh seems to rot away**

This remedy has two parts.

*First part:*

Acquire the meat of 8 *kukui* nuts and have them thoroughly baked in ki (*Cordyline* *terminalis*) leaves. Have the nuts pounded or finely ground then mixed with a teaspoon of the milk from *'uhu* (*Artocarpus altilis*).

*Second part:*

Thoroughly mix 1 teaspoon of finely ground *makaloa* fibers with 1 teaspoon of *lama* (*Diospyros sandwichensis*) powder.

Combine and thoroughly stir the two mixtures. Apply it to the sore or sores in the morning and at night for as long as the sores persist. Before application, affected area should be washed with *'ahakea* (*Bobea* sp.) bark tea. This is prepared by boiling the pounded bark, in 1 gallon of water, with 4 red-hot stones (Akana 1922).

**'*Ea* (sores in the mouth)— young children**

1. Pull the stem offof a green *kukui* nut. A bead of sap will collect at the point where the stem was connected to the nut. Dab it with the tip of the finger, let it dry for a moment and then rub on the inside of the child's mouth and tongue.

*or* 2. Have a cluster of *kukui* flowers pounded together with some boiled *'uala* (*Ipomea batatus*) and feed this to the child.

*or* 3. The mother could chew the *kukui* flowers herself and then feed it to her child.

*or* 4. Let the *kukui* nut burn to a charcoal and apply this to the infected area (Degener 1929; Kraus 1981).

**Sore throat**

1. Eat the flowers of the *kukui*

*or* 2. Collect some almost ripe *kukui* nuts in the early morning just before the sun touches them. Pull the stem off of the *kukui* nut. A bead of sap will collect at the point where the stem was connected to the nut. Swallow a teaspoonful of this liquid. The sore throat will "be relieved within a few minutes" (Gutmanis 1976).

**Swollen womb**

Cook a sufficient amount of *kukui* nut shells on live charcoals. Acquire a gourd with a long neck and the insides partly scooped out and cleaned. Carefully dump a sizable amount of burning *kukui* shells into the gourd. Have the patient position herself over the gourd by sitting on her heels and spreading her legs as far apart as possible. As the smoke rises out of the gourd allow as much of the *kukui* gourd smoke to fume the vagina. This activity is quite beneficial because it effectively warms the womb. Administer this treatment twice a day for five successive days. Have the patient drink *Campylotheca* tea regularly (Akana 1922).

**Cracking skin of the abdomen - pregnant women**

Have a handful of *kukui* kernels crushed well. Wrap it in *kapa* and rub all over the abdomen (Gutmanis 1976).

**Different Purgative Preparations**

Papaku treatments.

1. Mild,easy; for weak patients
   2 eggs
   2 mashed roasted *kukui* kernels
   pounded *kowali* (*Dioscoria alata*) root
   *ko* juice
   Mix these ingredients and serve with a small amount of food.

2. Most commonly used:
   1 mashed roasted *kukui* kernel
   1 egg
   a pinch of salt
   *ko* juice
   Collect the *moa* (*Psilotum nudum*) from the mountains. In a bowl have the herb heated in water with hot stones and strained when cooked. Add the above ingredients the moa "tea". Let this cook for a while. Strain the mixture once again. This "tea" was "sipped slowly by the patient."

3. *kukapihe*: extremelv strong; administer with care as it purges blood as well.
   Mix the bark of the *'akoko* (*Chamaesyce celastroides*) with the sap of the green *kukui* - nut. Dilute well.
   *or* Mix the sap of the *'akoko* with the sap of the green *kukui* nut.

4. Not as strong as *kukapihe*.
   Have a young *noni* fruit pounded and strained. Mix this with *ko* juice and mashed *kukui* nut.

**NOTE:** Serve all of these mixtures with a small amount of food. Be informed that as well as being considered laxatives, these mixtures will induce vomiting too. To counteract against the results of these medicines, one should consume raw *'uala* mixed with *pia* (*Taca leontopetaloites*) starch or *poi* mixed with *pia* starch (Gutmanis 1976).

**Enemas**

Enemas were usually administered with one of the above purgatives. Commonly, it was prepared by putting 2 handfuls of *pa'akai* into a container with water and left to stand for the night. Before administering, the salt water was warmed and the juice of *'ilima* (*Sida fallax*) or a mashed *kukui* nut was added to enhance the effects. Or, one could also add *'ulei* (*Osteomeles anthyllidifolia*) bark, that was pounded and mixed with a *kukui* kernel, to the salt water instead (Gutmanis 1976).

**Rheumatic joints/Deep bruises**

Wrap the affected area with *noni* or *kukui* leaves. Apply a hot-pack of salt, sand, or heated rocks, that was wrapped in kapa (Gutmanis 1976).

**Fractures**

The *kahuna* would have the bark of *kukui* pounded and mixed with some *ki* leaves and water until soft. This was then mixed with *poi*. The *kuhuna* would then apply the mixture around, but not on, the area of the broken bone five times a day until it was healed. This was a chant that usually accompanied this application (Gutmanis 1976):

E ho'i ka-iwi i ha'i i kona wahi iho,
a pela no ho'i i ka 'i'o o kona wahi iho
a pela no ho'i ke-a'a
e ho'i no lakou wahi iho
a pela me ke-a'a 'olona
e ho'i lakou ma ko lakou wahi iho

**Building up of body after it has recovered an illness**

Ground the meat of eight thoroughly baked *kukui* nuts. Also bake 12 very young *kalo* (*Colocasia esculenta*) leaves. Mash 4-6 shoots of the very young *kikawaioa* (*Solanum* sp.). While the ground *kukui* kernels and the baked *kalo* leaves are still warm, mix them with the mashed *kikawaioa*. Prepare this mixture with *'uala*, *poi* and *Campylotheca* tea. Fee ying on his side with a blanket for support. Administer this treatment twice a day for five successive days. Have the patient drink *Campylotheca* tea regularly. *Mai'a* and *papaia* should be eaten with regular food. Avoid eating salty foods (Akana 1922).

### *KUKUI*: FOOD

*Many informants cultivated plants for food and material in areas surrounding their house or, in some cases, on tracts of land that required a long hike. The types of plants or trees that were grown around the yard included* kalo, 'uala, mai'a, 'ulu, **kukui**, niu, papaia, lauhala, noni, ki, *etc. (Matsuoka 1996)*

Like most members of the Euphorbiaceae family, the *kukui* nut is poisonous in its raw state. But, being the intuitive people as they are, the Hawaiians discovered the delicious flavor of the *kukui* nut condiment, *'inamona*. After the *kukui* nut was thoroughly baked in an *imu*, it was removed from the shell and finely chopped. It was then mixed with the red Hawaiian salt.

Sometimes, when fish was hard to come by, Hawaiians would dab a small amount of *'inamona* on the tongue to satisfy their cravings. This was because the common use of *'inamona* was primarily to flavor raw fish or raw crab. My dad always said, "E, no eat too much *kukui* nut o else you going get diarrhea! " My dad taught me how to prepare raw fish and raw crab using *'inamona*, which I believe is the best way to prepare these. The *'inamona* gives an 'ono, or delicious, flavor that is unmatched by anything else. I would give my recipe but that kind of information is only reserved for close family and friends. But, production of *'inamona* is fairly simple.

I remember when I was a young boy we had to collect *kukui* nuts for my Aunty Anna. She would make *'inamona* for the family and my dad says that Aunty Anna makes the best *'inamona* around. She taught us how to make it when my cousins and I were young. First, only the good *kukui* nuts were used. Aunty Anna said to collect only the nuts that had just fallen out of the tree. This was easy enough because she made us collect nuts only when they were dropping during the months of September to November and the nuts were still in the outer shell. We brought the nuts back to the house, removed the outer shells and then left them out in the sun until they turned black. The black nuts were then put in the oven and thoroughly roasted. After being baked for a couple of hours, we would crack the shells with a hammer and remove the meat for my Aunty Anna. It was then chopped up very finely and the red Hawaiian salt was added to taste. This was never exact since Aunty Anna always said, "Put until taste good." The ink sack of *he'e* or chili peppers could also be added for the desired flavor.

Hawaiians were famous for wise sayings and riddles, *'olelo no'eau*, that kept them thinking. Here are a few examples that refer to the *kukui* nut:

'O ka 'inamona no ka i'a komikomi na welelau lima.
*Kukui* nut is the fish you eat
Answer: cooked *kukui* nut (Judd 1968)

lai ka welelau o ka lima
My fat fish that dances on the tips of the fingers.
Answer: cooked *kukui* nut (Judd 1968)

Pa ka 'ala, pa, pa i ka hua kau luna, ku i ka niau la holu, he walea ia na ke kuapu u.
The stone strikes, strikes the nut, it is placed above, a fish indulged by the hunch back.
Answer: cooked *kukui* nut (Judd 1968)

Ku'u wahi i'a ai no ami ana, ai no ami ana.
My little fish which you eat and twist, eat and twist.
Answer: cooked *kukui* nut (Judd 1968)

Ka i'a ka'a poipoi o kalapana, 'ina'i 'uala o Kaimu.
The round, rolling fish to be eaten with the sweet potato of Kaimu.
Answer: 'inamona (Puhli 1983)

omaia'ukou
I don't find even the fragrance of roasted *kukui* nuts in you.
(I don't find the least bit of good in you.) (Pukui 1983)

### *KUKUI*: A FISHING AID

*...Uliuli kai holo ka mano,*
*Moana koa hi kahala,*
*Pupuhi ke* **kukui** *malina ke kai,*
*Kaka ka ia o ka uhu...*

*...Where the sea is blue, the sharks dwell,*
*Where the feeding ground is deep, the kahala grows thin,*
*Where the* **kukui** *nut is spat on, the sea is smooth, the uhu are caught... (Fornander 1974)*

First and foremost, Hawaiians were fishermen. From ancient times, they were very knowledgeable of their surrounding oceans and utilized the available islands resources to effectively capture fish. The *kukui* was one of these resources. When *kukui* oil was placed on the ocean surface, it had the ability to smooth it out considerably, as if someone had put a piece of glass there. This allowed the fisherman to see clearly into the water, making it easier to see the fish or what ever they had planned to catch.

*"Now Makua understood what was in the mind of his companion. Kawelo wanted the great* uhu*! An encounter with that powerful fish would bring certain death to the fisherman though. "Let us go no farther," he begged, but spoke too late. The canoe was already off Ka'ena. There they fished.*

*With hook and line, Makua caught several fish while Kawelo dipped an* uhu *net deep in the ocean. He chewed* **kukui** *nut and spat the oil over the waves to quiet them so he could watch for the great* uhu*. But the Traveling Uhu did not come, only some smaller ones. "Let us return," Makua begged. "It is growing late."*

*...Sunrise found them once more off Ka'ena point. Kawelo was eagerly spitting* **kukui** *oil and watching for the great* uhu*. Many* uhu *of common size came to his net that day and he was so busy catching them that he failed to notice signs of a storm." (Pukui 1951)*

When a fisherman wanted to go fishing, he would put his *kukui* kernels into a gourd container of some sort, collect his fishing gear and put everything into the canoe. Upon reaching his fishing grounds, if he saw something of interest or if he knew where something an would spit the chewed kernels onto the water, since after a while the smoothing effect of the oil would wear off. This effectively allowed the fisherman to see what he was looking for. Chewing the *kukui* kernels and spitting them out onto the ocean surface was the common way to disperse the oil. This fishing technique, using *kukui* kernels, was most commonly used for catching *he'e* and *'uhu*, though it was used to catch other things as well.

> *The young man had prayed earnestly and watched the eel. Now, pointing silently, he directed the canoes. He was sure the eel hid in a cave in the ocean floor. He found this place by land marks on the shore. When the canoes reached the place 'Ai'ai chewed* **kukui** *nut and spat out the juice. Looking into the water quieted by the oil he plainly saw the cave mouth. (Pukui 1951)*

The *kukui* oil apparently worked as a fish attractant as well. Fishermen used the melomelo, which was a stick of *o'a* (*Alphitonia ponderosa*), *kauila* (*Colubrina oppositifolia*), *pua* (*Nestegis sandwicensis*), *koai'e* (*Acacia koaie*), or *'a'ali'i* (*Dodonaea riscosa*), that was cut to about about three to four feet in length. One end of this stick was tapered and rubbed with *kukui* oil, or sometimes *niu* oil and cooked over a fire until the end turned black. Often, pounded *kukui* kernels or niu meat was wrapped in *niu* leaf fibers and attached to the tapered end of the stick as well. The stick would be lowered into the water to attract fish. When a number of fish had been seen surrounding and nibbling at the bait, a net would be lowered into the water. Then, the stick would be moved to lead the fish into the net and "the fish would be caught" (Coryell 1986).

### *KUKUI*: A STAIN

*Kukui* oil was used as a water proofing stain on a number of different items. Probably the most often use of this stain was on the *koa* hulls and *'ama* of the canoe. Sometimes *kukui* wood was used in the construction of canoe hulls but, this was very rare. More often *kukui* wood was used to deck the front and rear of the canoes and also as trim. When the canoe was completed, it was first smoothed by coconut fibers intermixed with sand, shark skin, or by rough coral or stone (Coryell 1986). After it was sanded smooth, the *kukui* based lacquer-like paint/stain would be applied.

This stain was prepared in several different ways. *Kukui* oil could be mixed with the powder of intentionally burnt *kukui* kernels or collected from burnt *kalikukui* candles (Coryell 1986). The stain could also be made by combining the juice of a certain *Euphorbia* (maybe *'akoko*), the juice from the inner root bark of the *kukui* (*hili kukui*), the juice from a *mai'a* shoot, and *puhala* (*Pandanus tectorus*) leaf charcoal (Coryell 1986). The *hili kukui* juice, or the *kukui* gum (*pilali*), could also be mixed with the ashes from *'ama'uma'u* (*Sadleria* sp.) ferns, the leaves of *ko*, and *nanaku* (Coryell 1986). The stain was usually applied with a fibrous brush that had been made by pounding the end of an aerial root from a *puhala*. After the stain had cured, *kukui* oil was rubbed all over the hull to complete the sealing process.

The *kukui* oil's ability to repel water was not only used on canoes. Hawaiians used the same process to waterproof their surfboards and net-floaters. The floaters for the fishing net were most often made of *ikoi* or *lama* wood but, when these were hard to come by, *kukui* wood was a suitable substitute. Not only the floaters were protected, the entire net itself was soaked in a *kukui* mixture. This was known as tanning the net "to strengthen it and hinder decay, as well as to stain it to make it less conspicuous to the fish" (Degener 1929):

> *The inner bark was taken from an old (***kukui***) tree, pounded and put into a trough with water. After stirring, the bark was strained out. The nets were dipped into this liquid and allowed to dry, and thereafter dipped and dried a second time. This preserved them as well as stained them a reddish color. If a net is used frequently, it should be dipped at least once every month or six weeks in such a bark infusion as the effect of the treatment seems to become lost by long immersion in the ocean. Nets thus treated have been known to be serviceable for fifteen years.*

*Kukui* was also used to stain idols and drums. Bowls were also stained with the oil from the raw *kukui* but, the oil was only used on the outside because of its purgative qualities. The oil was often rubbed on light colored wood to darken and bring out the grain in the wood. Sometimes the this wood. This is an example of another use of this dark "paint":

*'Aukele looked eagerly about. "I see the opening," he whispered, "but it is too small for a man to enter. What shall I do?"*

*"Kamoho comes," she answered, "and reaches down for the water of life. Guards in the cave below place the gourd in his hands. But the hands of Kamoho are black. "*

*'Aukele looked at his own hands. "Mine are not black," he said. "What shall I do?"*

*"We must blacken them. Get herbs, 'Aukele, and* **kukui** *nuts. Then charcoal from my fire." 'Aukele got these things and pounded and mixed as the old woman directed. "Now rub the oily black stuff on your hands."*

*'Aukele laughed softly. "Now my hands are black," he whispered, "black as the hands of Kamoho." (Pukui 1951)*

### *Kukui*: A Dye

*Ehu, a man, was made the* aumakua *of* kapa-*dyers because he learned how to dip the cloth in dyes and give it color. He discovered the red dye in the blood of the* **kukui** *tree: therefore prayers were offered to him and sacrifices laid on his alter when the* kapa-*maker desired to color some of the work. (Westervelt 1963)*

Hawai'i alone produced more varieties of dyes and color patterns than any other part of Polynesia (Kamakau 1991). The dye colors that were used by the Hawaiians included light green, light yellow, lavender, yellow, red, brown, black gray, light gray, blue, and orange (Blitman 1972). Many dyes were permanent and required no special treatment to preserve the color. Others needed to be treated with a mordant to help fix the colors or make them richer in color. A number of different substances were used to act as mordants. Among the known substances used are salt, sea water, mud from the *kalo* patch, urine, burnt coral lime and sand, and the oil of *kamani* and *kukui* nuts (Blitman 1972).

Among the dyes for *kapa*, the *kukui* was one of the favorites of the Hawaiians (Krohn 1978). Different parts of the *kukui* produced different colors. The shell or rind of green mature *kukui* seeds were pounded and added to water which produced a water soluble black color. To produce a darker black, the kapa was first dyed with the *kukui* dye and then it was buried in the mud of the *lo'i* for a day or two. A red or copper color could be attained by pounding the inner bark of the *kukui* root into a fine powder and mixing it with water. The inner bark of the *kukui* trunk that was pounded into a powder also produced a similar copper-red color. The *kukui* oil could be added to the pounded materials to produce a paint for printing. *Kukui* oil was used often because "it dried quickly after the dye was applied to the cloth" (Blitman 1972). The oil could also be added the charcoal of burnt *kukui* nuts to produce a deep black color (Blitman 1972). To complete the dyeing process, sometimes the resinous gum from the *kukui* was applied to the painted *kapa* "to protect the dyes and to make the cloth stronger and water proof" (Krohn 1978).

The black "paint" produced from the charcoal of burnt *kukui* nuts mixed with *kukui* oil not only served as a dye for kapa but also as the ink used for tattooing. Tatooing is prevalent throughout the Polynesian Islands. Drawings made by haole who visited the early Hawaiians show terrific detail of the tattoo patterns of ancient times. Kahekili, a very powerful Hawaiian chief was said to have tattooed one-half of his entire body black (Kamakau 1961).

The charcoal needed to produce the black ink was obtained in a much different way than that of *kapa* dye. A stone was hallowed out and the insides were smoothed considerably. A *kalikukui* was burned inside of this hallowed out stone. The black smoke produced by the "candle" would adhere to the sides of the stone. When a sufficient amount of soot had collected, it was removed and placed into a container where it was mixed with *ko* juice (Fornander 1974). The liquid was then applied to the punctured skin.

### *Kukui*: A Lei

*Lei Kukui* is representative of the island of Moloka'i, The Friendly Isle. Two types of lei were fashioned from *kukui*: the *leiwili* and the *leihua*. Although there may be many methods of making these two *lei*, the part of the tree that is used remains the same. The nuts were used to make a *leihua*. The leaves with stems and flowers were used to make a *leiwili*. The leaves were braided together using the stems. The small flower bunches were stuffed into the braid as the lei was being made. This type of lei could be worn around the head or around the neck.

The *leihua* was a more durable type of *lei* that could last for many years. It was a kind of *lei* that took a little more attention to make. The first step in making a *leihua* is to gather up the nuts. Fresh nuts are preferred since rotten nuts tend to crack. The best way to ensure collecting good nuts is to collect them when they are dropping from the trees. The husks are then removed and laid out in the sun to dry. After the nuts have turned a dark color the nuts are arranged by color and size.

The next step is where most of the attention is focused. The number of nuts needed for a particular *lei* depends on how long it is going to be. First the length of the *lei* is measure to determine the number of nuts needed. Then, the nuts are sanded smooth with some sand paper. Ancient Hawaiians used to used shark skin for this purpose. The nuts are then brought down even smoother with a buffer. Next a small hole was drill through the nut lengthwise. This allows for the cord to pass through and also for the removal of the kernels. The kernels could be removed by one of two ways. It could be dug out with a sharp, skinny tool or the nuts could be buried to let the bugs do the job. The nuts were then strung on a cord of some sort. In ancient times, *olona* cordage was used, but now days one can see a variety of things used.

In the early days people took pride in making *kukui* nut lei by hand. Some even took it a step further and did engravings on the nuts that increased the value of the lei. There also a way to make a white *kukui* nut lei. When picking the green nuts while they are still in the tree the nuts inside are white. This type of *lei* is even harder to come by and much more valuable.

Today some people mass produce the *lei* to sell to the tourists, sometimes even skipping a step or two. Some tourists complained of having bugs eating their *kukui* lei. This is because the people who made them were too lazy to remove the meat from the nut and sold them to some unsuspecting tourists. Also, some people try to dip the nuts in plastic to get the polished look. Just plain laziness. Hawaiians take pride in the things they make!

### *KUKUI*: OTHER USES

*Kukui* could be used as a mulch. In wet-land *lo'i* the leaves and branches of the *kukui* were buried in the mud and the *lo'i* was allowed to lay fallow. When the decomposition was complete, the *kalo* was then planted. For dry-land *lo'i*, large holes were dug and *kukui* leaves and branches were buried in these holes. When the decomposition was complete, the *kalo* was planted directly in the hole. "A plant thus handled may grow to seven feet and over and the taro may weigh twenty pounds and over" (Beckwith 1978).

The *kukui* oil was also an aid in wrestling. Or, if a warrior went into battle he would cover himself with the slick secret. Because of it's slipperiness, it helped the warrior slip from his enemies grasps:

> *"...Then the chief came to the lava fields of Wahaula and lay down to rest. The ghost came to him again in a dream, telling him that great personal danger was near at hand. The chief was a very strong man, excelling in athletic and brave deeds, but in obedience to the spirit voice he rose early in the morning, secured oily nuts from a* kukui *tree, beat out the oil, and anointed himself thoroughly.*
>
> *...Almost all day the battle raged between the two men. Back and forth they forced each other over the lava beds. The chief's well oiled body was very difficult to grasp... (Westervelt 1976)*

*Kukui* was also used for the preparation of adzs. When the "raw" stone was soaked in a liquid called *wai la'au*, crushed green *kukui* nuts mixed with *palae* fern juice, it was thought to soften stone, making it easier to work with. After the adz had taken shape, it was put through a smoothing process. First a rough material, usually coral or lava, was used. Then maybe a smoother coral was used, which was followed by stingray or shark skin. Sand was used for the "final polishing." When all was completed, the adz was rubbed down with *kukui* oil. (Malo 1971).

> *Hiku was a* kupua *or demi-god in Hawaiian mythology, the son of the Mountain-Goddess Hina, who forbade him to visit the world of the people until he finally persuaded her to let him travel. He took his magic arrow Pua-ne and set out. His arrow was his guide: he would throw it up into the air and it would fly in the direction he had to go. One fated moment it landed at the feet of a queen, Kawelu. She picked it up and hid it. Then Hiku appeared, tall and handsome, calling: 'Pua-ne!'*
>
> *The arrow replied from the queen's bosom: 'Nei!' (Here!) So the queen had to give up the*

*speaking arrow. She fell in love with Hiku in her turn, using magic, she detained him in her palace. But after a time he grew wings and flew away over the ocean. Inconsolable, the queen died.*

*When the news reached Hiku, he decided to try and bring back her unhappy soul from Milu. He rubbed his body with* **kukui**, *an oil that smells like a corpse, and told his friends to lower him, by the means of the long stem of the kowali, into the Lua-o-Milo, where the spirits of the dead are gathered. No living man is allowed to visit Milo, but, deceived by his cadaverous odor, even the god Milo did not become suspicious. Kawelu's spirit soon recognized Hiku and sat down on his kowali swing with him. At once Hiku's friends, receiving his secret signal, began to pull the 'rope' up. But Kawelu did not really want to leave the dead-land. . . (Knappert 1992).*

### Conclusion

This paper does *kukui* no justice. I feel I have not fully covered this ancient Hawaiian resource. I was not aware of the many, many different uses that *kukui* has. There are many other aspects of the tree that I have not even touched on. This includes the belief that *kukui* was one of Kamapua'a's *kinolau*, or body forms. I believe that this would probably be a whole separate paper in itself.

Consequently, I have cut this paper 'short'. I was very surprised at the overwhelming amount of information available about this particular plant. I also believe that there is probably a lot of information that was lost.

*Kukui* enlightened the lives of the ancient Hawaiians as it did mine. They used this tree to it fullest potential as they did with the many other resources available to them. This research paper only strengthens my opinion of how sophisticated the Hawaiian culture is.

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# News and Announcements

## Algal Invasion in Tahitian Waters a Prelude to Hawaiian Events?

Dr. Claude Payri, marine algal ecologist with the Université Polynesie Française in Papeete, Tahiti was a recent visitor at the Botany department UHM and the Herbarium Pacificum at the Bishop Museum. In an informal speech in Botany, she told of the invasive spread of two common brown macroalgae (*Sargassum mangarevense* and *Turbinaria ornata*), both indigenous to the Society islands. This species of *Turbinaria*, which is also present in very low numbers in the Hawaiian islands, has been spreading for the last 10 years into the low coral atolls of the Tuamotus at the same time that *Sargassum* has invaded the crest of the barrier reefs of the high volcanic islands of the Societies. She described swimming through *Sargassum* beds as having to part the fronds to make a way (in similar fashion of swimming through low subtidal kelp forests in California). Increase in biomass of the *Sargassum* around Tahiti in the last 10 years has changed the temperature of the seawater where they are growing and has killed off about 60 percent of the coral. When the corals die, this leaves new surface for more *Sargassum* plants to settle, thus multiplying the spread of the invader. *Sargassum* plants also overgrow crustose coralline algae, the alternate reef builder in the tropics. The permanent damage to reef ecosystems has not yet been assessed.

In the Tuamotus, *Turbinaria* has spread to islets and atolls that are inhabited as well as uninhabited, and the massive increase in numbers of plants cannot be blamed on "pollution" or "pesticide run-off" if the plants causing environmental change are equally present in both places. The growth of these plants are certain to interfere with bottom dwelling fish and invertebrates such as octopus, snails and sea urchins which still remain the most inmortant sources of protein for these remote locations.

Neither of these species has a life history that can be interrupted as a control mechanism. The main remedy to the dismal situation is removing the perennial bases by hand, being careful not to leave pieces behind from which new erect plants can grow.

Dr. Payri brought with her a near-final copy of a Guide to the Common Algae of French Polynesia (Society islands, Tuamotus, and the Marquesas), containing colored illustrations, most of which were made underwater. Most of the taxa would be found in the Hawaiian islands as well.

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## Three Students Selected for HBS Awards at the State Science Fair

The 42nd State Science and Engineering Fair was held from March 29 to April 1, 1999 at the Neal Blaisdell Exhibition Hall. A total of 295 projects were entered from 59 participating schools.

The Hawaiian Botanical Society (HBS) applauds all of the students who were involved in science projects and displays at the school, district, and the State levels. Kudos also go to the hundreds of teachers. mentors, parents. judges, volunteers, donors, and awarding agencies (including the Botanical Society) who inspire our youth by promoting science and education.

The HBS awarded the Senior and Junior Research Division first place winners $50 and Isabella Abbott's book *La'au Hawai'i*. The Senior Research second place winner received $25 and La'au Hawai'i. There was no second place winner for the Junior division.

The following are the recipients of the HBS awards and their project titles:

### Senior Research, First Place

*Aurora K. Kagawa*, Kamehameha Schools. "Effects of Phosphate and Mycorrhizal Inoculation on the Growth of Plants in Nutrient-Deficient Soil." Her complete abstract is presented following this article.

### Senior Research, Second Place

*Aaron Nakamura*, Kapa'a High School, "The Use of a Solvent Refined Paraffinic Distillate as an Environmentally Safe Alternative to Diesel for the Effective Delivery of Triclopyr in the Eradication of *Psidium cattleianum* (Strawberry Guava)." (Done in cooperation with Koke'e State Park.)

**Junior Research, First Place**

*Chelsea M. Nagata*, Maui Waena Intermediate, "The Effect of Temperature on the Growth of *Ulva fasciata*."

***First Prize, Senior Research***

## *Effects of Phosphate and Mycorrhizal Inoculation on the Growth of Plants in Nutrient-Deficient Soil*

Aurora K. Kagawa
Kamehameha Schools

Kaho'olawe, the smallest of the eight major Hawaiian Islands, has a total land area of 28,800 acres and reaches an elevation of 1477 feet. In the early part of this century, the island was used for ranching, and much of the native vegetation was destroyed. Further damage was incurred when the U.S. military began using Kaho'olawe for target practice in 1941. The bombing by the Navy eventually came to an end in 1990, and the island was returned to the State of Hawaii in 1994. Since then, revegetation efforts have been made in order to slow erosion on the island. However, those efforts have been hindered by the lack of rainfall and the poor quality of the Kaho'olawe soil.

In the *Soil Survey of Island of Kaho'olawe, Hawaii*, the suggested soil treatment is phosphorus, to be applied at a rate of 200 pounds per acre at every planting. However, another, more environmentally friendly option exists—arbuscular mycorrhizal fungus inoculation. Mycorrhizae are the symbiotic relationships formed between specialized fungi and the roots of plants. These associations increase host plants' resistance to drought and pathogens and play an impoltant role in the survival and health of most of the world's plants (and hence ecosystems). Of the many mycorrhizal fungi, arbuscular mycorrhizal fungi are the most ubiquitous and least host-specific.

The goal of this study was to observe the benefits of arbuscular mycorrhizal inoculation versus phosphate fertilization on plant growth in the soil of Kaho'olawe. The hypothesis of this study was that inoculation of a certain mycorrhizal fungus in the degraded topsoil of Kaho'olawe would improve the growth of the native Hawaiian sedge *Fimbristylis cymosa*. The mycorrhizal fungus used was the arbuscular mycorrhizal fungus *Glomus aggregatum*. Eight different soil situations were created. Variables were the phosphate fertilization levels of the soil (O ppm, 88O ppm, 1760 ppm, and 3520 ppm) and inoculation (Uninoculated and Inoculated).

Data was collected in the form of top growth measurements, taken at intervals. The top growth measurements were of leaf blade lengths and leaf blade counts. Data was also collected in the form of dry weight measurements of both whole plant masses and root masses. In order to determine the effects of the inoculation on a microscopic level, staining of the roots for fungus spores was also performed.

The results of the study showed that optimal growth was achieved when the soil was treated with a combination of phosphate at 880 ppm and mycorrhizal inoculation. For most of the top growth and dry weight measurements, the differences between the inoculated and uninoculated growth rates were statistically significant.

Comparisons of *F. cymosa* in all situations showed that inoculation of *Glomus agregatum* produced increased plant growth at all phosphate levels. This is the most important conclusion in that it suggests phosphate fertilization can be complemented by mycorrhizal inoculation. However, this study is only of a single plant species coupled with a single mycorrhizal fungus species. In order for this technology to become truly practical, much more research must be conducted with other combinations of plants and fungi.

### Key References:

Habte, M. "Mycorrhizal Fungi and Plant Nutrition." Hawaii Soil Fertility Manual. Honolulu: University of Hawaii, December 1997.

Sylvia, David M. Mycorrhizal Symbioses. [Online] Available http://www.mycorrhiza.com, August 1, 1998 (downloaded).

United States Department of Agriculture, et al. Soil Survev of Island of Kaho'olawe. Hawaii. April 1995.

## Hawaii Conservation Conference

The annual Hawaii Conservation Conference is the largest gathering of people actively involved in the protection and management of native species and ecosystems in Hawai'i. The purpose of the conference is to facilitate interation among natural resourece managers and the scientific community. It is an opportunity to discuss and obtain up-to-date information on a variety of conservation activities in Hawai'i.

The Hawaiian Conservation Conference will be held July 27-28 at the Hilton Hawaiian Village in Honolulu, Hawaii. Information and the program for the conference can be found on the Secretariate for Conservation Biology website:

**http://www2.hawaii.edu/scb/**

Those needing additional information should contact Nancy Glover (808-944-7133; nglover@hawaii.edu). Registration for the meeting is due July 1, 1999. A late fee will be assessed after this date.

## Hawaiian Botanical Society Pre-Graduate Research Grant

The Hawaiian Botanical Society will be providing a grant this Fall for a small scale research project to be conducted by a high school or undergraduate student, under the guidance of a teacher or instructor of the parent institution. The Society annually awards a grant of $500 for original research on the Hawaiian flora, including the conservation and perpetuation of native plants, broadening the knowledge of the Hawaiian flora (e.g., flowering and fruiting times, seed germination, propagation, growth requirements, plant competition) and Hawaiian cultural plants. Horticultural type plants or projects will not be considered within the purview of this grant. The award is oriented towards small-scale projects in Hawai'i for high school or undergraduate students. Applicants are also encouraged to solicit grants from other organizations to fund research which cannot be funded entirely by the Society.

Complete application guidelines for the Hawaiian Botanical Society Pre-Graduate Research Grant and a sample application form which provides further guidance may be obtained by contacting:

**Alvin (Al) Keali'i Chock, Chair,**
**Pre-Graduate Research Grant Committee**
**Department of Botany**
**3190 Maile Way**
**University of Hawaii**
**Honolulu, HI 96822**
***or***
**e-mail: alchock@worldnet.att.net**

Completed research proposal application must received no later than November 1, 1999. The awardee will be notified on or about Dec. 1, 1999.

## *Newsletter* Now Has ISSN Number

In case you had not noticed on the front page of this issue, the *Newsletter of the Hawaiian Botanical Society* now has an ISSN Number from the Library of Congress. This number, similar to a social security number for serials such as ours (yes, that is how they refer to it!) should provide a number of benefits to the society (lower postage rates for one) and other publishers. If you would like more information about the benefits, feel free to contact the editor.