Kalo [Hawaiian Taro, *Colocasia esculenta* (L.) Schott] Varieties: An assessment of nomenclatural synonymy and biodiversity

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Research

Abstract

The prominence of **kalo** (*Colocasia esculenta* (L.) Schott.) in Hawaiian culture has declined after experiencing a decrease in cultivation, biodiversity and associated cultural knowledge. There was no documentation of diversity at its height. Previous estimates of biodiversity lack any sense of a methodlogical approach. A new attempt was made to assess levels of biodiversity around the peak cultivation period. Results were then compared to current levels. Nomenclatural synonymy and extinction have presented some challenges which made standard methods for quantifying biodiversity not viable. A set of new tools was used to sort through a master list of 676 varietal names. A comparison of what is known from the nineteenth century and modern time periods makes it apparent that changes in biodiversity, varietal prominence, ethnonomenclature, and ethnotaxonomy have occurred. This paper discusses the direction of such trends, and postulates a new estimate for **kalo** diversity at the end of the 19th century (approximately 100 years after the assumed peak of cultivation and diversity) to be between 368-482 distinct cultivars, while only 65-73 still exist today.

Introduction

Taro, *Colocasia esculenta* (L.) Schott, has been historically one of the most important crop plants in the tropical Pacific with distribution reaching as far east as the islands of Polynesia. The global trends in loss of both biodiversity and associated cultural knowledge have not escaped this species throughout its range. The most remote island group of Polynesia is Hawai'i, where taro is known as **kalo**.

Kalo is connected to origin stories of the Hawaiian culture (Handy *et al*. 1972, Kame'eleihiwa 1990) and is, therefore, often considered to be the most important crop plant from that perspective, at least on a symbolic level. On a practical level its prominence is rivaled only by **'uala** or sweet potato (*Ipomoea batatas* (L.) Lam.) (Handy 1940, Handy *et al*. 1972, Ladefoged *et al*. 2009). This is true especially in the era prior to contact with foreigners in 1778 (Handy 1940, Handy *et al*. 1972, Kamakau 1972, 1976, Kame'eleihiwa 1990, MacCaughey & Emerson 1913, Malo 2006). Contemporarily, **kalo** continues to be held in the utmost level of respect among many staunch cultural practitioners, although its general prominence in the Hawaiian culture as a whole is no doubt less than has been in previous generations. This is due, in large part, to various reasons such as changes in land tenure and socioeconomic systems which, in many cases, resulted in a loss of cultural identity (Kame'eleihiwa 1992, Trask 1999). Because of the glaring losses of both biodiversity and associated cultural knowledge it is important to gain a more refined understanding of **kalo** diversity at its height for several reasons, not the least of which includes quantifying its importance to the Hawaiian culture and gaining insight into the horticultural skills of the ancient Hawaiians.

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The intensity of **kalo** cultivation has changed over time. **Kalo** was originally brought to Hawai'i in Polynesian voyaging canoes (Abbott 1995) at least 1,000 years ago (Burney & Kikuchi 2006), and the intensity of its cultivation undoubtedly increased as the Hawaiian population did. It is assumed that this period of intensified cultivation was accompanied by a corresponding increase in intraspecies diversity (i.e., cultivar diversity) via somatic mutations (Handy *et al*. 1972) and possibly even cross-breeding (Handy *et al*. 1972, Irwin *et al*. 1998). Cultivation is assumed to have reached its peak at the height of population density around the time of contact with foreign cultures in 1778. At that time the Hawaiian population was estimated to be approximately 1 million people. This period was followed by a 90% population collapse due to introduced diseases (Stannard 1989). The intensity of **kalo** cultivation decreased dramatically during this same period (Anonymous 1879, Cho *et al*. 2007, Handy *et al*. 1972, Ladefoged *et al*. 2009, Müller *et al*. 2010). During this post peak-cultivation period, several authors attempted to record **kalo** diversity (Handy 1940, Henriques n.d., Iokepa & Kekahuna n.d., Kalaniana'ole n.d., MacCaughey & Emerson 1913, 1914, Rooke n.d., Whitney *et al*. 1939, Wight n.d., Wilder 1934), likely in reaction to the extinction crisis that they were witnessing. All of these authors were documenting biodiversity in the late 19th and early 20th centuries during the period of rapid diversity loss (see below), so in analyzing the works of these authors we could, at best, only gauge post peak-diversity levels.

The terms "cultivar" and "variety" are used throughout this paper. The word "cultivar" is used to describe an anthropomorphically recognized taxa that is genetically distinct from other taxa. The word "variety" is used to describe the name of a particular cultivar. It is important to note that a single cultivar can have several varietal names that are associated with it. These are considered to be synonyms.

A good measure of a crop's importance to any particular culture is the number of cultivars which are managed by that culture (Rhindos 1984). **Kalo** is no exception to this rule as the number of recorded varieties far surpasses that of any of the other crop-plants cultivated by the ancient Hawaiians (e.g., sweet potato (*I. batatas*), bananas (*Musa acuminata* X *balbisiana* Colla.), breadfruit (*Artocarpus altilis* (Parkinson) Fosberg), yams (*Dioscorea* spp.), and arrowroot (*Tacca leontopetaloides* (L.) Kuntze) (Handy 1940)). A major challenge in assessing biodiversity is the fact that there has been a substantial time-gap between the height of **kalo** cultivation in Hawai'i — when the highest levels of biodiversity are assumed to have existed — and the current era. This has been due, in large part, to a dramatic decrease in both area of **kalo** cultivation and the number of **kalo** farmers. In the course of this time gap most of the varieties have apparently gone extinct. Further complicating the situation is the concurrent decrease in associated cultural knowledge that has accompanied the decline in cultivation. This is perhaps best illustrated in the shift away from Hawaiian as the only language towards English as the only language that accompanied this period (Schütz 1994), and which undoubtedly had a negative influence on the general understanding of the ethnonomenclature and ethnoclassification systems of the Hawaiian language. This knowledge vacuum regarding the traditional names and relationships of the various kalo cultivars was eventually filled by horticulturalist-based views on the matter. Since neither the knowledge of traditional taxonomy, nor the high biodiversity-levels of **kalo** exists today, there is no standardized way to assess the former levels of biodiversity. Furthermore, there does not seem to be more than a few farmers alive today in all of Hawai'i who represent an unbroken link in the once widespread tradition of maintaining multiple (more than a dozen) cultivars on a family farm.

A major reason for this paucity of traditional farmers is the fact that, for several decades during the last half of the 19th century and the first half of the 20th century, much of **kalo** farming was done by Chinese and Japanese immigrants rather than Hawaiians (Cho *et al*. 2007, MacCaughey & Emerson 1913). Even today much of the **kalo** which is currently under cultivation is farmed by the descendants of Chinese, Japanese, and Filipino immigrant laborers; as well as first generation immigrants from the Philippines and Micronesia. In many cases contemporary Hawaiian **kalo** farmers, at some point in the last 150 years, have had at least a single generational break in tradition between themselves and the Hawaiian farmers of old. Because of this, and the now-prolific horticulturist-based views on **kalo** diversity, the general understanding of **kalo** diversity (i.e., nomenclature and taxonomy) held by contemporary farmers has likely changed in the past 150 years.

In spite of previous attempts to document **kalo** diversity there is still a lack of certainty about the true levels at, or near, the height of cultivation in Hawai'i. This lack of certainty stems from the information sources either lacking a strong understanding of traditional Hawaiian nomenclature and taxonomy, scientific rigor in their diversity assessments, or both. In order to more accurately assess the true diversity of **kalo** at or near the height of cultivation in Hawai'i, this study attempts to marry a firm understanding of traditional Hawaiian nomenclature and taxonomy, with a more rigorous assessment of the entire collection of names and descriptions amassed from several different sources.

A major contributing factor for our lack of understanding about previous levels of diversity, aside from the extinction crisis which started in the 19th century as described above, is the complexity of synonymy that exists in the body of recorded varietal names. Synonymy is the application of more than one name to a single taxon. Synonymy is known to exist in the Hawaiian language, and has been well documented broadly—in both the lexicon (Pu-

kui & Elbert 1979, 1986) and taxonomic systems (Abbott 1995), and for **kalo** specifically (Chun 1994, 1998, Handy 1940, Iokepa & Kekahuna n.d., MacCaughey & Emerson n.d., 1913, Pukui & Elbert 1986, Wilder 1934, field notes). In a review of the above sources it is apparent that there are two general classes of synonymy in the Hawaiian lexicon — linguistically-based synonymy and classification-based synonymy. Linguistically-based synonymy occurs when different regions which follow the same classification system have differing pronunciations of the same taxon. Such differences correspond to either vowel or consonant deletions, additions or substitutions. As an example, the variety name, **Mākohi**, was also called **Mākohe**, **Mōkohi**, **Mōkohe** and **Mākihi** (Handy 1940, MacCaughey & Emerson n.d., 1913, Pukui & Elbert 1986) in other areas that followed the same classification system. On the other hand, classification-based synonyms occur when one taxon is found in multiple areas, some of which follow differing classification systems. The same taxon, **Mākohi**, was known as **'Ele'ele mākoko** (Iokepa & Kekahuna n.d.) in another classification system, and also as **Maka'ōpio** (Chun 1994) in yet another. This recognition has influenced the methodological approach, data analysis and conclusions of this paper.

This publication is not meant to be the "end all, be all" definitive authority on **kalo** diversity. It is merely an attempt to add data and analysis to the contemporary body of knowledge, and to reawaken the discussion of **kalo** diversity. Recent research has acknowledged the formerly high levels of **kalo** diversity and its subsequent decline (Cho *et al*. 2007), but new data and analysis have not been contributed to the debate since Whitney *et al*. (1939) and Handy (1940).

Although it is not dealt with substantively in this manuscript, it is important to note that many varieties had (and some continue to have) unique and specific traditions associated with them. Examples of these are the now-extinct **Hoene**, which was used medicinally for enemas; and currently-rare **'Apuwai**, whose cup-shaped leaves catch rainwater that is used in ceremonies. Once varieties go extinct, so too die the cultural practices which required those specific taxa for implementation (Winter & McClatchey 2009). Further research may be able to quantify the cultural loss that has accompanied a loss of cultivars.

Methods

This study has three specific assumptions that are based in the idea that there are direct relationships both between biodiversity and linguistic diversity (Nettle & Romaine 2000), and also between biodiversity and cultural diversity (Winter and McClatchey 2008 & 2009). They are as follows:

1. **Kalo** biodiversity and associated cultural knowledge is linked, and this relationship has generally experienced both a coupled increase and a coupled decrease in the past 1,000 years,
2. The height of **kalo** diversity and associated cultural knowledge existed at the height of **kalo** cultivation in Hawai'i, and
3. The height of **kalo** cultivation existed at the point of contact with foreign cultures in 1778.

Since this study attempts to assess a level of intraspecies diversity that no longer exists, readily accepted methodologies for assessing diversity (i.e., field surveys and free-listing exercises to reveal relative abundance/varietal richness resulting in an index of diversity,) are not viable methods. In order to measure change over time, **kalo** diversity has been measured at two points in time: 1) The era ranging from the late 19th to early 20th centuries (citations ranging from 1879-1940) which represents a period of diversity decline after the presumed height of **kalo** cultivation, via an assessment of nomenclatural diversity; and 2) Contemporarily, via biodiversity assessments. Comparisons between these estimates were then made.

Surveys of Nomenclatural Diversity

Nomenclatural diversity assessments were done beginning with a review of published and archival resources in Hawaiian and English. Published and archival materials were qualitatively analyzed in two areas: adherence to trends in Hawaiian nomenclature and taxonomic systems, and adherence to the scientific method. Trends in ethnonomenclature and ethnotaxonomy were identified by Berlin (1992) and have been demonstrated to be applicable to Proto Oceanic ethnonomenclature and ethnoclassification systems (Evans 2008) which are the evolutionary precursor to Hawaiian nomenclature and classification systems. In Hawaiian systems, Berlin's (1992) trends have been substantiated by the descriptions of both Hawaiian plant experts (i.e., **kahuna lā'au lapa'au** or highly skilled herbal healers) (Chun 1994, 1998, Gon 2008) and botanists studying Hawaiian nomenclature systems (St. John 1982). These trends are later used in assessing the quality of citations (see below section, Rigor Assessments for Cited Authorities).

The trends seen documented in sources regarding synonymy in the Hawaiian lexicon (Abbott 1995, Chun 1994, 1998, Handy 1940, Iokepa & Kekahuna n.d., MacCaughey & Emerson n.d.,1913, Pukui & Elbert 1986, Wilder 1934, field notes) were used in assessing synonymy within the nomenclature of **kalo**. An attempt was made to sort through the collection of **kalo** names and descriptions to come to both a liberal and a conservative estimate of the number of distinct cultivars in the post-contact cultivation period, as this is the era when the documentation occurred. The first twenty-three rules (see below), which primarily deal with linguistically-based synonymy in nature, are applied to find the highest end of the estimated range (i.e., a liberal estimate of **kalo** diversity). Rule 23 is derived from the presence of documented varietal names

corresponding to proper names of **kalo**-based characters in stories such as the names seen in "The Story of Big Taro and Little Taro" (Anonymous1861, Nohokuaaina 1867). An additional twelve rules, which relate to adherence to trends in ethnonomenclature and ethnoclassification, are applied to find the lowest end of the estimated range (i.e., a conservative estimate of **kalo** diversity.

Synonymy or other erroneous nomenclature was identified by the presence of the below described conditions. All of the conditions are founded in already documented synonymy (Abbott 1995, Chun 1994, Handy 1940, Iokepa & Kekahuna n.d., MacCaughey & Emerson 1913, 1914, Pukui & Elbert 1979, 1986, Whitney *et al*. 1939, Wilder 1934), and then applied broadly. If any of these conditions were met the names were either consolidated in or eliminated from the master list. It is important to note that although these synonyms may initially appear questionable, due to their possible meaning-altering appearance, several of these are previously documented synonyms (i.e., **Kūʻoho** and **Kūʻohu**), and therefore may represent examples of linguistic engineering for ease of pronunciation.

Vowel substitutions and additions:
1. o/u substitutions (example: **Kūʻoho / Kūʻohu**)
2. a/o substitutions (example: **Hāakea / Hāokea**)
3. a/e substitutions (example: **ʻleʻie / ʻlaʻia**)
4. e/i substitutions (example: **Wehiwa / Wehewa**)
5. "a" additions on the end of a word (example: **Papakole / Papakolea**)
6. "o" additions at the end of a word (example: **Māna** / **Māna-o-**)

Consonant substitutions and deletions:
7. n/l substitutions (example: **Māna ʻowene** / **Māna ʻuwele**)
8. '/m/n substitutions (example: **Manauea** / **Mamauea** / **Maʻauea**)
9. "w" deletions (example: **Pualu** / **Puwalu**)

Various classes of reduplication:
10. Reduplication of first vowel (example: **ʻApu / ʻAʻapu**)
11. Reduplication of last vowel (example: **Māiʻi / Māiʻiʻi**)
12. Full reduplication of both species names (example: **Pia / Piapia**), and subspecies epithets (example: **ʻula / ʻulaʻula**).
13. Partial reduplications (example: **Hāpuʻu/ Hāpuʻupuʻu**)
14. Prefix reduplications (example: **Wehiwa / Wewehiwa**

Backformation:
15. Contractions (example: **ʻEleʻele / ʻEʻele**)

Miscellaneous:
16. Prefix additions of **hā** on subspecies epithets (example: **hāʻulaʻula / ʻulaʻula**)
17. Similar color descriptors unless indicated as separate cultivars (example: **kea / keʻokeʻo**, **melemele / lenalena**, **ʻulaʻula / lehua**)
18. **Maoli** as type specimen in group, and a **kalo** species with no subspecies epithet associated with it (example: **Hāpuʻupuʻu maoli / Hāpuʻupuʻu**)
19. Documented synonymy for group names where subspecies epithets are the same (example: **Piko ʻeleʻele / Haehae ʻeleʻele / Uaua ʻeleʻele**).
20. Obvious mis-spellings or transcription errors (example: **Haehae keʻokoʻa / H. keʻokeʻo**)
21. Similar meanings in subspecies epithets using synonymous words/terms (example: **Lehua kū-i-ka-wao / Lehua kū-kuahiwi**)
22. Names documented as being assigned to post-contact introductions (example: **Pākē**, **ʻIliuaua**)
23. Seemingly proper names (example: **Kalo nui e / Kalo iki e**)

Further consolidations for a conservative estimate, founded in adherence to trends in ethnonomenclature and ethnoclassification, were done if the following conditions occurred:
24. The name is poetic (example: **Kaʻawelu-i-ka-pali-o-Awakea**).
25. The name is a trinomial.
26. The name is seemingly vulgar (examples: **He-ʻowā-hulu-nui**, **Heu-ā-lehu, Heu-ʻele**, **Pani-kohe**).
27. Group names exist that are noted as synonyms for other crops (example: **Manini / Koaʻe**, **Mākea / Mahakea**)
28. **ʻUlaʻula** as a group name is a synonym for the **Kūmū** group
29. **ʻEleʻele** and **Nohu** as group-names are synonyms for the **Naioea** group
30. **ʻAla** as a group name is a synonym for the **Kāī** group.
31. A lack of documentation of the word "**maoli**" (meaning "type-specimen") in the subspecies epithet (example: for the **ʻApuwai** group three names are collectively recorded - **ʻApuwai**, **ʻA. keʻokeʻo** and **ʻA. ʻulaʻula**. These will be counted as two cultivars instead of three. For the **Hāpuʻu** group six names are collectively documented - **Hāpuʻu maoli**, **H. ʻeleʻele**, **H. kea**, **H. lenalena**, **H. nūkea**, and **H. ʻulaʻula**. These were counted as six cultivars).
32. The name is a monomial which is also the name of an **ahupuaʻa** (traditional land-division unit). Such names may have been given to honor the cultivar's place of origin when cultivars were transferred in the absence of knowledge about their original name.
33. Species-level names listed as monomials are subspecies epithets noted elsewhere in a binomial (**Lauloa papamū** / **Papamū**).
34. Species-subspecies nomenclatural reciprocations (**ʻUlaʻula poni**, **Poni ʻulaʻula**).
35. The various monomials which vaguely indicate either a black-colored or striped petiole are considered synonyms for other varieties accounted for elsewhere in the list (**Pōpolo**, **Hiwa**; **Kāniʻo**, **Niʻo**).

Data on the occurrence of documented synonymy for each respective source were also recorded. The percent-

age of synonymy was calculated for each source using the following equation:

ns / nt = synonymy percentage,

where, ns is the number of varietal names documented as having a synonym, and nt is the total number of varietal names documented.

Biodiversity Assessment

Kalo collections of botanical gardens, agriculture stations, and private individuals/families (including both commercial and subsistence farms) were surveyed on the islands of Kaua'i, O'ahu, Moloka'i, Maui, and Hawai'i between the years of 2003-2012. Accession information for living specimens was reviewed (if available), and the specimens' morphological traits were compared against the descriptions of Whitney *et al*. (1939) to confirm accuracy. Through the generosity of these entities and individuals, collections were made for propagation on the island of Kaua'i where a common garden experiment was conducted under a nursery setting between 2011-2012. The plants in the experiment were verified using Whitney *et al*. (1939), and also by recognized community experts on **kalo** diversity (Jerry Konanui & Penny Levin). Voucher specimens have been prepared of these varieties that have been deposited in the National Tropical Botanical Garden herbarium (PTBG), Kalaheo, Kaua'i, Hawai'i.

Rigor Assessments for Cited Authorities

Qualitative cultural and scientific rigor assessments were conducted. Cultural rigor was weighed against adherence to trends in Hawaiian nomenclature systems. Scientific rigor was weighed against whether or not data collection was qualitative or quantitative, and if comparative analysis was done.

Cultural rigor was assessed and given designations by the following criteria:

- High – Authors have produced other manuscripts and publications regarding ethnonomenclature and ethnoclassification.
- Medium – Authors did not produce other manuscripts and publications regarding ethnonomenclature and ethnoclassification, but data produced follows the trends articulated by Berlin (1992).
- Low – Authors did not produce other manuscripts and publications regarding ethnonomenclature and ethnoclassification, and data produced is in conflict with the trends articulated by Berlin (1992).

Scientific rigor was assessed and given designations by the following criteria:

- High – Collected quantitative data regarding morphology in a common garden experiment, and did comparative analysis of this data.
- Medium – Collected qualitative data regarding morphology in a common garden experiment, and did comparative analysis of this data.
- Low – Collected qualitative data regarding morphology from different locations and environments for comparative analysis.
- Non-existent – No evidence of either data collection regarding morphology or comparative analysis.

Status assessments for once-prevalent cultivars

Status assessments for once-prevalent cultivars were done based on the above described field observations. Field status was assessed and given designations by the following criteria:

- Common – Cultivar was documented in commercial farms, family farms/gardens, and botanical collections.
- Occasional – Cultivar was not documented in commercial farms, but was documented in family farms/gardens, and botanical collections.
- Rare – Cultivar was neither documented in commercial farms nor family farms/gardens, but was documented in botanical collections.
- Extinct – Cultivar was not documented in commercial farms or family farms/gardens, and there is no evidence of it existing in botanical collections.

Results

Previous Estimates of Synonymy

Fourteen documents (including published and unpublished archival-manuscripts) relating to names and descriptions of **kalo** diversity were assessed. These were written in Hawaiian and English. The document dates ranged from 1879-1986. The most recent of these (Pukui and Elbert 1986) was a compilation of previous works, not a representation of field work. Future mention of these document dates will refer to 1879-1940 which represents the range of time that field data was collected. Five of the manuscripts have no date associated with them, but judging from their presence in the Bishop Museum Archives they are likely from the same period. From the lists within these, a total of 669 varietal names of **kalo** were accumulated. Seven more were added from oral history documents representing a total of 676 names. Typographical errors and non-Hawaiian varieties (i.e., Asian and South Pacific cultivars that were given adoptive Hawaiian-names) were removed reducing the list to 598 varietal names (Appendix 1). Linguisitically-based synonyms were then consolidated to 512 varietal names (Appendix 1) that were used for further analysis including a calculation of synonymy. The manuscripts documented synonymy with a range from 0 - 80% (Table 1).

Table 1. Publications and manuscripts that documented **kalo** (*Colocasia esculenta* (L.) Schott.) diversity in the Hawaiian islands. Wight (n.d.) was used as a reference by Handy (1940) to make his list of varietal names. This work has been missing from the Bishop Museum Archives since the 1980s and was therefore unavailable for analysis.

Authors	Language	# of cultivars	Synonymy
Henriques n.d.	Hawaiian	34	0%
Iokepa and Kekahuna n.d.	Both	92	26%
Kalanianaole n.d.	English	26	0%
Rooke n.d.	English	42	0%
Wight n.d.	N/A*	N/A*	N/A*
Anonymous 1879	Hawaiian	37	0%
MacCaughey & Emerson 1913	English	272	20%
MacCaughey & Emerson 1914	English	298	8%
Fornander 1919	Both	30	0%
Wilder 1934, n.d.	English	95	35%
Whitney *et al*. 1939	English	141	80%
Handy 1940	English	354	12%
Pukui & Elbert 1986	English	235	25%
Chun 1994	Both	31	29%

Field Surveys

Field surveys of botanical gardens, agricultural stations, and individual collections (both commercial and subsistence farms) throughout Hawai'i have determined that there has indeed been a decline in **kalo** diversity, even in the recent historical period. At least 63 of the heritage **kalo** cultivars documented in Whitney *et al*. (1939) remain. In addition to these, nine more have been added to the list of confirmed Hawaiian varieties. These include two Hawaiian cultivars were added via hybridization in the 20th century (**Maui Lehua** which is a cross between **Lehua maoli** and **Pi'iali'i**, and **Pili-aloha** which is a cross between **Kāī kea** and **Moi**), one, **Moi 'ula**, which was documented by other sources (Handy 1940, Iokepa & Kekahuna n.d., Pukui & Elbert 1986, Wilder 1934), and one previously undocumented cultivar, **Pi'ikea**. The remaining five (**'Elepaio hāuliuli**, **Kāī** KBS, **Lauloa koukou'ai**, **Makalau**, and **Niumalu**) do not match with documented descriptions, but are debatably Hawaiian. A possible rediscovery of **Lauloa 'ōni'oni'o** via somatic mutation (not yet confirmed) brings the total number of remaining Hawaiian cultivars to 73 (Table 2). Outside of the Hawaiian cultivars, at least 71 cultivars have been introduced from around the Pacific and Asia. In addition to these, literally several thousand cultivars have been created since the 1980s via both officially sanctioned and unofficially sanctioned hybridization experi-

Table 2. The extant diversity of **kalo** (*Colocasia esculenta* (L.) Schott) representing documented cultivars, 20th century Hawaiian X Hawaiian hybrids, and undocumented cultivars *strongly-to-debatably assumed to be Hawaiian.

Cultivar Name	In Whitney *et al*. 1939		Modern Hybrid
	Yes	No*	
'Āpi'i / Moana	1	0	0
'Apowale	1	0	0
'Apu	1	0	0
'Apuwai	1	0	0
'Āweuweu / **'Āhē**	1	0	0
'Ele'ele lauloa	1	0	0
'Ele'ele mākoko	1	0	0
'Ele'ele naioea	1	0	0
'Elepaio (**kea**)	1	0	0
'Elepaio hāuliuli	0	1	0
Hāokea	1	0	0
Hāpu'u	1	0	0
Kāī 'ala	1	0	0
Kāī kea	1	0	0
Kāī uliuli	1	0	0

Cultivar Name	In Whitney *et al*. 1939		Modern Hybrid
	Yes	No*	
Kāī unknown (a.k.a., Kaua'i Branch Station)	0	1	0
Kalalau	1	0	0
Kūmū 'ele'ele	1	0	0
Kū'oho	1	0	0
Lauloa 'ele'ele	1	0	0
Lauloa ke'oke'o	1	0	0
Lauloa 'ōni'oni'o	0	1	0
Lauloa palakea	1	0	0
Lauloa papamu	1	0	0
Lauloa pakakea-ula	1	0	0
Lauloa koukou'ai	0	1	0
Lehua 'āpi'i	1	0	0
Lehua maoli	1	0	0
Lehua palai'i	1	0	0
Lihilihimolina	1	0	0

Cultivar Name	In Whitney *et al*. 1939		Modern Hybrid
	Yes	No*	
Maea	1	0	0
Makalau	0	1	0
Mana ʻeleʻele	1	0	0
Mana keʻokeʻo	1	0	0
Mana lauloa	1	0	0
Mana ʻokoʻa	1	0	0
Mana ʻōpelu	1	0	0
Mana ʻulaʻula	1	0	0
Mana uliuli	1	0	0
Mana ʻulu	1	0	0
Mana-piko	1	0	0
Manini kea	1	0	0
Manini ʻōpelu	1	0	0
Manini ʻowali	1	0	0
Manini uliuli	1	0	0
Maui Lehua	0	0	1
Moi (**kea**)	1	0	0
Moi ʻulaʻula	0	1	0
Nāwao	1	0	0
Nihopuʻu	1	0	0
Niumalu	0	1	0
ʻOene	1	0	0
ʻOhe	1	0	0
ʻOʻopukai	1	0	0
Paʻakai	1	0	0
Papapueo	1	0	0
Piʻialiʻi	1	0	0
Piʻikea	0	1	0
Piko ʻeleʻele	1	0	0
Piko kea	1	0	0
Piko keʻokeʻo	1	0	0
Piko uaua	1	0	0
Piko ʻulaʻula	1	0	0
Piko uliuli	1	0	0
Pili-aloha	0	0	1
Pololū	1	0	0
ʻUahi-a-pele	1	0	0
ʻUlaʻula kūmū	1	0	0
ʻUlaʻula moano	1	0	0
ʻUlaʻula poni	1	0	0
Waiākea	1	0	0
Wailana	1	0	0
Wehiwa	1	0	0
Total	63	8	2

ments (including hybrid crosses) conducted by University of Hawaiʻi researchers and affiliates using Hawaiian and non-Hawaiian cultivars. Countless numbers of these have been distributed to farmers, but there has not been rigorous documentation about their morphology and distribution. Due to the nature of this complexity, an analysis of these hybrids was excluded from this study.

Field surveys to assess collections of botanical gardens and University of Hawaiʻi agriculture stations took place on the islands of Kauaʻi, Oʻahu, Molokaʻi, Maui and Hawaiʻi which represented broad ranges in environmental conditions. These surveys occurred between 2003 and 2012. Accession information has revealed that the vast majority of these collections trace back to the original collections used to produce the Whitney *et al*. (1939) publication.

Rigor of Previous Diversity Assessments

All of the sources documenting **kalo** diversity were qualified as to the rigor of their cultural knowledge as indicated by their adherence to trends in Hawaiian nomenclature systems, and scientific rigor as indicated by scientifically-based data collection and analysis (Table 3). No source ranked high in both categories.

Taxonomic Trends

Traditional Hawaiian nomenclature and taxonomy as gleaned from the works produced in collaboration with recognized Hawaiian plant experts (i.e., those designated as having “high” cultural rigor in Table 3) conformed to the trends in ethnobiological classification as articulated by Berlin (1992). This is illustrated by Table 4 as an isolated example, and in Figure 1 as a contextual example.

Trends in Nomenclature

One of the trends seen in the data is that many of the species-level names fall into one of the following categories.

- Fish names (at least 26 species-level names)
  - **ʻAkilolo** – yellow-tail wrasse (*Coris gaimard* Quoy & Gaimard, 1824)
  - **Kūmū** – whitesaddle goatfish (*Parupeneus porphyreus* Jenkins, 1903)
  - **Manini** – convict tang (*Acanthurus triostegus* L., 1758)

Table 3. Cultural and scientific rigor of data sources used to qualitatively assess **kalo** (*Colocasia esculenta* (L.) Schott.) diversity in the Hawaiian islands. Cultural rigor was weighed against adherence to trends in Hawaiian nomenclature systems. Scientific rigor was weighed against the scientifically-based data collection and analysis. Wight (n.d.) was used as a reference by Handy (1940) to make his list of varietal names. This work has been missing from the Bishop Museum Archives since the 1980s and was therefore unavailable for analysis.

Author	Rigor	
	Cultural	Scientific
Henriques n.d.	Low	Non-existent
Iokepa & Kekahuna n.d.	High	Medium
Kalanianaole n.d.	Medium	Low
Rooke n.d.	Medium	Non-existent
Wight n.d.	N/A*	N/A*
Anonymous 1879	Medium	Low
MacCaughey & Emerson 1913	Medium	Low
MacCaughey & Emerson 1914	Medium	Low
Fornander 1919	High	Low
Wilder 1934, n.d.	Medium	Medium
Whitney *et al*., 1939	Low	High
Handy 1940	High	Medium
Pukui & Elbert 1986	Medium	Low
Chun 1994	High	Low

- Morphological trait (at least 17 species-level names)
  - **ʻApuwai** – “cup-shaped leaf”
  - **Lauloa** – “long leaf”
  - **Māna** – “branching corm”
- Forest plants (at least 15 species-level names)
  - **ʻAhakea** – *Bobea elatior* Gaudich., a hardwood tree
  - **Hāpuʻu**(**puʻu**) – *Cibotium* spp., a tree fern
  - **Lehua** – *Metrosideros collina* (J.R. Forst. & G. Forst.) subsp. *polymorpha* (Gaudich.) Rock, a hardwood tree
- Shared names with other crops varieties (at least 15 species-level names)
  - **Kawelo** – species-level name for a sweet potato (*I. batatas*) variety
  - **Loha** – species-level name for a banana (*M. acuminata* X *balbisiana*) variety
  - **Mahakea** – species-level name for an **ʻawa** (*Piper methysticum* C. Forst.) variety
- Group characteristic (at least 10 species-level names)
  - **ʻAla** – “fragrant when cooked”
  - **ʻApowale** – “easy to harvest”
  - **Uaua** – “hard to harvest”
- Seemingly esoteric (at least 9 species-level names)
  - **Mākohi** – ambiguous meaning
  - **Naioea** – unknown meaning
  - **Piʻialiʻi** – “ascending royalty”
- Shared name with an **ahupuaʻa** or land division (at least 5 species-level names)
  - **Kahaluʻu** – an **ahupuaʻa** name found on two islands (Oʻahu and Hawaiʻi)
  - **Kalalau** – an **ahupuaʻa** on the island of Kauaʻi
  - **Pololū** – an **ahupuaʻa** on the island of Hawaiʻi
- Bird names (at least 5 species-level names)
  - **ʻElepaio** – monarch flycatcher (*Chasiempis* spp.)
  - **Koaʻe** – tropic bird (*Phaethon* spp.)
  - **Pueo** – Hawaiian short-eared owl (*Asio flammeus sandwichensis* A. Bloxam, 1827)
- Predominant petiole color (at least 5 species-level names)
  - **ʻEleʻele** – “blackish”
  - **Poni** – “purplish”
  - **ʻUlaʻula** – “reddish”
- Genus-level names of other Polynesian-introduced plants (at least 4 species-level names)
  - **ʻOhe** – Polynesian bamboo (*Schizostachyum glaucifolium* (Rupr.) Munro)
  - **ʻŌlena** – turmeric (*Curcuma longa* L.)
  - **Pia(pia)** – arrowroot (*T. leontopetaloides*)
- Religious connotations (at least 4 species-level names)
  - **Pāʻū-o-Hiʻiaka** – “skirt-of-Hiʻiaka”
  - **Piko-o-Wākea** – “navel-of-Wākea”
  - **ʻUahi-a-Pele** – “smoke-of-Pele”

Table 4. Classification of the Hawaiian **kalo** (*Colocasia esculenta* (L.) Schott.) cultivar, **ʻApuwai kea**, following Berlin’s (1992) general system.

Classification System	
Berlin’s (general)	**Hawaiian (specific)**
Kingdom	**Lāʻau**
Life Form	**ʻAi / Meakanu**
Genus	**Kalo**
Species	**ʻApuwai**
Sub-species	**Kea**

A trend in subspecies-level nomenclature is that they mostly correspond to petiole color. Of the 295 subspecies epithets in the data (Appendix 1), 178 or 60% are undoubtedly given their epithet designations due to their petiole coloration (Table 5).

Discussion

Hawaiian Taxonomic Systems and Synonymy

In the context of traditional Hawaiian nomenclature systems, synonymy—especially among the islands—was prevalent for useful plants both wild and cultivated (Abbott 1995, Chun 1994, Pukui & Elbert 1986). Before the time of Kamehameha’s consoli-

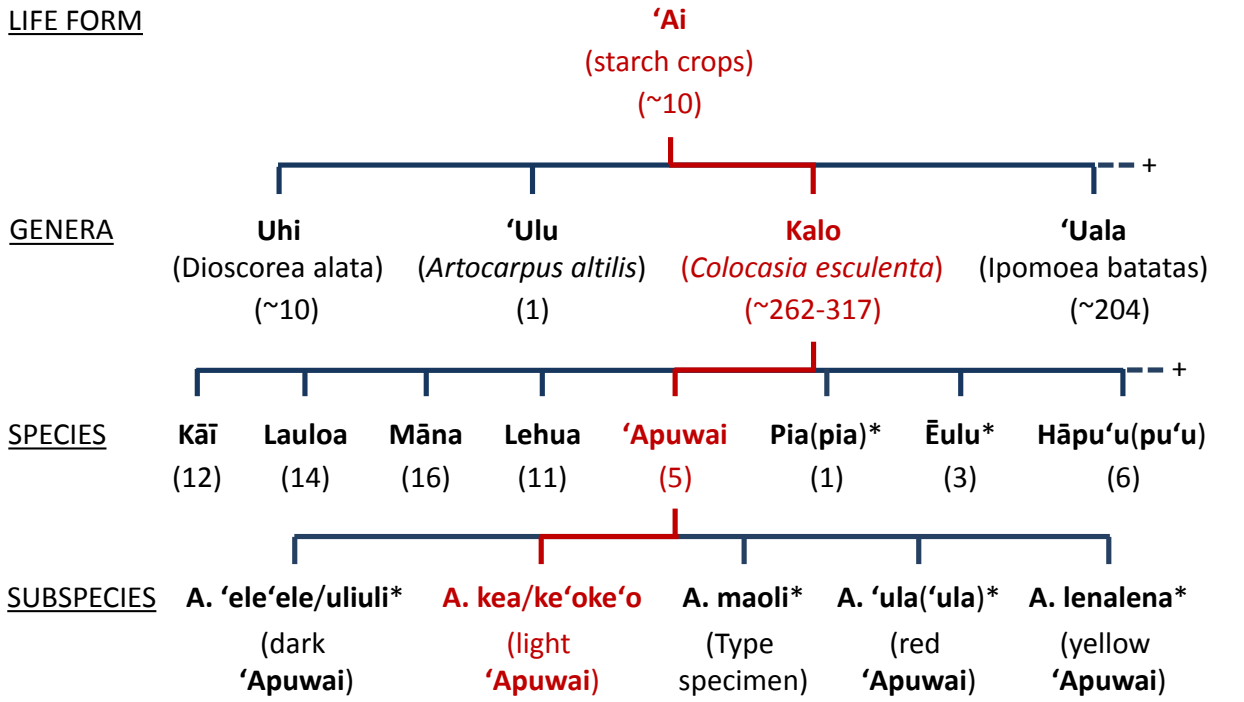

Figure 1. Classification of the Hawaiian **kalo** (*Colocasia esculenta* (L.) Schott.) cultivar, **ʻApuwai kea**, as an example in the context of other taxa following Berlin's (1992) system. The bracketed numbers for the generic level represent the documented diversity found in Handy (1940) except for kalo that is from this research. The bracketed numbers for the specific level represent former, not current, diversity. The current diversity is lower at the specific level due to extinction. Generic and specific taxa were chosen to demonstrate the range of diversity. Presumed extinct taxa noted with *.

Table 5. Trends in nomenclature for 255 **kalo** (*Colocasia esculenta* (L.) Schott.) sub-species.

Subspecies Epithet Designation	**# Documented**
Blackish petiole (**ʻeleʻele**, **hiwa**, **uliuli**, **hāuliuli**)	53
Whitish petiole (**keʻokeʻo**, **kea**, **hākeʻokeʻo**)	50
Often ambiguous, singly-occuring epitaphs	49
Reddish petiole (**ʻulaʻula**, **lehua**, **hāʻula**, **hāʻulaʻula**, **koko**, **weo**)	45
Type specimen (**maoli**), assumed	44
Yellowish petiole (**lenalena**, **lena**, **hālenalena**, **ʻulu**, **ʻoene**)	19
Streaked/blotched petiole (**manini**, **ʻōniʻoniʻo**, **hāniʻoniʻo**)	6
Leaf cut to sinus (**piko**)	5
Purplish petiole (**poni**)	4
Type specimen (**maoli**), specified	3
Red vascular hub on leaf (**piko**- **ʻula**)	3
Mackerel scad - *Decapterus* spp. (**ʻōpelu**)	3
Branching corm (**māna**)	3
Streaked-sunset colored petiole (**welowelolā**)	2
Unknown meaning (**ʻāniholoa**)	2
Ambiguous meaning (**pipika**)	2
Long leaf (**lauloa**)	2
Total	**295**

dation of the five kingdoms into one (i.e., the Kingdom of Hawai'i, around the turn of the 19th century) under his rule, each kingdom had their own systems to understand their world — including calendars and taxonomic systems (Handy *et al*. 1972). Despite differing levels of endemism (for both wild and cultivated plants) on each island, each island seemed to be dealing with the same core set of useful wild and cultivated plants. However, since each kingdom had its own system for understanding and working with the natural world, many plants had not only different names, but also different relationships (i.e., classifications) within taxonomic systems on the different islands (i.e., former kingdoms). The data collected and analyzed in this paper originated in different classification systems, documentation of which is spotty at best. This has added to the complexity of data analysis.

The Complexity of Synonymy and Previous Estimates of Kalo Diversity

Like the taxonomic system for native plants, some **kalo** varieties have different names on different islands. They also may be positioned differently within each island's respective taxonomic system (Handy 1940, Handy *et al*. 1972, MacCaughey & Emerson 1913).

The amount of synonymy within the collection of varietal names can cause much confusion. Collectors sometimes noted synonymy, but undoubtedly were not able to document every case. Furthermore, several contradictions exist in records of synonymy and descriptions. As an example the variety, **Pi'iali'i**, is listed by Wilder (1934) as having the following synonyms: **'Ahapi'i**, **Moi 'ula**, and **Mākohe**. Of these, **Mākohe** is listed as a synonym for **Mākohi** by MacCaughey and Emerson (1913, 1914). **Mākohi** is listed as a synonym for **'Ele'ele mākoko** by Iokepa and Kekahuna (n.d.), but Whitney *et al*. (1939) have treated **'Ele'ele mākoko** and **Pi'iali'i** as completely different and unrelated cultivars. Furthermore, **Mākohi** is listed as a synonym for **Maka'ōpio** by Chun (1994), but Whitney *et al*. (1939) treats **Maka'ōpio** as a synonym for **Piko 'ele'ele**, **Haehae 'ele'ele**, **Hele-mauna**, and **Ipu-o-lono** — each of which is listed as further synonyms for yet other varieties by the other authors, and the complexity continues on. Because of the contradictions that exist between the authors, the synonymy that they document was left out of the analysis of data accumulated here (Appendix 1), and linguistics and ethnoclassification became the primary tools for analysis.

Previous authors expressed different thoughts and conclusions on the matter of synonymy. Handy (1940) did not think that **kalo** had the same high level of synonymy as **'uala** (sweet potato):

> "…I am inclined to think that there is far less duplication of names than might be expected… The taros are more uniform in coloring than the sweet potatoes. Their cultivation was an all-year science, while sweet potato planting was spasmodic. The taro farmer was a systematic gardener, the sweet potato planter a casual farmer. Furthermore, taros are less easily transported for replanting than sweet potatoes. Hence there was great exactitude in nomenclature and less renaming—when the original name was unknown or forgotten—by the giving of a new descriptive name or the name of the person who brought in a new variety or created one from bud mutations." (Handy 1940)

Handy (1940) did not, however, state an estimated level of synonymy. Both MacCaughey and Emerson (1913), and Whitney *et al*. (1939) agreed that about 50% of collected varietal names could be considered synonyms (this will be referred to as the "50% Rule" from hereafter). However, this 50% Rule that they put forward seems to have no foundation as the estimate since it is not reflected in an analysis of their own data (see Table 1), and they provided no other reasons for the estimate. In fact, an analysis of the data collected by the various authors reveals that they documented synonymy ranging from eight (8) to 80% (see Table 1). This range is too broad to pin down even an approximation of actual synonymy that existed at or near the height of cultivation, and therefore further analysis was needed.

Previous works relating to the subject were assessed in an attempt to sort through the inconsistent nomenclature, synonymy, and taxonomic treatments. One problem is that several of the early authors (Anonymous 1879, Henriques n.d., Iokepa & Kekahuna n.d., Kalaniana'ole n.d., MacCaughey & Emerson 1913, 1914, Rooke n.d.) did not use a standardized method for collection or description. These sources range from only a collection of names with no descriptions, to a list of either vague or at best non-scientifically substantiated descriptions. It wasn't until Wilder (1934) and Handy (1940) that attempts were made to approach documenting diversity in a scientific manner. However, the data that they produced was qualitative and the rigor of their approach is questionable. Finally, Whitney *et al*. (1939) attempted to compile a comprehensive collection of names and scientifically quantified descriptions which were based on a common garden experiment. However, Whitney *et al*. (1939) state, regarding their study, that many of the Hawaiian **kalo** cultivars had already gone extinct or were so rare that they were not located. Whitney *et al*. (1939) tried to sort through synonymy via their common garden studies. Their conclusions lumped together several varieties that previous authors noted as being clearly distinct by using characteristics that do not change based on environmental conditions (e.g., petiole-base color). Specifically, Whitney *et al*.'s (1939) taxonomic treatment was in contradiction to those of Handy (1940), Wilder (1934) and Anonymous (1879) whose descriptions note greater differences between some of the cultivars, that Whitney *et al*. (1939) lumped together, than can be attributed to environmental influences (Winter, Field Notes 2003-2012). It is likely that

the high level of synonymy (80%) reported by Whitney *et al*. (1939) is not representative of the level of synonymy that existed at the height of cultivation. This figure is in fact substantially higher than any of the other authors who documented synonymy (6-26%), as well as Whitney *et al*.'s (1939) own stated estimate of 50%.

MacCaughey and Emerson (1913) were the first to put forward an estimate of **kalo** diversity at the height of cultivation. They asserted (presumably using their 50% synonymy estimate) that there may have been between 150-175 cultivars represented by approximately half of the names they collected. Handy *et al*. (1972) represented perhaps the most thorough examination of **kalo** ethnobotany, and estimated that there was once at least 300 cultivars. They qualify that there was a relatively small number of culturally salient cultivars that could be found throughout the Hawaiian islands, and further attribute the remainder of the diversity to the high number of localized cultivars occurring as endemics within various districts. Despite these estimates, there has been some hesitation to accept either of them because of the complex synonymy found within traditional **kalo** taxonomy. As a result of this hesitation there is no general agreement on even an approximate number of cultivars at the height of **kalo** diversity, although the diversity is generally qualified as high.

Iokepa and Kekahuna (n.d.) documented 92 varietal names that are the most accurate collection in terms of adherence to Hawaiian binomial-nomenclature trends. Iokepa was a lifelong **kalo** farmer, and well-respected elder of his area while Kekahuna was a learned Hawaiian who dedicated his life to documenting Hawaiian knowledge systems. Kekahuna's method was to seek out the most well-respected elders in a given area and document their knowledge (Kekahuna 1956). An analysis of Iokepa and Kekahuna's varietal list shows 26% synonymy. The sample size (92) and the level of cultural knowledge attributed to both Iokepa and Kekahuna points to a high level of accuracy. It is likely that 26% represents the best approximation for the actual synonymy level that existed at or near the height of **kalo** cultivation and, therefore, will henceforth be called the "26% Rule".

Secondary to the Iokepa and Kekahuna (n.d.) manuscript, is the work of Chun (1994). It also represents a high level of cultural knowledge in that the manuscript was a collaborative effort among **kahuna lā'au lapa'au** (highly skilled herbal healers) who are considered plant experts within the culture. Chun (1994) does not contain a comprehensive list of **kalo** varieties, but rather a list of 31 varieties that are used medicinally. Chun (1994) is considered secondary to Iokepa and Kekahuna (n.d.) because the report is of a relatively small subset of varieties. However, Chun (1994) does support Iokepa and Kekahuna's (n.d.) binomial nomenclature system, as well as synonymy level (29%), which will henceforth be called the "29% Rule".

Part of the discrepancy between the three rules may stem from the sources accounting for different classes of synonymy. Perhaps, the 50% Rule proposed by MacCaughey and Emerson (1939) and Whitney *et al*. (1939) stems from adding both linguistically-based and classification-based synonyms together. Either way, there is no data that support this estimate so it will not be used in further analysis. The other two rules—26% based on Iokepa and Kekahuna (n.d.), and 29% based on Chun (1994)—clearly only relate to classification-based synonymy. When the 26% Rule and the 29% Rule were applied to the list of 512 linguistically-consolidated names, an initial estimate was obtained which produced a possible range of 364-379 distinct cultivars. This maybe a good starting point for estimating a conservative and liberal range of **kalo** diversity; however this is just a cursory analysis. Therefore, this work puts forth a more systematic approach using linguistic tools, in concert with trends in ethnonomenclature and ethnoclassification (Berlin 1992), to assess diversity.

Taxonomic and Nomenclature Trends

As Berlin (1992) points out, human cultures, have systemized ways of classifying the biological world around them. Hawaiian culture is no exception. The system laid out by Berlin seems to describe well the way in which Hawaiians apply classification, taxonomy and nomenclature. Hawaiian nomenclature at the finest level is mostly binomial. Names applied to **kalo** cultivars in Hawai'i correspond to Berlin (1992) (Table 4).

About 92% of the 652 recorded **kalo** varietal names are binomials (or mononomials that fit into a binomial system). This certainly confirms to the binomial trend seen in publications produced in collaboration with herbal healers (Chun 1994, 1998, Gon 2008), and recognized by botanists who studied Hawaiian nomenclature systems (St. John 1982). Only two (2)% (14 names) of the entire collection are trinomials. There are three likely explanations for these trinomials:

1. They are names that were incorrectly recorded.
2. They reflect the extreme importance of **kalo** to Hawaiian culture resulting in development of a taxonomic level below subspecies.
3. They are a part of a taxonomic system created by scientists who did not adhere to Hawaiian nomenclature traditions.

Seven of 14 (50%) of the recorded trinomials are found in (Whitney *et al*. 1939). The others could be either misspellings, or debatable binomials. Whitney *et al*. (1939) admittedly created a system that achieved their goal of a dichotomous key, and this could have included creating the trinomials seen in the **lauloa** group (Appendix 1).

The remaining 5% of names are questionable, poetic names that stem mostly from Henriques (n.d.). These are

likely to be proper names of **kalo**-based characters in stories rather than cultivar names.

Nomenclature Trends at the Species and Subspecies Levels

Different trends emerged regarding naming at both the species and subspecies level. Species-level names include monomials with no clear relationship to other cultivars, and the group name for a set of binomials. In regards to monomials, many have no documented meaning or obvious source. These, perhaps, represent taxa that were named after people (Handy 1940). For the remainder of the monomials, a few have religious connotations indicating a possible role in ceremony. The remaining monomials indicate a strong tendency for either naming after a morphological resemblance to something in nature (reef fish, forest plant, forest bird, or other cultivated plants). If the name is binomial there is a pattern of the group name (i.e., species-level name for a set of subspecies) being given due to common morphological trait (such as branching-corm, or long-leaf) or other characteristic of the group (such as fragrant-when-cooked, or predominantly-black petiole).

In examining the subspecies epithets a different trend emerges. The majority (60%) of the subspecies epithets are color designations. This indicates that the ancient Hawaiians taxonomically grouped **kalo** together according to a common morphological trait, and separated out individuals that were different color variants of that common trait. About 16% of subspecies are either specifically indicated with the epithet, **maoli**, or otherwise assumed to be classified as such. "**Maoli**," is defined in Hawaiian as "Native, indigenous, aborigine, genuine, true, real, or actual" (Pukui & Elbert 1986:240). In effect, this is a Hawaiian term for the original or type specimen. The data reflects that subspecies outside of this type specimen are generally distinguished from one another by the predominant petiole coloring. This might indicate that the type-specimen is the original form from which somatic mutations produced subspecies that retain the general morphology, but differ in petiole color. If so, then the most common mutation colors are (in descending order) blackish, whitish, reddish, yellowish, and purplish (Table 5). Since it is likely that many have gone extinct, and the remaining cultivars represent a severe genetic bottleneck, so we can only speculate about whether or not the data reflect a genetic reality.

The Relationship of Reduplications and Backformations in Synonymy

While this paper identifies synonymy trends in data, it is beyond the scope to identify the linguistic foundations of this synonymy (such as various kinds of vowel substitutions and consonant substitutions). However, the relationship between reduplications or backformations is one form of synonymy that may be explored since it directly relates to physical morphologies differentiating taxa (Figure 2).

The question naturally arises, which came first the reduplication or the backformation (and how does this relate to why these taxa were named as such). Ross (2008) observed that, in Proto Oceanic (an evolutionary precursor to Hawaiian), reduplications were common when naming a plant that resembles another is some way, but is not the original. In Figure 2, **Hāpu'u** and **Hāpu'upu'u** are treated as synonyms. **Hāpu'u** is a native tree fern (*Cibotium* spp.). It has a dark trunk and green fronds. The **kalo** of the same name (**kalo Hāpu'u)** has dark petioles and green leaves. The **kalo** was named in reference to the tree fern. If the trends of Proto Oceanic carry forward into the Hawaiian language, then the original name given to the **kalo** would have been **Hāpu'upu'u** as it resembles, but is clearly not the tree fern. Over time, presumably for ease of pronunciation, a backformation likely took place, making **Hāpu'u** a synonym for the original, **Hāpu'upu'u**. The second example in Figure 2, **Pia** and **Piapia** cannot be confirmed since **Piapia** is extinct and unavailable for morphological analysis. However, if the above example is correct then **Piapia** might have been a **kalo** with a taste/consistency (or other character) that resembled **Pia** (*T. leontopetaloides*), and was therefore called **Piapia**. Over time, presumably for ease of pronunciation, a backformation took place, making **Pia** a synonym for the original form, **Piapia**.

Changes in Nomenclature and Taxonomy

Given the language shift in Hawai'i which went from Hawaiian as the only language, to Hawaiian as a second language, and going as far as English as the only language for the majority of Hawaiians, it can be predicted that there would also be associated shifts in nomenclature and taxonomy of biological taxa. There is evidence to support this. All indications are that Hawaiians used a binomial system until the mid-20th century when a horticulturalist-based understanding of kalo diversity began to fill the knowledge void left as more and more Hawaiian-speaking farmers passed away, and their knowledge of Hawaiian nomenclature and taxonomy was lost to time.

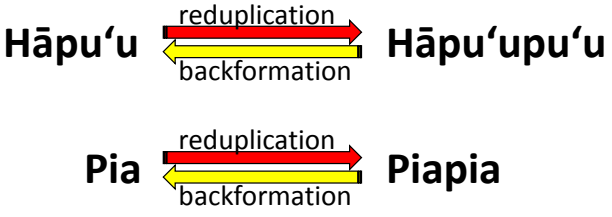

Figure 2. Two examples of the relationship between reduplication and backformation in species-level nomenclatural synonymy of **kalo** (*Colocasia esculenta* (L.) Schott.).

Whitney *et al*. (1939) is currently the authoritative work used in Hawai‘i botanical gardens and agriculture stations to distinguish the cultivars in their collections. Historically, these gardens and stations, not Hawaiian-speaking farmers, have been sources of planting material used by farmers desiring to enhance the diversity within their collections. Because of this, nomenclature and taxonomic systems currently used in Hawai‘i have been heavily influenced by Whitney *et al*. (1939). An example of their influence is the proliferation of trinomials that were previously rare or nonexistent. The results of this study propose that trinomials represent only 2% of all the varietal names collected, but are currently applied to 11% of extant varieties. Whitney *et al*. (1939) are the first to report trinomials with the Lauloa palakea group (**L. p. ‘ele‘ele**, **L. p. ke‘oke‘o**, **L. p. papamū**, and **L. p. ‘ula**) and the variety **Piko lehua ‘āpi‘i**. They alluded to the challenges they had in creating their taxonomic treatment, and indicated that they created trinomials as a solution. Their treatment lists binomial synonyms for all but one of these trinomials, and it is likely that these binomials were the actual names used by Hawaiians before 1939.

Whitney *et al*.’s (1939) influence over contemporary taxonomy and nomenclature is further evidenced in an examination of other varietal names. For example, the variety name **Maka‘ōpio** was once commonly used, as is evident from the high number of sources that documented its presence (Table 7). However, it is treated as a secondary synonym to **Piko ‘ele‘ele** (Whitney *et al*. 1939) which was documented by only five sources. Evidence suggests that the varietal name, **Maka‘ōpio**, was once more commonly used than **Piko ‘ele‘ele**, but today **Piko ‘ele‘ele** is the only name that is used and **Maka‘ōpio** has fallen out of use. From the above examples it is seen that Whitney *et al*. (1939) created a uniform nomenclature and taxonomic system that worked for their purposes, and it has had an influence on the nomenclature and taxonomic system used in Hawai‘i today.

Table 7. Importance of **kalo** (*Colocasia esculenta* (L.) Schott.) varieties based on number of citations between 1879 and 1940 verses current observations through field surveys. Only varieties with nine or more citations were compared. Documented diversity excludes synonyms.

Variety Name	Commonality	
	Citations	Currently
Hā-o-kea / **Hā-a-kea**	12	Occasional
Ipu-o-Lono	11	Rare
‘U(w)ahi-a-Pele	11	Rare
Nohu	10	Name not used
Kāī koi	10	Extinct
Mākohi	10	Name not used
Kāī kea / **K. ke‘oke‘o**	9	Rare
‘Elepaio	9	Rare
Maka‘ōpio	9	Name not used
Māna ‘ele‘ele	9	Rare
Pi‘iali‘i	9	Occasional

Aside from the changes in nomenclature and taxonomy articulated above there is evidence that other changes may have occurred. One piece of evidence comes from reviewing nomenclature for other Hawaiian crop plants with relatively high levels of recognized diversity—such as sweet potato, bananas, and **‘awa** (Handy 1940, Kalaniana‘ole n.d.). Although these crops do have species-level taxa that are named after colors (eg., **‘awa Hiwa**, **mai‘a ‘Ele‘ele**), these species names represent the finest level of diversity associated with those genera, and do not correspond with group-names at the species levels. However, within the review of **kalo** group-names (Appendix 1), a few colors—**‘Ele‘ele** (blackish), **‘Ula‘ula** (reddish), and **Poni** (purplish)—are seen. This deviation from the nomenclatural trend for Hawaiian crop plants makes these groups intriguing. Synonyms within the system (Table 8) imply traditions that are more consistent with the trends of other Hawaiian crop plants. These names were lumped together for the “conservative estimate” of **kalo** diversity. The color synonyms may be evidence that higher **kalo** diversity persisted into the period when the Hawaiian language, and thus knowledge of traditional nomenclature, was in decline. It is possible that these color group-names represent an evolution of **kalo** nomenclature corresponding to the 19th century, although there is not enough evidence to definitively determine the validity of this.

Decrease in Traditional Diversity and Effects on Cultural Diversity

No individual cultivars documented previously (1879-1940) as common are still common today (Table 7). Reduction of diversity since this period is further evidenced by examining the most diverse subspecies-groups of the past and comparing them with contemporary levels of diversity. Diversity within these groups have declined drastically (Table 9). Since individual cultivars and subspecies-groups have specific, and sometimes unique, traditions associated with them, it can be predicted that relative **kalo**-based traditions will shift over time with shifting levels of biodiversity. For example, the variety, **Nohu**, was once one of the most common in the period from 1879-1940 (Table 7). We could assume that specific traditions asso-

Table 8. **Kalo** (*Colocasia esculenta* (L.) Schott.) color group-names and possible synonyms.

Group-names	
Colors	**Possible synonym**
‘Ele‘ele	**Naioea** or **Nohu**
‘Ula‘ula	**Kūmū**

Table 9. The most important **kalo** (*Colocasia esculenta* (L.) Schott.) groups based on number of recorded subspecies names. Only groups with six or more cultivars are listed. Reported diversity excludes synonyms. Extant diversity is based on positive identification in current field surveys.

Kalo Group	Subspecies Diversity	
	Reported	Extant
Māna	16	5
Lauloa	13	5
Lehua	11	4
Kāī / **ʻAla**	12	4
Manini	9	5
Piko / **Haehae** / **Uaua**	7	6
Hā-o-kea	6	1
Hāpuʻu(**puʻu**)	6	1
Kūmū / **ʻUlaʻula**	6	3
Naioea / **Nohu** / **ʻEleʻele**	6	2

ciated with that variety were also common. Today, **Nohu** is a varietal name that is not even used anymore which is an indication that specific traditions associated with it are no longer practiced. If this trend were to be applied at the scale of interactions between all of **kalo** diversity and all of Hawaiian cultural-practices, it is predicted that shifts in biodiversity and cultural diversity will be linked. Such coupled changes relating to shifts in biodiversity and associated traditions are examples of ethnobiological evolution (Winter & McClatchey 2008, 2009). This presents an opportunity for further research.

Increases in Diversity via Modern Hybrids

Thousands of modern cultivars have been created via hybridization between Hawaiian and other Pacific and Asian cultivars since the 1980s (Cho *et al*. 2007, Quero-García *et al*. 2009). Lack of rigorous morphological documentation of these hybrids and their distributions is currently confusing identification, and stimulating controversy about whether or not these new hybrids are beneficial contributions to Hawaiian culture.

Conclusions

The data collection activities reported in the literature (1879-1940) and by the author were conducted in reaction to declining **kalo** diversity and associated cultural knowledge. Sorting through synonymy is complex, which is why there has been no consensus about levels of biodiversity at or near the period of peak of cultivation. The methods used to sort through synonymy presented in this paper are useful in estimating, but may not be enough for an accurate picture of the past due to insufficient positive records of cultivar names. Genetic tools could more accurately sort through the cultivars, however, since the majority have apparently gone extinct, the methods used in this study may represent the best that we have.

Estimates of a conservative and liberal range for former levels of **kalo** diversity were determined using two different methods. The first method, using synonymy percentages calculated by analyzing the most valid sources, provided a cursory estimate of 364-379 cultivars. This was followed by a more methodological approach of sorting through both linguistically-based and classification-based synonyms resulted in an estimate of 368-482 cultivars. It is important to note that there is only a difference of four between the two different methodologies of conservatively estimating **kalo** diversity, which is cross validation that these estimates may be accurate. This far surpasses previous estimates of 100-150 (MacCaughey & Emerson's 1913), and supports Handy *et al.*'s (1972) estimate of at least 300. The above estimates may still be low, however, due to missing information. The above estimate is of the level of biodiversity at the end of the 19th century. Assuming that the height of **kalo** diversity was approximately 100 years earlier, and given all the circumstances, it seems safe to assume that levels at the height of diversity at the end of the 18th century were even higher.

The high number of cultivars far surpasses those of other crop plants and reinforces the idea that **kalo** was indeed the most important crop plant in Hawaiian culture. The only other crop which rivals this level of diversity is the sweet potato (*I. batatas*). Emerging research (Ladefoged *et al*. 2009) is showing that sweet potatoes may have had more prominence within ancient Hawaiian culture at the point of contact in 1778 than most contemporary scholars have thought. Further research could apply the methods articulated here to a collection of sweet potato names.

Field surveys have confirmed that there are only between 65-73 **kalo** cultivars remaining in Hawaiʻi. Using the most conservative estimate above these field surveys indicate that there has been approximately an 80% extinction rate since the late 19th century. Due to the extent with which various individuals and institutions have worked to collect all remaining **kalo** diversity for the past century, it is broadly assumed that all other cultivars have been lost to extinction. However, extinction of **kalo** cultivars may not be a permanent status. Another team of researchers has located the previously undocumented, **Piʻikea**; and reportedly rediscovered the cultivar, **Lauloa ʻōniʻoniʻo**, via a somatic mutation. This rediscovery is not yet confirmed, but it does give hope that some of the lost cultivars can be regained.

An interesting and unforeseen outcome of this research is that we now also have insight into which individual cultivars and which taxonomic groups of **kalo** were the most important at or near the period of peak cultivation. None of these individual cultivars or taxonomic groups have the

same status today as they once did. All have experienced a drastic decline, and other commercial cultivars have taken their place. Given that each heritage cultivar has specific associated traditions relating to cultivation, preparation and ceremony; and that there has been both a decline in diversity, and a shift away from formerly important cultivars; then the role of **kalo** in Hawaiian culture has likely changed over time, and is an example of ethnobiological evolution. Such a phenomenon presents an interesting area for further research. It may be possible to quantify the amount of cultural loss that has been associated with a decline in **kalo** diversity.

Whitney *et al*.'s (1939) research has been an instrumental component to scientifically documenting and understanding **kalo** diversity, but the data and analysis provided by this paper demonstrates that they did change varietal nomenclature (i.e., creating trinomials) to create a taxonomic treatment and subsequent dichotomous key that worked for their purposes. Their nomenclatural and taxonomic treatment of **kalo** is founded in, but has deviated from, an originally Hawaiian world view of **kalo**. Furthermore, due to a shift away from the Hawaiian language by the general population there is not a firm understanding of nomenclature and classification within the Hawaiian lexicon. This, coupled with the contemporary reliance on Whitney *et al*. (1939) in understanding **kalo** diversity seems to be the largest factor for the contemporary shift away from an unadulterated Hawaiian nomenclature and taxonomic system. The most accurate example of Hawaiian nomenclature and taxonomy is seen the work of Iokepa and Kekahuna (n.d.) and Chun (1994).

It is entirely possible that yet more data may be uncovered relating to **kalo** diversity which may cause us to rethink the conclusions of this paper. The hope is that for now, the additional data, new forms of analysis, and conclusions of this paper will respectfully reawaken a debate about **kalo** diversity and its role in the evolving Hawaiian culture.

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Literature Cited

Abbott, I.A. 1995. *La'au Hawai'i: Traditional Hawaiian uses of plants*. Bishop Museum Press, Honolulu.

Anonymous. 1861. He wahi moolelo no kalo nui ma laua o kalo iki. *Ka Hae Hawai'i*, June 12, Honolulu.

Anonymous. 1879. Na inoa kalo a me ko lakou ano. *Ka Nupepa Kuokoa*, March 29, Honolulu.

Berlin, B. 1992. *Ethnobiological Classification: Principals of categorization of plants and animals in traditional societies*. Princeton University Press, Princeton, New Jersey.

Burney, D.A. & W.K.P. Kikuchi. 2006. A millennium of human activity at Makauwahi Cave, Māhā'ulepū, Kaua'i. *Human Ecology* 34:219-247.

Cho, J.J., R.A. Yamakawa, & J. Hollyer. 2007. Hawaiian kalo, past and future. *Sustainable Agriculture* 1:1-8.

Chun, M.N. 1994. *Native Hawaiian Medicines*. First People's Productions, Honolulu.

Chun, M.N. 1998. *Native Hawaiian Medicine.* Volume 2. First People's Productions, Honolulu.

Evans, B. 2008. *Ethnobiological Classification*. Pp. 53-84 in *The Lexicon of Proto Oceanic: The culture and environment of ancestral Oceanic society*. Volume 3, plants. Edited by M. Ross, A. Pawley & M. Osmond. Pacific Linguis-

tics, Research School of Pacific and Asian Studies, The Australian National University, Canberra.

Fornander, A. 1919. *Fornander Collection of Hawaiian Antiquities and Folk-lore*. Volume 6, part 1. B.P. Bishop Museum, Honolulu.

Gon, S. 2008. Revised list of Hawaiian names of plants native and introduced with brief descriptions and notes as to occurrence and medicinal or other values. *Ethnobotany Research and Applications* 6:405-442.

Handy, E.S.C.H. 1940. *The Hawaiian Planter*. Volume 1. Bulletin 161. B.P. Bishop Museum, Honolulu.

Handy E.S.C.H, E.G. Handy & M.K. Pukui. 1972. Native Planters in Old Hawaii: Their life, lore, and environment. B.P. Bishop Museum Press, Honolulu.

Henriques, L.C. n.d. *Na Inoa Kalo*. Manuscript in the B.P. Bishop Museum Archives, Honolulu.

Iokepa J. & H.E.P. *Kekahuna*. n.d. Manuscript in the B.P. Bishop Museum Archives, Honolulu.

Irwin, S.V., P. Kaufusi, K. Banks, R. de la Peña & J.J. Cho. 1998. Molecular characterization of Taro (*Colocasia esculenta*) using RAPD markers. *Euphytica* 99:183-189.

Kalaniana'ole, J.K. n.d. *Varieties of Kalo, Uala, Awa and Maia*. Manuscript in the B.P. Bishop Museum Archives, Honolulu.

Kamakau, S.M. 1972. *Ka Po'e Kahiko*. Bishop Museum Press, Honolulu. [Translated from the newspaper *Ke Au Okoa*.]

Kamakau, S.M. 1976. *Ka Hana a Ka Poe Kahiko*. Bishop Museum Press, Honolulu. [Translated from the newspaper *Ke Au Okoa*.]

Kame'eleihiwa, L. 1992. *Native Land and Foreign Desires*. Bishop Museum Press, Honolulu.

Kekahuna, H.E.P. 1956. *Recorded interview with Kenneth Emory*. Recording in the B.P. Bishop Museum Archives, Honolulu.

Ladefoged, T.N., P.V. Kirch, S.M. Gon III, O.A. Chadwick, A.S. Hartshorn & P.M. Vitousek. 2009. Opportunities and constraints for intensive agriculture in the Hawaiian archipelago prior to European contact. *Journal of Archaeological Science* 36(10):2374-2383.

MacCaughey V. & J.S. Emerson. 1913. The kalo in Hawai'i. *The Hawaiian Forester and Agriculturalist* 10:186-193.

MacCaughey V. & J.S. Emerson. 1914. A revised list of Hawaiian varietal names for kalo. *The Hawaiian Forester and Agriculturalist* 11:338-341.

Malo, D. 2006. *Ka Mo'olelo Hawai'i: Hawaiian Traditions*. Translation by Malcolm Chun. First People's Cultivations, Honolulu.

Müller, J.G., Y. Ogneva-Himmelberger, S. Lloyd & J.M. Reed. 2010. Predicting prehistoric taro (*Colocasia esculenta* var. *antiquorum*) lo'i distribution in Hawaii. *Economic Botany* 64(1):22-33.

Nettle D. & S. Romaine. 2000. *Vanishing Voices: The extinction of the world's languages.* Oxford University Press, Oxford, England.

Nohokuaaina, J.M. 18687. He wahi moolelo no kalo nui ma laua o kalo iki. *Ka Nupepa Kuokoa*, December 28, Honolulu.

Pukui, M.K. & S.H. Elbert. 1979. *Hawaiian Grammar*. University of Hawai'i Press, Honolulu.

Pukui, M.K. & S.H. Elbert. 1986. *Hawaiian Dictionary*. University of Hawai'i Press, Honolulu.

Rindos, D. 1984. *The Origins of Agriculture: An evolutionary perspective*. Academic Press, New York.

Quero-García, J., P. Letourmy, A. Ivancic, P. Feldmann, B. Courtois, J.L. Noyer & V. Lebot. 2009. Hybrid performance in taro (Colocasia esculenta) in relation to genetic dissimilarity of parents. *Theoretical and Applied Genetics* 119(2):213-221.

Rooke, E.K.N. n.d. *Observations on Varieties and Culture of Taro*. Manuscript in the B.P. Bishop Museum Archives, Honolulu.

Ross, M. 2008. Introducing Proto Oceanic plant names. Pp. 25-52 in *The Lexicon of Proto Oceanic: The culture and environment of ancestral Oceanic society*. Volume 3, plants. Edited by M. Ross, A. Pawley & M. Osmond. Pacific Linguistics, Research School of Pacific and Asian Studies, The Australian National University, Canberra.

Schütz A.J. 1994. *Voices of Eden: A history of Hawaiian language studies.* University of Hawai'i Press, Honolulu.

St. John, H. 1982. Vernacular plant names used on Ni'ihau Island. *B.P. Bishop Museum Occasional Papers* 25(3):1-10.

Stannard, D.E. 1989. *Before the Horror: The population of Hawaii on the eve of Western contact*. University of Hawai'i Press, Honolulu.

Trask, H.K. 1999. *From a Native Daughter: Colonization and sovereignty in Hawai'i*, Second Edition. University of Hawai'i Press, Honolulu.

Whitney, L.D., F.A.I. Bowers & M. Takahashi. 1939. *Taro Varieties in Hawai'i*. Bulletin 84, College of Tropical Agriculture and Human Resources, University of Hawai'i, Honolulu.

Wight, T.C. n.d. *A List of Names of Taros and Bananas in Kona*. Manuscript in the B.P. Bishop Museum Archives. Honolulu.

Wilder, G.P. 1934. *The Kalo in Hawaii*. Manuscript in the B.P. Bishop Museum Archives, Honolulu.

Wilder, G.P. n.d. *Ledger: Accounts of Sales of Plant Materials, 1915-1935*, etc. Manuscript in the B.P. Bishop Museum Archive, Honolulu.

Winter, K.B. 2003-2012. Field Notes. Surveys of farms, botanical gardens, and agriculture stations on the islands of Kaua'i, O'ahu, Moloka'i, Maui and Hawai'i. Manuscript with author.

Winter, K. & W.C. McClatchey. 2008. Quantifying evolution of cultural interactions with plants: Implications for managing diversity for resilience in social-ecological systems. *Ethnobotany: A Focus on Brazil. Functional Ecosystems and Communities 2* Special Issue 1:1-10.

Winter K. & W.C. McClatchey. 2009. The quantum coevolution unit: An example of 'awa (*Piper methysticum* G. Foster) in Hawai'i. *Economic Botany* 63(4):353-362.

Appendix 1. Conservative and liberal estimates of **kalo** [Hawaiian taro, *Colocasia esculenta* (L.) Schott] diversity in the Hawaiian islands. Consolidated from an original list of 676 names into 512 linguistically-based synonyms. Typographical errors in the original list have been eliminated. These names were used to determine a conservative and liberal estimate for biodiversity near the height of cultivation around the turn of the 19th century. Uncertainty in usage of Hawaiian diacritical marks is indicated by *.

Species (Group) Name	Subspecies Epithet	Estimate	
		Cons.	Lib.
A‘a / A‘e / A‘ea‘e		1	1
‘A‘ala-piko		0	1
‘A‘apu / ‘Apu / ‘A‘apo / ‘Apo / ‘Apua / ‘O‘apu	[**maoli**]	0	1
	‘ele’ele / hiwa	1	1
	ke‘oke‘o	1	1
	lehua / ‘ula‘ula	1	1
	lenalena	1	1
	wai	0	0
‘Ahapii		0	1
‘Āhē / ‘Ēhē	[**maoli**]	0	1
	‘ele‘ele	1	1
	ke‘oke‘o	1	1
	lenalena	1	1
	‘ula‘ula	1	1
‘Ahu‘ula		0	1
‘Aiwi-kea		0	1
Akaka*		1	1
Akiahiale*		1	1
‘Akilolo		1	1
‘Akoki / ‘Akohi		1	1
Akole ka uula*		0	1
‘Ala	[**maoli**]	0	1
	‘ele‘ele	0	1
	kea / ke‘oke‘o	0	1
	‘ōpelu	1	1
	o-Puna	1	1
	pipika	1	1
Alele*		1	1
Aneli‘i*		1	1
‘Ānunu		1	1
A-‘o‘ia-o-Kalalau		0	1
‘Ape	[**maoli**]	0	0
	kea	0	0
	poni	0	0
‘Āpi‘i / ‘Āpi‘ipi‘i	[**maoli**]	0	1
	kea	1	1
	lehua / ‘ula‘ula / ‘ula	0	1
‘Apuwai / ‘Apowai	[**maoli**]	0	1
	‘ele‘ele / uliuli	1	1
	kea / ke‘oke‘o	1	1
	lenalena	1	1
	‘ula‘ula / ‘ula	1	1
‘Apowale / ‘Apuwale	[**maoli**]	0	1
	‘ele‘ele / uliuli	1	1
	kea / ke‘oke‘o	1	1
	lenalena	1	1
	‘ula‘ula / ‘ula	1	1
Auau leo (lio) nui*		0	1
Awa-a-puhi*		1	1
‘Āweo / ‘Āweu / ‘Āweoweo / ‘Āweuweu		1	1
‘Ele‘ele / ‘E‘ele	[**maoli**]	0	1
	hiwa	1	1
	hiwapa‘a	1	1
	lauloa	1	1
	maka‘ōpio	1	1
	mākoko	1	1
	naioea	1	1
Elekai*		1	1
‘Elepaio		1	1
‘Eleua		1	1
Ēulu / Ēula	[**maoli**]	0	1
	ke‘oke‘o	1	1
	kohu-uauahi	1	1
Ha‘o	[**maoli**]	0	1
	‘ele‘ele	1	1
Ha‘aha‘a		1	1
Haehae	[**maoli**]	0	0

Species (Group) Name	Subspecies Epithet	Estimate	
		Cons.	Lib.
	ʻeleʻele	0	0
	keʻokeʻo	0	0
	ʻulaʻula	0	0
Hahu-ko-kai		0	1
Hale-o-Lono		1	1
Hāloa		0	1
Hāokea / Hāakea / Hāaʻākea / Hāʻawikea / ʻAhakea	[**maoli**]	0	1
	hāʻulaʻula	1	1
	hāuliuli	1	1
	keʻokeʻo	1	1
	māna	1	1
	piko	1	1
	piko-ʻula	1	1
Haole luahine		0	1
Hāpuʻu / Hāpuʻupuʻu	[**maoli**] / **maoli**	0	1
	ʻeleʻele / hāuliuli / uliuli	1	1
	kea / keʻokeʻo	1	1
	lenalena / lena	1	1
	kūkea / nūkea	1	1
	ʻulaʻula	1	1
Heʻe		1	1
Heilia*		1	1
Hekili		1	1
Hele-mauna		0	1
He-nele		0	1
He-ʻowā-hulunui		0	1
Heu-ā-lehu		0	1
Heu-ʻele		0	1
Heʻula		0	1
Hinale / Hinalea		1	1
Hinaliʻi		1	1
Hinapū		1	1
Hinu-kalo		1	1
Hinu-puaʻa		1	1
Hiwa		0	1

Species (Group) Name	Subspecies Epithet	Estimate	
		Cons.	Lib.
Hoeke*		1	1
Hoene	[**maoli**]	0	1
	black [sic]	1	1
	red [sic]	1	1
Hōkeo / Hōkea / Hākeo		1	1
Hona		1	1
Hōʻole-(i)-nā-wao		0	1
Hōʻole-ke-kalo-poʻo- honu(e)*		0	1
Houa*		1	1
Hualani		1	1
Huamoa		1	1
Huli-pū-loa		0	1
Humuhumu		1	1
ʻleʻie / ʻlaʻia	[**maoli**]	0	1
	ʻiliʻā*	1	1
Iheihe		1	1
Iheihei lei		1	1
ʻIhi-lani		1	1
ʻIʻi		0	1
ʻIliʻā / ʻIliʻaʻa		1	1
ʻIliuaua		0	0
Ipu-o-Lono	[**maoli**]	0	1
	kea / keʻokeʻo	1	1
	ʻulaʻula	1	1
	piko-ʻula	1	1
Kapuʻukōnane		0	1
Kaawelu-i-ka-pali-o-ʻAwakea		0	1
Kaena-ke-kanaka*		0	1
Kahaluʻu		1	1
Kahu-kō-kai / Kahe-kō-kai		0	1
Kāī	**maoli**	1	1
	ʻala	1	1
	ʻāweuweu	1	1
	ʻeleʻele / uliuli	1	1
	hoʻōkia*	1	1

Species (Group) Name	Subspecies Epithet	Estimate	
		Cons.	Lib.
	kea / keʻokeʻo	1	1
	koi	1	1
	koi-welawela	1	1
	nenene / nenenene	1	1
	pala	1	1
	ʻulaʻula	1	1
	welowelokā (likely a typo for **welowelolā**)	1	1
Kaimoi*		1	1
Kaina-i-ke-kanaka*		0	1
Kaina-i-ke-kaua*		0	1
Ka-io-aweawe*		0	1
Kala	**niʻo**	1	1
	poni	1	1
Kalaniu		1	1
Kalalama makahi*		0	1
Kalalau		1	1
Kalani pili		1	1
Kalo-i-kū		0	1
Kalola		0	0
Kāmau		1	1
Kanaio		0	0
Kanawao		1	1
Kaneliʻi		1	1
Kāniʻo		0	1
Kapai-o-ākea*		0	1
Kapala		1	1
Kapalili		1	1
Kapuhili		1	1
Kauanio		1	1
Kaue*		1	1
Kauhaikalehuhoole*		0	1
Kawale uaua*		1	1
Kawele ole*		0	1
Kawelo		1	1
Kepoe		1	1
Kiʻi hekekē		1	1
Kīkī panapala / K. palapala		1	1

Species (Group) Name	Subspecies Epithet	Estimate	
		Cons.	Lib.
Kīkiʻi		1	1
Kili ʻoʻopu		1	1
Koʻi aweawe*		1	1
Koaʻe	[**maoli**]	0	1
	ʻeleʻele	0	1
	keʻokeʻo	0	1
	ʻulaʻula	0	1
Kohikū*		1	1
Kokoko-he-uhi*		0	1
Koʻokā		1	1
Kū loa		1	1
Kuamu		1	1
Kuapapa		1	1
Kueha*		1	1
Kukaiʻiole [sic]		1	1
Kumakau*		1	1
Kūmū	[**maoli**]	0	1
	ʻeleʻele	1	1
	kea / keʻokeʻo	1	1
	kūloa	1	1
	poni	1	1
	ʻulaʻula	1	1
	welowelolā	1	1
Kūʻoho / Kūʻohu	[**maoli**]	0	1
	hai*	1	1
	piko	1	1
Kūpala		1	1
Laʻo uaua		1	1
Laʻaloa / Olaʻaloa		1	1
Laholoa		0	1
Laʻi-o-kona		1	1
Lapa		1	1
Lau ʻape		1	1
Lau kapalili		0	1
Laukōnā		1	1
Lau lele		1	1
Lauloa	[**maoli**]	0	1
	ʻeleʻele / hāʻeleʻele / palakea-ʻeleʻele	1	1

Species (Group) Name	Subspecies Epithet	Estimate	
		Cons.	Lib.
	‘ele‘ele-‘ōma‘o	0	1
	‘ele‘ele-‘ula	0	1
	ke‘oke‘o / hāke‘oke‘o / kea	1	1
	koko / hā‘ula / ‘ula‘ula	1	1
	uliuli / hāuliuli	1	1
	manini / ‘ōni‘oni‘o / palakea-ke‘oke‘o	1	1
	palakea	1	1
	palakea-‘ula	1	1
	pāna‘e*	1	1
	papamū / palakea-papamū	1	1
	piko-‘ula	1	1
	poni	1	1
Launui	[maoli]	0	1
	pa‘akai	1	1
Lehua	maoli	1	1
	aola*	1	1
	‘āpi‘i	1	1
	‘ele‘ele / hāuliuli	1	1
	hō‘ole*	1	1
	ke‘oke‘o	1	1
	kū-i-ka-wao / kū-kuahiwi	1	1
	lenalena	1	1
	‘ōni‘oni‘o	1	1
	palai‘i	1	1
	‘ula‘ula	1	1
Lele		1	1
Le‘o		1	1
Lī‘apu		1	1
Lihilihi ke‘oke‘o		0	1
Lihilihi-molina	[maoli]	0	1
	ke‘oke‘o	1	1
	‘ele‘ele	1	1

Species (Group) Name	Subspecies Epithet	Estimate	
		Cons.	Lib.
Liko-lehua		1	1
Līlī-lehua		1	1
Loha / Lola		1	1
Mā‘au(w)ea / Mā‘au(w)eo / Mānau(w)ea / Mānau(w)eo / Māmau(w)ea / Māmau(w)eo	[maoli]	0	1
	hāuliuli	1	1
	‘ula	1	1
Ma‘awe		1	1
Maea		1	1
Mahaha*	[maoli]		1
	ke‘oke‘o	1	1
	‘ula‘ula	1	1
Mahai		1	1
Mahakea / Mākea		1	2
Mahamaha ke‘oke‘o		1	1
Māhuna		1	1
Mai ahua*		1	1
Mā‘i‘i / Mā‘i‘i‘i		1	1
Mā‘i‘o		1	1
Maka‘iole		1	1
Maka ‘ōpio / M. ‘ōpi‘i		1	1
Maka ua		1	1
Maka weo		1	1
Mākihi / Mākohe / Mākohi / Mōkohe / Mōkohi	[maoli]	0	1
	‘ula‘ula	1	1
	‘ele‘ele	1	1
Mākoko		0	1
Mākole		1	1
Mākūkū		1	1
Malihini-a-ka-wai		0	1
Māmane		1	1
Māmanu*		1	1
Māna / Māna-o-	[maoli]	0	1
	‘āniholoa*	1	1
	‘ele‘ele / uliuli	1	1
	‘ula‘ula / hā‘ula‘ula	1	1
	hua	1	1

Species (Group) Name	Subspecies Epithet	Estimate	
		Cons.	Lib.
	kea / keʻokeʻo	1	1
	lauloa	1	1
	ʻulu / lenalena / melemele / ʻowene / ʻuwele	1	1
	ʻohe	1	1
	ʻokoʻa	1	1
	ʻōpelu	1	1
	piko	1	1
	pipika	1	1
	uauahi	1	1
	uhapua*	1	1
	wai / wai-ke-ohe	1	1
	weo / wea	1	1
Mana-piko		1	1
Mānawai ākea*		1	1
Manini	[**maoli**]	0	1
	ʻeleʻele	1	1
	hākikokiko	1	1
	uliuli / hāuliuli	1	1
	kākau*	1	1
	kea	1	1
	lau-kikokiko	1	1
	ʻōpelu	1	1
	ʻowali	1	1
	ʻula	1	1
Manouulu*		0	0
Manu		1	1
Manuia*		1	1
Manulele		1	1
Maua	**melemele**	1	1
	ulu	1	1
Mauna		1	1
Melemele		1	1
Mimi'iole		0	1
Moa		1	1
Moana / Moano		0	1
Mōhihi		1	1

Species (Group) Name	Subspecies Epithet	Estimate	
		Cons.	Lib.
Moi	[**maoli**]	0	1
	ʻeleʻele	1	1
	kea / keʻokeʻo	1	1
	ʻula	1	1
Mokihana		1	1
Mōlina		1	1
Na-kalo-aola-o-kalalau*		0	1
Nahiolea		1	1
Naio		1	1
Naioea	[**maoli**]	0	1
	ʻeleʻele	0	1
	keʻokeʻo	0	1
	lehua / ʻulaʻula	0	0
Nā-kalo-i-kūʻē*		0	0
Nāliliko'i*		1	1
Nana	[**maoli**]	1	1
	piko	1	1
Nana-i-puhene-na-kalo		0	1
Nao		1	1
Nāpili		1	1
Naua		1	1
Nāwao		1	1
Neʻineʻikekanaka*		0	1
Neʻeneʻe		1	1
Nihopuʻu		1	1
Nina		1	1
Niʻo		0	1
Nohiapele*		0	0
Nohu	[**maoli**]	0	1
	ʻeleʻele	0	1
Nūkea	dark [sic]	1	1
	light [sic]	1	1
Nuku ʻeʻehu		1	1
Nuku kau		1	1
Nuku-manu		1	1
O-ka-heʻe-kō-kai		0	1
ʻO(w)āʻo(w)ā		1	1
Oalu / Oolu		1	1

Species (Group) Name	Subspecies Epithet	Estimate	
		Cons.	Lib.
Oaulu nui		1	1
ʻOhe	[maoli]	0	1
	ʻeleʻele	1	1
	kea / keʻokeʻo	1	1
	ʻulaʻula / ʻula	1	1
ʻŌhiʻa		1	1
ʻŌhuehue		1	1
ʻŌlena		1	1
ʻŌnihinihi		1	1
ʻOʻopu		1	1
ʻOʻopukai / ʻOpukai	[maoli]	0	1
	keʻokeʻo	1	1
	ʻulaʻula	1	1
ʻOpae-ʻula		1	1
ʻŌpelu		0	1
ʻŌpelu haoee*		1	1
ʻŌpule		1	1
Owale*		1	1
ʻOwau		1	1
ʻO(w)ene	[maoli]	0	1
	ʻeleʻele	1	1
	keʻokeʻo	1	1
	lenalena / melemele	1	1
	māna	0	1
	ʻulaʻula	1	1
Paʻakai		1	1
Paʻakai mikomiko		0	0
Paʻakea		0	0
Paʻapaʻaʻina		1	1
Pae		1	1
Paʻea			
Paʻele-hili-mānoanoa		0	1
Paʻiaha		1	1
Paipu lana		1	1
Pākē		0	0
Pākea		1	1
Pala	[maoli]	0	1
	hāokea / kea	0	0
	mahiki	1	1
Palapalaha / Pālaha*		1	1
Palaʻiʻi	[maoli]	0	1
	ʻeleʻele	1	1
	kea / keʻokeʻo	1	1
	pohā	1	1
	poni	1	1
	ʻulaʻula	1	1
Palakea	ʻeleʻele	1	1
	keʻokeʻo	1	1
Pālau		1	1
Palili	[maoli]	1	1
	ʻulaʻula	1	1
Pana		1	1
Pani-kohe		0	1
Papakole(a) kāwaʻa		1	1
Papakole(a) koaʻe		1	1
Papala kea*		0	0
Papamu		0	1
Papapueo		1	1
Pāʻū-o-hiʻiaka		1	1
Paua		1	1
Pauʻiole		1	1
Pehua		1	1
Peke		0	1
Pelu hāʻele		1	1
Pelu haole		0	0
Peu	[maoli]	0	1
	ʻeleʻele	1	1
	kea / keʻokeʻo	1	1
	lena	1	1
	ʻulaʻula	1	1
Peue		1	1
Pia / Piapia		1	1
Pihalole / Pihalale		1	1
Piʻi hālāwai		1	1
Piʻialiʻi	[maoli]	0	1
	ʻeleʻele	1	1
	keʻokeʻo	1	1

Species (Group) Name	Subspecies Epithet	Estimate	
		Cons.	Lib.
	melemele	1	1
	ʻulaʻula	1	1
Piʻikea		1	1
Piko	[maoli]	0	1
	ʻeleʻele	1	1
	hao*	1	1
	kea	1	1
	keʻokeʻo	1	1
	lehua-ʻāpiʻi	0	1
	uaua	1	1
	uliuli / uli	1	1
Piko-a-Wākea		1	1
Pikoʻele		1	1
Piko-nui		1	1
Pilimai		1	1
Pipiko		1	1
Pōhina		1	1
Poi pulana* / P. pulaua*		1	1
Pololū		1	1
Poni	[maoli]	0	1
	ʻeleʻele / uliuli	1	1
	kea	1	1
	mana	1	1
	ʻulaʻula	0	1
Poʻo hunue* [honua]		0	1
Pōpolo		0	1
Pua kawaihae		1	1
Puakai mikomiko		1	1
Pueo	[maoli]	0	1
	hālenalena	1	1
	keʻokeʻo	1	1
Puhi		1	1
Pulani*		1	1
Puʻu		1	1
Puʻu kōnane		1	1
Puʻu nānā		1	1
Puwalu/Pualu		1	1
U(w)ahi-a-pele	[maoli]	1	1
	ʻulaʻula	1	1
Ua lehua		1	1
Uahi ʻoki*		1	1
Ualehu / Ūlehu		0	1
Uaua	[maoli]	0	0
	ʻeleʻele	0	0
	keʻokeʻo	0	0
	mōlina	1	1
	piko	0	0
Uhai*		1	1
Uhu		1	1
Uia		1	1
Ula	[maoli]	0	1
	liʻi	1	1
	nui / mani / maui / mau	1	1
	iʻa*	1	1
ʻUlaʻula	[maoli]	0	0
	ʻāhiu	1	1
	ʻāniholoa	1	1
	kūmū	0	0
	moano	1	0
	poni	0	0
	uahi-a-pele	0	1
ʻŪlei		1	1
Uli / Uliuli		0	1
ʻUme / ʻUmi / ʻUmiʻumi		1	1
Uwauwahi		0	1
Waʻe		0	0
Waiākea		1	1
Waiʻanae		1	1
Waiānuenue		1	1
Wailana		1	1
Wehiwa / Wehewa / Wewehiwa	[maoli]	0	1
	ʻōniʻoniʻo	1	1
	uliuli	1	1
Welehu		1	1
Welowelolā		0	1
Weo	[maoli]	0	1
	black [sic]	1	1
	red [sic]	1	1
Wewemana		1	1

Species (Group) Name	Subspecies Epithet	Estimate	
		Cons.	Lib.
Wia		1	1
Wolu		1	1

Species (Group) Name	Subspecies Epithet	Estimate	
		Cons.	Lib.
Total		**368**	**482**