

Society & Natural Resources

An International Journal



ISSN: 0894-1920 (Print) 1521-0723 (Online) Journal homepage: <http://www.tandfonline.com/loi/usnr20>


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To cite this article: Aimee You Sato, Melissa Renae Price & Mehana Blaich Vaughan (2018) Kāhuli: Uncovering Indigenous Ecological Knowledge to Conserve Endangered Hawaiian Land Snails, *Society & Natural Resources*, 31:3, 320-334, DOI: [10.1080/08941920.2017.1413695](https://doi.org/10.1080/08941920.2017.1413695)

To link to this article: <https://doi.org/10.1080/08941920.2017.1413695>

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

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ABSTRACT

Indigenous knowledge is a multilayered 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 19th and early 20th 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.

ARTICLE HISTORY

Received 3 February 2017
Accepted 19 October 2017

KEYWORDS

Endangered species;
Hawaiian; indigenous
knowledge; land snail;
traditional ecological
knowledge; tree snail

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, Berkes, and Folke 1993; Uprety et al. 2012) by providing missing insight into the biology of culturally significant species (Garibaldi and Turner 2004; Ramstad et al. 2007; Ceriaco et al. 2011). Further, indigenous knowledge can enhance understanding of species significance, and why it is imperative to conserve them (Turner and Spalding 2013), as well as enhance conservation education (Kimmerer 2002; Berkes and Turner 2006).

Indigenous knowledge, sometimes referred to as traditional ecological knowledge, consists of an adaptive “cumulative body of knowledge, practice, and belief,” which is culturally transmitted across generations and explains the relationships between all living things (including humans) and the environment (Berkes 2012). Finding and interpreting indigenous knowledge has its challenges, as local knowledge is commonly rooted in families, and encoded through stories, songs, dances, rituals, and practices (Xu et al. 2005). Yet, extensive natural resource knowledge has been researched in indigenous communities across the globe (Toledo 2002; Posey 1999). In some cases indigenous

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 Supplemental data for this article can be accessed on the [publisher's website](#).

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knowledge may conflict with conservation goals (Raymond et al. 2010) or western scientific understanding (Agrawal 1995) and there is extensive research on both challenges and guidelines to effective integration (Agrawal 1995; Raymond et al. 2010). Indigenous knowledge is not a static artifact, but an adaptive resource built across generations of observations, and in reaction to changes in resources within a particular location (Briggs and Sharp 2004; Berkes and Turner 2006). Indigenous knowledge can include harvest and management practices that developed over time to conserve species (Turner and Berkes 2006; Motaleb 2010). In some cases, integration of indigenous knowledge into conservation has been associated with enhanced species abundance (Poepoe, Bartram, and Friedlander 2005; Colding and Folke 1997), biomass (Friedlander, Shackeroff, and Kittinger 2013), biodiversity (Xu et al. 2005), and decision making for resilience and adaptation to climate change (Turner and Spalding 2013).

Beyond utilitarian purposes, many rare species are valued by indigenous cultures for cultural significance and their role in cultural identity (Sobrevila 2008). In contrast to charismatic vertebrates, which are often well-documented by explorers, naturalists, and scientists, invertebrates often receive less attention (Black, Shepard, and Allen 2001). However, nearly all species of plants and animals, including invertebrates, may be known and valued, if not used for human survival by indigenous people (Black, Shepard, and Allen 2001; Bisht et al. 2006). The conservation of rare and endangered species provides a unique opportunity to integrate indigenous knowledge with western science (Colding and Folke 1997). The Hawaiian Islands are a great platform for such a case study, with a vibrant, enduring indigenous culture and threatened biological diversity (Pukui, Haertig, and Lee 1972; Régnier et al. 2015; James 2004). In this study we examined native Hawaiian knowledge of rare and endangered endemic land snails. Endemic land snails were once abundant throughout Hawai'i, and included over 750 diverse species (Cowie, Evenhuis, and Christensen 1995), in diverse habitats (Pilsbry and Cooke 1912–1914). Kāhuli, as they were called by native Hawaiians, held a prominent cultural presence in written records through their role in chants, songs, and stories (MacCaughy 1917; Bryan 1935).

Along with other flora and fauna of Hawai'i, the abundance of land snails changed with human arrival (Hadfield 1986; Régnier et al. 2015). Population declines due to shell collection, predation by alien species of rats (Atkinson 1977; Hadfield, Miller, and Carwile 1993), *Chamaeleo jacksonii* (Holland, Montgomery, and Costello 2009; Chiaverano and Holland 2014), and the predatory snail *Euglandina rosea* (Hadfield, Miller, and Carwile 1993; Holland et al. 2012), and habitat loss have severely impacted snail diversity and distributions. Extinction rates are estimated to be approaching 75–90% across all Hawaiian land snails (Cowie 2001), but these rates vary across taxa. The Hawaiian tree snail genus *Achatinella*, endemic to O'ahu Island, once numbered a total of 41 species (Hadfield, Miller, and Carwile 1993), but today only 11 species remain in the wild, all of which are listed as endangered (U.S. Fish and Wildlife Service 1993; Price et al. 2015). Other genera of land snails in the family *Amastridae* have declined from 325 species to approximately 15 species (Régnier et al. 2015).

What can indigenous knowledge teach about the (1) cultural significance and (2) ecology of rare and endangered species such as kāhuli? How can indigenous knowledge contribute to efforts to restore and protect these species? In this study, we compile Native Hawaiian knowledge of this rare invertebrate, in an effort to answer these questions.

Methods

We conducted a literature review of written 19th century Hawaiian language records, along with semistructured interviews with cultural practitioners. The two sources of information reinforced one another, revealing common themes, and the interviews helped to interpret the written records. We used criteria-based sampling to identify six cultural practitioners with knowledge of the kähuli. All interview participants were kumu (teachers) in different fields of cultural expertise (i.e., hula, Hawaiian language, chant, and ecology). The 10 interview questions (Methods SOM1) were open-ended to allow respondents to express their individual knowledge (Weiss 1994). We inquired about: (1) Hawaiian names for the kähuli, (2) Hawaiian literature related to kähuli, (3) cultural significance, and (4) ecology of the species, such as plant associations. Hand written notes were taken during interviews, which were not recorded using audio or video. These notes were analyzed for common themes (Weiss 1994), which were then applied to the archival written records.

Early missionaries to Hawai'i created the Hawaiian alphabet to allow translation of the Bible and writing of a previously solely oral language (Nogelmeier 2003). From 1834 to 1948, Native Hawaiians used the new venue to record knowledge as people died in large numbers due to introduced diseases (Friedlander, Shackeroff, and Kittinger 2013).

We used multiple online Hawaiian databases to access these newspapers and other written records on the kähuli (Table 1). The Papakilo Database (2016), provided by The Office of Hawaiian Affairs has digitized 75,000 pages of newspapers, with 25–30% remaining to be digitized. We used the online Huapala archives to find lyrics to Hawaiian compositions which included references to kähuli (Hawaiian Hula Archives 1997–2015). We also analyzed translations of mo'olelo (historical narratives) including Lā'ieikawai (Haleole and Beckwith 1918), Pele and Hi'iaika (Emerson 1997), Lauka'ie'ie (Westervelt 1915), and stories and chants in the Unwritten Literature of Hawai'i (Emerson 1909). A total number of 30 written records were translated and used in this study. We found 10 stories, 14 chants and songs, and 6 articles (Table 1).

We used multiple keywords associated with kähuli to search the databases, some of which were suggested by interviewees. Key word searches produced volumes of written records (Tables 1 and 2); however, many did not refer to the snails. For example, the name kähuli can also mean change, resulting in written records that related to changes in the government. To narrow down our results to relevant records, we combined specific keywords such as the name of a snail with an associated plant (Table 2). Lines directly related to the snails were translated, along with surrounding lines to provide context. We used online Hawaiian dictionaries (The Hawaiian Electronic Library 2004) to translate records. A Hawaiian language expert reviewed all translations. Five resources, providing more than two lines of snail reference, were translated in their entirety. For each written record found through the database searches, we noted the source of data, and references to place (island, region, etc.), plant interactions, climate (wind, rain, mist, clouds, etc.), visual characteristics of kähuli such as color or size, animals or insects that share habitat, elevation (upland/lowland), cultural knowledge including the use of snail shells, significance to indigenous people, characteristics of snails, and the use of the species metaphorically. Common elements across written records revealed key themes related to the ecology and cultural significance of the snails (Tables 3 and 4), all of which were also raised in the interviews. We present results based on the themes that emerged from the interviews, and then use the written records to illustrate examples of these themes.

Table 1. List of all written records of Kāhuli in the study.

Written record (<i>N</i>)	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)	Mele
Laukaieie	1915	Legends of Gods and Ghosts (text)	Mo'olelo
Pele and Hiiaka	1997	Text	Mo'olelo
Aia I Nu'uuanu Kou Lei Nani	1880s	Huapala	Oli Lei
Piano Ahiahi	1930s	Huapala	Mele
`Ike I ke One Kani A'O Nohili	1920s	Huapala	Mele Pana
Pa Ka Makani	?	Huapala	Oli
Ku`u Pua Mikinolia	1800s	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
He moolelo kaao no Keamelemele	1884	Papakilo/Ka Nupepa Kuokoa	Mo'olelo
Hiiaka I Ka Poli O Pele	1909	Papakilo/Kuokoa Home Rula	Mo'olelo
He moolelo kaili puuwai no	1912	Papakilo/Ke Au Hou	Mo'olelo
Ka po o ka poalima	1868	Papakilo/Ke Au Okoa	Mele
Ka wahine uhane	1869	Papakilo/Ke Au Okoa	Mo'olelo
He Wehi No Miss. Ane Bell	1894	Papakilo/Ka Oiaio	Mele
Ka moolelo ka ao Hawaii no La-ukaieie	1894	Papakilo/Ka Oiaio	Mo'olelo
He kanikau no Maraea Haumea	1863	Papakilo/Ka Hoku o ka-Pakipika	Article
Auwe! Walohia Wale	1885	Papakilo/Ko Hawaii Pae Aina	Article
He inoa no wili kiwini	1887	Papakilo/Ko Hawaii Pae Aina	Mele
He inoa no Kalaninuiahilapalapa	1893	Papakilo/Ka Leo o ka Lahui	Article
Laukaieie	1894	Ka Leo o ka Lahui	Mo'olelo

Written records were sourced from Text, Huapala, or Papakilo. Text includes any printed text from reference books. Huapala is an online collection of popular Hawaiian songs and chants. Papakilo is an online Hawaiian database of Hawaiian language newspapers. Newspapers includes: Ka Nupepa Kuokoa (1861–1927), Ke Au Hou (1910–1912), Ke Au Okoa (1865), Ka Hoku o ka Pakipika (1861–1863); Ho'olaupii Hawaiian Nupepa Collection (1834–1948) including Ka Oiaio, Ko Hawaii Pae Aina, Ka Leo o ka Lahui, Kuokoa Home Rula. Written record types are categorized into: Oli (chant); Oli lei (chant given as a gift); Mele (song); Mele pana (song to honor a place); Mo'olele (historical story); article (not able to distinguish as a mele, oli, or mo'olelo). A few dates of composition are estimated due to a lack of information from the original source. *N* = 30.

Table 2. A list of key terms used as input for the Papakilo Database search engine with count of written records produced.

Search terms	Number 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

Results

Part 1, Cultural Significance

What can indigenous knowledge teach us about the cultural significance and ecology of rare and endangered kāhuli?

Table 3. Prevalent themes of Kāhuli.

	Common names for snails			Other themes		
	Kāhuli	Pūpūkani-oe	Pololei	Voice	Romance	Hō'ailona (signs/omens)
No. of references	23	16	3	21	11	2
Total (%)	76.67	53.33	10.00	70.00	36.67	6.67

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'uuanu Valley); Kaua'i island (Nohili Coast)
Elevation-upland	11	Hawai'i island (Mā'eli'eli, Malama, Lanimaomao, all 12 districts); O'ahu island (Wahiawā, Ka'ala, Wai'anae, Kawaihoa); Kaua'i island (Hihimanu, Waialeale)
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	Ki (3); 'le'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.

The following themes emerged regarding cultural significance: the variety of names used for the snails; snail-attributed voice or singing; snails as symbols of romance; hō'ailona (signs and omens); and significance for hula (traditional dance) (Table 4).

Significance of names

Names hold great significance in Hawaiian culture (Pukui, Haertig, and Lee 1972). The importance of endemic snails is evident in their number and variety of names. All of the interview participants were familiar with the most common name, kāhuli, referenced in 77% of the written records. Practitioners suggested that the name kāhuli, meaning to turn or change, potentially refers to the way kāhuli shells shift from side to side as the snails travel, or the swirling form of shell growth. The name kāhuli sometimes represents the ability to change physical form. For example, the famous story of “Hi'iaka i ka poli o Pele” follows the goddess, Hi'iaka, on her travels as she meets a fisherman by the name of Pahulu. Pahulu agrees to get her fish if Hi'iaka pleases his sexual desires in return. She responds with:

Kāhuli lei 'ula lei 'ākōlea.

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

When Pahulu attempts to embrace her for his reward, she transforms into a rock. Like the shifting movement of a kāhuli shell, Hi'iaka shifts her form to escape Pahulu's advance.

Most of the interview participants and 53% of written records also used the name pūpūkani-oe or pūpūkani-oi, the literal translation being “shell sounding long.” The name pūpūkani-oe references the sweet pure sound of the snails. In the chant “Ike I ke One Kani A'O Nohili” the words read:

Pūpūkani-oe ko Kaua'i, kūnihi Hā'upu 'au i ke kai.

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

Though this particular chant refers to the land snails (*Carelia* spp.) found in the sand dunes of Kaua'i, other records from Hawai'i Island used pūpū-kani-oe; suggesting the name is not limited to a particular island, or species.

A few written records (10%) referenced the name pololei, meaning perfect or correct, which also came up in interviews. Pololei in mele is usually followed poetically with “kani kua mauna/singing in the mountain ridges.” This name may describe the visual perfection of the shells, perfect singing of the snails, or recognition of something extraordinary in nature.

Less common names referenced in under 10% of written records and interviews included: pūpū-moe-one, shell that sleeps in the sand; pūpū-kuahiwi, mountain shell; hinihini, delicate voice (Emerson 1997); naka, quiver (The Hawaiian Electronic Library 2004); pūpū-hinahina'ula, shell with beautiful rainbow colors (Westervelt 1915); and pūpū-mokalau, shell clinging to mokihana, *Melicope anisate* (Westervelt 1915).

Voice

All interviewees mentioned the theme of singing snails, also present in approximately 70% of written records. Interviewees offered possible explanations for the voice attributed to these invertebrates. Five centuries ago, snails and other native species were plentiful throughout the uplands and lowlands, representing the voice of the forest. Today the habitat of the snails has changed drastically with invasive species. The wind does not travel through the forest in the same way as in the past.

One explanation for the voice of the kähuli was the relationship with wind and the placement of ample kähuli snails. Constant gentle breeze over the shells could provide a faint whistle frequently associated with kähuli and their sweet singing. In contrast, a stronger wind intensified the kähuli activity. The chant Pa Ka Makani (Table 1) can be interpreted as:

Pa ka makani, ha'u ka waha o ke kähuli i ka nahele.

The wind blows, the land shells trill (mouths tremble) in the forest.

Pa Ka Makani tells the story of the mythological rooster god Ka'au-hele-moa, whose extraordinary presence made the land shells trill, bringing with him the pouring rains and clouds of Kaupe'a.

Some interviewees suggested that cricket sounds may have been attributed to kähuli. Though crickets were plentiful in Hawaiian forests, they would have been visually difficult to detect. In the Hawaiian mind, a beautiful voice would naturally belong to something as exquisite as the kähuli. Though they offered explanations, interviewees also suggested that Native Hawaiians would not have questioned the source of the kähuli's voice. A voice serves the purpose any voice would, to communicate a message, serve as a sign, or a warning.

The kähuli's beautiful voice could also personify a character. The mele, He Inoa No Manoana (Table 1), describes a person's singing skill through poetic reference to the kähuli. In a well-known story, “Lauka'ie'ie,” the snails become actual characters with beautiful voices (Westervelt 1915). Lauka'ie'ie, a woman from Hawai'i Island, had two friends, Pūpū-kani-oi, the singing snails of the forest trees and Pūpū-hinahina'ula, the snail with beautiful rainbow colors. Lauka'ie'ie chooses Pūpū-kani-oi to journey to find her the man of her dreams. The snail calls for aid from the laukoa leaves of the koa tree (*Acacia koa*), lauanau leaves of the paper-mulberry tree (*Broussonetia papyrifera*), the sea snails,

and the pūpū-mokalau snails on the mokihana (*M. anisate*) of Kauaʻi. Pūpū-kani-oi states, “Come and look at me, for I am one of your family! Call all the shells to aid me in my journey! (Westervelt 1915)” Here the snails that inhabited different ecological niches and islands were all considered part of the same family.

In Laukaʻieʻie, snails had human characteristics, such as the gift of voice and ability to travel long distances. Ka-poe-kino-pūpū names a category of snails possessing special powers (Westervelt 1915). Snails were also held in high regard as supernatural kupua (magical deities) who had the ability to change forms. Sometimes referred to as ʻeʻepa people, they were similar to fairies, and slightly deformed. Not all species in Hawaiʻi were known to take on human form, suggesting that snails were held in high regard.

Romance

A majority of the cultural practitioners agreed that the snails added an element of romance to a story, song, or chant. Approximately 37% of the written records are mele aloha, songs of wooing or love. These mele aloha included characteristics associated with romance in Hawaiian literature, including night, cool temperatures, rain, mist, forests, and singing kähuli. The composition, Piano Ahiahi (Table 1) refers to the kähuli in the lines:

Hoʻolono i ka leo o ke kähuli leo honehono i ka pili o ke ao.
The caressing voice of the snails, and the togetherness of dawn.

The romantic words describe an extraordinary event, the composers’ visit to the ship Naukilo, where they saw a mirror and heard a piano for the first time. The lyrics suggest comparison of the piano with the kähuli’s singing.

The singing of the snails signaled something extraordinary, and being in love was an extraordinary event to the Hawaiians. Kuʻu Pua Mikinolia (Table 1) is a mele aloha that describes lovemaking amidst the scent of Magnolia, the singing kähuli, and the sound of rain. Another song, “He Inoa No Pua Rose,” (Table 1) follows two companions into the late of the night, as the voice of the snails float above them. The presence of land snails in a story or song signaled romantic interests and actions that may not be made explicit through words.

Hōʻailona

The kähuli were also hōʻailona (symbols or omens) of significant events or individuals. Hōʻailona can include natural phenomenon such as rolling thunder or the ocean turning red. The appearance of certain animals, including other creatures with the gift of voice such as birds, served as hōʻailona, but the kähuli are the only land invertebrate that played this symbolic role. Eye-catching symbols were selected as hōʻailona aliʻi (omens associated with chiefs and other high ranking individuals) and hōʻailona akua (godly omens). Kähuli were considered hōʻailona not only for their exquisite shells but for their beautiful singing. Some mōʻi wahine, females of royalty, wore kähuli lei, a strung necklace of native shells, to signify their high rank.

The use of kähuli as hōʻailona most commonly occurred in longer narratives where kähuli appear along the extended journey of the protagonists. In the story of Lāʻieikawai (Table 1) the singing acts as a notification preceding a wedding. The singing snails foreshadowed positive events or offered affirmative signs that proper action had been taken. In Hawaiian literature, all was pono (righteous) again when the kähuli sang.

Significance for Hula

Interviews presented significance of kähuli to hula practitioners. Kähuli shell adornments were thought to provide the hula practitioner with a deeper understanding of chant and song which housed and transmitted mana (spiritual power) allowing for genealogies, stories, and ancestral knowledge to be passed down orally. Most shells used in hula adornments were marine shells, representing the ocean. If a dance spoke of the mountains, plants were chosen instead as adornments. Interviewees recounted the historical use of kähuli as adornments when they were more plentiful. Though hula practitioners no longer wear actual shells, they continue to hold these snails in high esteem today. Some wear kähuli-tattoo which may be a traditional pattern or a modern adaptation to compensate for the lack of shells. All species hold significance in Hawaiian culture, yet the tree snails were especially esteemed, with their diversity, beauty symbolism of voice, romance, hō‘ailona, and hula.

Part 2, Kähuli Ecology

What does indigenous knowledge teach about the ecology of rare and endangered kähuli?

Ecological variables collected on kähuli included elevation range, preferred climate (night, cold, rain, mist, and wind), plant interactions, and native bird associations (Table 4).

Diminished Habitat Range

The majority of interview participants expressed their lack of experience with wild kähuli. Much of the kähuli habitats no longer overlap with human occupied ranges due to heavy predation and habitat destruction in lowland areas (Hadfield 1986). Thirteen sites of past kähuli habitat were identified in written records. Kähuli were known to have been found at a range of elevations in both mesic and wet forests. Locations included lower elevation sites (23%) such as Nu‘uanu valley on O‘ahu Island, the Nohili coast on Kaua‘i Island and a few references to Waipi‘o valley on the windward side of Hawai‘i Island (Table 4).

Kähuli are described in Waipi‘o valley, where elevation ranges from approximately 100 to 1000 feet in elevation, in the historic chant “A lalo maua o Waipi‘o (Table 1).” This chant opens in Waipi‘o valley and describes Hi‘ilawe, a high waterfall that falls to the eastern floor. The chant goes on to describe one of the few references to an extinct bird, the ‘ō‘ō (*Moho nobilis*) sharing habitat with the kähuli. Both snail shells and ‘ō‘ō feathers were symbols of royalty used exclusively to adorn high ranking chiefs. This chant describes the singing of the ‘ō‘ō, accompanied by the kähuli chirps, thus combining prior themes of royalty and voice, while also providing information on species associations and distribution.

Another chant, “Aia i Nu‘uanu kou lei nani,” (Table 1) takes place in the Nu‘uanu valley on the southern end of O‘ahu Island, another low elevation site that begins at 200 feet elevation. There are several key ecological characteristics of the valley described in the chant:

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

This mele begins with the Ki‘owao wind, specific to western Nu‘uanu. Ki‘owao is known to be a gentle wind that can also become a stationary heavy fog. The lines that follow describe other well-known features of the area such as the Waipuhia “upside

down” waterfall, the ‘ā-puakea rain of the windward side of the Ko‘olau Mountain, the cliffs of Maunawili, and the singing snails. In this chant kähuli are associated with cold and wet habitats at low elevations (Table 4). The chant ‘Ike I ke One Kani A‘o Nohili (Table 1) was the single reference found in this study to land snails in warmer lowland elevations. Here snails are described along the coast on Kaua‘i Island, referencing the pūpū-kani-oe snails, known from fossils in the sand dunes of Nohili in Northwest Kaua‘i.

Higher elevation sites (77%) included Mā‘eli‘eli, Malama and Lanimaomao on Hawai‘i Island; Wahiwā, Ka‘ala, Waihe‘e, Wai‘anae and Kawaihoa on O‘ahu Island; and Hihimanu and Wai‘ale‘ale on Kaua‘i Island (Table 4). Covering the entire span of the islands, the snails are referred to in upland forests, ridges, and mountain peaks. For example, the previously mentioned song, Piano Ahiahi (Table 1), situates the author at the high elevation of Mā‘eli‘eli, a small land area in the Kā‘ū district of Hawai‘i Island, where the tree snails sing. There is also a reference to the rains of Po‘aihala which is known to be near the upland slopes above Wai‘ōhinu.

Aia i ka luna i Mā‘eli‘eli, ka nene‘e a ka ua Po‘aihale.
Up on the heights of Mā‘eli‘eli, the rains of Po‘aihala creep by.

Another chant set on Hawai‘i Island, Haina Nane (Table 1), makes reference to the land snails being present in all the 12 districts of the island.

These records suggest that kähuli historically thrived in a wide range of habitats in the Hawaiian archipelago. The most common habitat descriptions in the written records (Table 4) included cool temperatures (13%) with a mention of a rain, mist, or wind (41%).

Plant Associations

We also collected references on plants associated with kähuli, for comparison with published records (Meyer et al. 2014, Price et al. 2016). The two main plants that the kähuli were traditionally known to be found on are the endemic trees ‘ōhi‘a (*Metrosideros polymorpha*) and olopuā (*Nestegis sandwicensis*). According to interviewees, the kähuli have a preference for smooth leaf surfaces. Some ‘ōhi‘a have pubescent leaves with small hair-like protrusions on their surfaces, but the snails were more likely to be found on lehua ‘āhihi (*Metrosideros tremuloides*), an O‘ahu Island endemic known for smooth leaves. The chant “Aia i Nu‘uanu kou lei nani” described earlier, begins with reference to the lehua ‘āhihi of Nu‘uanu valley before noting the singing kähuli. A small native shrub, ‘ōhelo (*Vaccinium reticulatum*), also smooth leaved, is commonly seen growing in close proximity with ‘ōhi‘a and also serves as suitable snail habitat.

In a few written records there is a mention of plants, such as the kī/lauī/lai (*Cordyline terminalis*), ‘ie‘ie (*Freycinetia arborea*), and the halapepe (*Pleomele* spp.) all of which are endemic woody plants, with smooth elongated leaves. A riddle “Haina Nane” (Table 1) describes the habitat of the snails in the uplands of the Malama forest in the Puna District of Hawai‘i Island:

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.
The ‘ie‘ie and the halapepe, there is love in the thick growing fern, drenched by the mist.

‘Ie‘ie and halapepe are both endemic woody plants whose leaves form rings in the plant center, creating optimum environments for microbial growth. This plant structure, with its

accessible food source, makes an ideal habitat for snails. Kāhuli in protected forest enclosures today retain their preference for 'ie'ie. It is very rare to see the snails on kī today, a plant more commonly found in lowland ecosystems, however, there is mention of snails on the plant in the song "He Inoa No Wili Kiwini" (Table 1):

Pūpū-kani-oe o ka waokele, kāhuli leo le'a pili lauī.

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

It is possible that the lack of snail presence on kī today is due to the loss of species specific habitat for a particular snail that is now extinct. There is also a possibility that the kī habitat resulted from intraspecific competition in the past. The lack of large snail populations today may allow individuals to choose more preferable plants for habitat.

Another plant commonly associated with the kāhuli is the endemic fern, 'ākōlea (*Athyrium microphyllum*). One chant referring to the two species, Kāhuli Aku (Table 1) set to music by Winona Beamer in the 1930's, remains a popular children's song. The chant describes the relationship between the kāhuli snails, the 'ākōlea, and the kōlea bird (*Pluvialis fulva*). Another chant, "Haina Nane" (Table 1) also mentions 'ākōlea as a habitat for the snails. In addition to 'ākōlea, the ama'u fern (*Sadleria* spp.), and kī are acknowledged:

Aia kona wahi e noho ai iluna o ka 'ākōlea, ke ama'u, ka laī.

There is the place, high above where I reside, of the 'ākōlea, the ama'u, the laī.

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

Indigenous knowledge of kāhuli enhances understanding of species ecology by providing information on environmental conditions associated with snails, from cool and wet climatic conditions, and plants with common characteristics that may have facilitated feeding. Cultural sources also document historic land snail distributions that range from low to high elevations throughout the Hawaiian Islands, ground and tree dwelling.

Discussion

Key themes and information collected through this study on indigenous knowledge of kāhuli included the variety of snail names, the beauty of their voice, symbolism for romance, role as hō'ailona or omens, importance in hula, and aspects of their ecology including historical range, climate, and associated plants. How can this indigenous knowledge enhance conservation and restoration of rare and endangered species such as kāhuli?

Enhanced Knowledge of Ecology to Inform Conservation and Restoration

Indigenous knowledge gathered in this study can complement and enhance existing information from fossil records, taxonomic evaluations, and ecological studies (Drew and Henne 2006; Wilder et al. 2016), to better understand the ecology of rare species. For

example, written records of the kāhuli recognized the historic broad geographic distribution of kāhuli, offering some of the only existing records of suitable habitat at both low and high elevations. Fossils are primarily found at low elevations, with few well-preserved records at higher elevations due to the accelerated deterioration of shells in moist environments¹. Early naturalist records contain little data on lowland snail species due to habitat loss from deforestation (Gulick 1872, 1905). Indigenous knowledge can help to increase understanding of the full historic distribution of rare and endangered species, their past resilience to ecosystem change, and possible future sites for reintroduction which may otherwise be overlooked. Indigenous knowledge research can also enhance habitat restoration targets for endangered species and guide identification of the point in history to which you are restoring.

Using indigenous knowledge together with fossil records, we were able to identify specific native assemblages of plants that occurred in the past. Though additional field research is needed regarding the plant preferences of native snails, recent studies have found that native snails are more fecund on native plants such as ‘ōhi‘a (Meyer et al. 2014; Holland, Chiaverano, and Howard 2017) rather than invasive plants. Further cultural research on snail habitat may provide insight into specific plant characteristics, such as leaf texture or structure, enhancing the ability to appropriately assemble native and possibly even non-native substitute plants for restoration efforts. Understanding historical ecosystems of endangered species may offer innovative ways to decrease extinction risk and improve resiliency in native ecosystems in the face of climate change.

Biocultural Significance

In addition to enhancing conservation and restoration, indigenous knowledge can highlight the importance of rare and endangered species. To Hawaiians, the snails were not just small shells, but valued symbols spoken and chanted about through generations. The snails added elements of beauty and played protagonists in historical narratives. Snail shells were prized and reserved for prestigious individuals, such as mō‘ī wahine (high chiefesses), perhaps a sign of appreciation for their rarity and a form of management for its protection.

Our study is consistent with other research suggesting that the symbolic significance of species may be as important as their material use (Garibaldi and Turner 2004). The most prevalent theme across cultural sources was the singing of the snails. These references may never be fully understood, despite multiple explanations for the source of their voice including wind, and the chirping of crickets. Still, voice was a key characteristic woven into many chants, songs, and stories, which also underpinned their importance in hula. The singing snails were used to signal romance, righteous action, or something extraordinary. The symbolism of voice illustrates that indigenous knowledge should be interpreted carefully and considered for its many layers of meaning, both literal and metaphoric (Roberts et al. 1995).

In this study, the majority of cultural records focus on the symbolic and cultural significance of kāhuli, which may not seem directly relevant in informing restoration efforts. However, ecological information can be embedded in metaphorical references. Further, managers that seek cultural sources solely for ecological information risk overlooking the value and interconnectedness of biocultural understanding. Indigenous knowledge

may also provide inspiration and support for efforts to conserve rare and endangered species by enhancing understanding of why they matter.

Challenges with Indigenous Knowledge Research

While there is clear value in considering indigenous knowledge of rare and endangered species, this knowledge is not easily accessible. In cases where written resources exist, research requires in-depth knowledge of these archives and the indigenous languages in which they are recorded. This study relied largely on secondary sources or translations of written records by second-language speakers. The complexity of translating written material may have left some material unexplored. Working with indigenous scholars revealed a few discrepancies in written records, such as spelling of Hawaiian words and names. Typography of old newspapers also changed some letters, such as “ni” to the letter “m.” Cultural/archival research of rare species will be enhanced by collaborations with indigenous language scholars.

Much indigenous knowledge relies upon oral transmission across generations. It is important to note resulting inconsistencies (Davis and Ruddle 2010). Interviews in this study largely supported one another and the written records in explanations of names, and cultural significance of snails. The one area where they varied was in their explanations for the snails’ voice discussed above. Debates between cultural practitioners may result from oral transmission and also from figurative indigenous use of language, leaving room for interpretation. Archival research should be supplemented through interviews with practitioners from different geographic backgrounds or areas of expertise to provide both context, and diversity of perspective. However, in this study it was a challenge to find practitioners who felt confident about their knowledge of land snails. When species become rare, practitioners may be less likely to interact with them, reinforcing loss of understanding (Nabhan et al. 1993). Decreases in familiarity may in turn contribute to further declines in these rare species due to public apathy. Indigenous knowledge may combat apathy by preserving the significance of rare species through stories, chants, and songs (Nabhan 1991). While conservation emphasizes the maintenance of biodiversity, preservation of cultural diversity may be equally crucial to the conservation of rare and endangered species (Nabhan et al. 1993; Turner and Spalding 2013).

Conclusion

“Their value must be understood beyond the ranks of a few scientific specialists. Story is the way we encode such values in our culture (Nabhan 1991).”

Our study highlights the many ways one indigenous culture can place great value on a small, easily overlooked and increasingly threatened invertebrate. Indigenous knowledge of kāhuli reveals their tremendous importance and high level of esteem in Hawaiian culture. Understanding the cultural significance of a species through chants, songs, and stories may enhance broader appreciation of the need to preserve them. The loss of the cultural importance of the kāhuli is equal to the physical loss of these creatures. Indigenous knowledge of a species can bring together science, conservation, and a community to fight what was once seen as a losing battle. The day we hear again the kāhuli singing will be the day we know that our efforts, like many across the world, have not been in vain.

Pipī holo ka’ao (May their story always continue).

Note

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

Acknowledgments

The authors thank the many people that assisted in this study including the Snail Extinction Prevention Program, Bishop Museum, Oahu Army Natural Resources Program (OANRP), the University of Hawai'i, and the various professionals that shared their expertise in this study. This study would not have been possible without the shared knowledge of our esteemed interviewees, each respected cultural practitioners and kumu hula trained by masters (in no particular order) Devin Kamealoha Forrest, Sam 'Oahu Gon, Nathan Liberato Kahikolu Kahapea Kalama, Maile Loo Beamer, Jerald Kimo Alama Keaulana, and Marvin Puakea Nogelmeier. We also thank our family and friends for the loving support.

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