



Kāhuli: Uncovering Indigenous Ecological Knowledge to Conserve Endangered Hawaiian Land Snails

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Abstract:	<p>Indigenous knowledge is a multi-layered knowledge system that can inform contemporary management in both natural observations and cultural value. Centuries old observations preserved within song, chant, and story has been globally recognized as a resource to integrate with conservation efforts for endangered species. In the case of the endemic land snails, kāhuli, of the Hawaiian archipelago, there is a prominent cultural presence preserved in oral tradition and written records in nineteenth and early twentieth century's Hawaiian language newspapers. As we witness the dramatic decimation of one of the greatest models of species radiation, the unveiling of the repositories of indigenous knowledge is crucial for conservation of these endemic land snails. This paper reports on indigenous knowledge that informs about the cultural significance (i.e. poetic device, metaphorical role, importance to hula) and ecology of kāhuli, and how indigenous knowledge can contribute to conservation efforts of rare and endangered species.</p>

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This manuscript has been submitted as a General Research Article. General Research Articles describe research based work guided by a theoretical foundation that contributes significantly new scholarship by advancing new theory or knowledge for transforming practice on the relationships between society and natural resources. Empirically based articles should have a clearly described sound methodology/research design and a well-developed data analysis section.

Kāhuli: Uncovering Indigenous Ecological Knowledge to Conserve

Endangered Hawaiian Land Snails

Introduction:

As climate change, novel species introductions, and massive habitat alterations take place globally, endemic species may only remain in fragmented habitats, where associated plants, animals, or fungi have declined or become extinct, or where microhabitats may be severely altered. Indigenous knowledge can inform studies in ecological restoration (Gadgil et al. 1993, Uprety et al. 2012) by providing missing insight into the biology of culturally significant species (Ceriaco et al. 2011, Garibaldi & Turner 2004, Ramstad et al. 2007). Further, indigenous knowledge can enhance understanding of the significance and unique qualities of species, and why it is imperative to conserve them (Turner and Splading 2013), as well as enhance conservation education (Berkes & Turner 2006, Kimmerer 2002).

Indigenous knowledge, sometimes referred to as traditional ecological knowledge, consists of an adaptive “cumulative body of knowledge, practice, and belief,” which is

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3 culturally transmitted across generations and explains the relationships between all living
4 things (including humans) and the environment (Berkes 2012). Finding and interpreting
5 indigenous knowledge has its challenges, as local knowledge is commonly rooted in families,
6 and encoded through stories, songs, dances, rituals and practices (Xu et al. 2005). Yet,
7 extensive natural resource knowledge has been researched and documented in indigenous
8 communities across the globe (Posey 1999, Toledo 2002). When effectively integrated with
9 Western Science, indigenous knowledge has improved diverse natural resources including
10 nearshore fisheries in Hawai'i (Friedlander et al. 2013), forest landscapes, water catchments,
11 and biodiversity in Asia (Xu et al. 2005). In some cases indigenous knowledge of species
12 may result in improved harvest and management practices that are developed over time to
13 conserve species (Motaleb 2010, Turner and Berkes 2006) or even enhance their abundance
14 (Colding and Folke 1997, Poepoe et al. 2005). Indigenous knowledge is adaptive, built across
15 generations of observations, and in reaction to changes in resources within a particular
16 location (Berkes and Turner 2006). This set of place-specific in-depth knowledge can
17 enhance planning and decision making for resilience and adaptation to climate change
18 (Turner and Spalding 2013).

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21 Beyond utilitarian purposes, many rare species are valued by indigenous cultures for
22 cultural significance and their role in cultural identity (Sobrevila 2008). In contrast to
23 charismatic vertebrates, which are often well-documented by explorers, naturalists, and
24 scientists, invertebrates often receive less attention (Black et al. 2001). However, nearly all
25 species of plants and animals, including invertebrates, may be known and valued, if not used
26 for human survival by indigenous people (Bisht et al. 2006, Black et al. 2001). The
27 conservation of rare and endangered species provides a unique opportunity to integrate
28 indigenous knowledge with Western Science (Colding and Folke 1997). The Hawaiian
29 Islands is a great platform for such a case study, with its vibrant, enduring indigenous culture

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3 and extensive, highly threatened biological diversity (James 2004, Pukui et al. 1972, Régnier
4 et al. 2015). In this study we examined Native Hawaiian knowledge of rare and endangered
5 endemic land snail species.
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10 Endemic land snails were once abundant throughout Hawai‘i, and included over 750
11 diverse species (Cowie et al. 1995), in diverse habitats (Pilsbry and Cooke 1912-1914).
12 Kāhuli, as they were called by Native Hawaiians, held a prominent cultural presence in
13 written records through their role in many chants, songs, and stories (Bryan 1935,
14 MacCaughey 1917).
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20 Along with other flora and fauna of Hawai‘i, the abundance of Hawaiian land snails
21 changed with human arrival (Hadfield 1986, Régnier et al. 2015). Population declines due to
22 shell collection, predation by alien species of rats (Atkinson 1977, Hadfield et al. 1993),
23 *Chamaeleo jacksonii* (Chiaverano and Holland 2014, Holland et al. 2009), and the predatory
24 snail *Euglandina rosea* (Hadfield et al. 1993, Holland et al. 2012), and habitat loss have
25 severely impacted endemic snail diversity and distributions. Extinction rates are estimated to
26 be approaching 75-90% across all Hawaiian land snails (Cowie, 2001), but these rates vary
27 across taxa. The Hawaiian tree snail genus *Achatinella*, endemic to the island of O‘ahu, once
28 numbered a total of 41 species (Hadfield et al. 1993), but today only 11 species remain in the
29 wild, all of which are listed as Endangered (Price et al. 2015, USFWS 1993). Other genera of
30 ground dwelling snails in the family *Amastridae* have declined from 325 species to
31 approximately 15 species (Régnier et al. 2015).
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48 We aimed to answer the questions: (1) What can indigenous knowledge teach about
49 the cultural significance and (2) ecology of kāhuli, a rare and endangered species? (3) How
50 can indigenous knowledge contribute to efforts to restore and protect these species? In this
51 study, we compile indigenous knowledge of an invertebrate fauna, kāhuli, in an effort to
52 answer these questions. We illustrate ways in which indigenous knowledge held by cultural
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3 practitioners and found in historic archival data can improve knowledge and conservation of
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5 rare and threatened species.
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8 9 **Methods:**

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11 We conducted a literature review of written nineteenth century Hawaiian language
12 records, along with semi-structured interviews with cultural practitioners. The two sources of
13 information reinforced one another, revealing common themes, and the interviews helped to
14 interpret the written records. We used criteria-based sampling to identify six cultural
15 practitioners with knowledge of the kāhuli, approached every individual suggested to our
16 team, including other interviewees. All interview participants were kumu (teachers) in
17 different fields of cultural expertise and practice, including hula, Hawaiian language, chant
18 and ecology.
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29 The ten interview questions (Methods SOM1) were open-ended to allow respondents
30 to express their individual knowledge of the kāhuli (Weiss 1994). We inquired about: (1)
31 Hawaiian names for the kāhuli (2) Hawaiian literature related to kāhuli (3) cultural
32 significance; and (4) ecology of the species, such as plant associations. Hand written notes
33 were taken during interviews, which were not recorded using audio or video. These notes
34 were analyzed for common themes (Weiss 1994), which were then applied to the archival
35 literature.
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45 In addition to oral history, much cultural knowledge is recorded in archival, written
46 Hawaiian language resources dating from 1834 to 1948 (Nogelmeier 2003). Early
47 missionaries to Hawai‘i created the Hawaiian alphabet to allow translation of the Bible and
48 writing of a previously solely oral language (Nogelmeier 2003). Native Hawaiians used the
49 new venue to record knowledge as people died in large numbers due to introduced diseases
50 (Friedlander et al. 2013).
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3 We used multiple online Hawaiian databases to access written records on the kāhuli
4 dating from 19th century to the present (Table A1.1). The Papakilo Database (2016), provided
5 by The Office of Hawaiian Affairs provides access to 19th century historical newspapers and
6 other written records. Papakilo has digitized seventy-five thousand pages of newspapers, and
7 25-30% remains to be digitized. We used the online Huapala archives to find lyrics to
8 Hawaiian compositions which included references to kāhuli (Hawaiian Hula Archives 1997-
9 2015). We also analyzed translations of mo‘olelo (historical narratives) including Lā‘ieikawai
10 (The Hawaiian Romance of Laieikawai 1918), Pele and Hi‘iaka (Emerson 1997), Lauka‘ie‘ie
11 (Westervelt 2012), and stories and chants in the Unwritten Literature of Hawai‘i (Emerson
12 1909). A total number of 30 written records were translated and used in this study. We found
13 10 stories, 14 chants and songs, and 6 articles. Approximately 30% of the written records
14 were suggested by interviewees, while the other 70% emerged from database searches.

15
16 To thoroughly search the Papakilo Database we used multiple keywords associated
17 with kāhuli, some of which were suggested by interviewees. Key word searches produced
18 volumes of written records (Table A1.1, Table A1.2); however, many did not refer to the
19 snails, but were alternative interpretations of these search terms. For example, the name
20 kāhuli can also mean to turn or change, resulting in written records that related to changes in
21 government, or other types of transitions. To narrow down our results to relevant records, we
22 combined specific keywords such as the name of a snail with an associated plant (Table
23 A1.2). Lines directly related to the snails were translated, along with the surrounding lines in
24 order to provide context. Online Hawaiian dictionaries were used (The Hawaiian Electronic
25 Library, 2004) to translate records. Translations then followed a review with a Hawaiian
26 language expert. Five resources, that provided more than two lines of snail reference, were
27 translated in their entirety.

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3 For each written record found through the database searches, we noted source of data,
4 reference to place (island, region, etc.), reference to plant interactions, climate (wind, rain,
5 mist, clouds, etc.), reference to visual characteristics of kāhuli such as color or size, reference
6 to animals or insects that share the habitat, elevation (upland/lowland), cultural knowledge
7 including the use of snail shells, significance to indigenous people, characteristics of snails,
8 and the use of the species metaphorically.
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10
11 Common elements across written records revealed key themes related to the ecology
12 and cultural significance of the snails (Table A1.3, Table A1.4), all of which were also raised
13 in the interviews. Themes include those related to the cultural significance of snails along
14 with historical ecological information (Table A1.4). We present results based on the themes
15 that emerged from the interviews, and then use the written records to illustrate examples of
16 these themes.
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31 **Results:**

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33 **Part 1, Cultural Significance:** What does indigenous knowledge teach us about cultural
34 significance of rare and endangered species?
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38 The following themes emerged regarding cultural significance: the variety of names
39 used for the snails; snail-attributed voice or singing; snails as symbols of romance; hō‘ailona
40 (signs and omens); and significance for hula (traditional dance) (Table A1:4).
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45 ***Significance of names:***

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48 Names hold great significance in Hawaiian culture (Pukui et al. 1972). The importance of
49 endemic snails is evident in the number and variety of names given to these species. All of
50 the interview participants were familiar with the most common name, kāhuli, referenced in
51 77% of the written records. Practitioners suggested that the name kāhuli, meaning to turn or
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3 shift, potentially refers to the way kāhuli shells shift from side to side as the snails travel
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5 across a leaf, or the way the shell turns or swirls as it grows. The name kāhuli is sometimes
6
7 given to a person if they are capable of changing form, shifting or transformation. For
8
9 example, the famous mo‘olelo “Hi‘iaka i ka poli o Pele” alludes to the kāhuli to represent the
10
11 main character’s ability to change her physical form. One portion of this historical narrative
12
13 follows Hi‘iaka, a goddess of forests, hula, and restoration, on her travels as she meets a
14
15 fisherman by the name of Pahulu. Pahulu agrees to get her fish if Hi‘iaka pleases his sexual
16
17 desires in return. She responds with:
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20
21 Kāhuli lei ‘ula lei ‘ākōlea.

22 The kāhuli is a red ornament in the lei of the ‘ākōlea fern. (Table A1.1)

23
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25 When she lies down and Pahulu attempts to embrace her for his reward, she changes into a
26
27 rock. Like the shifting movement of a kāhuli shell, Hi‘iaka shifts her form to escape Pahulu’s
28
29 advance.
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31
32 Most of the interview participants and fifty-three percent of written records also used
33
34 the name pūpūkanioe, the literal translation being “shell sounding long.” The name
35
36 pūpūkanioe references the sweet pure sound of the snails. In the chant “‘Ike I ke One Kani
37
38 A‘O Nohili” the words read:
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40
41 Pūpū kani oe ko Kaua‘i, kūnihi Hā‘upu ‘au i ke kai.

42 The land shell is Kaua‘i’s, steep Hā‘upu juts into the sea. (Table A1.1)

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45 This particular chant refers to the land snails (*Carelia*) that are found in the sand dunes of
46
47 Kaua‘i. Other written records from Hawai‘i Island used the name Pūpūkanioe; therefore this
48
49 name does not appear limited to one particular island, or to one particular species.
50

51
52 Ten percent of the written records referenced the name pololei, meaning perfect or
53
54 correct, which also came up in interviews. Pololei in mele is usually followed poetically with
55
56 “kani kua mauna - singing in the mountain ridges”. This name may describe the visual
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3 perfection of the shells, the perfect singing of the snails, or recognition of something
4
5 extraordinary in nature.
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8 Less common names that were referenced in less than 10% of written records and
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10 interviews included: pūpūmoeone, shell that sleeps in the sand; pūpū-kuahiwi, mountain
11
12 shell; hinihini, delicate voice (Emerson 1997); naka, quiver (The Hawaiian Electronic Library
13
14 2004); pūpūhinahinaula, shell with beautiful rainbow colors (Westervelt 2012); and
15
16 pūpūmokalau, shell clinging to mokihana *Melicope anisate* (Westervelt 2012).
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20 ***Voice:***

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22 All interviewees mentioned the theme of the singing snails, which was also present in
23
24 approximately 70% of written records. The singing of the snails is often mentioned in
25
26 traditional chants and songs about the kanahēle (forest) and aumoe (night). Interviewees
27
28 offered possible explanations for the voice attributed to these invertebrates. Five centuries
29
30 ago the sound of forests was different from the sound of the forests today. Snails and other
31
32 native species were plentiful throughout the uplands and lowlands of the islands, creating
33
34 what the Hawaiians referred to as the voice of the forest. Today the habitat of the snails has
35
36 changed drastically with the introduction of invasive trees. The wind does not travel through
37
38 the forest in the same way as in the past. Interviewees said that to hear the singing that the
39
40 Hawaiians spoke about, Hawai‘i’s forests would need to be restored to their original state.
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45 One explanation for the voice of the kāhuli was the relationship with wind and the
46
47 placement of ample kāhuli snails. A constant gentle breeze over the shells would provide a
48
49 faint whistle frequently associated with kāhuli and their sweet singing. In contrast, a stronger
50
51 wind intensified the kāhuli activity. The chant Pa Ka makani (Table A1.1) can be interpreted
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53 as:
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55 Pa kama kani, Ha‘u ka waha o ke kāhuli i ka nahele.

56
57 The wind blows, the land shells trill (mouths tremble) in the forest.
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3 Pa Kama Kani tells the story of the mythological rooster god Ka‘au-hele-moa, an
4
5 extraordinary presence that made the land shells trill, bringing with him the pouring rains and
6
7 clouds of Kaupea.
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10 Some interviewees suggested that the sounds of the crickets that share the same
11
12 habitats as the snails may have been attributed to the kāhuli. Though crickets were plentiful
13
14 in Hawaiian forests, they would have disappeared with any movement betraying human
15
16 presence, leaving only the kāhuli to be detected by the observer. In the traditional Hawaiian
17
18 mind, a beautiful voice would naturally belong to something as exquisite as the kāhuli.
19
20 Though they offered explanations, interviewees also suggested that Native Hawaiians would
21
22 not have questioned the source of the kāhuli’s voice. The leo (voice) serves the purpose any
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24 voice would, to communicate a message, serve as a sign or warning.
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28 The kāhuli’s beautiful voice also personifies a character when telling a story. The
29
30 mele, He Inoa No Manoana (Table A1.1), describes a person’s singing skill through poetic
31
32 reference to the kāhuli. In oral storytelling of old Hawai‘i, character names describe their
33
34 characteristics or skills. In a well-known mo‘olelo, “Lauka‘ie‘ie,” the snails become actual
35
36 characters with beautiful voices (Westervelt 2012). Lauka‘ie‘ie, a beautiful woman on
37
38 Hawai‘i Island, had two friends, Pūpūkanioi, the singing snails from the leaves of the forest
39
40 trees and Pūpūhinahinaula, the snail with beautiful rainbow colors. Lauka‘ie‘ie chooses
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42 Pūpūkanioi to journey to find her the man of her dreams. The snail calls for aid in her journey
43
44 from the laukoa leaves of the koa tree (*Acacia koa*), lauanau leaves of the paper-mulberry
45
46 tree (*Broussonetia papyrifera*), the snails of the sea, and the Pūpūmokalau snails on the
47
48 mokihana (*M. anisate*) of Kaua‘i. In this mo‘olelo the snails seem to be family and helpers.
49
50 Pūpūkanioi states, “Come and look at me, for I am one of your family! Call all the shells to
51
52 aid me in my journey! (Westervelt 2012).” The snails that inhabited different ecological
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54 niches and islands were all considered part of the same family.
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3 In the story of Lauka‘ie‘ie the snails had human characteristics, such as the gift of
4 voice and ability to travel long distances. These snail people were held in high regard as
5 supernatural kupua (magical deities) who had the ability to change forms. Sometimes referred
6 to as ‘e‘epa people, they were similar to fairies, and slightly deformed. The snails fall into the
7 classification of ka-poe-kino-pupu, a category of kupua that contains all snails possessing
8 special powers (Westervelt 2012). Not all species in Hawai‘i were known to take on human
9 form, suggesting that snails were held in high regard. The snails were one of the few things
10 in nature that were credited with creating sounds, along with wind, rain, thunder,
11 earthquakes, and birds.
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24 ***Romance:***

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26 A majority of the cultural practitioners agreed that the snails added an element of beauty and
27 romance to a story, song, or chant. Thirty-seven percent of the written records are mele aloha,
28 songs of wooing or love. The setting of these mele aloha were in the cool forests with
29 characteristics that commonly signal romance in Hawaiian literature, including night, cool
30 temperatures, rain, mist, and the forest sounds of the k ahuli singing. The composition, Piano
31 Ahiahi (Table A1) refers to the k ahuli in the lines:
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40 Ho‘olono i ka leo o ke k ahuli leo honehone i ka pili o ke ao.
41 We have often paused to listen to the sweet singing of the land shells.
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43 The literal translation of “leo honehone I ka pili o ke ao,” is the caressing voice at the arrival,
44 and the togetherness of dawn. However the romantic words describe an extraordinary event,
45 the composers’ visit to the ship Naukilo, where they saw a mirror and heard the sounds of a
46 piano for the first time. The use of the k ahuli in Piano Ahiahi suggests comparison of the
47 piano with the singing of the k ahuli.
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54 The sweet singing of the snails signalled something extraordinary, and being in love
55 was an extraordinary event to the Native Hawaiians. K ahuli appear frequently in mele that
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3 suggest wooing or love making between two individuals. Ku‘u Pua Mikinolia (Table A1.1) is
4
5 a mele aloha that describes lovemaking in the presence of the Magnolia scent, the singing
6
7 kāhuli, and the sound of rain. Another song, “He Inoa No Pua Rose,” (Table A1.1) follows
8
9 two companions into the late of the night. The mele refers to the voice of the snails floating
10
11 above them in the mountains that the land snails inhabit. To the Hawaiian reader or listener,
12
13 just the presence of land snails in a story or song, signalled romantic interests and actions that
14
15 may not be made explicit through words.
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20 21 *Hō‘ailona:*

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23 The kāhuli were also hō‘ailona (symbols or omens) in Hawaiian culture that signalled
24
25 significant events or the presence of important individuals. Hō‘ailona can include natural
26
27 phenomenon such as rolling thunder or the ocean turning red. The appearance of certain
28
29 animals, including other creatures with the gift of voice such as birds, served as hō‘ailona,
30
31 but the kāhuli are the only land invertebrate that played this symbolic role. Eye catching
32
33 symbols were selected as hō‘ailona ali‘i (omens associated with chiefs and other high ranking
34
35 individuals) and hō‘ailona akua (godly omens). Kāhuli were considered hō‘ailona not only
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37 for their exquisite shells but for their beautiful singing. Some mō‘ī wahine, females of
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39 royalty, wore kāhuli lei, a strung necklace of native shells, to signify their high rank.
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44 The use of kāhuli as hō‘ailona most commonly occurred in longer narratives such as
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46 Lā‘ieikawai, and Pele and Hi‘iaka, in which kāhuli appear along the extended journey of the
47
48 protagonists. For example, in Lā‘ieikawai the singing acts as a notification and precedes a
49
50 wedding event. The singing of the kāhuli foreshadowed a positive event or offered an
51
52 affirmative sign that proper action had been taken. In Hawaiian literature, all was pono
53
54 (righteous) again when the kāhuli were heard singing.
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58 *Significance for Hula:*

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3 Interviews presented the significance of kāhuli to hula (traditional dance) practitioners
4 in particular. Adornments, or lei of the kāhuli shells, were thought to provide the hula
5 practitioner with a deeper understanding and knowledge of chant and song. Traditional chant
6 and song housed and transmitted mana (spiritual power) and allowed for genealogies, stories,
7 and traditional knowledge to be passed down orally as part of hula practice.
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14 A majority of shells used in hula adornments were marine shells, representing the
15 ocean. If a song or dance spoke of the mountain or forest, plants were chosen instead as
16 adornments. Interviewees referred to historical accounts of hula practitioners using the kāhuli
17 as adornments when they were more plentiful. Though they no longer wear actual shells,
18 practitioners today continue to hold these snails in high esteem, and some are adorned with
19 kāhuli-tattoo. It is not clear whether the kāhuli tattoo is a modern adaption to compensate for
20 the lack of shells, or a traditional pattern of adornment. All species hold significance in
21 Hawaiian culture, yet the tree snails were especially esteemed, with their diversity, beauty
22 and, symbolism of voice, romance, hō‘ailona, and hula.
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35 **Part 2, Kāhuli Ecology:** What does indigenous knowledge teach about the ecology of
36 kāhuli, a rare and endangered species?
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39 Ecological variables collected on kāhuli, included elevation range, preferred climate
40 (night, cold, rain, mist, and wind), plant interactions, and native bird interactions (Table
41 A1.4).
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48 *Diminished Habitat Range:*
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50 The majority of interview participants expressed their lack of experience with wild
51 kāhuli in their natural habitat. Much of the kāhuli habitats no longer overlap with human
52 occupied ranges due to heavy predation and habitat destruction in lowland areas (Hadfield
53 1986). Thirteen sites of past kāhuli habitat were identified in written records. Different land
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3 snails were known to have been found at low elevations such as the valleys, mesic forests,
4
5 and wet forests. Locations included lower elevation sites (23%) such as Nu‘uanu valley on
6
7 O‘ahu Island, the Nohili coast on Kaua‘i Island and a few references to Waipi‘o valley on the
8
9 windward side of Hawai‘i Island, such as in the historic chant “A lalo maua o Waipi‘o”
10
11 (Table A1.1).
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14 Kāhuli are described in Waipi‘o valley, where elevation range from approximately
15
16 100 to 1000 feet in elevation, in the historic chant “A lalo maua o Waipi‘o”, or, we two are
17
18 down there at Waipi‘o. This chant opens in Waipi‘o valley and describes Hi‘ilawe, a very
19
20 high waterfall that falls to the eastern valley floor. The chant goes on to describe the
21
22 surrounding area, including native flora such as the hala and lehua. This is also one of the few
23
24 references to an extinct bird, the ‘ō‘ō (*Moho nobilis*) sharing habitat with the kāhuli. Both
25
26 snail shells and o‘o feathers were symbols of royalty used exclusively to adorn high ranking
27
28 chiefs. This chant describes the singing of the ‘ō‘ō, accompanied by the kāhuli chirps, thus
29
30 combining prior themes of royalty and voice, while also providing information on species
31
32 associations and distribution.
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35
36 Another chant, “Aia i Nu‘uanu kou lei nani,” (Table A1.1) takes place in the Nu‘uanu
37
38 valley on the southern end of O‘ahu Island, another low elevation site that begins at 200 feet
39
40 elevation. There are several key ecological characteristics of the valley described in the chant
41
42 including references to wind, rain, and a waterfall:
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44

45 He aha ka hana Waipuhia, e ho‘oma‘u nei i ke oho palai.
46 The swirling Waipuhia falls that wets the palapalai fern.
47

48
49 This mele begins with the Ki‘owao wind is specific to the Pali on the Kalihi side of Nu‘uanu.
50
51 Ki‘owao is known to be a gentle wind that can also become a stationary heavy fog. The lines
52
53 that follow describe the Waipuhia “upside down” waterfall, the ‘ā-puakea rain of the
54
55 windward side of the Ko‘olau Mountain, the cliffs of Maunawili, and the voice of the land
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2
3 snails. In this chant kāhuli are associated with cold and wet habitats at low elevations (Table
4 A1.4). The chant 'Ike I ke One Kani A'o Nohili (Table A1.1) was the single reference found
5
6
7 in this study to land snails in warmer lowland elevations. Here snails are described along the
8
9
10 coast on Kaua'i Island, referencing the Pūpūkanioe snails, known from fossils in the sand
11
12 dunes of Nohili in North West Kaua'i.

13
14 Higher elevation sites (77%) included Mā'eli'eli, Malama and Lanimaomao, all on
15
16 the island of Hawai'i; Wahiawā, Ka'ala, Waihe'e, Waianae and Kawaihoa on the island of
17
18 O'ahu; and Hīhīmanu and Waialeale on the island of Kaua'i (Table A1.4). Covering the
19
20 entire span of the islands, the snails are referred to in upland forests, on ridges, and atop
21
22 mountain peaks. For example, the previously mentioned song, Piano Ahiahi, situates the
23
24 author at the high elevation of Mā'eli'eli, a small land area in the Kā'ū district of the Big
25
26 Island, where the tree snails sing. There is also a reference to the rains of Po'aihala which is
27
28 known to be near the upland slopes above Waiohinu.
29
30

31
32 Aia i ka luna i Mā'eli'eli, ka nene'e a ka ua Po'aihale.
33 Up on the heights of Mā'eli'eli, the rains of Po'aihala creep by.
34
35

36 Another chant set on Hawai'i Island, Haina Nane (Table A1.1), makes reference to the land
37
38 snails being present in all the twelve districts of that island, covering over 4028 square miles,
39
40 as big as the land surface of all the other islands combined.
41
42

43 These records suggest that kāhuli historically thrived in a wide range of locations and
44
45 forests in the Hawaiian archipelago, in both high and low land elevations. The most common
46
47 habitat descriptions in the written records (Table A1.4) included cool temperatures (13%)
48
49 with a mention of a rain, mist or wind (41%). These chants also reveal that the upland snails
50
51 were not only limited to trees. The pūpū kuahiwi (mountain shells) were found on the forest
52
53 ground and leaf litter.
54
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57
58 *Plant Associations:*
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2
3 We also collected references on Hawaiian knowledge of plants associated with kāhuli, for
4 comparison with published records (Meyer et al. 2014, Removed by SNR). The two main
5 plants that the kāhuli were traditionally known to be found on are the endemic trees ‘ōhi‘a
6 (*M. polymorpha*) and olopua (*N. sandwicensis*). According to interviewees, the kāhuli have a
7 preference for smooth leaf surfaces. Some ‘ōhi‘a have pubescent leaves with small hair-like
8 protrusions on their surfaces, but the snails were more likely to be found on lehua ‘āhihi
9 (*Metrosideros tremuloides*), a species of ‘ōhi‘a known for smooth leaves. The chant “Aia i
10 Nu‘uanu kou lei nani” described earlier, begins with reference to the lehua ‘āhihi of Nu‘uanu
11 valley before noting the singing kāhuli:
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23 Aia i Nu‘uanu kou lei nani, o ka ‘āhihi popohe i ka nahele.

24
25 There in Nu‘uanu is your beautiful lei, the shapely ‘āhihi flower in the woodland.

26
27 The ‘āhihi is endemic to only the island of O‘ahu. A small native shrub, ‘ōhelo (*Vaccinium*
28 *reticulatum*), also smooth leaved, is commonly seen growing in close proximity with ‘ōhi‘a
29 and also serves as a suitable habitat for the snails.
30
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33
34 In a few written records there is a mention of plants like the kī (*Cordyline terminalis*),
35 ‘ie‘ie (*Freycinetia arborea*) and the halapepe (*Pleomele spp.*) all of which are endemic
36 woody plants, with smooth elongated leaves. A riddle “Haina Nane” (Table A1.1) describes
37 the habitat of the snails in the uplands of the Malama forest in the Puna District of Hawai‘i
38 Island:
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45 O ka hala ‘ie‘ie me ka halapepe, he aloha e ka nu‘a a o ka palai, ho‘opē ia nei e ke kēhau.
46 The ‘ie‘ie and the halapepe, there is love in the thick growing fern, drenched by the mist.

47
48 ‘Ie‘ie and halapepe are both endemic woody plants whose leaves form rings in the plant
49 center, creating optimum environments for mold and algae growth. This plant structure, with
50 its accessible food source, makes an ideal habitat for snails. Kāhuli in protected forest
51 enclosures today retain their preference for ‘ie‘ie. It is very rare to see the snails on kī today,
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3 a plant more commonly found in lowland ecosystems, however, there is mention of snails on
4
5 the plant in the song “He Inoa No Wili Kiwini” (Table A1.1):
6

7 Pūpūkanioe o ka waokele, kāhuli leo le‘a pili lauī.

8
9 The land snails of the rainforest, kāhuli joyfully sing clinging to the Ti-leaf.
10

11 It is possible that the lack of snail presence on kī today is due to the loss of species
12 specific habitat for a particular snail that is now extinct. There is also a possibility that the kī
13 habitat resulted from intraspecific competition in the past. The lack of large snail populations
14 today may allow individuals to choose more preferable plants for habitat.
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20 Another plant commonly associated with the kāhuli is the ‘ākōlea (*Athyrium*
21 *microphyllum*) an endemic fern. One chant referring to the two species, Kāhuli Aku (Table
22 A1.1) set to music by Winona Beamer in the 1930’s, remains a popular children’s song. The
23 chant describes the relationship between the kāhuli snails, the plant ‘ākōlea, and the kōlea
24 bird (*Pluvialis fulva*). In the song, the name kāhuli refers to the snail as well as to the action
25 of the bird drinking water, and the water seems to also refer to the water from the plant
26 ‘ākōlea which could be accessible by the kāhuli snails as well. Another chant, “Haina Nane”
27 (Table A1.1) also mentions ‘ākōlea as a habitat for the snails. In addition to ‘ākōlea, the
28 ama‘u (*Sadleria spp.*), an endemic genus of ferns, and kī are acknowledged:
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40 Aia kona wahi e noho ai iluna o ka ‘ākōlea, ke ama‘u, ka laī.

41
42 There is the place, high above where I reside, of the ‘ākōlea, the ama‘u, the ti-leaf.
43

44 Interviewees also listed additional plant species considered to be habitat for tree
45 snails. These include the olomea (*Perrottetia sandwicensis*), a native shrub or small tree;
46 kalia (*Elaeocarpus bifidus*), a native tree of Kaua‘i and O‘ahu; and the na‘ena‘e (*Dubautia*
47 *spp.*), a native shrub or small tree found in lowland forests. Data collected from both
48 interviews and written records suggests that ferns such as ‘ākōlea and ama‘u were most
49 common for kāhuli habitat, as well as the various ‘ōhi‘a and woody plants (Table A1.4). All
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3 of these plants have relatively smooth leaves for the snails, along with epiphytic microbial
4
5 communities for food (O'Rorke et al. 2015; Price et al. 2016).
6

7
8 Indigenous knowledge of kāhuli enhances understanding of species ecology by
9
10 providing information on environmental conditions associated with snails, from cool and wet
11
12 climatic conditions to individual plants snails lived on, with common characteristics that may
13
14 have facilitated feeding. Cultural sources also document historic land snail distributions that
15
16 range from low to high elevations throughout the Hawaiian Islands, and include leaf litter on
17
18 the ground, as well as in trees.
19

20 21 22 **Discussion:**

23
24 Key themes and information collected through this study on indigenous knowledge of
25
26 Hawaiian land snails included the variety of Hawaiian names for the snails, the beauty
27
28 of their voice, their symbolism for romance, their role as hō'ailona or omens, their
29
30 importance in hula, and aspects of their ecology including historical range, climate, and
31
32 associated plants. How can this indigenous knowledge enhance conservation and
33
34 restoration of rare and endangered species such as kahuli?
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40 ***Enhanced knowledge of ecology to inform conservation & restoration:***

41
42 Indigenous knowledge gathered in this study can complement and enhance existing
43
44 information from fossil records, taxonomic evaluations, and ecological studies (Drew and
45
46 Henne 2006, Wilder et al. 2016), to better understand the ecology of rare species. For
47
48 example, indigenous knowledge of the kāhuli recognized the historic broad geographic
49
50 distribution of Hawaiian land snails, offering some of the only existing records of suitable
51
52 habitat at low and high elevations. Fossils are primarily found at low elevations, with few
53
54 well-preserved records at higher elevations due to the accelerated deterioration of shells in
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3 moist environments¹. Early naturalist records also contain little data on lowland snail species
4
5 due to habitat loss such as deforestation that occurred prior to their arrival (Gulick 1872;
6
7 1905). In light of climate change, indigenous knowledge can help to increase understanding
8
9 of the historic distribution of rare and endangered species, their past resilience to ecosystem
10
11 change, contemporary vulnerability, as well as possible future sites for reintroduction which
12
13 may otherwise be overlooked. In this study, cultural sources provided specific information
14
15 on associated species such as plants², and specific aspects such as leaf structure, which may
16
17 need to be considered when preparing for reintroductions or restoration efforts.
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23 ***Bio-cultural Significance:***

24
25 Indigenous knowledge can highlight the characteristics and historic importance of
26
27 rare and threatened species. To Hawaiians the snails were not just small shells, but symbols
28
29 of valued qualities spoken and chanted about through generations. The snails added elements
30
31 of beauty and were even protagonists in historical narratives. They were perhaps the only
32
33 invertebrate groups observed to be hō‘ailona akua, good omens and affirmations. Snail shells
34
35 were prized and reserved for individuals of prestigious ranking, such as mō‘ī wahine (high
36
37 chiefesses), perhaps a sign of appreciation for their rarity and a form of management for their
38
39 protection.
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43 Our study supports prior research suggesting that the symbolic significance of species
44
45 may be as important as their material use. The most prevalent theme across cultural sources
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47

48
49 ¹ Thus, true fossils are missing for high-elevation species, or may be misidentified as lowland species,
50
51 if shells wash downhill post-mortem.

52
53 ² The results are consistent with published ecological studies (Meyer et al. 2014; Removed by SNR)
54
55 that demonstrate kahuli have a strong association with habitat dominated by ‘ōhi‘a, as well as
56
57 preferences that varied among snail species for mokihana., ‘ōhelo, olomea, and na‘ena‘e.
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2
3 was the singing of the snails. These references may never be fully understood, despite
4
5 multiple explanations for the source of their voice including wind and the chirping of
6
7 crickets. Still, voice was a key characteristic woven into many chants, songs, and stories of
8
9 old Hawai'i, which also underpinned their importance in hula, and as adornment. The singing
10
11 of the snails was used to signal romance, righteous action, or something extraordinary and
12
13 not of this world. As analysis of the figurative poetry of the kahuli shows, indigenous
14
15 knowledge must be interpreted carefully and considered for its many layers of meaning, both
16
17 literal and metaphoric.
18
19

20
21 In this study, the majority of cultural records focus on the symbolic and cultural
22
23 significance of Hawaiian land snails, which may not seem directly relevant in informing
24
25 restoration efforts. However, ecological information can be embedded in metaphorical
26
27 references. Further, managers that seek cultural sources solely for ecological information risk
28
29 overlooking the value and interconnectedness of bio-cultural understand. Indigenous
30
31 knowledge may provide inspiration and support for efforts to conserve rare and endangered
32
33 species by enhancing understanding of why they matter. Educational outreach to the public
34
35 and policy members can focus on how species virtually unknown today influenced human
36
37 lives through centuries of interaction.
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43 ***Challenges in Accessing Sources of Indigenous Knowledge:*** 44

45 While there is clear value in considering indigenous knowledge of rare and
46
47 endangered species, this knowledge is not easily accessible. In the rare cases where written
48
49 resources, such as Hawaiian language newspapers exist, researchers require in-depth
50
51 knowledge of these archives and the older versions of indigenous languages in which they are
52
53 recorded. This study relied largely on secondary sources or second-language speaker
54
55 translations of archival materials. The complexity of translating written material may have
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3 left some material unexplored. Efforts to research indigenous knowledge of rare species will
4
5 be enhanced by collaborations with indigenous language scholars and native speakers.
6

7
8 Most indigenous knowledge, however, is oral and relies upon transmission between
9
10 individuals across generations. Thus, archival research efforts should be supplemented
11
12 through interviews with practitioners from different geographic backgrounds or areas of
13
14 expertise. In this study it was a challenge to find practitioners who felt confident about their
15
16 knowledge of land snails. When species become rare, practitioners may be less likely to
17
18 interact with them, reinforcing loss of understanding. Decreases in familiarity may in turn
19
20 contribute to further declines in these rare species due to public apathy. Indigenous
21
22 knowledge may combat apathy by preserving the significance and unique characteristics of
23
24 rare species through stories, chants, and songs. While conservation emphasizes the
25
26 maintenance of biodiversity, preservation of cultural diversity may be equally crucial to the
27
28 conservation of rare and endangered species.
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34 Conclusion:
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3 “Their value must be understood beyond the ranks of a few scientific specialists.

4
5 Story is the way we encode such values in our culture (Nabhan 1991:3).”

6
7 Our study highlights the many ways one indigenous culture can place great value on a
8
9 small, easily overlooked invertebrate. Indigenous knowledge of the snails, such as that
10
11 shared in this paper, reveals their tremendous importance in Hawaiian culture and the
12
13 high level of awareness and esteem that the Hawaiians held for these snails as recently
14
15 as 150 years ago. Understanding the cultural significance of a species through their
16
17 inclusion in chants, songs, and stories can enhance broader appreciation of their beauty,
18
19 uniqueness, and the need to preserve them.
20
21

22
23 The loss of the cultural importance of the kāhuli is equal to the physical loss of these
24
25 creatures. Indigenous knowledge of a species can bring together science, conservation, and a
26
27 community to fight what was once looked at as a losing battle. The day we hear the hō‘ailona
28
29 of the kāhuli singing will be the day we know that our efforts, like many across the world,
30
31 have not been in vain. *Pīpī holo ka ‘ao* (May their story always continue).
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For Peer Review Only

Table 1. List of all written records of k ahuli in the study.

Written Records (N)	Date	Source	Type
Kahuli Aku	1862	Laieikawai (Text)/Huapala	Oli/Mele
Page 249	1862	Laieikawai (Text)	Mo'olelo
Page 120	1909	Unwritten Literature of Hawaii (Text) Legends of Gods and Ghosts	Mele
Laukaieie	1915	(Text)	Mo'olelo
Pele and Hiiaka	1997	Text	Mo'olelo
Aia I Nu`uanu Kou Lei Nani	1880's	Huapala	Oli Lei
Piano Ahiahi	1930's	Huapala	Mele
`Ike I ke One Kani A`O Nohili	1920's	Huapala	Mele Pana
Pa Ka Makani	?	Huapala	Oli
Ku`u Pua Mikinolia	1800's	Huapala	Mele
He inoa no Pua Rose	1862	Papakilo/Ka Nupepa Kuokoa	Mele
Ka Hoku Nani O Ke Kakahiaka	1907	Papakilo/Ka Nupepa Kuokoa	Mele
Haina Nane	1907	Papakilo/Ka Nupepa Kuokoa	Article
Haine Nane #2	1909	Papakilo/Ka Nupepa Kuokoa	Article
Hoonipo i ka Malu o ke Ao	1878	Papakilo/Ka Nupepa Kuokoa	Article
He Ahamele Nui	1906	Papakilo/Ka Nupepa Kuokoa	Announcement
He inoa no Manoana	1862	Papakilo/Ka Nupepa Kuokoa	Oli
Mele Kahiko	1866	Papakilo/Ka Nupepa Kuokoa	Mele
Ka moolelo o Kamaakamahiai	1871	Papakilo/Ka Nupepa Kuokoa	Mo'olelo

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3	He moolelo kaao no-			
4		1884	Papakilo/Ka Nupepa Kuokoa	Mo'olelo
5	Keaomelemele			
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8	Hiiaka I Ka Poli O Pele	1909	Papakilo/Kuokoa Home Rula	Mo'olelo
9				
10	He moolelo kaili puuwai no	1912	Papakilo/Ke Au Hou	Mo'olelo
11				
12	Ka po o ka poalima	1868	Papakilo/Ke Au Okoa	Mele
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14				
15	Ka wahine uhane	1869	Papakilo/Ke Au Okoa	Mo'olelo
16				
17	He Wehi No Miss. Ane Bell	1894	Papakilo/Ka Oiaio	Mele
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19				
20	Ka moolelo ka ao Hawaii no La-			
21		1894	Papakilo/Ka Oiaio	Mo'olelo
22	ukaieie			
23				
24			Papakilo/Ka Hoku o ka-	
25				
26	He kanikau no Maraea Haumea	1863		Article
27			Pakipika	
28				
29	Auwe! Walohia Wale	1885	Papakilo/Ko Hawaii Pae Aina	Article
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31	He inoa no wili kiwini	1887	Papakilo/Ko Hawaii Pae Aina	Mele
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34	He inoa no Kalaninuiahilapalapa	1893	Papakilo/Ka Leo o ka Lahui	Article
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36	Laukaieie	1894	Ka Leo o ka Lahui	Mo'olelo
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3 Table 2. A list of key terms used as input for
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5 the Papakilo Database search engine with
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7 count of written records produced.
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Search Terms	# of Produced Articles
kahuli	3055
kahuli leo	1866
kahuli akolea	39
pupu kani oe	639
pupukanioe	260
pupukanioe leo	217
kahuli uwalo	117
pololei pupukanioe	88
pupu moe	1031
pupu kuahiwi	408

Table 3 Prevalent themes of the kāhuli and the amount of references found in the written records for each theme.

	Common Names for Snails			Other Themes		
	Kāhuli	Pupukanioe	Pololei	Voice	Romance	Hō‘ailona (signs/omens)
# of references	23	16	3	21	11	2
% of total	76.67%	53.33%	10.00%	70.00%	36.67%	6.67%

The percent of total is the percent of the number of references found to N=30.

Table 4. Historical ecological data found in the written records on the Kāhuli.

Historical kāhuli ecology	Total references found	Additional notes
Elevation- Lowland	5	Hawai`i island (Waipi`o Valley (2), Hi`ilawe); O`ahu island (Nu`uanu Valley); Kaua`i island (Nohili Coast) Hawai`i island (Ma`eli`eli, Malama, Lanimaomao, all twelve districts); O`ahu island (Wahiawā, Ka`ala, Waianae, Kawaihoa); Kaua`i island (Hīhīmanu, Waialeale)
Elevation-Upland	11	
Night	5	
Climate- Cold	4	
Rain/Mist	8	Puakea rain; Po`aihala rain
Winds	5	Ki`owao; Kiu; Mikioi; Ha`u ka waha
Plants- Ferns	6	‘Ākōlea (4); Palai; ‘Ama‘u
Plants- Lehua	5	‘Āhihi
Plants- Woody		
Plants	5	Kī (3); ‘Ie‘ie; Halapepe
Birds	4	Kōlea (2); ‘Ō‘ō (2)

Any specific references of place/rain/wind/species name are included in the Additional Notes column. References that occur more than once have a numerical value of references in parenthesis. N=30.

Supplemental Online Materials. 1

Interview questions

- 1) How have you received ‘ike (knowledge) of the kahuli snails?
- 2) What other inoa have you heard for our Hawaiian land snails?
- 3) What chants, mele, or mo‘olelo do you know that refer to the snails?
- 4) Do these chants, mele, mo‘olelo have any similar themes?
- 5) Why do you think the kahuli were mentioned in our chants and mele?
- 6) What other similarities have you noticed between Hawaiian language sources including kahuli?
- 7) What do you think the role and significance of the kahuli was/is? to Hawaiians?
- 8) Why do you think the kahuli have a leo?
- 9) Do you know of any other importance or use of the snails in the culture?
- 10) What kinds of conditions and habitat do you think the kahuli thrived in?