SEARCH AND IDENTIFICATION OF THE HAWAIIAN ‘NIU HIWA’ WITHIN HAWAI‘I’S COCONUT DIVERSITY

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By

Indrajit Kumara Samarasingha Gunasekara

Thesis Committee:

Noa K. Lincoln, Chairperson

Heather McMillen

Kent Kobayashi

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Abstract

The coconut tree (*Cocos nucifera* L.), known as niu throughout the Pacific and some parts of Asia, is the sole species of the genus Cocos belonging to the family Arecaceae and subfamily Arecoideae. The subfamily includes 27 genera and 600 species that are diploid with 32 chromosomes (2n=2x=32). Thriving for perhaps 80 million years, the coconut developed the means to scatter across vast areas of the ocean where, before human dispersal of coconuts, their original distribution was the Central Indo-Pacific and regions of Maritime Southeast Asia and Melanesia. The coconut has been an integral part of tropical living for many millennia, connecting every part of this tree with meaningful functions through in-depth traditional knowledge. Evidence of the selection and domestication of coconuts is at least 5,400 years old where those Indigenous cultures have continued not only passing down millennia of legends and cultural practices that define who we are within our place in the Tropics but also maintaining the associated coconut knowledge and practices with close ties to human existence as "the tree of life." Due to the depth of time and widespread spatial nature of the coconut tree, it is notable that a high number of coconut varieties were developed that serve a range of functions that occupy various needs. Although Hawaiʻi provides evidence of a rich Indigenous coconut culture it lacks a practice of holistic conservation of these invaluable coconut genetic resources. It's clear that without any record-keeping or strategic coconut conservation practices to keep populations alive, extinction could easily go unnoticed, and niu varieties will thus succumb to genetic erosion. Therefore, this thesis attempts to bridge this gap in coconut research and associated literature in Hawaiʻi to recognize Hawaiian coconut diversity and the revitalization of coconut as a resource of cultural, nutritional and ecological importance. The holistic practice of recognizing niu diversity is accomplished by introducing a simplified coconut tree tracking system to collect a set of vital ethnobotanical and morphological information on any given coconut tree. Specifically, the understanding and recognition of a historically respected variety of coconut Niu Hiwa is used to exemplify and deepen a common comprehension of Hawaiian niu diversity. This research process has utilized a morphological tracking system along with expert tree observation and an

ethnobotanical data gathering system as well as oral interviews with various knowable cultural partitioners in addition to reviewing written ethnobotanical material related to Niu Hiwa.

As a result, coconut tree data was collected on a diverse population of 260 trees in 5 different Hawaiian Islands. The study expanded our understanding of Niu Hiwa and revealed the specific characteristics of Niu Hiwa described in historical texts that had direct correlations with current Niu Hiwa trees identified by research participants. In addition, the study acknowledged the vast existence of a genetically diverse coconut gene pool in Hawaiʻi today as well as some of the unique characteristics of ancient Hawaiian uluniu (coconut groves). In addition, the study has developed a morphological tracking system aligned with culturally embedded coconut practices that bring forward the current understanding of scientific classifications of coconut genetic diversity. This study thus created a coconut tree data management system and educational material that can be used to select quality coconut planting material. This process enhances understanding of coconut genetic diversity in Hawaiʻi by using only the traits that a trained farmer would identify as important for differentiating coconut diversity.

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within our places…

This work hopes, in some way, to contribute to a better understanding of niu diversity. In turn, I hope to provide some rejuvenation to Hawaiian cultural niu practices, along with providing a renewed interest in niu as a food source that nourishes local communities and helps with Hawai‘i’s ecological needs. This thesis may be a tool for understanding the noa huna (hidden meaning) of "*Kupu ka niu kupu ke kanaka - When coconuts grow, humanity flourishes" as* noted in the Pule Niu. This interpretation allows us to deepen the current understanding of Hawaiian Niu Hiwa and supports the diversity of niu to rejuvenate the ancient Hawaiian uluniu system. As the urgency of today’s need for reliable, locally utilized, and culturally connected foods intensifies because of climate change and global challenges, I hope this work contributes to a better understanding and meaningful relationship with this tree. Healing is activated by recognizing that every part of the niu is useful and functionally connected, culturally rooted, and has the potential to support our well-being. This work acknowledges and enhances the understanding of Hawai‘i’s coconut genetic diversity through the existence and recognition of ancient Hawaiian uluniu systems. This supports preexisting understanding by providing a set of notable morphological characteristics that can be observed by a trained eye aligned with culturally embedded understanding along with scientific classifications of coconut genetic diversity. By gaining awareness of various forms and uses of the coconut, I hope this work contributes to the regaining of respect and appreciation of this historically known and spiritually connected “tree of life” so once again niu can inspire the growth of Hawaii‘s uluniu – ancient coconut groves.

Chapter 1. Introduction

Kupu ka niu kupu ke kanaka.

When coconuts grow, humanity thrives.

(He Pule Niu, Ka Nupepa Kuokoa, Volume XXXVI, Number 42, 15 October 1897)

The coconut tree (*Cocos nucifera* L.), known as niu throughout the Pacific and some parts of Asia, is the sole species of the genus Cocos belonging to the family Arecaceae and subfamily Arecoideae. The subfamily includes 27 genera and 600 species that are diploid with 32 chromosomes (2n=2x=32). Thriving for perhaps 80 million years, the coconut developed the means to scatter across vast areas of the ocean and overcame many biotic and abiotic challenges to take hold in new lands (Batugal et al., 2005). Before the human dispersal of coconuts, their original distribution was the Central Indo-Pacific and regions of Maritime Southeast Asia and Melanesia.

The coconut has been an integral part of tropical living for many millennia, connecting every part of this tree with meaningful functions through in-depth traditional knowledge. Evidence of the selection and domestication of coconuts is at least 5,400 years old, (Muñoz-Pérez et al., 2019). Since humanity took interest in the coconut tree, coconut-growing cultures have continued not only passing down millennia of legends and cultural practices that define who we are within our place in the Tropics but also maintaining the associated knowledge and practices with close ties to human existence. The extreme usefulness of the tree as food, fiber, timber, oil, thatching, mulch, fuel, appearances in the spirit world, and other uses has supported its affectionate reference as the “tree of life.” Due to the depth of time and widespread spatial nature of the coconut tree, it is not surprising that a high number of coconut varieties were developed that serve a range of functions and occupy various niches. Safeguarding practices regarding coconut diversity and varieties were also developed.

In Hawaiian and other Indigenous cultures, as well as in the common vernacular, coconuts are generally considered to be trees. Indeed, the Hawaiian word for a growing coconut is *kumu niu*, which refers to a trunked (kumu) tree (Pukui and Elbert, 1964). In other Indigenous cultures, such as in ancient Sri Lankan understanding (Mahavamsa in 5th century BC and Sarartha Sangrahaya in 390 AD), the verbiage "pol gaha" (pol=coconut, gaha=tree) is used that considers coconut as a tree while many other species are categorized in their true forms such as grasses, ferns, vines, shrubs. On the other hand, in current scientific literature, coconuts are not considered to be trees but rather palms, due to their fibrous root system and lack of a woody core. Therefore, while we acknowledge the current Western scientific botanical classification as a "tree-like palm," to honor and support the Indigenous perspectives embraced by this paper, I will refer to the coconut throughout this publication as *kumu niu* or coconut tree.

There has been a growing interest in the classification and conservation of coconut varieties and genetics (Bourdeix, 2008; Bourdeix and Prades, 2017). More recently, research institutions have worked to capture, codify and build upon the traditional knowledge regarding coconuts, coconut varieties, and relevant practices (see Figure 1). For instance, ancient coconut gene banking and genetic safeguarding practices such as the ancient Polynesian practices known as polymotu, planting several of the same variety in small motu or "islands" have been spotlighted by current experts and advocated as a comprehensive scientific strategy for current global coconut genetic conservation (Bourdeix, 2008). Research institutions such as the Coconut Genetic Resources Network (COGENT) and the Pacific Community (SPC) have developed subject matter experts and specific mechanisms for recognizing coconut genetic material and managing those genetic resources on both the local and global levels by strategizing in situ and ex situ germplasm missions. Although Hawai‘i provides evidence of a rich Indigenous coconut culture, exhibited by the naming of specific coconut varieties and defining multiple stages of fruit maturity connected with associated functions (Pukui, 1986; Handy and Handy, 1972; Neal 1965; Abbott, 1972), it is absent of a coconut research strategy or a respectable mechanism to pinpoint ancestral Hawaiian coconut varieties. Currently, there is no dedicated institution for coconut study in Hawai‘i or coconut germplasm or gene banking practices that acknowledge local coconut cultivars.

Furthermore, Hawai‘i lacks a practice of holistic conservation of our invaluable coconuts' genetic resources.

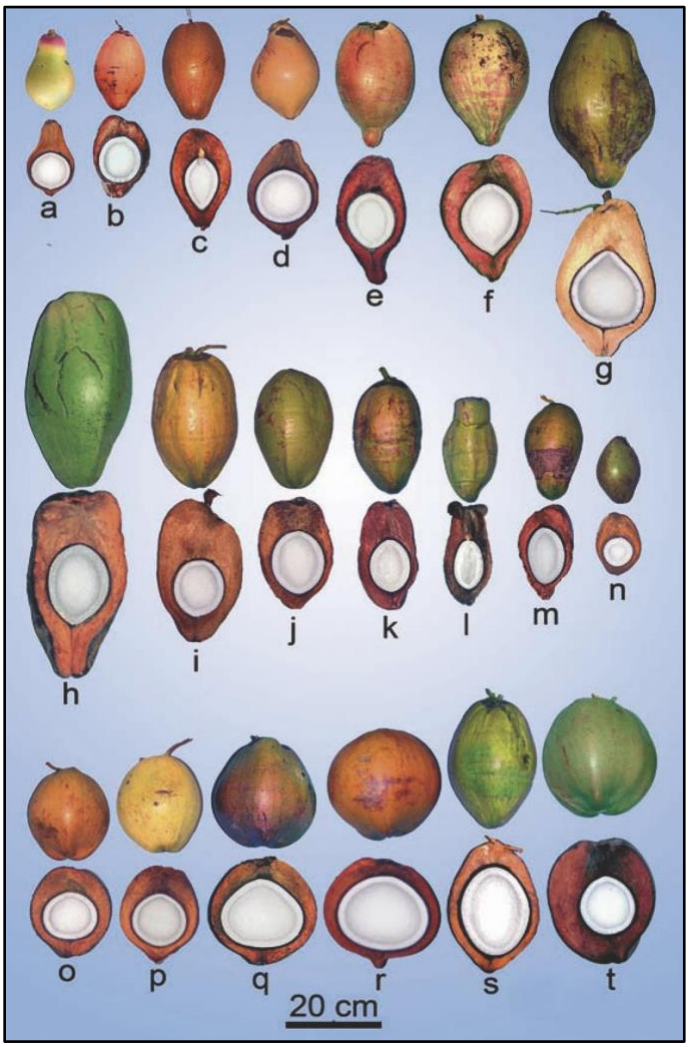

Figure 1: *An example of the great diversity of coconut. Source Bourdeix (2008).*

The archipelago of Hawai‘i is one of the most isolated groups of islands in the world with many ancient *uluniu* (coconut groves) systems—closely tied to Hawaiian royalty—and there is a high probability of having unique varieties of niu, as there are with other crops (Kagawa-Viviani et al., 2018; Lincoln 2020). Unfortunately, many old uluniu are in their last stands today, while the importation of other coconut genetics for landscaping and agricultural production comes with the potential for the dilution of the unique Indigenous varieties. In some cases, such as the uluniu of Kalaeloa (see Figure 2), these groves stood for many centuries with limited access to cross-pollinate with any other more recently introduced coconut varieties. Such conditions have naturally provided a quintessential opportunity for individual coconut varieties to maintain unique genetic lineages; however, today the absence of a coconut genetic resource management strategy may cause the extinction of some unique coconut varieties in Hawai‘i. Already existing challenges are exacerbated by the introduced coconut rhinoceros beetle (*Oryctes rhinoceros*) in 2013 (Russo, 2019). Without any record-keeping of unique

varieties or strategic coconut conservation practices to keep those populations alive, extinction could easily go unnoticed and undetected. How would we even know the existence of such varieties if they succumb to genetic erosion?

Therefore this thesis not only bridges this gap in coconut research and associated literature in Hawai‘i but also supports the practice of understanding Hawaiian coconut diversity and the revitalization of coconut as a resource of cultural, nutritional and ecological importance. This task will be accomplished by introducing a simplified coconut tree tracking system to collect a set of vital ethnobotanical and morphological information on coconut trees. Specifically, the thesis will focus on a historically respected variety of coconut, Niu Hiwa, in order to deepen the common comprehension of Hawaiian niu diversity.

1.1. Coconut Overview

> "…from these [coconut] trees and their fruit are made the following things: sugar, honey, oil, wine, vinegar, charcoal, and cordage..., and matting..., and it serves them for everything they need. And the aforesaid fruit, in addition to what is thus made of it, is their chief food, particularly at sea" (Manuel, King of Portugal, 1501).

The coconut palm tree, scientifically known as *Cocos nucifera*, stands as a singular genus of palm trees chiefly prized for its sizable, edible fruit. Botanically, the coconut fruit is categorized as a monospermic drupe, featuring a solitary embryo encased within a hollow core of white endosperm, enveloped by a tough endocarp (the shell), a fibrous mesocarp, and a thin outer exocarp, which may present in hues of green, yellow, or red. While immature coconuts harbor coconut water, the liquid content diminishes gradually as the fruit ripens (Batugal et al., 2005). Typically, the coconut palm emerges as a solitary, towering stem reaching heights of up to 30 meters, adorned with expansive, pinnate leaves spirally arranged around the trunk. Characteristically, the coconut palm tree boasts a fibrous root system characteristic of monocots, devoid of a taproot. The inflorescence, comprising separate male and female flowers, emerges from the leaf axils of mature palms throughout the year. Coconut palms are enduring perennials, capable of bearing fruit over numerous decades under favorable conditions (Liyanage, 1954).

1.2. Coconut Variation

Coconuts can be broadly categorized into two distinct fruit types: the ancestral niu kafa form characterized by a thick-husked, angular fruit, and the niu vai form featuring a thin-husked, spherical fruit with a higher ratio of endosperm. These terms originate from the Samoan language and were formally incorporated into scientific discourse by Harries (1978). The niu kafa variety represents the wild ancestral type, notable for its robust husk designed to safeguard the seed, its angular and deeply ridged shape facilitating buoyancy for ocean dispersal, and a pointed base aiding in anchoring the fruits in sand, thereby preventing them from being washed away during germination on new islands. This form predominates among Indo-Atlantic coconuts. However, there is evidence to suggest that these coconuts may have undergone selective pressure favoring thicker husks, potentially to enhance coir production—a significant aspect of Austronesian material culture utilized for cordage in constructing houses and boats.

Conversely, the niu vai form represents the domesticated variety prevalent in Pacific coconuts. Austronesian peoples selectively bred these coconuts for their larger endosperm-to-husk ratio and increased coconut water content, rendering them more suitable as food and water reserves for sea voyages. The diminished buoyancy and heightened fragility of this spherical, thin-husked fruit were inconsequential for a species that had transitioned to being dispersed by humans and cultivated in plantations. Archaeological findings of niu vai endocarp fragments in sites such as the St. Matthias Islands of the Bismarck Archipelago, dating back to approximately 1000 BCE, suggest that the cultivation and artificial selection of coconuts were already practiced by the Austronesian Lapita people.

Coconuts are also sometimes broadly categorized into two main types based on their growth habits: the “Tall” (var. typica) and “Dwarf” (var. nana) varieties (Arumugam et al., 2022). These two groups exhibit distinct genetic profiles, with the dwarf variety undergoing significant artificial selection for ornamental features and early germination and fruiting. Unlike the tall variety, which primarily relies on cross-pollination, dwarf palms are predominantly self-

pollinating, leading to a higher level of genetic uniformity within the dwarf group. Dwarf coconut cultivars have undergone full domestication, contrasting with tall cultivars that display a wider spectrum of domestication statuses. A striking finding is that all dwarf coconuts share three specific genetic markers among thirteen, which are present at low frequencies in tall cultivars, suggesting a common origin from a single domesticated population.

Figure 2*: Uluniu of Kalaeloa, West O'ahu: picture taken in November 2021. A famous ancient grove documented in ethnohistorical sources. The ancient and isolated grove demonstrates how heirloom Hawaiian coconut genetic resources are threatened with extinction due to declining health, but often represent isolated stands that can preserve the genetic purity of the varieties. We witnessed the crown falling off of the last living tree here in October 2021.*

The divergence of Philippine and Malayan dwarf coconuts into two distinct types occurred early on. Upon introduction to new regions, these dwarf cultivars typically remained genetically isolated, facilitating the tracing of their origins. Furthermore, numerous other dwarf cultivars have emerged through hybridization with various tall cultivars as the initial dwarf cultivar spread to different regions. The Southeast

Asian region, which houses the tall cultivars genetically closest to dwarf coconuts, is believed to be the origin of dwarf varieties (Gunn et al., 2011).

Another ancestral variety, the niu leka of Polynesia (sometimes referred to as "Compact Dwarfs"), shares similar characteristics with dwarf coconuts, including slow growth. However, it is genetically distinct, suggesting independent domestication, likely in Tonga. Other niu leka cultivars may exist in various Pacific islands, some possibly arising from advanced crosses between Compact Dwarfs and Southeast Asian Dwarf types. While these broad categories help think about general coconut forms, much more nuanced differences exist in the growth, leaf, and fruit structure that define a broad range of coconut diversity. Unfortunately, because the coconut palm remains one of the crops that has received relatively little attention from scientists in terms of its economic significance and cultural relevance, documentation of distinct varieties remains limited (Bourdeix, 2008). Under Dr. R. Bourdeix's coordination, the International Coconut Genetic Resources Network (COGENT), has listed 419 coconut cultivars collected in 23 countries, (personal communication with Dr. Bourdeix, 2024). Among this collection, 22 varieties of coconuts were reported from Samoa as well as many coconut varieties from other Pacific Islands, which were documented and some distributed to various *in situ* and *ex situ* gene banks. Within the Samoan coconuts, "Niu Afa" and "Niu Kogau" are noted for their exceptional morphological appearance and associated traits. The Niu Afa is a Samoan ancestral niu variety associated with the function of sennit making where it holds the reputation to be the world's largest coconuts that is internationally named "Niu Kafa Tall Samoa (NKFT)." The Niu Kogau is also internationally named "Samoan Tall Spicata" (SMOT02)" and this extremely rare and exceptional form of the special appearance of spicate coconut inflorescences was well documented, acknowledged, and safeguarded (COGENT, 2017). Yet none of the local, national or international studies have included any Hawaiian coconut accessions. Thus, many of the Hawaiian coconut varieties remain undocumented.

1.3. Coconut Reproductive Biology

Coconut reproductive behaviors are complex and the conditions depend on various contributing biotic and abiotic factors. Understanding these multiplex sexual behaviors is a critical component of understanding coconut diversity and genetic lineages. Each coconut inflorescence emerges from the axil of most coconut fronds in a pointed spathe and gradually increases in size. When the inflorescence is fully grown it may be about 2.5 feet long and about 15” in diameter at the mid part. Once fully developed, the spathe splits open within 8-10 months to release the coconut inflorescence. Normally, each coconut inflorescence would carry 20 to 40 spikelets, which is monoecious by having both male and female flowers. Each spikelet is about 10” to 30” long and holds about 100 to 300 male flowers from the top down. Most of the spikelets (but not all) carry one or more female flowers at their base. The total number of female flowers in an inflorescence may vary based on genetic and environmental factors. The male flowers are the first to mature as the inflorescence opens beginning at the top of each spikelet and proceeding towards the base where each male flower has six stamens to release pollen. The duration of the male phase is about 20 days, but this varies according to variety and season (Bourdeix, 2012). The female flowers are spherical in shape with a diameter of 1” to 2” where they become receptive to male pollen about 3 weeks after the opening of the inflorescence. When they become receptive, the stigma expands as three erect teeth. The stigmas remain receptive to pollen for 1-4 days before they dry up. Once the pollination period is over, the stigma necrosis leaves a black dot at the end of the flower replacing the place of the stigmas (Bourdeix, 2018). At that point the fertilization is successful and the flower generally develops into a coconut that will fully mature within the next 11 months (see Figure 3).

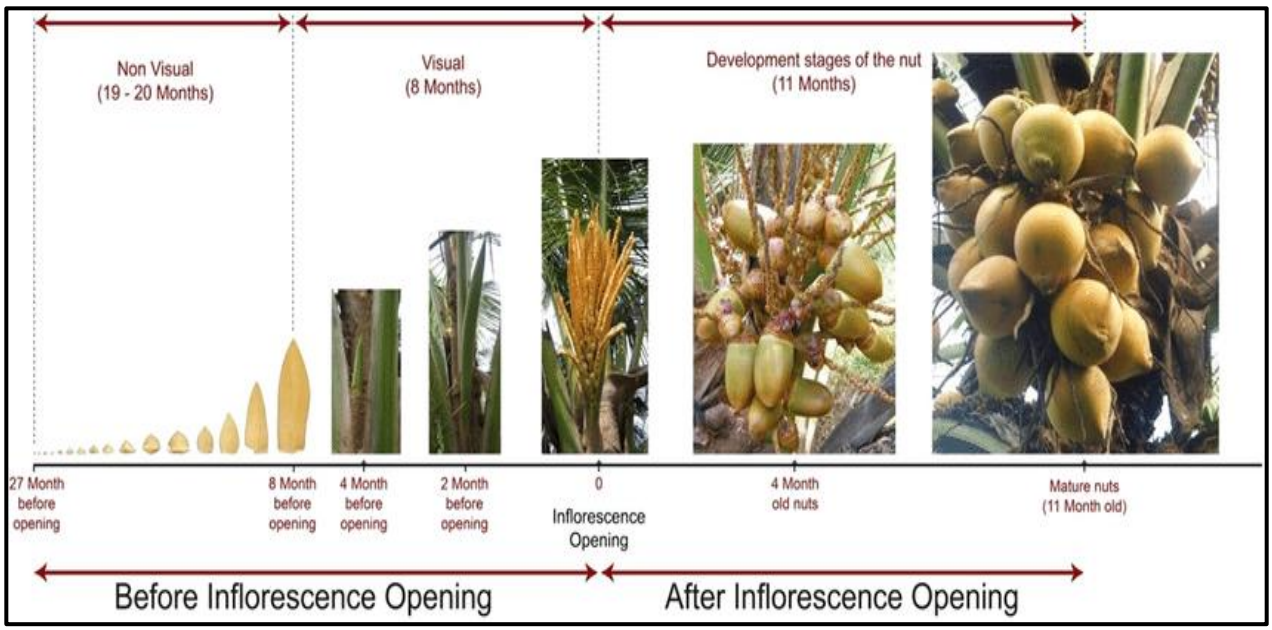

Figure 3: *Development stages of a coconut bunch (Source: Coconut Research Institute, Sri Lanka)*

The International Coconut Genetic Resources Network classifies coconut varieties into four groups based on their mode of reproduction (Figure 4):

- Type I, (strict allogamy): Short female phase with no overlap with the male phase of the same inflorescence or with the male phase of the following inflorescence.
- Type II, (preferential allogamy): Short female phase with no overlap with the male phase of the same inflorescence, but with partial, or rarely total, overlap with the male phase of the following inflorescence.
- Type III, (direct autogamy): Long female phase completely overlapping with the male phase of the same inflorescence, with or without overlapping with the male phase of the following inflorescence.
- Type IV, (semi direct autogamy): Short female phase partially overlapping with the male phase of the same inflorescence and with that of the following inflorescence.

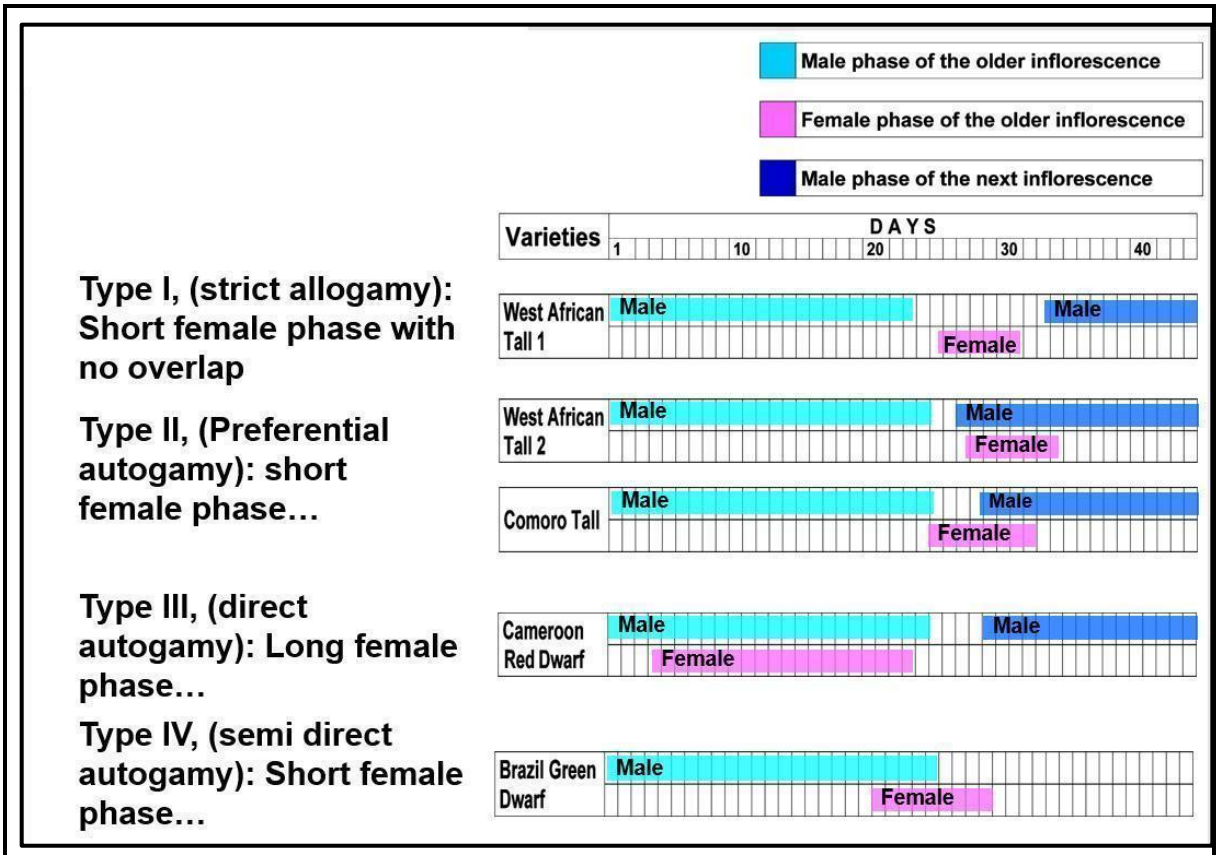

Figure 4: *Classification of coconut varieties into four groups according to their mode of reproduction.*

Source: Bourdeix, 2022.

Chapter 2. Coconuts in Hawai‘i

He niu aha kēi– What kind of coconut prayer/assembly is this?
He ‘aha niu ho‘ohui lāhui, ho‘ohui ‘ā– A prayer/assembly to unite people and land
He ‘aha niu, ho‘ohui aku, hui – A prayer/assembly to restore and reunite
(He Pule Niu, Ka Nupepa Kuokoa, Volume XXXVI, Number 42, 15 October 1897).

There are discrepancies between European and Hawaiian accounts of the importance of niu in Hawai‘i. Several historical botanical authors indicated that “Coconut did not do well in some parts of Hawaii nor Indigenous Hawaiian did not fully utilize the coconut as a vital resource to the near extent as some other Pacific Nations" (Buck, 1957). One of the earliest references connected to such accusations can be found in William Hillebrand’s 1888 book of *Flora of the Hawaiian Islands*, where he indicates that “the coconut palm reaches on our group the northern boundary of its range in the Pacific…although it does not yield such abundant harvests of fruit as in more equatorial latitudes…it [coconut tree] still thrives very well” (p. 452) in the Hawaiian Islands. From the early twentieth century till now, a number of authors continue to repeatedly present that statement on underutilization of the coconut as a vital resource (e.g., Handy and Handy 1972; Buck, 1957; Mitchell, 1982), but in repeating the original statement, many fail to acknowledge that the coconut tree “still thrives very well” (William, p. 452) in most parts of the Hawaiian Islands. In addition, Meyen, F. J. F. in the book *A Botanist’s Visit to Oahu in 1831* describes that the “The Indians [Hawaiian] scrambled up extraordinarily high trees quite like monkeys… As soon as the Indians had brought the nuts down, they took the nearest available stones and broken open the soft hull of the nut, which was then pulled off with the help of their teeth (Meyen, 1981, p. 52-53). Then he went further and provided an explanation of “coconut water” as “coconut milk” where he reported, “next a stone was driven into the soft upper part of the nut itself and the milk drunk out of it. To us the coconut milk, which is so often praised, seemed to be quite a tasteless drink” (p. 53). Knowing that to extract coconut water and milk are two separate processes and are totally different entities. Also, there are several contributing genotypic and phenotypic factors involved in determining the quality of coconut

water so premature statements of shortcomings like these have committed a greater disservice to researchers who later explained Hawaiian coconuts without in-depth place-based background situated within a more cultural and experiential understanding of the coconut.

Arts and Crafts of Hawaii, 1957, Buck discussed that "...early Hawaiians made less use of the coconut than did their kinsmen," where he further discussed coconut using a "...statement made by American soldier during World War II that the Solomon Islands coconuts were poisonous" (p. 66) and Buck rationalized this statement by saying that "was probably due to their having drunk the fluid from mature nuts that had fallen to the ground, in which case the results could have been poisonous" (p. 66). For a fact, today it's clear that the water of a matured coconut does not carry any kind of quality that can be labeled as poisonous for human consumption. But this man may have possibly unknowingly drunk an immature nut that fell off the tree and aged with rotten water and flush that sat for some time in the ground as the coconut trees may sometimes drop nuts prematurely to remediate biotic or abiotic stress conditions. Also, understanding the historical injustice to Indigenous Hawaiian cultural history allows us to better understand the current systematic mistreatment of coconut trees in Hawaiʻi. After the overthrow of the Hawaiian Monarchy in 1893, "urban spaces became increasingly defined by military occupation and efforts to erase Hawaiian cultural practices, geographies, and communities where more broadly, urban has come to connote congestion, ecological degradation, poorly planned development, and the excesses of tourism" (Āina of Kaʻōnohi at el., 2023). This increasing urbanization has forced many to lose the Indigenous Hawaiian understanding of kumu niu as a "the tree of life"- providing food, ecological services, and holding cultural value. Systematically becoming receptive to this adaptation, the perceptions of the coconut have shifted to thinking of these kumu niu as just a fruitless and formless "ornamental palm."

2.1. Niu in Hawaiian Practice

In 1875, coconuts from the uluniu (coconut grove) of Pōkaʻī Bay were showcased by the Hawaiian community of Waiʻanae to manifest their commitment and love for Her Majesty Queen Emma. A group traveled with sweet-watered coconuts from the coconut grove of Pōkaʻī

to gift to Her Majesty during her Oʻahu Island tour in October 1875 where "natives from distant Waiʻanae brought to Her Majesty quantities of their famous fine-flavored coconuts, called Pōkaʻī" (Girvin, 1910). This very uluniu was also mentioned in 1793; Captain George Vancouver, a British Royal Navy Officer, described in his log a coconut grove in Barber's Point as well as at Pōkaʻī Bay while navigating along the coast of Waiʻanae (McGrath, 1973). The book, *In Gardens of Hawaii* highlights that "formally in olden days, Hawaiian[s] ha[d] large groves of coco palms [where] like other Polynesians, [they] made use of all parts of the tree…the leaves were used for thatching and for plaiting baskets and fans, the midribs of leaflets made good brooms, and were used to string kukui nuts and copra for lights, to string some kinds of leis, and for pins" (Neal, 1965 p.130). On the Island of Molokai, Uluniu of Kapuāiwa provides an example of an anthropomorphic relationship where Hawaiian Royalty selected kumu niu to represent each one of 1,000 Hawaiian warriors. This spectacular commemoration, in 1860 by His Majesty King Kamehameha V, created this Hawaiian coconut grove that still exists today (Handy and Handy, 1972). During that very same decade of 1860, a letter written to a Hawaiian Newspaper, Nupepa Kuokoa, on 15 December 1865 by a Hawaiian mahiʻai (farmer) named Luhua expressed a coconut concern at that time as he wrote passionately: "…my fellow farmers, let us plant coconuts. Before, when our ancient chiefs were living, all of our beaches were made beautiful by the coconut groves. But we are the new generation who have grown tired of coconut trees and let them fall. These beautiful groves which made Hawaii proud are vanishing", he continued, "this is true, and we should be ashamed of ourselves" (English translation by Pukui). The decline of Hawaiian uluniu (coconut groves) planting practice had taken place since 1840 (Summers, 1990), but perhaps, this may have been a common community concern that mahiʻai Luhua had shared in writing. Also, the historical records show that during that very same decade of 1860, the Royal Uluniu initiative took place to establish an Uluniu at Kapuāiwa (Pukui, 1957) as maybe a solution to addressing such common cultural concerns.

However, today, over 158 years later the practice of uluniu in Hawaiʻi is yet to be rejuvenated. The deterioration of associated coconut knowledge, practices, and genetic material has

continued, and we have even greater concerns of a larger systematic coconut genetic erosion. There has still been very little done to document, preserve, and understand Hawaiian traditional coconut knowledge and/or coconut diversity within the Hawaiian Islands. With a lack of record-keeping or comprehensive coconut conservation strategies, the extinction of specific and unique coconut varieties could easily go unnoticed and undetected.

Accepting an invitation from a respected cultural organization, Queen Liliʻuokalani Trust and the Nihipali ʻOhana, a team from the non-profit organization Niu Now led by Dr. Manu Auli Meyer organized a visit to Molokai in February 2022 with a vision and a plan to document coconut diversity, select planting material and to set up a niu nursery system. During this visit, we witnessed the last standing of some of the oldest kumu niu in the uluniu of Kapuāiwa and Mapulehu, two of the oldest uluniu remaining in Hawaiʻi. Many of the ancient Hawaiian coconut groves are speeding toward the end of their life cycles without being acknowledged, replanted, or given proper maintenance. In a similar experience, in 2021, we witnessed an unsparing extinction of another glorious coconut grove of Hawaiʻi in West Oʻahu at the makai (ocean) tip of the ahupuaʻa (land division) of Honouliuli, at Kalaeloa point. Local cultural practitioners and kūpuna believe that this is the very location where Captain George Vancouver's log in 1793 described the existence of a coconut grove in the area at Barber's Point while navigating along the coast of Waiʻanae (McGrath, 1973).

2.2. Hawaiian Understandings of Niu

> "Niu-ole-hike (or Niuolahiki, Niuloahiki) occurs in Hawaiian legend as a mythical ancestor who can take the form of man, a coconut tree, or an eel at will, and those stretching power serves to form a bridge along which his descendant travels from Hawaii to the land of his ancestors" (Kamakau, S.M, 1961).

Hawaiian *moʻolelo* (traditional stories) and other written and oral sources provide evidence of the preexisting, sophisticated coconut practice and a strong embodiment of the coconut tree in the cultural epistemology of the Hawaiian Islands. Ethnohistory provides evidence that the

Indigenous Hawaiians had a strong relationship with the coconut tree. Examples include the hundreds of unique ways to describe the coconut, the uses, the fruit maturity stages (see Figure 5), the stories, ancient chants, and songs that describe the value of niu, the humanistic relationship, as well as the locations of uluniu and their linkages with deities of each island (Buck, 1957; Malo, 1951; Pukui, 1986; Edmondson, 1941; Handy and Handy, 1972; Neal 1965; Abbott, 1972; Graves et al., 2015). In addition, Native Hawaiian ethnobotanist Isabella Abbott revealed and revoked some thought-provoking questions on Indigenous Hawaiian uses of niu where "the unearthing of niu cordage and of a coconut grater at Waimanalo, one of the earliest known sites of Hawaiian Habitation, firmly establishes the plant's antiquity in the island and its early use, but questions about its history remain unanswered" (Abbott, 1972).

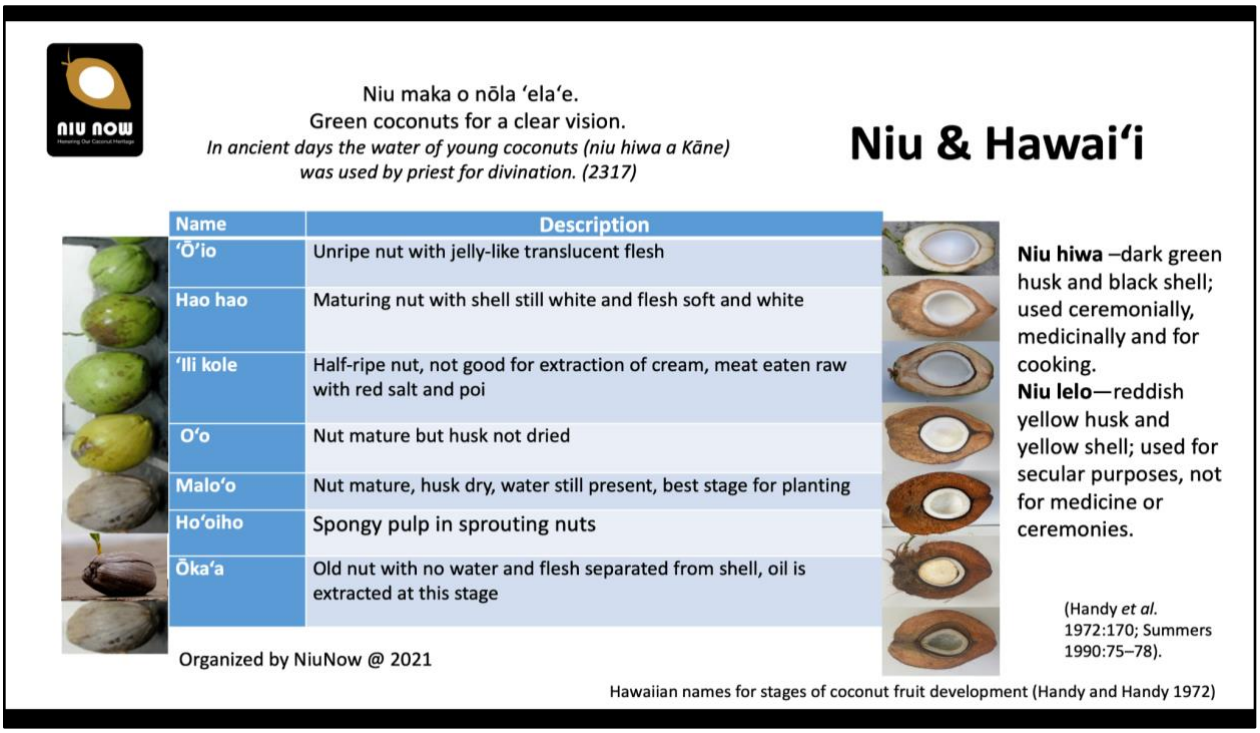

Figure 5: *Examples of knowledge detail in Indigenous Hawaiian descriptions of coconut fruit maturity stages and their usages.*

2.3. Indigenous Hawaiian Niu Varieties

> "Maui observes the sun from Wailohi and see where it rises. He fashions strong cord of coconut fiber from Peeloko (Paeloko) at Waihee" (Blackwith, P. 231, 1940).

It is commonly said that only two varieties of coconut are mentioned in historical writings, known as Niu Hiwa and Niu Lelo (Abbott, 1972; Handy & Handy, 1972). However, previous work in other Hawaiian crops has shown that these simplified dichotomies are incorrect. For instance, when research into kō (Hawaiian sugarcane varieties; *Saccharum officinarum*) was initiated, common rhetoric stated that only two varieties—kō 'ula (red cane) and kō kea (white cane)—existed, but deep ethnographic research uncovered over 80 names and 30 living varieties that have been shown to be uniquely Hawaiian (Lincoln 2020; Lincoln et al., 2022). It is not unlikely that Hawaiian niu varieties could be similar. For instance, Pukui (1957, p. 268) described five coconut varieties known to ancient Hawaiian communities:

1. Niu Hiwa – A variety of coconut with the husk of fruit dark green when mature and shell black. Used ceremonially, medicinally, and for cooking.
2. Niu Lelo – A variety of coconut with fruit reddish and shell yellow, used in many ways, but not ceremonially or medicinally.
3. Niu Hua Lau – A variety of coconut with very numerous small sweet fruits, coconut with many fruits.
4. Niu Polapola – A variety of coconut with large fruits.
5. Niu Kahiki – Foreign [or more lately introduced] coconut.

In addition, Pukui describes a special coconut tree management practice, Niu moe o Kalāpana, the supine coconut palm of Kalāpana where "young trees were bent over and made to grow crookedly, in order to commemorate great events; two of such trees were at Kalāpana in 1950" (Pukui et al., 1957). Today the concept of coconut trees with bending capacity is scientifically understood. as a very special variety of coconut trees with genetically embedded quantitative traits that allow the tree fibers to be flexible (Bourdeix, personal communication, 2023).

Scientists have also spotted trees with such flexible traits in Tahiti and other Pacific Islands. Today, observing Hawaiian coconut diversity by applying some of the scientifically understood standard morphological characteristics combined with the Indigenous traditional understanding of niu, the existence of vast coconut diversity is well notable (see Figure 6).

Figure 6: *22 of phenotypically differentiated coconut varieties from the island of O'ahu (Gunasekara 2020).*

2.4. Introduction to Niu Hiwa

Among any known ancient Hawaiian coconut varieties, the variety known as Niu Hiwa is considered to be the most respected and appreciated within most historical ethnobotanical writings and mo'olelo (Abbott, 1992; Buck, 1957; Malo, 1951; Pukui, 1986; Handy and Handy, 1972). According to historical studies, this particular coconut variety is closely associated with Hawaiian royal, ceremonial, and spiritual practices, in which Niu Hiwa was even protected within the kapu system (system of religiously-backed laws) restricting who should have access to Niu Hiwa. During the past decade of my independent coconut study in Hawai'i, I became aware of several contradicting descriptions regarding Niu Hiwa as well as many other coconut varieties,

including perspectives that Niu Hiwa appears only in mythological descriptions but not in real ethnobotanical existence. Yet, a few historical writings provide some morphological evidence (Abbott, 1992; Pukui, 1986; Handy and Handy, 1972) on how to differentiate some of the traditional Hawaiian varieties of coconut from other existing varieties. In addition, Hawaiian *mo'olelo* and other functionality-based oral traditions also have maintained knowledge of identifiable characteristics. Since Niu Hiwa was protected within one of the Hawaiian Indigenous conservation strategies (i.e. the kapu system), it is reasonable to believe that the recognition of 'Niu Hiwa' was not esoteric but once had been common knowledge among Hawaiians, as such knowledge systems still exist in many other historically coconut-related traditions in many tropical nations.

2.5. Niu Hiwa in Written Ethnohistorical Materials

A broad literature review was conducted of ethnohistorical sources with the primary goal of locating specific descriptions or identifying characteristics of Niu Hiwa. After conducting a thorough review of written material in English, a set of six morphological characteristics of Niu Hiwa were identified as (1) dark green fruits, (2) elongated coconut, (3) used in rituals and ceremonies, (4) protracted under Hawaiian kapu system, (5) black shell, (6) water of Niu Hiwa used to reach divination and to bless tools and weapons of war (Abbott, 1992; Malo, 1951; Pukui, 1986; Handy and Handy, 1972). A particular emphasis was given to the primary resources, as most written accounts in contemporary literature rely on second-hand accounts. Of particular interest was Hawaiian language resources. A preliminary search was conducted on the Papakilo Database to find mentions of "Niu Hiwa" in Hawaiian newspaper sources, all of which were assessed for relevance and translated as appropriate; however, after reviewing several newspaper articles that were translated from Hawaiian to English, we were not able to locate any subject-specific written description on Niu Hiwa. The only description found referred to the use of Niu Hiwa in cultural practices and some of the value status associated with Niu Hiwa. Two additional articles, written in 1858 and 1866, were located in which the community expressed great concern about cutting down coconut trees at "Waikiki Kai" and the decline of the planting

of uluniu practice (Ka Hae Hawaii,1856). While reviving the Papakilo database, Kumu Aulii Mitchell was able to locate a few mentions of Niu Hiwa and Aiponokamoku Valente assisted in this review in collaboration with Dr. Noa Lincoln and the Indigenous Cropping Systems laboratory.

2.6. Hawaiian Knowledge and Conservation of Niu

> "Kane-huna-moku, Hidden Island of Kane… Kane-huna-moku has its birth from another island called Ni‘u-roa-hiki, Long-coconut-that-travels. This land belongs to Hawaii but it is farther away and does not come to Hawaii. It is a land of the gods. Here Kane, Lono and Kanaloa first made land, then they made man there, Ni‘u-roa-hiki is the name of the path by which one reaches that land. It is a land of sacred coconuts. Only the gods are there" (Kepelino et al., p. 189, 1932).

As with most Hawaiian crops, the substantial decline in their production and usage accompanied the cataclysmic decline in the Hawaiian population and the overthrow of the socio-cultural systems that governed the islands before European arrival (Lincoln and Vitousek, 2017). The mo‘olelo and a historical record reveal that a well-known uluniu of Helumoa in Waikiki was planted by Chief Kākuhihewa, the ruling Chief of O‘ahu from 1640 to 1660. The mo‘olelo discusses that a supernatural rooster flew down from Ka‘au Crater in Pālolo and then landed at Helumoa where the rooster scratched the dirt at Kākuhihewa's feet and then mysteriously disappeared. At that event, Chief Kākuhihewa immediately ordered his people to plant a coconut tree at the exact site which grew to be the tallest in the area. Then later that single tree has become the parents of an entire grove of over 10,000 coconut trees that became to known as Helumoa (Stone, 1926). Then continuing this legendary practice, in the 1860s King Kamehameha V, who established the uluniu of Kapuāiwa in Molokai also chose the uluniu of Helumoa as his home in O‘ahu.

Today, these types of historical associations are globally respected and appreciated by the scientific communities, especially by The International Coconut Genetic Resources Network (COGENT). Their publication *A Global Strategy for the Conservation and Use of Coconut*

Genetic Resources, 2018-2028 pinpoints that "at the global level, coconut research remains insufficient with regard to the social, economic and cultural importance of the plant" (Bourdeix et al., 2017). In particular, Hawai'i remains weaker in coconut-related research as coconut hasn't yet been officially recognized as a vital cultural, nutritional, or ecological resource. Further, COGENT, in particular, values and empathizes with the existence of Indigenous coconut knowledge:

> "Local traditional knowledge, especially from the elders, must be preserved and shared by elders with other community members and the younger generation. Scientific and technical knowledge produced by researchers must be made more easily accessible, understandable and user-friendly to these farmers. In some cases, the scientific and traditional knowledge can be contradictory. Such situations must be carefully managed because scientific knowledge can obliterate traditional knowledge" (p. 157).

Thus, gaining a better understanding of Indigenous Hawaiian knowledge related to Hawaiian coconut diversity is vital.

Globally, various researchers have attempted to expand the worldwide understanding of the original ancestral varieties of coconut and the original base of coconut. Among those studies, the scientific journal article *Floating, Boating and Introgression: Molecular Techniques and the Ancestry of Coconut Palm Populations on Pacific Islands* (Harries et al., 2004) has described about 340 vernacular names of coconut varieties in 32 different demographic locations most in the Pacific Ocean and some in the Indian ocean. Among those about 340 varieties, 34 of those vernacular names are directly associated with the same name describing the general coconut name 'niu' that is also used in the Hawaiian Language. Also, some of the names used to describe coconut varieties are used commonly in different demographic locations. However, the name Niu Hiwa or any other known Hawaiian vernacular names of coconut varieties are not identified in any of those mentioned 32 locations. Another analysis that attempted to draw an understanding of the original ancestral home base of coconut has highlighted two predominant fruit types based on coconut fruit morphology linking them with two known traditional Polynesian varieties. One

form is the ‘niu kafa’ characterized by oblong, triangular fruits surrounded by a larger proportion of fibrous husk. The second form ‘niu vai’ fruit is described as being rounded with a large proportion of liquid endosperm (Whitehead, 1966; Harries, 1981). According to this argument of coconut migration using only the outside physical shapes of coconut fruit, Whitehead and Harries discuss that the form of ‘niu kafa’ is closely related to the existence of ancestral morphology that assembles. Harries discusses that natural selection mainly took place in independent ocean dispersal while the form of ‘niu vai’ is to be an assembly of human selection for coconut cultivation purposes. However, this finding will not make a conclusion but makes that arguable since (1) the wild coconut populations are unknown and the population selection made for the study is based on cultivated coconut, (2) the assumption made on dispersal as a essentially mechanistic, but not considering probabilistic conditions and potential impacts on such events of tsunamis, hurricanes and other forces of nature on long-distance coconut dispersals, (3) the Indigenous understanding of coconut was disregarded as some of the well-known large and long thick-husked fruits such as niu afa were also selected by Polynesians and Arabs to produce ropes (COGENT, 2017).

Chapter 3. Thesis Purpose and the Methods Applied

Wāhi ka niu. Break open the coconut. The breaking open of a young fresh coconut for the gods was a sign of piety in ancient times, (Pukui, 2899. 2011).

Hawaiʻi is in great need to conduct a comprehensive study on Hawaiʻi's coconut genetic diversity and to aggrandize the associated Indigenous practices. There has yet to be a targeted approach to differentiate and document the uniqueness of Hawaiian coconut genetics and not just compare similar varieties found in Polynesia or elsewhere. In addition, there is a need for a culturally driven scientific approach to support the coconut grove system and to encourage the community to utilize coconut as a sustainable, climate change resistant and culturally appropriate food source in Hawaiʻi. To contribute to the understanding of Native Hawaiian coconut diversity and to develop a better understanding of appropriate documentation of current coconut genetic resources in Hawaiʻi, I proposed to conduct a subject-specific survey to clearly describe the characteristics of Niu Hiwa and facilitate the identification of the morphological characteristic of coconuts with a trained eye. Broadly, to answer the following questions:

1. What are the distinguishing characteristics of Niu Hiwa?
2. Does Niu Hiwa still exist?
3. Using the distinguishing characteristics of Niu Hiwa found in ethnobotanical literature, contemporary ethnographic research, and data collected from current knowledge holders can Niu Hiwa be differentiated from other coconut varieties today?

During a two-day event called *AHA HOOLOKAHI* - 2023 a Native Hawaiian Health & Wellness *Summit* at the University of Hawaiʻi West Oʻahu in June 2023 - a team of us led a coconut workshop to describe Hawaiian niu diversity and coconut fruit maturation stages. During this event, I met with three Indigenous Hawaiian Cultural practitioners who were interested in gaining a better understanding of niu diversity and were also knowledgeable of niu-related traditional practices. While discussing matters regarding the Hawaiian understanding for recognizing Niu Hiwa, we discussed several associated complications. All three practitioners

discussed Niu Hiwa-related misinformation within their fields. These three practitioners often conduct ‘awa ceremonies. One practitioner shared his understanding of Niu Hiwa to be only a “niu with a dark shell” without any regard to any other characteristic or appearance to an actual coconut tree, not taking into account any other morphological characteristics of the fruit of the coconut tree. At the end of each discussion, participants shared a desire to improve their own knowledge of Niu Hiwa and find a path for getting a better understanding of Niu Hiwa as a coconut variety.

3.1. Unstructured and Semi-structured Interviews

I utilized a methodology of ethnographic engagement specifically adapted to Hawaiian communities called Mā‘awe Pono (Kahakalau, 2019). Mā‘awe Pono, compared to traditional ethnographic methods, includes a greater commitment to place-based knowledge about Hawai‘i and its people. Central concepts include local protocols, communication styles, and trust building. Mā‘awe Pono also includes a strong heuristic element, similar to planning research methodology (Raja et al., 2018), in that it involves the researchers on a personal level, includes intuitive judgment and a spiritual dimension and relies on common sense (Kahakalau, 2019). Accordingly, the interview process was designed to be participant-led, with the flow and order of questions for each interview based on each practitioner's experience, mood, and topics they introduced. This is essential in Hawaiian cultural approaches where “mining” for information can be seen as extractive and exploitative. In many cases the more direct your pursuit of specific information, the less likely you may be to receive it. The questions asked were open-ended and were directly related to the themes of the practice that each practitioner conducted that related to the use of niu, and their understanding and experience with Niu Hiwa. The style of the interview was to let the practitioner share stories and only ask questions to gain a deeper understanding of the parts that are associated with niu. The specific questions asked would include but was not limited to Niu Hiwa-associated mo‘olelo, stories of places, land use, niu-associated land and community, spiritual applications, and history of uluniu.

One of the significant challenges was to locate a diverse group of knowledgeable practitioners who were willing to share their knowledge and understanding of Niu Hiwa. Several cultural practitioners that we approached for this study were unable to share or discuss much-needed information on Niu Hiwa or any subject-relevant information about Hawaiian niu diversity. Thus, it took over 3 years to make the connection and to specifically connect with 10 respected cultural practitioners who are able to describe Niu Hiwa. Those interview connections were made through personal relationships and direct outreach. Many connections were made through practitioners in our Niunow.org coconut revitalization social network, many of whom I have worked with previously. From his ethnobotanical network, Dr. Noa Lincoln suggested several other respected practitioners, resulting in two respected interviewees knowledgeable of Hawaiian epistemology, ethnobotany, and especially Niu Hiwa. All 10 interview participants are well aware of this study and 8 of them—Kumu Aulii, Kumu Kahiapo, Uncle Calvin, Kumu Pulama, Kumu Kalei, Uncle Bobby, Brothers Juston and Mahi—have provided verbal approval to use their names and the information shared. At the time of writing, 2 practitioners in a remote location in Maui had yet to get back to me to confirm their consent to be included. Thus, those 2 practitioners are left without identifying with their names and titles in this survey. The meeting locations were determined by each interviewee. They primarily chose to meet where they conduct their practice. A single interview (Kalei Nu‘uhiwa) was conducted by video conference (Zoom) as we were unable to meet in person. Interview meetings often included a field tour to visit surrounding coconut trees and/or significant ancient sites. Interviews were conducted in a private area, typically with only the two of us present. Interviews were conducted over 4 years from March 2020 to February 2024 and some of them met over 6 times during this period. The trust and relationship-building approach based on’Mā'awe Pono methodology of ethnographic engagement (Kahakalau, 2019) was critical in conducting interview processes.

Subject-specific questions explored the specific characteristics, associated functions, and historical ethnobotanical and demographic information of Niu Hiwa. Although specific questions were prepared, the timing and phrasing of their delivery was based on the flow of the discussion with the interviewees. Interview participants were identified and selected for this interview

process based on their ethnobotanical understanding of Hawaiian plants and associated Hawaiian knowledge systems, with some based specifically on Niu Hiwa. The interview participants were selected to represent multiple islands, including participants from the islands of Oʻahu, Molokai, Maui, and Hawaiʻi Island. Three practitioners were interviewed on Oʻahu; two practitioners were interviewed in addition to having an informal "talking story" type discussion with two cultural practitioners on Maui; two in-depth discussions with practitioners were conducted on Molokai and one interview with a Kumu Hula on Hawaiʻi island. All 10 participants were born and raised in Hawaiʻi, and are respected cultural practitioners who take active roles in the communities as educators and activists.

Where possible, the interviews were digitally recorded using an iPhone voice recorder; for the Zoom meeting, the Zoom recording option was used. For all interviews, written notes were taken during and immediately after the discussion. Semi-structured interviews were transcribed or summarized depending on the formality of the interview and all of those records were copied into a Microsoft Word doc and indexed. As the topics discussed in the interviews were necessarily wide-ranging to adhere to our methodology, the transcriptions/notes of the interviews do not include the entire interview, but only the parts that are directly or indirectly related to the subject of Niu Hiwa and the key points (see Appendix 1). For all interviews, key takeaways are identified and summarized, then organized into common themes.

3.2. Engagement in a Reciprocal Relationship with Participants

During this interview process, various coconut-related questions were discussed. Also, various questions were asked by practitioners knowing that I'm also a lead in Niu Now and engaged in various coconut-related community activities. Thus, collectively sharing what each one of us knows about the best practices on safeguarding coconut diversity and planting of uluniu and the discussion of rare varieties also became a part of our discussions.

3.3. Morphological Documentation

A morphological survey assessing demographic information and 10 morphological characteristics was designed using select features from the existing surveys from (1) the International Coconut Genetic Resources Network (1996), (2) the International Union for the Protection of New Varieties of Plants (2014) and (3) the subject-specific personal training I received in Taveuni, Fiji, from May 20 to 22, 2021 attending "FAO – BSF4-PR363 Project" on safeguarding threatened coconut diversity within the upgraded International Coconut Genebank for the South Pacific.

To explore if Niu Hiwa has a unique morphology by standards today, a set of ten morphological factors that are easily observable and represent features commonly important to Indigenous coconut practitioners were applied to document trees today (Table 1). Between October 2019 to February 2024, 260 trees were documented on 5 islands: O'ahu (n=152), Molokai (n=28), Maui (n=42), Hawai'i (n=35), and Lanai (n=3). Trees were opportunistically sampled and selected to represent diverse morphologies and a broad geographic range. For instance, in traversing the Puna coast of Hawai'i Island, throughout the islands of Maui and East Molokai, thousands of trees were observed, but primarily were of the same type, and only a handful of trees that exhibited unique features were documented. To the extent possible, ethnographic data was collected by talking to the tree owners, knowledgeable kupuna (elders) or community members. Trees that were sampled occurred in a range of settings, including ancient groves in remote locations, historic groves, state parks, landscaped areas, and backyard trees. The purpose of this broad sampling was to build a database that represented the overall coconut diversity in Hawai'i. Several outreach methods were used to get access to various private properties, to build needed social and professional relationships, and utilize various communication methods and tools including social media and NiuNow's social network. In addition to the opportunistic sampling, we specifically sought trees that were identified to be Niu Hiwa. This was done by (1) leveraging social networks of cultural practitioners and ethnobotanical researchers to request access to Niu Hiwa trees and (2) leveraging the interviews to request access to Niu Hiwa trees.

All trees were documented in terms of their location, ethnographic information, and morphological features. A complete list of the morphological features documented, the potential outcome for each feature, and method used for determination, and the source of the documentation standards are compiled in Table 1. Post-collection data processing converted the number of fruits per bracket, which was originally collected as a continuous variable, into an ordinal classification using a natural breaks algorithm in JMP (SAS, Cary, NC). The morphological features were selected to (1) be relatively easily observable so that community members and practitioners might be able to undertake the observations without excessive trouble, (2) to be culturally relevant, such as including the classification of female and male descriptions that is derived some indigenous understanding (having a pointed fruit with a small nipple to be male, and if inward to be female (Bourdeix et al., 2013), but not related to botanical sex, and (3) to include breeding behavior so as to understand the potential for genetic preservation or dilution. To determine the age of an adult palm, a correlation with the number of leaf scars divided by 13 was used to give the approximate age of the palm in years (Mahindapala, 1991).

Place-specific coconut-related historical information specific to the area and the trees are documented, place-specific ethnobotanical information and local vernacular and understanding of some of the coconut varieties was collected by talking with tree owners, knowledgeable kupuna (elders) and various community and private stakeholders where possible. Open-ended, questions were asked in order to assess available historical and cultural information as well as the condition of the other surrounding coconut trees in the given environment. Place-specific information was also gained through research on historical sites and place names of Hawai'i as well as by utilizing existing social connections. Mediation theories (Rogers et al., 2019) were also employed.

Ethnographic data was coded using an Excel sheet into groups that included (1) Niu Hiwa, which was all the trees that had testimony by practitioners to be of the Niu Hiwa Variety, (2) Old Type, which was all the trees that had strong ethnographic evidence to have clear lineage to pre-European contact trees in Hawaiʻi and a high likelihood of genetic isolation from introduced

varieties, (3) Dwarf, which were all trees exhibiting a dwarfing growth pattern, (4) Foreign, which were coconut trees that were described as introduced varieties with given names, (5) Old Groves, which were trees from large old groves which may have been pre-contact or during the historic era, and (6) Unknown, for which inadequate ethnographic data existed to make a confident classification.

Morphological characteristics were inputted into a spreadsheet database and then used to create a dendrogram in JMP depicting phenotypes. The dendrogram was explored using ethnographic classifications. In addition, special attention was given to the trees testified by practitioners to be Niu Hiwa trees.

Table 1: Morphological features used to characterize coconut tree phenotypes through ethnobotanical survey with 10 selected characteristics applied.

Characteristics Selected	**Information Collected**	**Method Applied & Tools used**	**Referenced Used:**
Stem Stature	1). Tall, 2). Dwarf, 3). Compact Dwarf	Measurement of the distance within 13 base scars; appearance of fronds, and length of the petiole considered	ICGRN (1996), IUPNVP (2014), GSCUCGR (2018), personal training by R. Bordiex
Stem Bole	1). Yes, 2). No	Visual observation of the trees and documentation using digital pictures.	IUPNVP (2014)
Size of the Fruit	1). Large, 2). Medium, 3). Small	Visual observation of the fruits and documentation with digital pictures.	MSRTCB (1996), IUPNVP (2014)
Shape of the Fruit	1). Circular, 2). Elliptic, 3). Obovate, 4). Ovate	Visual observation of the fruits and documentation with digital pictures.	IUPNVP (2014)
Dominant Color of the Fruit	1). Green, 2). Brown, 3). Orange, 4). Yellow	Visual observation of the fruits and documentation with digital pictures.	IUPNVP (2014)
Number of fruits in a branch	Average number of fruit per branch	Visual observation of the fruits and documentation with digital pictures.	MSRTCB (1996)

Gender of the Fruit	1). Male, 2). Female	Visual observation of the fruits and documentation with digital pictures.	Bourdeix et al., (2013)
Size of the Crown	1). Large, 2) Medium, 3). Small	Visual observation of the fruits and documentation with digital pictures.	IUPNVP (2014)
Shape of the Crown	1). Spherical, 2). Semi-spherical, 3). X-shaped, 4). V-shaped	Visual observation of the fruits and documentation with digital pictures.	IUPNVP (2014)
Breeding behaviors	1). Allogamy, 2). Direct Autogamy (I), 3) Indirect Autogamy, 4). both Direct and Indirect Autogamy	Used high zoom camera (x800) and/or drone images, visual examination.	Subject-specific personal training in Taveuni, Fiji, from May 20 to 22, 20“1 "FAO – BSF4-PR363 Project Safeguarding threatened coconut diversity within the upgraded International Coconut Genebank for the South Pacif’c." GSCUCGR (2018), and personal communication with Dr. Roland Bourdeix.
Resource abbreviations: MSRTCB (1996), Manual on Standardized Research Techniques In Coconut Breeding (1996); IUPNVP (2014), International Union for the Protection of New Varieties of Plants (2014); GSCUCGR (2018), A Global Strategy for the Conservation and Use of Coconut Genetic Resources, 2018-2028; ICGRN (1996), Bourdeix et al., (2013).			

3.4. Expert Observation

I am also the co-founder of Niu Now, a grass-roots movement of a community-based coconut gene banking practice active since 2018 with a vision where “we envision niu as a relationship rooted in community and aloha ‘āina.” Since 2018, Niu Now has initiated various coconut-centered community functions. In 2022 Niu Now provided a five-day ‘ike niu (coconut workshop) with kupa‘āina (locals) in Molokai and returned an additional three trips to plant and disperse from a community-planted niu nursery in Ho‘olehua. We have since helped with planting four uluniu on Molokai. In addition, I’m leading the Niu Now in Hawaiian niu diversity documentation, various professional coconut workshops, setting of 13 different documented niu germplasm and supporting the planting of 25+ uluniu throughout O‘ahu, Molokai, and Maui. In addition, In November 2023, I was invited by COGENT to present (on Zoom) some of my work at the International Conference on Conservation Valorization and Exchange of Resources and Germplasm for Economic Development of the Coconut Industry (I-CONVERGED) held in Laguna, Philippines. Combining the scientific understanding of coconuts with my inherited Southern Sri Lankan coconut practice carrying over 20 years of field experience combined with a team of local subject matter experts including Mahi LaPierre (who is one of the interviewees) and Jesse Mikasobe-Kealiinohomoku and a team of us has developed an export observation strategy to deepen our understanding of Hawaiian niu diversity. In May 2023 I received a specialized coconut training in Taveuni Island in Fiji attending a three-day hands-on workshop on “Safeguarding Threatened Coconut Diversity Within the Upgraded ICG-–P - Workshop.” In addition, during the same visit, I assisted one of the world’s senior coconut researchers, Dr. Roland Bourdeix for 4 days of special field observations of coconut diversity on some documented varieties where I also received subject-specific one-on-one training. Collectively, this expert understanding of coconut diversity is also being utilized as one of the methods.

Chapter 4. Results

Overall, this research process was conducted over 4 years and some of the interviews were conducted multiple times. In addition, a number of the coconut trees reported on this survey were visited multiple times to ensure the accuracy of the morphological data documented.

4.1. Interviews Overview

In total, six interviews and four informal discussions were conducted with various coconut practitioners, educators, and kūpuna across the state. For some interviews and discussions, we collectively asked questions, conducted uluniu field explorations, examined trees, and mapped characteristics. The times of the interviews were varied, with the shortest interview being about 40 minutes long while the longest was over 10 hours altogether including discussion, specific Niu Hiwa site visitation, examination of shells for dark color, and other related activities over a period of 3 years (and still to be continued). Following interviews, participants discovered new information regarding Niu Hiwa (whether through a historical record or from a discussion) and they notified me. I incorporated this additional information into the dataset. The framework of Mā‘awe Pono has an embedded heuristic element involving the researcher’s personal connections and common sense—a shared Indigenous practice in the aspect of building relationships (Kahakalau, 2019). Thus, this framework allows the interview participants to speak their truth in their own words and to feel comfortable in sharing their perspectives. Application of institutional-based standardized methods would not have been successful in reaching this subject-specific practitioner community with rich esoteric knowledge of Niu Hiwa. During most of the interviews, the style of unstructured interviews and discussions led to interviewees sharing their stories related to their practice while discussing different subjects. I ask specific questions that enable me to get a better understanding of specific characteristics, associated functions, associated historical ethnobotanical, and demographic information related to niu. One of the main components taken into consideration for selecting parties for this interview process is the participants’ ethnobotanical understanding of Hawaiian plants and associated Hawaiian

knowledge systems. Thus, all of those components created a mutually understood sincerely harmonious environment where all of the interviews took a natural flow in a culturally grounded comfortable setting where I felt safely invited to ask questions. Most interviews took place in a private area with only the two of us present. Most of the time the practitioners I interviewed connected Niu Hiwa with Hawaiian epistemological understanding where we discussed many other niu, land, and people-related practices embedded within Hawaiian culture and Sri Lankan understanding as well as techniques on recognizing coconut fruit maturity, genetic diversity and planting of coconut grove systems, as well as we sharing meals and gifting each other with what we grow in our māla. Instead of asking a fixed list of ordered questions, the questions asked are open-ended and are directly related to the themes of the practice that each practitioner conducted that related to the use of niu and their personal understanding and experience with Niu Hiwa. Practitioners shared stories and discussed the parts that are associated with niu in their practice and the questions were asked only to seek more information regarding the subject. During the discussion, most of Niu Hiwa-related themes were opened naturally by the practitioners and they shared with me without directly asking about them. Interviews took the shape of "talking story" that also included several associated mo‘olelo stories of places, land use, needs of the communities, land and community related deeper spiritual applications, history of uluniu and associated knowledge and related current issues. During the interviews they also asked questions regarding the coconut work that Dr. Manu Aluli Meyer and I are involved as co-founders of Niu Now which allowed us to build a common ground, deepen our common understanding of coconut diversity as well as each other's work and build even connections to deepen our personal relationships as well as our future work on revitalizing niu associated functions. Therefore, the interviews allowed us to document an Indigenous relationality-based practical sense of place as it relates to use of Niu Hiwa from the perspectives related to a number of different cultural applications.

At the beginning of this interview process, a personal discussion with a Hawaiian *apu* (coconut shell cup) making practitioner and a wood carver, Lance (Mahi) LaPierre describes the challenges he faces in recognizing the true characteristics of Niu Hiwa today. Mahi uses over

1000 coconut shells to create ‘*apu* in any given year. Over decades of practice, he has not yet been able to come across the true tree of Niu Hiwa tree. Since Mahi and a team of us began our observations to gain a better understanding of Niu Hiwa and Hawaiian niu diversity where we have learned to identify some of the true characteristics of Niu Hiwa.

Out of the 6 interviews and 4 discussions, 9 participants have had some direct connection with the Niu Hiwa tree as they used the apu made of Niu Hiwa during ‘awa ceremonies. Also, 3 of them were able to direct me to a tree and testified the trees to be Niu Hiwa as they would go to those kumu niu to find fruits to support culturally rooted spiritual functions. Common features were described that closely align with descriptions found in the ethnohistorical literature review, including the green fruit, elongated fruit shape, black shell to the nut, and sparse fruiting patterns (Abbott, 1992; Malo, 1951; Pukui, 1986; Handy and Handy, 1972). Some of the practitioners have inherited this specific knowledge to recognize Niu Hiwa from their kūpuna and were able to apply that esoteric knowledge to recognize the tree as Niu Hiwa. One of the interviewees, brother Justin Kawai‘ae‘a Avelino, moved to Molokai from Hawai‘i Island. As a mahi‘ai practitioner, he needed to find Niu Hiwa on Molokai in order to perpetuate his ceremonial practices. Specifically, he was in search of coconut trees with sharply pointed and very elongated green fruits. In addition, taking us over to see the Niu Hiwa tree, he explained the appearance of the “clean shape of the tree crown” with very few fruits as another indication of the Niu Hiwa tree. Also, Kumu Aulii Mitchell explained how he inherited the esoteric knowledge to recognize Niu Hiwa fruits when he was a student under his Kumu Hula mother who would bring Niu Hiwa from Puna, Hawai‘i Island to conduct ceremonies and rituals associated with Hula practice. Many other practitioners who had access to Niu Hiwa trees were confident of their characteristics because they knew where the tree originally came from and that Niu Hiwa were elongated green fruit with dark black shells. On many occasions, the original trees had been gifted by a respected kupuna as a cultural gift similar to the Niu Hiwa tree at Ka Papa Lo‘i ‘o Kānewai, which Kumu Kahiapo confirmed to be a gift Uncle Harry Michel brought from Keanae, Maui. Kumu Kahiapo connected planting Niu Hiwa to Hawaiian epistemological practice as “supporting Hawaiian varieties of niu to keep their genealogy alive.” On the other

hand, one interviewee from Maui expressed a doubt on Niu Hiwa where she thought the Niu Hiwa was not an actual coconut tree but an expression of a mythology. According to her, after reviewing a number of early Hawaiian newspaper articles and discussing with a number of botanists, she's still unable to locate any Niu Hiwa trees or to find anyone who can identify Niu Hiwa trees confidently after over a decade of her practice. Also, due to the extreme level of cultural value and respect associated with Niu Hiwa, she began to believe Niu Hiwa may not be an actual coconut tree. On the other hand, she's knowledgeable of the characteristics of Niu Hiwa to be a dark green, elongated fruit with a very dark black shell.

In addition, while a team of us were working on organizing a coconut germplasm on the Island of Molokai in February 2021, a respected community elder and agroforestry practitioner, Uncle Bobby Alcain introduced us to another coconut variety very similar to the one Pukui (1957) categorized as Niu Polapola (see Figure 7),"a variety of coconut with large nuts." On the Island of Molokai, according to Uncle Bobby Alcain, this large nut is locally recognized as "Niu Cocolele" (coco-lele) connecting it to an ukulele-style musical instrument that is made using a part of the large coconut shell. He also explained that this variety holds a reputation for being able to hold a large amount of sweet wai niu (coconut water) which is another reason why he chose to plant this variety of niu in his dry land māla (farmland). During this same visit to Molokai, another well-respected community elder introduced us to Niu Hiwa. Examining the morphological characteristics comparison with Pukui's 1986, description, the tree appeared to meet the description of "a variety of coconut with husk of fruit dark green when mature and shell black." We collected eight matured coconuts, known in Hawaiian as malo'o, to set on our germplasm. Later, a student from Queen Liliuokalani Trust identified the seed coconut and presented us with the seed nuts as Niu Hiwa (this conversation was experienced by Adam Kekaulalani Hanohano).

Figure 7: *A sectioned (left photo) and whole (right photo) Maloʻo, fully matured fruits of Niu Cocolele (top right corner) and Niu Hiwa (bottom left corner) within a selection of old varieties of niu of Mapulehu and Kapūaiwa, Molokai, 2022.*

4.2. Morphological Overview

Data was reviewed to find some of the characteristics common to Niu Hiwa and other coconut trees, especially the trees reported as old types and from old groves. Out of the 260 trees classified morphologically, 126 were confidently prescribed to an ethnographical category, while 134 were classified as unknown. Five trees were testified by interviewees to have been Niu Hiwa. In addition, 52% of the trees (136 trees) were reported to have direct or indirect autogamy, and 41% of the total tree (122 trees) crowns appeared to be a "semi-spherical" shape. Old type and old grove have a higher percentage of trees where 56% of trees appeared to have a semi-spherical shape.

The 260 trees classified demonstrated a broad range of morphological combinations to show a large number of phenotypes (Figure 8). While we observed the resulting dendrogram for patterns based on location and ethnographic description, no strong patterns were evident. The strongest clustering based on our classification was the dwarf varieties largely grouping together in the lower half of the resulting dendrogram. Even trees that were classified as "Old Type" displayed a broad diversity of phenotypes, which could suggest that coconut variation in old Hawaiʻi was diverse, or that even these trees that we had good reason to suspect were old type varieties have experienced cross-breeding with newly introduced genetics.

Five trees were testified to be Niu Hiwa in four separate locations on O‘ahu, Maui and Molokai islands. All five Niu Hiwa trees clustered together, representing the first cluster in the dendrogram (see figure 8). The five Niu Hiwa were clustered with 12 other trees, 4 “Old Type”, 6 “Old Grove" and 2 “Unknown” varieties. All 17 trees are very tightly clustered, differing only in the size of the fruit, with four having large fruits and the other nine having medium fruit. That all the testified Niu Hiwa cluster together, despite the large amounts of phenotypic variation documented, strongly suggests that Niu Hiwa is a specific variety of coconut that is identifiable and consistently recognized by those who understand the variety.

Table 2: Morphological features of the trunk, crown, and breeding and their distribution according to ethnographic classification of the coconut trees observed on five Hawaiian Islands for this study.

Classification	Bole		Crown Size			Crown Shape			Breeding Behavior			
	No	Yes	Large	Medium	Small	Semi-spherical	Spherical	V-shape	Allogamy	Autogamy (D, I)	Autogamy (D)	Autogamy (I)
Dwarf	25	13	9	28	1	15	23	0	11	0	15	12
Foreign	3	7	4	6	0	3	6	1	4	0	6	0
Hiwa	0	5	0	5	0	5	0	0	0	0	0	5
Old Grove	21	10	13	18	0	24	6	1	19	0	0	12
Old Type	25	17	27	14	1	20	20	2	22	1	1	18
Unknown	57	77	90	39	5	55	62	17	68	0	39	27

Table 3: Morphological features of fruit size, shape and color and their distribution according to ethnographic classification of the coconut trees observed on five Hawaiian islands for this study.

Classification	Gender		Fruit Size			Fruit Shape				Dominant Color				Number of Fruits				
	F	M	Large	Medium	Small	Circular	Elliptic	Obovate	Ovate	Brown	Green	Orange	Yellow	< 5	5 to 8	8 to 11	11 to 16	> 16
Dwarf	25	13	14	24	0	21	5	7	5	4	26	8	0	4	14	17	3	0
Foreign	4	6	3	2	5	4	2	3	1	0	2	8	0	1	2	3	3	1
Hiwa	0	5	1	4	0	0	0	0	5	0	5	0	0	5	0	0	0	0
Old Grove	3	28	18	13	0	1	3	8	19	1	24	6	0	12	14	5	0	0
Old Type	16	26	15	27	0	6	11	2	23	5	31	6	0	10	5	12	13	2
Unknown	83	51	91	35	8	30	27	30	47	19	85	29	1	16	47	44	18	9

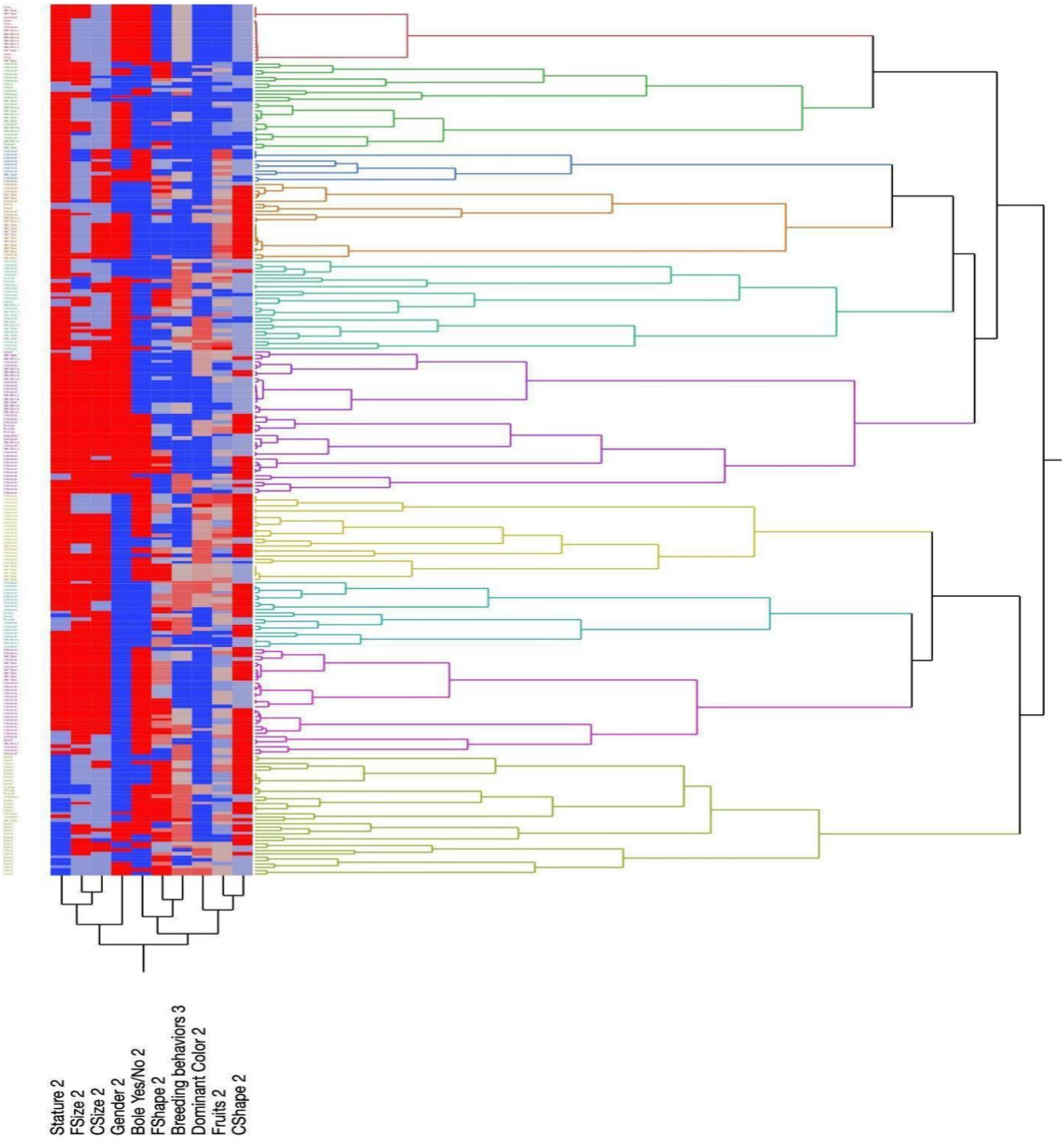

Figure 8: *Dendrogram of 260 coconuts documented in Hawai'i. Importantly, the tight cluster at the top of the diagram consisting of the 17 trees includes all five trees testified to be of the Niu Hiwa variety.*

4.3. Characteristics of Niu Hiwa

Taking into consideration all the information gathered through examining ethnobotanical writing, interviews, and discussions, and the morphological characteristics gathered over 3 years on the Niu Hiwa (including three other testified Niu Hiwa trees not recorded in this study since the needed morphological characteristics and breeding behavior were not able to be collected promptly), there is very strong alignment between historical, contemporary practitioner descriptions, and morphological features that define the Niu Hiwa.

The tree of Niu Hiwa can be described as follows: The trunks of this tall growing tree start with a semi-elongated bole at the bottom of the tree and then the trunk graduates into a slender stem with a surrounding to light-white color on the outside compared to an average coconut tree. The fronds have longer petioles than an average size and relatively thin leaflets and the tree carries an average of 25 to 35 fronds at any given time. The spikelets on newly open inflorescence are whiter than the average inflorescence. In average reproductive behavior during a normal year, female flowers become receptive after all the male flowers are receptive and have been dropped off. During this period the following inflorescence in the next frond will open up allowing male pollen to be available for the autogamy in the manner of indirect self-pollination. The inflorescence carries less than 10 female flowers and it is very rare to see a single branch carrying more than 5 coconuts at any given time; 7 out of 8 Niu Hiwa trees examined carried only 1 to 4 fruits on each branch. In addition to observing the Niu Hiwa, neighboring coconut trees in the same environmental condition were observed. These neighboring trees are noted to have some fluctuation in fruit production during different seasons of the year whereas Niu Hiwa stays low even when the neighbors are in a period of high production Niu Hiwa may not produce any fruits during low production times for neighboring trees. Another notable characteristic of the Niu Hiwa is that the inflorescences are thinner and longer than the average inflorescences which allows fruits to reach a bit farther away from the tree crown. The color of the maturing Niu Hiwa fruits matches the green color of the petioles underneath each branch; then the color of the fruits and the fronds begins to slightly fade as they mature. The crown takes a semi-circular

shape keeping the oldest living fronds about a 90-degree angle from its leaf base. This exceptional biological shape allows the tree to easily disconnect and drop the aged fronds.

The color of the fruits ranges from green to dark green; they exhibit elongated-shaped fruits with distinct longitudinal three-dimensional ridges around the outside of the husk with a triangular shape. Adjunctively, the morphology of Niu Hiwa fruit reflects the characteristic of ‘niu kafa’ and is associated with that ancestral coconut form. The size of the fruits can vary from medium to large. Also, the husk end of the fruit is outward, some with a nipple pointing out. Matured fruits carry less water compared to the average coconut, and some coconuts completely dry out while they mature. The malo‘o—fully matured coconuts—of the Niu Hiwa have a quality endosperm, are average in thickness of meat, rich with cream, and in higher oil content. The endocarp is elongated and darker black in color. The front of the endocarp carries the usual plugged pores and the functional pore where all 3 of them are in closer proximity compared to the average endocarp. Some of the endocarps have a small notable elongated shell point pointing outward on the back end of the endocarp. The mesocarp of the husk is filled with long fibers and when the fruit is matured the fibers turn into a dark brownish-black color. The exocarp is thick and harder than average, stays green until they matures, and then turns brown while some immediately begin to turn darker in color, even black, starting from the mid-section of the matured fruit. Unlike some other kumu niu, Niu Hiwa trees naturally drop all of their fruits after they fully mature. The germination of the coconut remains very low due to the low water content inside of the matured coconuts and many may not be suitable to use as planting material due to lack of water. A team of us had the honor of collecting 8 matured Niu Hiwa fruits and setting 6 of them in a niu nursery next to 216 of the other 15 selected seed niu of old varieties on the Island of Molokai in 2022. Out of those, 3 germinated and were planted in a single triangle in a newly-created uluniu at Ho‘olehua, Molokai.

The Niu Hiwa trees were closely observed for their reproductive behavior. This observation was conducted three different times over a 2 year period and during each observation trees were found to be consistent with their morphological appearance and to continuously behave in type 2

reproductive behaviors (as listed in Figure 3); where all of the five Niu Hiwa trees reported in this survey have the potential of indirect autogamy as the receptive female flowers would be available to get pollinated by the early opening stage of the male flowers from the next inflorescence from the same tree.

A number of experienced cultural practitioners interviewed were able to vividly describe the morphological appearance of Niu Hiwa. This information, combined with their own personal experience of decades of learning and studies to understand Niu Hiwa better, became an exciting process that made this research possible. One such instance was Mahi LaPierre's explanation on recognizing the longer length of inflorescences allowing fruits to appear a bit distant from the tree crown; he even noted the appearance of a similar feature in one of the ancient Hawaiian tattoo drawings from the 18th century (see Figure 9).

Figure 9: *Thought to be an earliest reflection of a tattoo drawing of Niu Hiwa tree (suggested by a Hawaiian Cultural Practitioner Mahi LaPierre) shown on the right shoulder of the 3rd person standing from the left. Reported by Choris, Louis, 1795-1825, "Voyage pittoresque autour du monde XV." Inhabitants of the Sandwich Islands, Event Date 1816-1817.*

Consequently, all 5 Niu Hiwa trees reported in this survey and the 3 other trees that were observed but not reported appeared to resemble this very characteristic (see Figure 10). Thus, the interview process allowed us to expand the explanations that were found through some of the ethnobotanical literature connecting to the real existence of a tree that resembled the mentioned

features. In addition, some of the characteristics described by a number of the practitioners are their own experience with Niu Hiwa and various self-taught observations that are generated by a culturally inspired, self-fulfilling legacy of their determination to understand Niu Hiwa better. Combining the descriptions found in ethnobotanical writing with this diverse set of local practitioners' esoteric knowledge that they generously shared allowed me to observe some of the common characteristics of Niu Hiwa for this study. All of Niu Hiwa trees examined were in good hygienic condition, free of coconut mites or any other pests and diseases. The semicircular shape of the tree crown combined with longer petioles of fronds and longer inflorescence seems to support the tree to keep the fruits away from its crown. Professional observation of the tree would show that the above-mentioned reasons support the Niu Hiwa to keep the tree crown naturally clean and the fruits are in good condition.

Figure 10: *The Niu Hiwa slice of fruit with an elongated dark shell, the appearance of mature fruit, sprouting of a seedling (circulated in red), and the appearance of a Niu Hiwa tree crown; the variety is testified by Justin Kawai'ae'a Avelino in Molokai, 2023.*

4.4. Uses of Niu Hiwa

All 10 interviews and discussions acknowledge Niu Hiwa as a Hawaiian ancestral coconut variety with significant ties to cultural, spiritual, ceremonial, and social importance. Kumu Kahiapo spoke of the overall well-being and balance of natural elements of the Niu Hiwa. Some expressed Niu Hiwa as a tool that needed to be with them in order to connect with the spiritual world. Commonly, all of the interviewees shared some application of significant functional use of Niu Hiwa in several forms (see Table 4). Kumu Aulii, Kumu Kahiapo, Uncle Calvin, Kumu Pulama, Kumu Kalei, Uncle Bobby, Brothers Justin and Mahi, and the other 2 practitioners emphasized the Niu Hiwa as a dark black elongated coconut with green husk. Kumu Aulii specified Niu Hiwa as the “desirable black” that distinguished it from any other form of dark color or black. In addition, according to Kumu Kalei’s explanation the name Niu Hiwa is not only used to recognize this particular variety of niu, but also the breaking of two niu at an ahu (altar) by hitting both niu against each other and cracking them on the first hit at a Hawaiian spiritual function. This is named “breaking of Niu Hiwa " and does not refer to the specific variety of niu being used. In addition, she explained that “young green coconuts” are being used in the spiritual function of breaking Niu Hiwa. She also shared that anciently, the Niu Hiwa trees were grown next to a Heiau; she and some other interviews even specified Niu Hiwa to be found in the Heiau that exercises the practice of human sacrifice. According to Kumu Aulii the Niu Hiwa is the “clear clean desirable black” that contributed significant value to ceremonies and cultural functions, especially the functions associated with gaining new knowledge and the perpetuation of practices. Four of the interviewees mentioned the name Uncle Harry Kunihi Mitchell as a cultivator of Niu Hiwa in Keanae, Maui. Kumu Kahiapo specifically mentioned how Uncle Harry brought a Niu Hiwa seedling from Keanae Maui to O‘ahu to be planted at their māla at UH Manoa in the early 1980s. The interviewees also expressed that the deterioration of niu-related knowledge is similar to many other Hawaiian crops such as kalo; Western colonization has had a detrimental effect on traditional agricultural knowledge and associated functions. The breaking of Niu Hiwa and uses of the water of Niu Hiwa was also discussed with Kumu Kalei, which emphasized the significant use of the water of Niu Hiwa to “anoint" tools,

weapons of war, and people before the start of such special functions. In fact, I experienced such a powerful event with the mighty use of the water of Niu Hiwa at the establishment ceremony for the Waianae niu germplasm that a team of us set down to safeguard Waianae niu diversity against the rapidly spreading CRB infestation on West Oahu (Star Advertiser, 12/19/2023). At the beginning of the ceremony, a well-respected Kahuna, Uncle Kamaki Kanahele honored this effect by granting our niu nursery with an ancient chant mentioning the name of Great Niuolahiki, the origin of which he directed to the island of Niʻihau; he then anointed all of our seed niu with the water of Niu Hiwa knowing the seriousness and urgency of the situation. A similar spiritual use of Niu Hiwa was also noted in the book "Kamehameha and His Warrior Kekūhaupiʻo" where "the third cup was the one offered to the god. The liquid mixed in this cup of ʻawa was the water of the niu hiwa, or black coconut, that had been brought from Wailua, Kauaʻi, which had become the water for Kalaniʻōpuʻu's war god" (Desha et al., 2000).

Table 4: Niu Hiwa is described as the "desired black" or the darker color and value and used in a number of functional applications. Listed in the table are a summary of the Niu Hiwa associated functions mentioned in the interviews.

Functions	**Parts of Niu Hiwa Used**	**Application**
Cultural Ceremonies	entire coconut, shell, water	Dark shell is valued as respect and power in 'awa ceremonies. As a gift offering to acknowledge individual accomplishments such as graduation, marriage, to respect a kupuna, to offer as a high level of respect in a funeral.
Godly and Spiritual Functions	entire coconut fruit, water, shell	Breaking of Niu Hiwa for divination, offering for Gods as whole fruit, use of water to mix wiyh 'awa, shells are used as a container to offer other Godly offerings. Water of mashing of two Niu Hiwa is used to anoint tools, weapons of war,

		also to put water over themselves and weapons before heading war related functions.
Food	coconut water, over 6 different fruit maturity stages as for food,	Removal of husks and extract water and meats
Medicine	Matured coconut, husks, shells	Made into oil, used for healing functions, shells are used as containers and made into ‘apu to be used as servings
Planting for as an acknowledgement	Sprouting coconut	Planted next to heiau to mark the sacredness of the site
Kapa making	Male flowers from newly open inflorescence	Tapping flowers into the design and makers on kapa cloth
Hula dance	Use of whole coconut	Offering to the Hula God Laka as a superior offering
Acknowledgement of value system, natural elements	Entire coconut tree, elongated black shell, water, meat, husk, leaves,	Connecting to the godly elements of Hiwa, superiority of natural element, power

4.5. Coconut “Gender” in Indigenous Perspective

During the interview with Kalei Nu‘uhiwa, she explained the understanding of Niu Lelo and Niu Hiwa being brought to Hawai‘i during early settlements because of the necessity for those two varieties for the use of ceremonies. Niu Lelo was dedicated for females and the Hiwa for the men; the two varieties were planted separately to keep the purity of each variety. Thus, with this explanation, Niu Hiwa is directly related to male functions. Also, according to Indigenous Hawaiian ethnobotanical understanding, kumu niu is considered to be the body form of the God Kū (Malo, 1951; Pukui, 1986; Handy and Handy, 1972; Lincoln and Vitousek, 2017). Another

powerful homological description of the kumu niu is found in the spiritual existence of Niuolahiki as the God of coconut trees, who appears in three forms—eel, man, and coconut tree reaching skyward (Pukui & Varez, 2011; Kamakau,1961). In addition, wai niu, the coconut water, is associated with Kāne (Handy and Handy, 1972; Malo, 1951), where niu is connected with honoring Kāne (Malo, 1951). Thus, this concept can be used to support the association of coconut trees with masculinity and male figures in culturally related spiritual understanding. An additional supporting factor has also become closely linked with connecting this understanding abroad with a traditional coconut concept associated with the male and female gender that also exists within Polynesian nations. Summarizing coconut surveys conducted from 1997 to 2011 covering 27 high islands and atolls of 8 nations of the Pacific region, Dr. Roland Bourdeix and a team of researchers revealed a set of regional Indigenous knowledge associated with the gender-based recognition and classification of function-based coconut identifications. Based on this classification, they noted an ethnobotanical understanding of coconut to be male or female based on four morphological characteristics (see Figure 11). First, applying a similar manner to how Niu Hiwa is described in Hawaiian ethnobotany, as well as revealed by a number of practitioners during my interview process, one of the Niu Hiwa fruit's most notable characteristics associated with the shape of the distal part of the outside shape of the coconut husk. Also, the survey mentioned above reported that according to traditional Polynesian coconut knowledge, if the end of the husk is pointed with a small nipple outward, the fruit is to be classified as male (Figure 10). When protuberances terminate with a concavity, the fruits are considered to be female (Bourdeix et al., 2013). This classification of female and male descriptions is directly linked to the morphological shape of the coconut fruits' distal part of the husk. The existence of this very coconut knowledge in Hawaiian Indigenous understandings of niu was confirmed by three different practitioners from three different Islands: Uncle Calvin from the island of O'ahu, Kumu Pulama from Maui, and Uncle Bobby from Molokai. Thus, I utilized this place-based understanding of coconut morphological distinction as one of the characteristics of this coconut tree survey datasheet (see Appendix 2). This very specific Polynesian classification of male description is found to be true with the morphological description of the fruit of Niu Hiwa on each tree testified to me as Niu Hiwa appears with the sharp or sharper pointed nipple at the end

of the husk. The second female or male classification is regarding the general appearance of the adult coconut tree based on the fruit production where highly-producing trees are recognized as "female" while the trees producing few or no coconuts are called "male" (Bourdeix et al., 2013). The third gender classification is linked to the way seed coconut germinates. The seedling would be considered to be female if the sprout emerges through the peduncle and considered to be male if the sprout emerges from the husk elsewhere (Bourdeix et al., 2013). The fourth characterization is associated with the seedlings aged from one to two months. The seedlings with large, wide, and oblong first leaves are identified as female while seedlings with long narrow first leaves are said to be male (Bourdeix et al., 2013). Consequently, the Indigenous Hawaiian understanding of niu also supports the Niu Hiwa to be male associated functional existence. On the other hand, most of the coconut "fruits result from the crossing of two coconut palms but some come from self-pollination of the mother palm and, as there is an inbreeding depression, the resulting coconut palms produce 20 to 30% less than average" (Bourdeix et al., 2013). When closely examining (1) the Niu Hiwa fruits, (2) the entire tree itself, (3) the seed nut germination pattern, and (4) the appearance of the true-to-the-kind seedling: it is clear that the Niu Hiwa matches all of those 4 culturally-understood characteristics to be the male tree as well as scientifically acknowledging its monoecious capacity of autogamy.

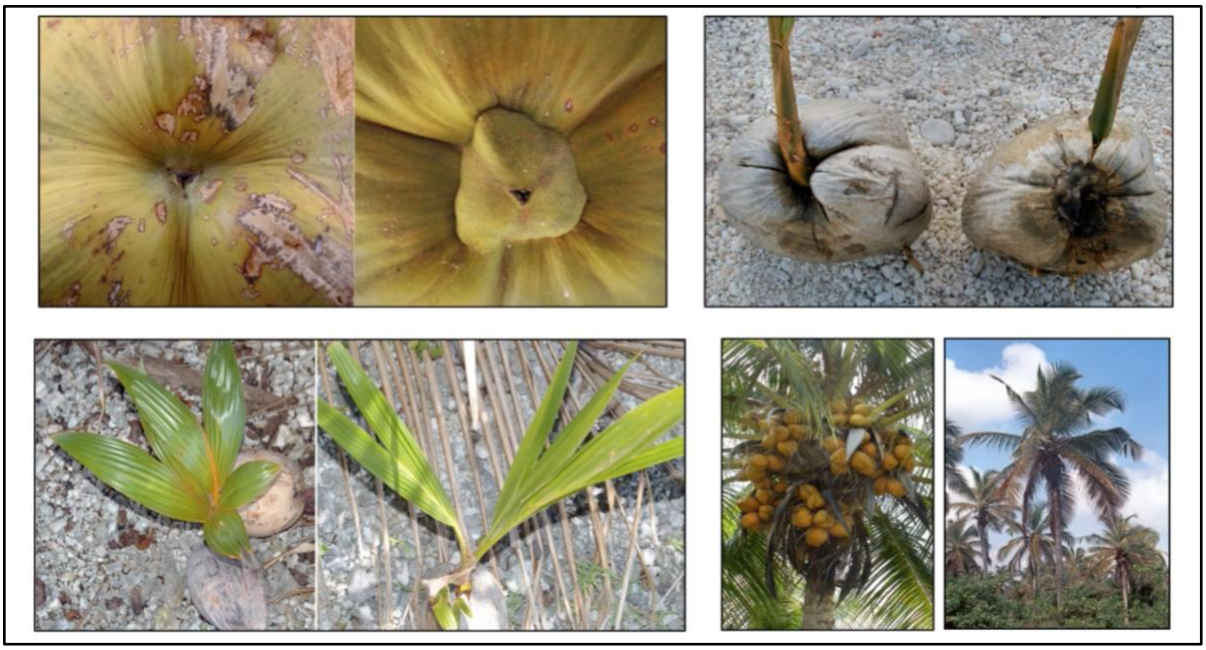

Figure 11: *The 4 characteristics of Indigenous Polynesian cultural understanding of niu as male or female. Source: Bourdeix, 2013.*

4.6. Planting of Niu Hiwa

The interview process revealed that the planting of Niu Hiwa was conducted in culturally specific locations. Kumu Kalei mentioned that the Niu Hiwa and Niu Lelo were planted separately, not in the same location. Specifically, Niu Hiwa was planted near Heiau but not at all of them; they were typically planted at Heiau where human sacrifice was practiced. The Niu Lelo variety was planted in a separate area away from Niu Hiwa as a grove of Niu Lelo. All 8 Niu Hiwa trees observed over the course of this study appeared to be intentionally planted to use the matured coconuts for apu making, ceremonies, and gifts for Hawaiian cultural practices.

In addition, planting Niu Hiwa and Niu Lelo in separate locations for spiritual and ceremonial purposes was mentioned in a number of interviews (Kumu Kalei, Kumu Aulii, Brother Justin, Uncle Calvin, and Uncle and Aunty in Maui). Keeping the favorable niu varieties with valued traits genetically isolated was also a well-respected ancient Pollination practice known as

“Polymotu” (many islands) and is currently brought forward by modern-day researchers (Bourdeix et al., 2013) and promoted through COGENT.

Chapter 5. Discussion

‘Aha-niu, ‘aha-aloha—A coconut prayer/assembly, a loving assembly
‘Aha-ho‘ohui lāhui - e ho‘ohui—A prayer/assembly to unite the Hawaiian nation
‘Aha-ho‘ohui ‘āina - e ho‘ohui—A prayer/assembly to unite land and people
Mau ka pono o ka niu—The nature of the coconut is continuous
Mau ke ea o ka ‘āina—The life of the land is infinite
(He Pule Niu, Ka Nupepa Kuokoa, Volume XXXVI, Number 42, 15 October 1897)

5.1. Coconut Morphological Diversity in Hawai‘i

Tracking down the current Hawaiian coconut diversity, the time of their arrival, and their true origins is extremely challenging and often unrealistic. However, through social and professional relationships such tasks can be advanced. Consider the ancient grove of Pōka‘ī Bay and its surrounding areas, for example. During the late 1970s and 1980s landscape developers took over 10,000 coconut trees from the Waianae coast. One of the previous interviewees who had a leading role in that process explained this removal as “taking a massive number of trees every day for several years unstopping,” where each niu owner was offered $100.00 for a tree–in cash. Tracking down those trees remains challenging since there is no documentation of the final destinations where most trees were planted. Even if they are tracked down, we may be unable to collect much-needed morphological data as the trees are harshly trimmed to maintain the current ornamental status. Unless we’re able to come to an agreement with the property owners to abstain from trimming those trees for at least a period of 11 months, morphological data cannot be collected. These types of agreements were made to collect some of the data presented in this survey. Thus, the survey was able to confirm the authenticity of some of the original descendants of the grove of Pōka‘ī.

Globally, most of the tall types of trees are preferably understood to be allogamous, most preferably pollinated by male pollen brought from another palm by insects or wind (Konan et al., 2008). However, surveying the “breeding behaviors” of the trees in this study found that a

significant amount of Hawaiian Tall trees conduct autogamy directly or most likely indirectly. Out of 260 trees surveyed, 202 are tall trees and a good amount of trees were surveyed over 3 different times during the year. Among those 202 trees, 91 trees, 45% are capable of autogamy including the principal object of Niu Hiwa.

It has been globally acknowledged that a higher percentage of dwarf varieties tend to be autogamous while most of the tall varieties are allogamous (COGENT, 2018). Thus, special attention is given to the tall types, which had some similar traits with Niu Hiwa found to practice autogamy in this survey. It appears that more than 50% of the trees that are ethnobotanical class classified as “old types" have a semi-spherical shape of the tree crown, whereas 58% of those trees can self-pollinate, with a significantly higher number of trees reported from ancient grove systems (see Table 5). The highest rate of self-pollination (69%) takes place in trees with simi-spherical crowns. On the other hand, the trees with spherical shapes have the lowest rate of self-pollination at 35% as 65% of those trees are allogamous. Thus, due to this reproductive behavior, tracking down their authenticity or regeneration of true-to-type offspring will remain a challenge.

Also taking into consideration the understanding of niu kafa and niu vai, two categories were built based on the fruit shape to be predominantly: 1) the trees surveyed on ovate and obovate shapes resemble niu kafa and 2) the trees with elliptic and circular fruits resemble niu via.

- Over 60% of tall trees resemble niu kafa shape except for the trees with spherical shape.
- Tall trees of old types have over 75% fruits resembling the shape of niu kafa.
- Tall trees of the old type with semi-spherical shape has the highest percentage of niu kafa as of 78%
- 100% of Niu Hiwa trees observed carry the niu kafa shape

Table 5: classification of tall trees with reproductive behavior and fruit shapes as “niu kafa” and “niu vai.”

Classification of Tall Trees	Total of tall trees	Autogamy		Allogamy		Fruit shapes			
						Ovate & Obovate (kafa)		Elliptic & Circular (vai)	
		Trees	%	Trees	%	Trees	%	Trees	%
Tall trees	202	91	45%	111	55%	123	61%	79	39%
Tall trees of Semi-spherical shape	102	59	**58%**	43	42%	76	**75%**	26	25%
Trees from Old type and old grove	78	37	47%	41	53%	59	**76**%	19	24%
Tall trees of old type of semi-spherical	49	34	**69**%	15	31%	38	**78**%	11	22%
Trees with spherical shape	81	28	35%	53	65%	38	47%	43	53%
Unknown tall trees	122	54	44%	68	56%	74	61%	48	39%
Niu Hiwa Trees	5	5	**100%**	0	0%	5	**100%**	0	0%

5.2. Identifying Niu Hiwa

All of the 6 interviews and 4 discussions were able to provide some identifiable characteristics of Niu Hiwa. Even the one interviewee who suggested that Niu Hiwa may not be an actual botanical tree but rather a ceremonial and spiritual one was still able to describe a set of morphological characteristics that would align with Niu Hiwa. The dendrogram indicates a strong cluster of Niu Hiwa with consideration to (1) statue, (2) fruit size, (3) crown size, (4) gender, (5) appearance of bole, (6) fruit shape, (7) breeding behavior, (8) dominant color, (9) number of fruits in a branch and (10) crown shape. The only characteristic that was not in perfect

alignment was the size of the fruits from ‘large’ to ‘medium’ on two of the Niu Hiwa trees examined in a dry area of Ho’olehua, Molokai. The size of the fruit has many other controlling environmental conditions, especially the experience of drought conditions during any state of inflorescence and maturity while fruits were young. This size difference from large to medium does not contribute to a major difference and dispute of that still should be able to describe as likely the primary characteristics.

The set of 10 morphological data collected for this survey was gathered with minimal physical interaction with the trees or their parts. Though, I didn’t examine the color or the quality of the shells as each interviewer emphasized on the importance of the color of the shell and even the apu made of the shell of Niu Hiwa, where this color is described as the “desirable black”. Thus, the color and quality of the shells as described by interviewees were documented and analyzed. Even though it was not recorded here, this survey also examined several matured Niu Hiwa fruits to confirm the darkness of the shell (and the quality of the meats) which did align with this description. Also, the black color was compared to a number of shells from different varieties and discussed with a number of ‘apu makers.

5.3. Preserving Niu Hiwa

We envision niu as a relationship rooted in community and Aloha ‘Āina (Niu Now).

A notable characteristic observed in the Niu Hiwa tree is that each one of the brackets carried 1 to 5 coconuts at any given time and all of the fruits appeared to be notably elongated. During this observation, environmental conditions are taken into consideration such as dry and rainy seasons, but the amount of fruits carried in brackets showed constancy while other coconut trees in the surrounding area carried different amounts during different periods. Some notably carry over 10 to 20 coconuts in a bracket while the shapes of the fruits were not exactly consistent. Notably, abiotic conditions affect coconut fruit production such as having significantly large amounts of fruit production during a good season and having less productivity on the trees that experience abiotic challenges and are malnourished. This observation confirmed that when a cluster of

coconut trees are situated in a location having access to a similar level of nutritional intake and similar environmental conditions while some of the trees enhance the coconut production, the Niu Hiwa remained low coconut production. During each observation the reproductive behavior of each tree was also tracked down and found that Niu Hiwa behaves as indirect autogamy during each observation; which means that when the older inflorescence loses its male flowers before the female flowers they were then receptive for male pollen (Figure 10). At the same time while female flowers start their receptivity period on these inflorescences, the next youngest inflorescences would open and become successive to pollinate the female flowers in the older inflorescence. In order to keep the Niu Hiwa as a "true-to-the kind" coconut variety the tree's ability to inbreed may have been noted by ancient Hawaiian practitioners. Globally, a previous study conducted on the *Population of Self-pollinated Mapanget Tall Coconut Line No.32*, by using a mixture of selected trees until the third generation with the capacity of autogamy conducting self-pollination from the same tree on the fourth generation, showed symptoms of inbreeding depression in fruit production where the fruit production declined significantly during the 3rd and 4th generations (Pandin, 2019). All of the trees testified to be Niu Hiwa also appeared to represent the low production of fruits, perhaps manifesting a similar effect of an inbreeding depression.

5.4. An Understanding of Coconut Grove System vs Industrial Coconut Plantation

In addition, the Hawaiian coconut grove system can be set apart from the commonly known colonial coconut plantation system. Taking into consideration that most of the global coconut tree population studies were conducted through the International Coconut Genetic Resources Network, the previous studies were from most countries that heavily experienced colonization and colonial-driven coconut plantation systems. Especially in the Pacific, it was well acknowledged by researchers that the coconut landraces (mainly Tall type), which were originally created over millennia by Indigenous Pacific islanders, were progressively diluted in the mass of coconut palms selected only to produce copra. The cataclysmic socio-economic changes that affected these islands exacerbated the erosion of both traditional knowledge and

biological resources where scientists estimate that at least 50% of the coconut varieties created by Pacific Islanders over centuries were already lost, and the extent of the loss of traditional agricultural knowledge is certainly much higher (Bourdeix et al., 2013). On the other hand, Hawai‘i did not engage in this historical coconut colonial era of the plantation system and remained as uluniu (coconut groves) with the direct support of Hawaiian Royalty. Unlike commercially motivated coconut plantations with highly productive trees, the Hawaiian grove system may have focused on original varieties and culturally valued practices; such as producing materials for ceremonies, food, rituals, musical instruments, representation of royalty and other various community and ecological needs.

Despite the colonial perspective associated with the coconut plantation system, some of the remains of living evidence of this common understanding of the ancient grove system still stands alive even in Fiji and Sri Lanka with some of the originally known coconut varieties. In May 2023, when I visited Mua Coconut Genebank in Taveuni Island in Fiji to attend a three-day training on “Safeguarding Threatened Coconut Diversity Within the Upgraded ICG-SP - Workshop." In addition, I assisted Dr. Roland Bourdeix for 4 days of field observations of coconut diversity on some documented varieties where we also visited some of the original Royal grove system within Fiji's Viti Levu island. Some of the original Fijian niu varieties we observed have “semi-spherical” crowns such varieties as “magimagi”, and “bulund‘lau” where Dr. Bourdeix pointed out and showed me some of the original Fijian varieties with notably long petioles. Also, some of the original coconut varieties known and I’m familiar with from Sri Lanka are “pora pol,” “thambili” and “ranthabili also have similar characteristics and additionally those varieties can self-pollinate (Bourdeix and Perera, personal communication, 2021). It is notable that, unlike many other crown forms, when the trees carry a “semi-spherical” shape, trees are more able to drop the fruits a bit far away from the base of the tree as well as drop off aged fronds naturally. Thus, unlike trees with “spherical” shape, trees with semi-spherical shape don't have to rely much on human assistance to maintain in much of hygienic appearance. On the other hand, most trees with spherical crown shape are unable to drop off the mature fronds or fruits naturally due to its shape and heavily rely on them to be picked by human

hands. In addition, such a semi-spherical shaped variety with the ability to self-pollinate, will still be able to secure its gene pool, even when growing in isolation. This raises the following questions:

- Will the majority of trees having a semi-spherical crown shape be evidence of a least domesticated form that has not become a symptom of domesticated syndrome?
- Or, are the remaining semi-spherical shapes in ancient uluniu the result of a specific selection of niu made by Indigenous Hawaiians?

Figure 12: *Example of an indirect self-pollination in a Tall type coconut variety, between two successive inflorescences.*
The inflorescence at the left will lose all of the male flowers before its female flowers would become receptive. Then at that time when female flowers are receptive the male pollen in the newly opened inflorescence at the right side would be able to pollinate female flowers at the left side. Source: Bourdeix, 2013

From 2020 to 2023: I made 3 visits to 2 of the ancient uluniu in Mapulehu and Kapuaiwa, Molokai; I observed over 4 of the known ancient groves in Hana, Maui; and conducted 4 visits to Maui during a period of 2 years from 2021 to 2023. Since 2018, I have been observing a set of 18 old types of kumu niu 3 to 4 times a year in Waianae, Kalauha‘iha‘i, and Maunalua on O‘ahu.

One of the notable common patterns that I observed at each uluniu, especially at the uluniu of Mapulehu, is that 3 clusters of coconut trees with similar morphological appearances stood in clusters as groups. Each group has 3 to 6 trees approximately 30 to 40 years old (determined by counting the base marks of each of the trees). Out of those 3 clusters observed, one of them had an old tree (about 100 years old) in the center with similar characteristics as the surrounding trees suggesting to be the parent tree where the 2 closer niu were centered with a cavity making an old tree that departed suggesting that tree parented the clusters of the trees that surrounded it. In addition, mostly all of the trees in those clusters appeared to be self-pollinating and simi-spherical, as was reported in this survey. Knowing that those groves existed in isolation from any newly introduced coconut varieties for many centuries or without much human intervention suggests that autogamy and semi-spherical shape are characteristics of the original coconut varieties of Hawai‘i.

5.5. Application of Morphological Isolation in Genetic Conservation

We have observed a similar pattern of organized genetic isolation in the uluniu of Kalaeloa, O‘ahu. The last remaining of the grove we witnessed stood in the shoreline in a plot measuring about 600 feet by about 200 feet. Since 2019, Mahi LaPierre, Jesse Mikasobe-Kealiinohomoku, and a team of us collected some of the remaining niu and grouped them by (1) matching the shape and size of some of the aged coconut with their dead mother trees that still had the last bunch of oka‘a (aged brown coconuts) hanging with matching shape and size, (2) spotting the coconuts on the ground with the connecting mother trees standing next to them and (3) measuring how aged the coconuts found under the mother trees, with the years how long the trees were been death. We organized a set of those oka‘a (aged coconut) based on the exact location where they were found from ‘Ewa to Waianae lining from East to West. We noticed 3 different shapes of fruits in 3 different sizes as the trees were situated in clusters of neighboring trees with similar fruits to each other as followed from ‘Ewa side to Waianae: (1) trees with large fruits of elliptic shape were closest to ‘Ewa end, (2) trees with medium size fruits with obovate shape were in the midsection, and (3) trees with very small size fruits with ovate shape are faced the Waianae end (see figure 13). This set of morphological evidence also compared with some of

the old pictures of this uluniu suggesting original planting structure similar to Polymotu, which is seen even years after the entire grove died.

Historical ethnobotanical writing explains that Captain George Vancouver's log had described the existence of a uluniu in this location in 1793 while navigating along the coast of Wai'anae (McGrath, 1973). Today, combining the current observations at the Kalaeloa coconut grove combined with general morphological understanding, I hypothesize: (1) the life expectancy of the average coconut trees in this grove was about 100 years (by counting the base marks of some of the oldest trees), (2) conditions existed for self-pollination and trees reproduced without much human intervention (like the current condition of the Uluniu of Mapulehu in Molokai), thus these groves have been able to regenerate themselves to be true-to-the-kind and maintain their unique genetic traits for many years after they were planted originally, and (3) in 1793 what Captain George Vancouver witnessed, provided what he had seen this grove from the ocean at least 400 feet way, may have seen this very coconut grove having a combination of trees about the oldest trees to be 100 year and youngest trees to be 10 years old. Thus, the remaining trees we saw in 2018 are the descendants of those old trees of the 3rd and 4th generations since Captain Vancouver's log. This uluniu may have been intentionally planted by Hawaiians resembling a similar concept of Polymotu, the similar pattern that exists and is known throughout Polynesia as an effective practice to maintain coconut varieties. Unfortunately, by 2010 all the favorable growing conditions were forcefully removed leading to a systematic ecological degradation and genetic erosion of this very grove.

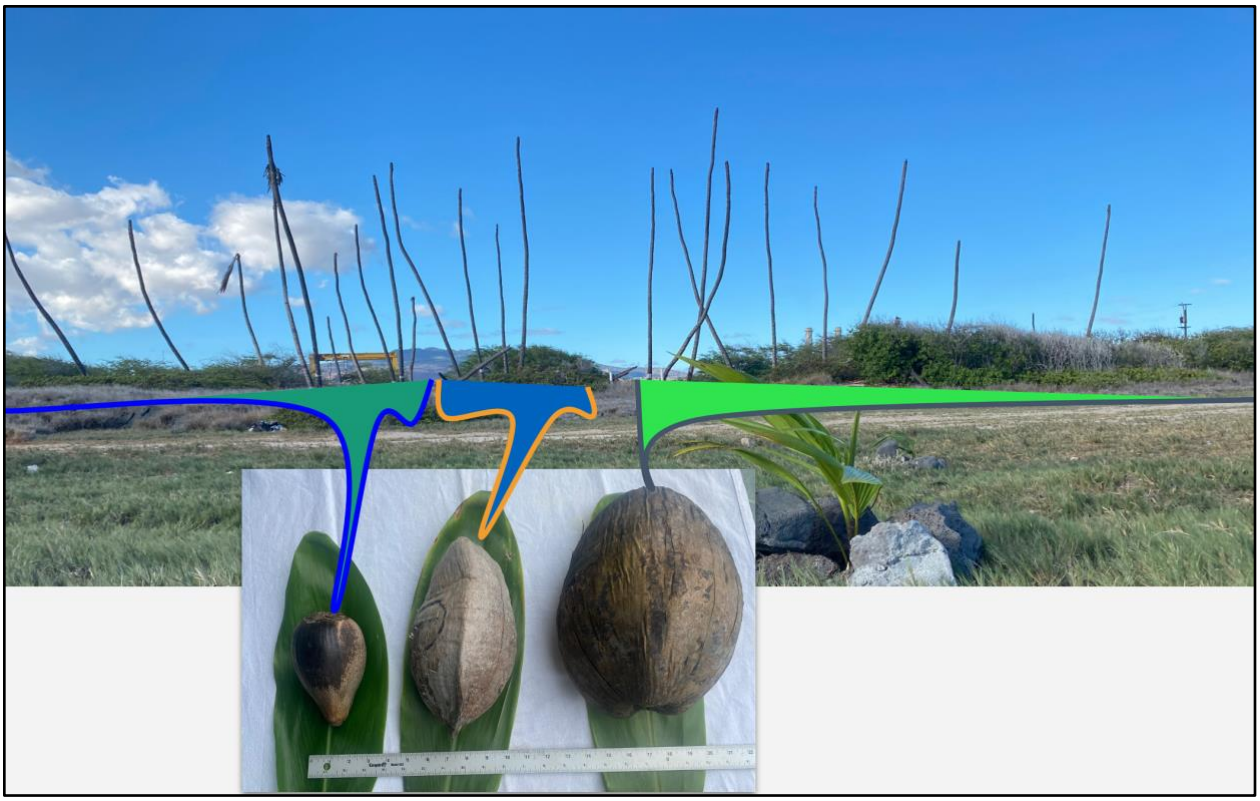

Figure 13. The last badge of remaining oka'a (aged coconut) was collected on uluniu of Kalaeloa; Suggesting an organized coconut grove planting pattern similar to Polymotu appeared from facing the east end of 'Ewa to the west of Waianae end (left to right).

Chapter 6. Conclusion

Mau ka pono o ka niu. Mau ke ea o ka ʻāina.

The goodness of niu is continuous. Freedom is found in relationality with land.

(He Pule Niu, Ka Nupepa Kuokoa, Volume XXXVI, Number 42, 15 October 1897)

6.1. Safeguarding of Niu Hiwa

The characteristics of Niu Hiwa described in historical texts have a direct correlation to the kumu niu that are identified by research participants. In addition, there are 6 other trees identified as Niu Hiwa by 4 Hawaiian practitioners of ʻawa ceremony and mahiʻai that correspond with the written ethnobotanical characteristics. I was unable to include those trees in this survey since I was not able to observe all of the listed 10 morphological characteristics. In conclusion, all of the Niu Hiwa trees that are testified and reported in this survey appeared to be "elongated green nuts with dark shells" as well as all of the Niu Hiwa trees resembled in a specific morphological form. Thus, the Niu Hiwa appears to be a rare variety of coconut since (1) the tree does not produce much fruit, (2) the maturing fruits don't carry much water which is a key factor of a quality seed coconut that can be used as planting material and (3) the germination rate of Niu Hiwa is comparatively very low. Previously, we experimented with germinating good Niu Hiwa maloʻo (seed nut) yet the germination rate is below 50% while most of the other seed niu collected exceeded over 70% to 100% of germination (Molokai niu nursery experiment, 2021). Interview participants confirmed this trend as well. Given its rarity and low germination rate, safeguarding this anciently respected royal niu variety must be taken into serious consideration. Such a mission should be accomplished by: (1) conducting assisted pollination to ensure that the female flowers get pollinated by the same variety, and then (2) tracking down the Niu Hiwa seedling's gene color from the nursery setting after selecting seed coconut from open pollination as a set of Niu Hiwa seed niu. As both Kumu Kalei Niuʻuhiwa and Kahiapo Kashman mentioned during the interviews, keeping the variety separated could also be the very niu gene-banking style known throughout Polynesia as Polymotu. If applied, this style of replanting of Niu Hiwa back in

Hawaiian culturally significant ancient sites may be an ideal, mindful and culturally appropriate practice for safeguarding Niu Hiwa.

6.2. A Functional Application of this Study

The objectives of this study are to document, acknowledge, and enhance the holistic understanding of Hawaiʻi's coconut genetic diversity; and the existence of the ancient understanding of the Hawaiian uluniu system. This study created a database and coconut tree tracking system (see Appendix 2) that can be used to support that preexisting understanding aligning culturally embedded coconut practices with the scientific classification of coconut genetic diversity.

This process and engaged methodology also worked to equip traditional coconut growers with the necessary information and proper tools that allow them to effectively understand and conserve coconut diversity. That is the main objective of the selection of such variables for this survey where I use only the traits that a trained farmer would identify as important for differentiating coconut diversity. Properly identifying and selecting appropriate coconut varieties for various uses will expand an appreciation for and an awareness of the various uses of the coconut. I hope this work contributes to the regaining of respect and appreciation that this historically known and spiritually connected "tree of life" will once again be closely connected in Hawaiʻi as kumu niu.

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Appendix 1 - Interview Transcripts and Takeaways

Brother Lance Genson Mahi LaPierre (Mahi):

A Hawaiian *apu* (coconut shell cup) making practitioner and a traditional wood carver, where he goes over about 1000 coconut shells creating *apu* in any given year. Also, Mahi is employed at UH Hawaiʻi Honolulu Community College as a Cultural Practitioner Educational Specialist for Hawaiian Studies where he conducts his practice connecting a number of colleges connected to the UH Hawaiʻi system. Mahi is a personal friend and a niu colleague where we have got together to do over 10 coconut related activities including seed niu (maloʻo) gathering for the nursery setting, documenting niu diversity, working on ʻapu making, niu planting, etc. Most of the time during our work, we discussed and exchanged information regarding morphological recognition of Hawaiian coconut diversity, especially the Niu Hiwa. This interview took place in several forms from July 2021 to Jan 2024:

Q. **What is your understanding of Niu Hiwa?**

1997 I join a lua group, a Hawaiian fighting art group, in our training they told we need apu for awa ceremony, one of the coconut needed is the Hiwa, it was like 1996 to 97 that's 1st time I heard about Niu Hiwa variety, that time all I know about coconut was making desert with my Filipino grandmother. She tells me there is a pile of coconuts back of the house, then I go husk and scrape them, I get scolded if not good husking or scraping. Biko is what she made, it is a dessert. That's my relationship with coconut at the time. I did not do many things with shells at the time, this was my preteen to highschool time, along the way not having a much relationship with coconut, drinking nuts here and there, not heavy like now I do.

I was given a niu at the time 1997, told me that was Niu Hiwa, smaller size nut, call me Hiwa, in 98 I was given another one that is different then the 1st one.

Q. How different is that one compared to the 1st one?

It was a thick shell, pointed, began to occur to me to see the different patterns and I began to use it in ceremonies, then a couple of years back I stopped training with them, that was my main introduction to Hawaiian Culture; they were like my 2nd family.

Then I was told, in more recently in 2011 when I join a group of Hawaiian healers with Keola Chang, during that time learning about Hawaiian healing, lomilomi, he also told us to seek out for Niu Hiwa, not only for ‘apu, ‘awa, some of the ceremonies they mash them for water to tell what may happen on future, too offer in ahu, we were told to seek out Niu Hiwa, grow it so forth, What it did to me set me in this path to seek out, more and more I seek, I began to learn how much I don’t know. People would tell me that UH Kanawai, Uncle Harry Michel brought that nut, I think I saw once one broken nut, I tried to make it out on my mind, what the color of the nut, husk… then I was told, one big revelation was to me was you know Backman hall, my brother involved in planting, he’s from Kauai, he ask me to get plants from Oahu to be planted to represent Oahu there. I asked him what one is Niu Hiwa from Kauai, he told me the tree close to the Kauai, I went there to get nuts, open and compare them, at the meantime I’m trying to learn about Niu Hiwa but not getting any revelation, because nut are not the same, I thought now I have a tree to go because now someone told me this is Niu Hiwa, I open 16 nut but no different.

Q. When you open 16 nuts, what makes you think it’s not Niu Hiwa?

Nut’s color was different, in the bunch has different shape of nuts and has different colors of shells, nothing was really black, it confused me, if they tells me this is the mother trees, I began able to see this is not consistent, it make me became frustrated, but also became to know not knowing who’s pollinating what tree will not make it real Niu Hiwa…

Q. Then what did you do?

Then what I found was really interesting ..

Then in 2013 I joined another Cultural group, they also told me they need me to find Niu Hiwa and to make apu, I even went to the grove that you went to in Hana, Maui [Mū‘olea], the grove that was known for Niu Hiwa. I opened several coconuts there and they seemed more consistent, I was doing that there for 3 days.

Q. What do you mean by more consistent, what do you mean?

Shape, shells, color of the shell, size of the nut, from different places around with different trees

I tell you this intrigues me, we're looking into history and trying to use what our kupuna used those days.

I hear some respected kupuna make blank statements [on Niu Hiwa], telling this person saying they saw Niu Hiwa pointing to any tree with green nuts, and then others say the same using that as a reference. That's scary for me, I'm kind of shy away, I never say this is Niu Hiwa, even now I am involved in Makahiki ceremony, whoever brings niu call Niu Hiwa I go with it. We go at sunset, before Makali'i rises to chant and to brack Niu Hiwa water. It's Niu Hiwa. It's interesting, I'm trying not to mislead people, who are the knowledge keepers, but do they have the knowledge to know Niu Hiwa?

You saw the pic with Hawaiian tattoo, [referring to the man shown in right on Choris, Louis, 1795-1825, "Voyage pittoresque autour du monde " XV. Inhabitants of the Sandwich Islands, Event Date 1816-1817] when I see that pic, I don't know what they intend, but I think they are drowning Niu Hiwa. Over the years, I have had more and more relationships with niu, I tattooed niu into my body.

This Niu Hiwa question comes to me a lot, but I can't shere, I can't misguide them, I tell them straight forward: I don't know.

This tree in KCC, pretty consistent, but sometimes dark, brown, not consistent, I don't know, I see sometimes wood changes, brown to black, I don't know…

I share only what I know, I open over 450 niu a year, eating, educational workshop, apu workshop, When I open 450, I get to see other over 450 been open by others as well, [during 'apu making workshops] to see and taste every part of niu, after meeting with you now I'm trying to give people opportunity to eat different part of niu. I remember teaching in windward side, kids from Kamehameha asking me I had a coconut with sprout coming out. They ask me "how did I do that?" "What did I do?" They don't know that niu grows like that. It scares me, because they don't know that's how coconut grows, they may know mango, but not coconut, way too disconnected.

How many trees have you seen that people pointed to as Niu Hiwa?

One at Maui, UH Manoa, Palolo, and I received nut from Kahana tree, but haven't seen the tree

When we're in huakai someone tells, the green trees [trees with green nuts] are Niu Hiwa, then everyone tells me "I saw Niu Hiwa," then people tell others "I saw Niu Hiwa, I know Niu Hiwa." I think it's dangerous, misinformation has been spread out…

Mahi's Interview Summary: This interview confirms that the Niu Hiwa is an actual coconut variety that is closely associated with ceremonial and spiritual functions as well as healing and other cultural recreational functions. Also he makes it clear that the finding of Niu Hiwa today is a great challenge and several forms of interpretation of Niu Hiwa are out there among cultural practitioners.

Kumu Makahiapo Cashman (Kahiapo):

Director, Ka Papa Loʻi ʻo Kānewai. Kumu Makahiapo is a member of ʻOnipaʻa Nā Hui Kalo and Mālama Hāloa. These organizations are made up of local kalo farmers dedicated to protecting the integrity of Native Hawaiian kalo varieties. Meeting in Jan, 2024:

We walked around the mala, Kumu Kahiapo showed me the tree that they recognized as the Niu Hiwa where he collect all of the matured nuts come out of this trees as many would come to him for finding Niu Hiwa for various cultural functions such ʻawa ceremonies, graduations, Hula rituals, and other cultural practices. He explained that the Paeloko where Maui went to collect niu to make rope to catch the sun with. Papa Mau used to bring us niu from Sarava Island, he has some of his ones, one of his students that go between Sarawa and here brings his ropes which he uses to rap iwi so niu is very important and significant.

Q. By any chance do you know Where did this tree originally came from?

Kianaʻe Maui, near that church area, Uncle Harry Kunihi Mitchell, he brought this small plant ovr from here, he's from there and it's came from the area near the church.

Q. How long ago was it?

1980's early 80-81s,

When you look at Niu Hiw tree what are the characteristics you look at?

I look at the snout on the front [back] end, the pointed end, even on ‘apu that is pointed, let me bring one to show you, even when I talk to Hana guys, they are familiar with this tree, they are familiar with this tree, when we’re in Hana we drink awa they bring ‘apu that pointed, we point to the tree and see the shape like that,

[pointed at apu] see all of them are different, see this one, they have a point, even like a tall, when I drink awa in them it shows everyone that I have Hiwa, longer the tall that the sassier, like, look he got the longer tall. See [pointing at a set of ‘apu] see them not all are Hiwa but the pointed one are the Hiwa,

Q. In the color vise what are we looking?

It’s the darker, other than looking like that, it’s the black, Hiwa looking color, even kupun used to say it’s like pig, Hiwa kalo, Hiwa uala, ko, they all have dark.

Q. When we look at the dark, there are different levels of darkness, if we line up 1 to 10, the 10 to be the darkest, where would Niu Hiwa stand?

I think it’s kind of dependent, all different ones, but I think if you sand it out it gets darker, I think it’s the critical point, blackness of the shell.

Q. How about the thickness of the shell?

It rarely depends, some are really thick, even in ceremony they break it.

Q. When we look at Niu Hiwa, how important is it in the cultural setting? What type of role would you say it played compared to other coconut and other plants?

I see, I known, because we are here we have Hwa, we see it mainly used for ceremony, ‘awa, offering in ceremony, and then use for making ‘apu, and it’s easy to make a ceremony, I’m not a part of the ceremony, they know that we have it, that’s my role. Sometime Hula Halau come for it.

Q. Historically looking at the Niu Hiwa, what do you think about how it was looked at and treated in History?

You know just like a lot of things here, language, knowledge of taro, everything got forgotten, you know it wasn’t till to the people came back and writing, it usually not a lot, when everyone disappearing, so the knowledge, to me I think hawaii is a worst example of, it’s the best example of colonization, no one want to be like Hawaii, so much lost, I think niu is one of those, people

don’t know a lot about it, like taro, a lot of people don’t know much about taro. When you go to other Pacific Islands you see how important niu is, I was in the Cook Island, whole island is a grove, we’re sitting down for dinner, they make a joke, what you like to drink pepsi, diet coke, then they go out and bring a coconut, that’s your drink. To me, being from Hawaii there is a lot of stuff going on, especially for niu, I couldn't get over how much they have.

Old days Puanluu used to have a line of tall trees, then they cut down the trees. When I was a kid in Hana there used to have a grove in the Island Alau, then all the niu died slowly, when you look out the island you see a grove, then they replanted the grove. Hana around Hamoa, that’s where we do iwi kupuna work, there is a small fishpond, then our houses here, Kaani, English is there, my grate grandmother bought a land there, when was a school teacher at Kipahulu, when the school closed, she came there to be a school teacher and got that land. There are some old coconut trees there. See that one is the border of my parent's house and Kalani English, that where the water source for the fish ponds where the Kia Wahine come out, that were the grove of niu is, even the area around my parents house has a grove of niu around. Now some of the trees are not doing well.

I talk to different residents in Molokai, they were our students, when I see them 1st thing they say I need to go work on the coconut grove, you know i need to work on the grove, everyone thinking of that, Molokai has big niu groves, Kukui groves, large amount of them still there. Those trees here, a lot of people come to [for asking for Niu Hiwa]

Q. How many nuts do you see coming in one bronch [bracket] at any given time in this tree [Niu Hiwa]?

Not sure, if you see, not many [I saw about 1 to 4 nuts in each bracket], usually not much, maybe 4 - 5.

Q. I read that the Niu Hiwa was in the Hawaiian Kapu System and it was protected in that setting…

Yes, yes, even how it is cut, everything is taken into consideration, even for different ceremonies it was cut differently, like sometime I hear guys going do not cut this way it means that if you cut like that means that, but I don’t know what it is, I heard that.

Q. Why do you think specifically why this variety is put into the Kapu system to be protracted?

I think it is used for ceremonies, ceremonies are very strict and require strict function, people touching it, looking at it, it is sacred, want nobody to pick it, only Ali‘i to have it.

Q. Would you say that it would be in the common knowledge system and people know different niu varieties, what is Niu Hiwa, and that everyone knows how to recognize this variety since it was protected in this manner?

Yes, I think so, I think that everyone know the function, it’s special, that one is special, even you hear that something like pig running around the village that everyone knows is the Ali‘i’s pig, no one touches that pig, that’s the common knowledge, you don’t tough, not to feed. I would imagine that there were specific people who took care of it [Niu Hiwa], looking after that, and everyone knew who that person was, like the pig that everyone knows like this grove is for the King. Obviously they are going to take the best for the ceremonies. I don’t think they are mean, they know the importance for the ceremonies, they are trying to make sure everyone can take, to have enough, to do what they got to do.

I think chants, stories of mo‘olelo are important, they have all the information, if you’re going to look at newspapers they have information, but chant, mo‘olelo has knowledge that is most critical. It’s not much about people but elements, even the characters in sorites, it’s not much people, it’s elements, describing element that most critical for survival, wind, fire, water, kind of waters, flood, spring water, those kind of things some kind of element of force coming to attacking that, our kupuna is telling us but we’re not savvy enough to know, we got to know where to go. Even in chants that’s what is explaining, what it’s saying is where the information. Not only Hwaiian, all other cultures, Indigenous people that’s where all the information are.

I think even genealogy chants, specific order, where the niu come from, hierarchy, that is the foundation, like the fish, before the fish come in they needed ocean, they needed coral, they needed everything else is goring, then the fish can come in, other animal can come in, then the human came in, human didn’t come till all that others came in, that way how human can survive, over kupuna is giving us hints, this is like domino effect. How the niu is doing, how taro is doing, how water is doing is a direct reflection of us. You look at the people, Hawaiian the same

thing, same thing, this like water, niu, you don't see any more, push down, no more the right conditions, all the foundational pieces are disappearing, you are been affected… we are creating an environment for them to survive. If you want to see how people are doing, come look at their plants, water, it reflects the way people are doing, those are the foundational pieces. If they do good, we do good. It is way certain ones a Kapu, for the order for place to survive those guys [plants] needed to do their job, they have a certain jobs, people recognize that, them to do good they needed to take care of those guys [Niu Hiwa]. This is what genealogy chants are doing, keeping things in order to take care of them, now you are born, your kulean is to take care of them, you still got to take care of them now, you got to take care of the genealogy, each one has a genealogy, taro has genealogy, niu has a genealogy, you gotta help them take care of their genealogy.

Summary: Kumu Kahiapo confirmed Niu Hiwa to be an actual ancient Hawaiian variety of Niu, yet to be a rare type of niu. Alos, Niu Hiwa is closely associated with the royal and spiritual functions where it is often used as offering for the highest in ritualistic manner. The name, functions and uses of Niu Hiwa is mentioned in chants. He recommended to search through chants and pule instead of directly looking into a dictionary to find such meanings. The locational name of Keʻanae Maui is pointed as one of the original places where Niu Hiwa was found and came from.

Uncle Calvin Hoe:

Calvin Hoe is a Hawaiian artisan, musician, educator, farmer, and activist from Hakipuʻu, Oahu. Uncle is a mentor to me and I've known and worked with him over the last 15 years doing a number of different projects, often we discussed planting of uluniu. This informal talk, interview is a summary of a number of different discussions from December 2019 to Feb 2024.

Key takeout:

- Conformed Niu Hiwa to be a true niu variety with dark green nuts. This niu variety has a high value in Hawaiian ceremonies; in the old days kupuna would know where the Niu Hiwa tree was. Niu Hiwa is not a commonly found coconut variety.

- Niu Hiwa represent a key element of living ,suraving, wellbeing of Hawawaiian people as well as the wellness of the spiritual world.
- Niu Hiwa is use as a peace offering to Akua, the Spirit world as to maintain the well balanced.
- Niu Hiwa trees are found only in very special sites, mostly next to heiau
- Drinking of wai niu is a good practice of keeping good health in natural way without taking any medication

Kumu Pulama Collier:

Pūlama Collier is a Native Hawaiian scholar, educator, philosopher and artist who continues to share her knowledge of the Hawaiian language, culture and traditions. A kama o Maui, child of Maui and mother of three living in Kūʻau, Pūlama is currently an instructor at Kula Kaiapuni ʻo Kekaulike, the Hawaiian Language Immersion Secondary School on Maui, and a Hawaiian Language Instructor at the University of Hawaiʻi Maui. Her professional responsibilities and experience include a vast spectrum of genres within the realm of Hawaiian education, edification and practice. Pūlama cultivates and elevates Hawaiian Indigenous intelligence, virtues and beliefs - yet most importantly the incorporation of those virtues and beliefs into daily life with others.

Key Take away:

- Niu Hiwa is a variety of Niu that is very specious, we’re still trying to recover, and to truly understand what Niu Hiwa is.
- Entire coconut without husking is used for the ceremonies as an offering as a kupu in the beginning of Lono season, it’s the end of Ku and beginning of peace.
- Then the end of Makahiki Niu Hiwa will come to lele as the Niu Hiwa is Ku, that Ku will come to the lele at the end of peace of Makahiki season.
- Officering of Niu Hiwa at lele is specific to the ceremony what is the ceremonies for, it’s mostly be offered with a pua hiwa (black pig)

- Black pig and black niu is always been partnered, Niu Hiwa means supreme with elongated nut with darker shell
- The meaning of Hiwa is very important, specious, dark color,

Kumu Kalei Nu‘uhiwa:

Kalei Nuuhiwa is a Hawaiian cultural practitioner, born and raised on Maui, and now lives in Hilo, Hawaii Island. Kalei works as one of the researchers for Papaku Makawalu with the Edith Kanakaole Foundation. She has co-authored the Papahulilani section of the cultural use plan for Kanaloa-Kahoolawe: Kukulu Ke Ea O Kanaloa, Kumokuhalii: Forest Resource Cultural Use Plan and the Keauhou-Kahaluu Educational Cultural Use Plan for Kamehameha Schools. Kalei has worked and volunteered with the restoration of the island of Kahoolawe with both the Kahoolawe Island Reserve Commission and Protect Kahoolawe Ohana. Her primary discipline is Papahulilani (the study of the atmosphere), including it’s phenology, energies, and cycles from a Hawaiian perspective. In the traditional Hawaiian worldview, these atmospheric elements embody the pantheon of kino akua Hawaii and provide a fundamental function in ancestral memory, still essential in the modern Hawaiian consciousness. She also works as one of the researchers for Papaku Makawalu with the Edith Kanakaole Foundation. She has coauthored the Papahulilani section of the cultural use plan for Kanaloa-Kahoolawe: Kukulu Ke Ea O Kanaloa, Kumokuhalii: Forest Resource Cultural Use Plan and the Keauhou-Kahaluu Educational Cultural Use Plan for Kamehameha Schools. Interviewed on Jan 26, 2024

Key Points:

- Niu Hiwa is a variety of niu that is elongated, dark green and stay green till fully matured and turn brown, dark shells, doesn't have much water and meat.
- Niu Hiwa is planted in Heiau not all of them, typically the one had human sacrifices
- Her experience with Uncle Harry Michel,when taken niu for rituals, takes a young green coconut as Niu Hiwa, in ritualistic mashing Niu bracks 2 nuts on each other.

- Had an experience with Uncle Harry Michel, when they uses to go to Kaholawe, need Niu Hiwa fro rituals they would ask Uncle Michel for Niu Hiwa. One particular incident asked him for Niu Hiwa, he went to his grove in his property, down below of Keanae, went around and came back with a coconut which was a green coconut, niu in the growth stage, not from a actual Niu Hiwa plant, then they all said “is this Niu Hiwa”, he confirmed as yes it to be Niu Hiwa. Later duing her PhD study she has become familiar with sources that Niu Hiwa can be any kind of green coconut that is yong used for the ceremony.
- Niu Hiwa is a variety also as well as a growth stage
- The water of mashing those 2 nuts, water is used to anoint tools, if going to war, water is used to put over themselves and weapons. In this case, use a green young coconut with a lot of water because it’s going to mash using only one time. Therefore Niu Hiwa also represents a growth stage of any green cococount used for the function of ritual.
- Niu names and fruit maturing stages and uses are on chants and mo‘oleo on descriptions how they are been used and the different conditions of the meats in the inside.
- 2 coconut na,mes are often mentioned, Niu Lelo is yellow small coconut, planted in one area, planted only that variety in a one area,
- Hawaiian brought only 2 varies because they needed for different ceremonies
- Then the arrival of others, they brought different varieties
- Niu Lelo has white shells, and Hiwa has black shells.
- Recommended to search through chants and pule instead of directly looking into a dictionary to find such meanings and descriptive uses.

Kumu Aulii Mitchell:

Charles E. “Aulii " Mitchell is a Kumu Hula, committed to creating, preserving, and perpetuating the practice of carving and dressing images for the ritual dancing of Hula Ki’i that is closest to the oldest written accounts. He’s a cultural anthropologist and cultural specialist in the disciplines of archaeological and cultural impact studies, with a primary focus on Hawai‘i. His

many projects include the repatriation of human remains, associated and unassociated funeral objects, and objects of cultural patrimony under NAGPRA (Native American Protection and Repatriation Act). He is well versed in the translation of Hawaiian language newspapers, writing of cultural impact assessments (CIA) including the process of formal, informal, and "talk story" cultural interviews with nā kūpuna, elders, Native Hawaiians, and traditional cultural practitioners connected to specific project areas. He is also the President and co-founder of Hoʻoulu Lāhui and is the cultural advisor to Kua O Ka Lā Public Charter School in the Puna district of Hawaiʻi island. Kumu Aulii is also a close friend where we often discuss our practices.

Takeaways from the Interview:

- In my Hula lineage, that we call old school kind, we use Niu Hiwa to honor Kuahu, the embodiment of the goddess Laka of Hula. All ceremony rituals are done in front of this cooler who and, and for the three who are who have hula. So for us, the black coconuts signify ritual and ceremony in our Uniki or graduate ceremonies,
- Niki means all the knowledge they gain binds the Hamana, for the hula students to all the knowledge that they gain from the years, many years of learning the hula practices, and thus, is significant to the Aha niu that that bring together and ties us as a chord to this ritual ceremony,
- The new Hiva issues in many different practices in Lua, Makahiki and many others.
- Niu Hiva is the desired black, different from other blacks, like to pua hiwa, that symbolizes the ceremonial food, clean and clear black desired Black as some other backs sometimes carry negative connotations, but not in this case. Hiva you know, is that descriptive of a very clear and clean kind of black.
- Lono is the husband of Laka, pua hiwa is the embodiment of Lona, Niu Hiwa is always use as apu all the hula ceremonies Niu Hiwa was always used for.
- It's a elongated nut and blac shells and used many kind of sand papers to get it polish
- The Brown and Todes family in Puna has the Niu Hiwa and that's where the niu is found for the ceremonies and every part of the nut is eaten.
- The shape of the net was a little bit like this, longer than a normal coconut, not a round coconut.

- The shell of the nut is strong, where one time he dropped the nut on cement flow by accident, but it did not crack or damage.
- Nut appear to be green to medium green and the whole nut is been used for ceremony as wai niu is been used for the ceremony and the nut is also been eaten at the ceremony
- it's to tie to one what defined offering of Niu Hiwa
- Hiwa is highly value, beloved, precious, the most favorite,
- Code of niu sennit is a connection to the ancestral land, which tie together to the ancestor by the cenit of niu, that is Niu, beginning to the migration to now
- Niu Hiwa is also used for, husks, the medicine, dyes,
- Niu Hiwa is the clear clean desirable black something that intimate to the practitioner's world
- braking of Niu Hiwa symbolic of the opening of a ceremony
- Niu Hiwa has think deeper shell and was very hard to sandpaper out the fiber off

Brother Justin Kawai‘ae‘a Avelino:

Informal talk, met with Justin 3 separate occasions from Fed and Oct 2022, and Fed 2023. Key takeaways:

- When Justin moved to Molokai from the Hawaiian Island, he was keen to find Niu Hiwa in his new home islands as he's custom of offering Niu Hiwa as a gift at community ceremonies and celebrations including weddings, graduations, respected elders's funeral, Makahiki rituals, etc.
- Justin recognizes the Niu Hiwa apart from other trees and he is familiar with the shape of Niu Hiwa where he was able to show us 2 trees of Niu Hiwa.
- For him, very hard to find anywhere in Hawaii, the fruit is longaged, with very little water, nuts would fall off from the tree hitting the point down, matured nuts are dark color, hard to germinate the nuts.
- Old days there are groves of Niu Hiwa were planted and took cared by Ali‘i

- Also he mentioned the existence of a coconut variety with very large elongated fruits in a very isolated location in the Island of Molokai (the measurement he showed the fruit is about 24” of length).

Uncle Bobby Alcain:

informal talk in February 2022 and December 2023 and key takeaways:

Uncle Bobby is a respected agroforestry practitioner and an activist in the Island of Molokai where I met with him during our Niu Now Molokai Uluniu planting trips.

- We discussed the traditional Hawaiian understanding of recognizing coconut fruits to be male or female using the same morphological understanding used in other Pacific islands such as Fiji, Tonga, Tahiti.
- Told us that Niu Hiwa is a variety of niu, was used on ceremonial occasions. The Niu Hiwa is very important to Hawaiian culture and the trees were in Molokai before and now very difficult to find them
- Niu Hiwa is mentioned as male and offers a range from a kanaka to akua

Appendix 2: Appendix 2. A Copy of the Morphological Tracking Sheet used in this Survey

indrajit@hawaii.edu

Collection Number	Ethnogarfic information	Stem Morphology		Fruit Morphology					Crown Morphology		Breeding behaviors
		Stature	Bole Yes/No	Size	Shape	Color	number of fruits in a branch	Gender	Size	Shape	