Mollusk loves: Becoming with native and introduced land snails in the Hawaiian Islands

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Abstract: Hawaiian island land snails once represented one of the most diverse archipelagic evolutionary radiations. Historically, indigenous Hawaiians (Kānaka maoli) and Westerners also heard some snails (kāhuli) sing. Today, most of these species are extinct or endangered. One major cause has been the intentional mid-20th century introduction of a land snail, *Euglandina rosea*, for the biological control of another mollusk, *Lissachatina fulica*. In this article, I join efforts of noticing and engaging landscapes of the situated Anthropocene with the goal of demonstrating the potential for mollusks to be dynamic alliance-forming companions. In articulating methods of becoming with snails, I pass kāhuli through Western and Kānaka maoli knowledge-making projects. First considering the evolutionary biological work of John Gulick and his counterparts to genealogize contemporary snail-love, I then elaborate on what care and hope might mean with Pacific Island land snails living through ongoing environmental dispossession and alteration. I then reconsider *Euglandina* on parallel conceptual terms, engaging natural historical and laboratory accounts to think with the introduced mollusk beyond its categorization as 'alien invader'. Loving *Euglandina* as well as kāhuli may help realize livable futures for indigenous and introduced Hawaiian island mollusks alike, in a world hopefully full of snail-song.

Keywords: kāhuli, Euglandina, Kānaka maoli, Anthropocene, snail-love

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Introduction

Along the roadside on the northern tip of Key Largo Island, Florida, is a spindly hardwood I know well. Littering the crabgrass beneath its sparse branches I spot half a dozen shells patterned in shades of yellow, green, and brown. These belonged to *Liguus fasciatus* tree snails, and their proportions, coloration, and life history recall one subject of this paper, Hawaiian Achatinelline tree snails. To find empty shells beneath this roadside tree is not rare, usually reflecting ordinary predation and passing time, but these shells are freshly cleaned and left unmarked. A new variety of predator has arrived, the New Guinea Flatworm (*Platydemus manokwari*). *Platydemus* takes well to new island environs, and — unlike Key Largo's endemic molluscan predator *Euglandina*, another globally circulated organism and the other subject of this paper — *Platydemus* prefers

Liguus as prey. *Platydemus* spreads across the contemporary Florida Keys and Hawaiian archipelago, as Floridian *Euglandina* spread across Hawai‘i beginning in the 1950s, each leaving cleaned shells in their wake. On a sea-breezy Floridian day, I can close my eyes and picture myself at the base of an 'ohi'a tree on an O‘ahu ridgetop, surrounded by dead *Achatinella*. The Florida Keys and the Hawaiian Islands are differently situated within the histories of U.S. neo-colonialism and of species introduction. The places that appear here are not figures from which universalizing consolations for the Anthropocene might be extracted, but rather sites sharing ecological patterns of community change wrought by *Euglandina*, *Platydemus*, and other introductions from whose traces I argue an ethics of engagement might be crafted. Scanning the dead *Liguus* peppering the roadside, I think of Latour's (2014) meditation on Frankenstein's encounter with his creator. Latour finds that our vilification of hybridity confounds monster with creator, flipping symptom and cause in a move that distances ecological tinkering from its consequences. His answer is a compositionist perspective, where a post-environmental character revels in unintended consequences from a detached stance. Ecological compositions might produce soul-stinging reverberations. I argue for alternatives that hold the pain of absence in one hand and the potential of becoming in the other. Snails making meaning with humans is my point of departure for positing ways of life otherwise.

The Reverend H. Glanville Barnacle arrived on O‘ahu in the Hawaiian Islands as a government astronomer to observe the transit of Venus in 1874. High in the mountains, he was seized by a sound carried on the breezes, like that made by a hundred aeolian harps (Barnacle, 1883). Barnacle's "native" companion informed him that the sounds were produced by singing shells. Tree snails resting on a nearby branch offered proof, with the collective grating of their shells against wood apparently creating the music. Barnacle collected more than 100 snails on the trip, mostly of the singing Achatinelline variety. Nearly a hundred years later, Hawaiian malacologist Dr. Yoshio Kondo wrote to Dr. Roland Force, director of the Museum of the American Indian, on the matter of the singing. "Belief in the snails' singing," wrote Kondo (1965), "was ubiquitous among early Hawaiians, still commonly held today, and will likely be for generations to come." Robert Perkins, in his *Fauna Hawaiiensis* (1913), had asserted that the songs do not belong to snails, but rather to crickets in the genus *Paratrigonidium* that live alongside them. Kondo agreed, and he tape recorded the nighttime grounds of the Bishop Museum in Honolulu and the forest on the slopes of O‘ahu's Mt. Tantalus, where *Achatinella* no longer lived, to demonstrate this hypothesis. In collecting information on the subject, he was offered a chant in 1949 from Mary Kawena Pukui which went: "Kahuli aku, kahuli mai/Kahuli lei ula, lei akolea/Kolea, kolea, ho'i i ka wai/O wai ‘akolea." Kondo (1965) writes that there is "a poetic meaning to the above pupukanioi (snail; ‘shell sounding long’ or ‘shell which gives a note like a whistle’) song which only a Hawaiian well versed in that particular phrase of the language can give with exactitude," but he reproduces a literal translation of the chant, wherein the snail is communicating with a plover bird: "Turn over this way / turn over that way, Turn with love to the fern fringed pond; / Plover, plover, drink of the water, / The waters of Wai ‘akolea."

In 1981, Kondo would pen a different kind of document concerning kāhuli, wherein he would urge the U.S. Fish and Wildlife Service (FWS) to include the entire genus *Achatinella* on

the Endangered Species List. Thirteen comments from individuals and organizations were submitted to FWS in support of listing *Achatinella* (U.S. Fish and Wildlife Service, 1981). John K. Obata gave commentary on his more than twenty years of experience observing *Achatinella* in the wild, offering estimates regarding total decline of the genus since 1960 and anecdotal evidence supporting the notion that some *Achatinella* were under pressure from the introduced predatory Rosy Wolf Snail (*Euglandina).* In 1981, Michael Hadfield and Barbara Shank Mountain, of the University of Hawai'i, reported on the results of their recently completed six-year study of a population of *A. mustelina* in the Waianae Mountains, in which they ascertained an exceptionally slow growth rate, late age of maturation, and low fecundity for the species, all of which made the snails vulnerable to the arrival of *Euglandina* to the site in 1978. By 1979, only shells and no living snails could be found. Nine comments mentioned the relationship with *Euglandina*, noting instances of observed predation and observations of mirrored shifts in range for *Achatinella* species and *Euglandina*. In this paper, I pursue the experiences summed in the 1981 FWS report on the listing of *Achatinella* as the first-ever and to-date only endangered genus on the U.S. Endangered Species List, as well as the related efforts that continue to circulate around *Achatinella* and *Euglandina* in Hawai'i. I parse the histories of knowing *Achatinella*, and *Euglandina* through the lens of kāhuli (a word that most often, and hereafter, refers to larger Hawaiian tree snails) in the Hawaiian material-symbolic landscape. In doing this, I argue for an ethic of snail-love that, in (re)crafting relationships among varied humans and snails, permits communication between indigenous Hawaiian (hereafter 'Kanaka maoli' when singular and 'Kānaka maoli' when plural) and Western scientific knowledge paradigms. This opens space for assessing how human-snail relations intersect and diverge in a shifting and shared landscape, with snails cast as holding polyvalent meaning.

Achatinelline snails have crawled out of biological sciences and into the anthropology and social studies of science. Scholars have sought to enlist human and nonhuman participants in what Anna Tsing (2015, p. 160) terms "noticing" — the application of natural historical and ethnographic methods to "know the histories humans have made in these places and the histories of nonhuman participants." In 2019, Michael Hadfield and Donna Haraway (p. S229) followed the slime trails of Pacific tree snails, asking: "How DO these mollusks make a living, make babies, make companions both technical and organic, and make their scientists?" Hadfield and Haraway (2019) insist that research practices relating humans and nonhumans must be materially dense and historically and methodologically situated for one to make a real difference for another; practices that Haraway asserts begin and end with falling in love with snails. Tsing, Mathews, and Bubandt (2019, p. S188) suggested that what is needed in tree snail worlds is a kind of "radical hope" (Lear, 2006); of a pragmatism directed at some future goodness whose contours remain to be determined. I argue for methods for engagement among collectives of heterogeneous humans and nonhuman invertebrates as aligned with these kinds of care and hope, each necessary and complementary methods toward loving another (van Dooren, 2015, 2017). One falls in love with another and stays in love by practicing care and hope, thereby addressing anxieties of an unknowable future with persistent, committed, acts of collaboration. With mollusks, these collect under a rubric I call snail-love.

As I follow *Euglandina* from Hawai'i to its home and back again, I place Hawaiian and Western epistemologies of knowing snails into dialogue. I do so not to make demands of Hawaiian knowledges that the same Western projects I narrate have often parasitized and disappeared, and not to craft a generalized and ahistorical 'us' to place that figure at home in the world, but to pursue an islanded relationality with mollusks that attends to historically situated practices of becoming (Pugh, 2018). Here, I situate snail-love as contributing to a theoretical intervention as much as a historical one. Island studies theorists are increasingly in dialogue with Indigenous scholars in viewing bodies as archives of imperial and colonial environmental alterations and dispossessions. One way this view is produced is in storiation, what Elena Burgos Martinez (2021, p. 2) calls "a radical view of ecology," where the embodiment of every-day experiences indexes the traces and effects of ongoing colonialisms (Burgos Martinez, 2021; Chandler & Pugh, 2021). Through becoming with snails, Kānaka maoli and Western ecological epistemologies order the world into desired relations. In parsing the colonial traces of mollusk and flatworm appearances and disappearances, I consider mele, mo'olelo, and other modes of Hawaiian storytelling that make and order knowledge of the world alongside claims made by Western (techno)science. This takes place in a frame where the environmental scientific knowledge subtending storytelling, and the stories subtending scientific claims work together to unsettle the question of how science is practiced, and stories are embodied (Fujikane, 2021). Holding onto the violences enacted by islanded scientific modernity, snail-love asserts that Kānaka maoli and Western epistemologies might profitably be placed into exchange.

Snail-song, both songs of snails and songs about snails, orient this exchange. Snails and their shells emerged from a Romantic tradition in the Western literary imagination to become mediating figures, acting as lively mediums helping us locate the arrival of our human experiences from places very distant to our powers of apprehension (Helmreich, 2015). Snail-sound lives similarly in the Kanaka maoli imaginary. Aimee Sato, Melissa Price, and Mehana Vaughan (2018) sutured together immediate and communicated knowledge experiences in recovering a range of Kānaka maoli perspectives on kāhuli, alongside parsing Kanaka maoli knowledge for data on kāhuli habitat ranges and host-plant associations, towards the goal of collaborative conservation. They found through mining Kanaka maoli knowledge repositories that kāhuli have taken on many roles for native Hawaiians, alluding to romance, referring to change, transition, or shift, and portending or affirming positive or desired action (Sato et al., 2018). It is through these three identities that I pass the living bodies of not only Achatinellids, but also their companions, including *Euglandina*.

That *Euglandina* is having a deleterious effect on most Hawaiian land snail taxa remains as clear today as it was in 1981. Yet, with the goals in mind of Achatinellid survival and making tractable further complex species introductions like that of *Platydemus*, I contend that there is potential in reconsidering relationships with islanded *Euglandina*. This entails provincializing the notion of 'alien' — and thereby reconsidering links between 'native' and 'alien' categories — in knowing *Euglandina*. In practice, 'native' and 'alien' are taxonomies often deployed paratactically in pursuit of understanding species arrangements across patchy landscapes where the figuring of natives-becoming-alien and aliens-becoming-native is always in flux (Helmreich, 2005;

Wanderer, 2020). Helmreich (2005) identified that invasive species biologists in Hawai'i assess the category of 'native' according not to context, but rather parameters of time, agency, and the politics of nature and culture that render Kānaka maoli and Western taxonomies as adjacent and sometimes mutually intelligible. Figuring *Euglandina* along these lines expands contested perspectives on the emplacement of nature in island species introductions, particularly in the rubric of the Anthropocene (Hayward, 2021; Subramaniam, 2014). Reconsidering *Euglandina* also entails engaging the colonial hauntings of island ecologies, to which scholars have increasingly attended in marking islands as sites of multispecies worldings in the Anthropocene (DeLoughrey, 2019; Moore, 2019). Any re-conception of *Euglandina* in Hawai'i must keep in tension constructions of the Anthropocene with the history of settler colonialism and its ongoing afterlives (Hadfield & Haraway, 2019; Erickson, 2020). Hawaiian and Pacific studies scholars have carefully attended to the Pacific character and Hawaiian particulars of the colonial experience constellated by plantation agriculture, land and resource dispossession, nuclear and other militarisms, and globalizing capitalism (Emde et al., 2020; Goodyear-Kaopua et al., 2014; Perez, 2021; Silva, 2004). It was particular humans in particular technopolitical programs who were responsible for the global circulation of *Euglandina*. Proportionally few introduced species prefer to be invaders, and few invaders do the invading unaided. Keeping *Euglandina* in historical and conceptual tension permits reflection on the contingencies of our ethics, which in turn coheres our responsibilities in a multispecies world. Dreams of eradication and regression to a pre-*Euglandina* home for Hawaiian snails seem evermore unattainable, particularly as new species like *Platydemus*, which leave fewer material traces, continue to arrive. I argue that loving *Euglandina*, through tactics of care and hope that continue to be deployed around Achatinellids, holds open the possibility for a future in which *Achatinella*, *Euglandina*, and their mutual relations might live.

Snail-love sutures together several registers of becoming. Kāhuli, as well as *Euglandina*, have preferences for living and relating. The relationships that form or go unformed among humans and snails in individual lifetimes on account of noticing these preferences reverberate across naturalcultural worlds on other time-space scales, making the histories of people, snails, evolutionary theories, and worlds. Snail-love recalls the history of the Hawaiian Islands in the Anthropocene as sites of colonial techno-biological experimentation, alteration, and eradication, while also recalling a time not long ago when tree snails sang the forest alive. Snail-love works not from the premise that island futures will be built from celebrating a generalized resilience of all islands and islanders, but rather that genealogizing human-snail epistemologies of care and hope productively disrupts the flattening of island places and beings, and, as such, contributes to dialogues among island and decolonial studies (Chandler & Pugh, 2021). Snail-love is operative in dreamworlds as much as it is in laboratories. If Kānaka maoli and Western ecological epistemologies are to collaboratively hold open potential for shaping the realities of our era, then it must live in both places. Snails teach us that love, along with its attendant methods of engagement, contributes to a tractable ethic of multispecies becoming — and it starts with a story.

Beginnings: Falling in love

The beautiful woman Lauka'ie'ie had two friends, the Pūpūkanioi (the singing snails of the forest trees) and the Pūpūhinahinaula (the snail with beautiful rainbow colors). Lauka'ie'ie was introduced to her snail friends by mutual relations, members of the leaf family, who felt her singing and that of the tree snails was similarly beautiful. She and the snails sang together in the night. When endeavoring to find a male companion of whom she had dreamt, Lauka'ie'ie sent the pūpūkanioi out from Waipio Valley to look for him. The pūpūkanioi, in turn, called out for help in this task from the leaves of the koa tree, from the leaves of the wauke (paper-mulberry) tree, the snails of the sea, and the pūpūmokalau snails of Kaua'i, saying, "Come and look at me, for I am one of your family! Call all the shells to aid me in my journey" (Westervelt, 2013). On O'ahu, the journeying singing shell falls in love with a local chief and remains on the island. In the Hawaiian relational world conveyed through this mo'olelo, not only are shells of all islands and ecological niches seen to be of a mutually recognizable family, but they also readily make companions of many organisms, including humans. Singing kāhuli commonly allude to building romance, courtship, and love between characters in Hawaiian mele: stories, chants, or poems (Sato et al., 2018). In 1863, S. N. Hale'ole published *Ke Kaao o Laieikawai*, the first work of fiction in the written Hawaiian language (Hale'ole, 1863/1918). Kumu Oli and senior scientist at The Nature Conservancy of Hawai'i Sam 'Ohu Gon III (Tani, 2017; 'Ohu Gon & Winter, 2019) cites the romance as exemplary of the Hawaiian practice of interpreting and acting upon signals from the landscape — practices that 'Ohu Gon works to integrate Hawaiian knowledge into conservation biology through biocultural approaches. Haraway asks *how* snails make such companions. One answer is by singing the desire for companionship into being, and another is by traveling to find it, both of which are different ways of saying through love.

Genealogies of island snail loving

Perhaps nobody has seen as many kāhuli alive as John Thomas Gulick did. After reading Darwin as a young man, he delivered an impassioned speech at Honolulu's Punahou School on Darwinian evolution, biogeography, and islands. He urged his peers to take up the study of natural history, pronouncing: "Nowhere is the operation of these [biogeographic] principles more beautifully and strikingly displayed than in the natural history of isolated groups such as […] these the Hawaiian Islands" (Gulick, 1853, in Amundson, 1994, p. 117). In the same year, Gulick began important activities that would inform the rest of his life's work in evolutionary biology. He began making exhaustive collections of Achatinellidae on O'ahu, aided by Kānaka maoli guides and collectors, and he undertook taxonomic training with malacologist Dr. Wesley Newcomb, who himself had pioneered the captive rearing of several species. Passionate about understanding the underlying mechanisms of evolution, taxonomic expertise in hand, and a meticulously labeled comprehensive collection of Hawaiian snail shells, Gulick was well-prepared to author foundational theoretical and taxonomic works in conversation with evolutionary biology's disciplinary leaders. Gulick's personal collection, developed through circulating

knowledge and materials among Kānaka maoli and Western figures (though importantly, only non-indigenous interlocutors are given recognition by name) enabled his engagement with — and, frequently, challenge of — prevailing evolutionary theories.

Gulick systematically assessed the biotic and abiotic characteristics of snail habitats and noted that while some species exhibited preferences for fidelity to one tree species, most were spread over a variety of hostplants which were themselves ubiquitous across valleys. In attempting to correlate myriad ecological parameters with the morphology of tree snails, he could find no adaptive significance for their hugely variable forms. This intimate investigation of Achatinellids led Gulick to two major conjectures: that of the significant role of isolation in evolution, and that of the organism which participates in its own evolution — the latter of which found him ahead of his time and in disagreement with Darwin. Using his work on *Achatinella* biogeography published in the 1870s, Gulick made the claim by the 1880s that natural selection is not the action of the external environment's forces alone but, rather, selection is a relational phenomenon that acts in accordance with the way that an organism situates itself in a variable "external nature" (Amundson, 1994, p. 125). The spontaneously active organism with evolutionary agency continues to vex mainstream evolutionary biology, where it has often been seen as either aligned with creationism or iconoclastic of evolutionary biology's central axes. Still, the notion continues to be recovered as a "rigorously naturalist, scientific approach to the self-making, meaning-making capacity of living things" (Riskin, 2020). Gulick's evolutionary theorization was the result not only of collecting practices, but also the non-adaptive habits of snails making meaning in and of their Hawaiian landscapes. Developing the science of evolutionary biology was and is a contingent process, shaped in part through the interactions of natural historians, collectors, snails, trees, and island geography.

Moreover, Gulick's active organism holds potential through storiation to contest the relational qualities imputed to islands. Chandler and Pugh (2021) assert that it was Darwin and his theorization of the island effect in biogeography that set the stage for imagining islands to possess powers of immanence in the frame of natural selection, producing and intensifying relational differentiation. The spontaneously active organism affecting its own selection relocates the site of creative potential from theorized islands to the embodied experiences of individuals. Parsing the relations that compose natural selection through individuals becoming-in-environments contests island colonial projects that posit endless differentiation as a capacity inherent to islands and as a hedge against lasting harm, while also complementing approaches to displacing island ontologies from echoes of evolutionary theory and recentering them in lived islander experience.

We do not know if Gulick, high in the Ko'olau range, ever heard kāhuli sing. But I argue that Gulick's approach marks the beginnings of a genealogy of a multispecies collaborative science. Indispensable to care, in evolutionary biological and ecological frames, is situated, exhaustive, and committed practice; it is these rich relational wells from which tractable multispecies hopes might spring. Gulick's deeply situated research practices alongside Achatinellids demonstrated the limits of environmental determinism, emphasized the need to theorize more collaborative relationships between natural selection and living units of selection,

and revealed the contingencies of evolutionary theories that continue to shape and define the potential for understanding how species evolve together. Gulick co-constituted an evolutionary theory and practices of caring for and about Achatinellids while also collecting snails by the thousands. Recalling that we might readily hurt those about which we care and noting the disappearing of indigenous actors in his scientific and narrative work, his work serves as one substrate for world-making practices that characterize snail-love.

The putatively non-adaptive nature of the Achatinellid radiations remains an unsolved evolutionary puzzle. Contemporary efforts towards working out its dynamics, in the face of so much extinction of both snails and their hostplants, are reliant on engaging the vast museum collections made by Gulick, Newcomb, C. M. Cooke, and others. Rebecca Rundell (2011), based on Robert Cowie's unpublished data, asserts that molecular data collated from a combination of surviving wild and captive individuals, especially of the non-Achatinelline Achatinellid genera surviving today in greater numbers, might allow us to query Gulick's evolutionary concepts through comparison with dried and preserved museum specimens. Conchological and natural historical studies of shell morphology from sub-fossil Achatinellids and Amastrids can also help us understand the recent ecological and evolutionary patterns of snail radiations in their adaptive and non-adaptive contexts (Holland & Cowie, 2009). Justin Gerlach (2014), a specialist in *Partula* biology, offers more methods for knowing snails. Innovations in gut content analyses have made it possible to infer in some cases down to species level the habitat and feeding preferences of historical *Partula*, many of which are now extinct, from Crampton's fluid-preserved collections. Gerlach further collaborates with Paul Pearce-Kelly (Gerlach, 2014, 2015) to compare gut contents across species and time to identify whether changes have transpired in the parasitic, commensal, and symbiotic microbiological acquaintances of *Partula*. Familiar technologies enlisted in a multispecies commitment can rearrange older assemblages that crisscross the boundaries of extant and extinct life in Pacific archipelagos.

Gulick's active organism takes on new valances in a multispecies dynamic. It is through engaging the past worlds, real and theoretical, in turn encountered and constructed by natural historians and evolutionary biologists, that situated practices of loving snails can be scaled towards anticipating the conditions of a broadly unknowable future (Cowie, 2017; Régnier et al., 2015). Undertaking descriptive taxonomic work allows for organisms to enter conservation discourses amid widespread and ongoing Pacific Island extinctions. Crossing the boundaries of time in museum collections and subfossil deposits allows for previously overlooked and geographically disparate groups of related snails to enter a common movement against land mollusk extinction; all the while, new and cryptic living species of tree snail emerge into description through the same work, seeding fresh hopes for livable futures (Yeung et al., 2020). As Lauka'ie'ie's kāhuli called out to the snails of other islands and seas to aid her in her journey, so too do endangered and extinct snails the Pacific world over call out to each other through the taxonomic and political work of biologists.

Cultivating attachments: 'Ohi'a homes and love shacks

Another way of scaling the situatedness of love for mollusks is via living dynamically with and alongside captive, semi-captive, and re-introduced snails. Michael Hadfield and Barbara Shank Mountain (1981) spent six years in the 1970s following perhaps the last remaining population of wild *Achatinella mustelina* in the Waianae Mountains, during which time they ascertained the very low growth and fecundity rates of *Achatinella* that are now thought to be unique in the pulmonate molluscan world. Following this demographic work, Hadfield and his team inaugurated studies around the Hawaiian Islands designed to study snail relationships with their changing environments, which underwent frequent periodic checks over fifteen years (Hadfield & Haraway, 2019). One of these was initiated in 1982 in a stand of 'ohi'a trees (*Metrosideros polymorpha*) on a Molokaʻi plateau, where the relationship was assessed between *Partulina redfieldi* and their 'ohi'a homes (see Figure 1). Using mark-recapture, the team estimated birth size, age at maturity, maximum life span, and growth rate, as well as rates of movement between trees and total population size. Empty shells found at the bases of trees were used to understand why snails die at various ages. Researchers found that single trees contained single color patterns of *P. redfieldi*, and that this was likely a consequence of the virtual total lack of movement among trees. Individual snails came to be familiar to researchers, with several observed continuously for more than a decade.

Figure 1. *Partulina redfieldi* on 'ohi'a leaf, Molokaʻi. *Source*: David Sischo.

By 1986, Hadfield's team at UH Manoa began the captive habitation and rearing of Achatinellid snails. The effort began with the transplantation of disappearing Achatinellid populations from their remaining wild homes into captive climate-controlled living chambers. The first of these species was *Partulina redfieldi*. Laboratory-born offspring were placed back in a small 'ohi'a in the meadow, named 'Tree L' to denote the snails' laboratory births (Hadfield & Prior, 2008). Within three years, there were newborns in Tree L. Populations among all observed

trees increased gradually over the years before dropping rapidly after 1995. Having learned how to tell the difference between the marks left by predators, whether rats or *Euglandina* snails, from other studies at other sites, it was determined that the decline was precipitated by rats (Hadfield & Prior, 2008). The team determined that some rats in the surrounding area had switched prey preferences around 1994, and since rats learn from and follow the snail-hunting successes of other rats, snail populations were quickly decimated. In the years since, both rat and snail populations have been unstable. Establishing stability in wild and reintroduced snail populations now seems dependent on carefully attending to predation, which in turn hinges on understanding the preferences of predators to the same degree that biologists have come to know those of snails.

After *P. redfieldi*, Hadfield's group began collecting the founding populations of sixteen Achatinelline snails from across the Hawaiian archipelago. Experimentation with breeding and keeping snails alive led the program to the innovation of environmental chambers adjusted to the environmental preferences of kāhuli. 'Ohi'a leaves were collected fortnightly, and a black mold on which the snails feed was cultured in the lab (Hadfield & Haraway, 2019). In 2015, Hadfield's snail populations were inherited by David Sischo, who did graduate work on *P. redfieldi* and founded the Snail Extinction Prevention Program (SEPP). In 2016, the SEPP moved into a new facility, affectionately called the "love shack," (Wilcox, 2019) which manages the more than 2,000 individuals of thirty species currently in the care of SEPP. Over at least five generations (in kāhuli time) of care in the SEPP facilities, biologists have been open to learning, relearning, and being surprised by the ways that snails live and die (Price et al., 2015; van Dooren 2015, 2017). Snail-love with Achatinellids is a living and evolving effort, inheriting from — and contributing to — a rich genealogy of becoming with snails. Written into the letters of support published by FWS in 1981 for the listing of *Achatinella* on the US Endangered Species List was an intergenerational and ongoing relationship among humans and snails. Genealogizing snail-love reveals the extent to which evolutionary theories story the embodied experiences of many wild, semi-wild, built, and managed entanglements. It shows how important it has been, in the interest of making sustained differences in the lives of other species, to know those others and their relations intimately. And it reveals the amount of imaginative space open to considering introduced predators of kāhuli, including *Euglandina*, with the same urgency.

Sato, Price, and Vaughan (2018), tracing the path of kāhuli through Hawaiian knowledge, identify that of many attributions the most common meaning of kāhuli refers to an act of turning, shifting, or changing. The meaning can be commonly found in historical periodical articles telling of social or political shifts. Practitioners they interviewed thought that perhaps such meaning reflects the way the kāhuli shell shifts from side to side as it travels through space, or the way that the shell coils to the left or right as the mollusk grows its home. Sato and colleagues (2018) tell us that in one part of the moʻolelo "Hi'iaka i ka poli o Pele," Hi'iaka, goddess of forests, hula and restoration meets the fisherman Pahulu. Pahulu agrees to give Hi'iaka fish in exchange for sexual favors, and to this proposition Hi'iaka responds, "Kāhuli lei ʻula lei ʻākōlea (The Kāhuli is a red ornament in the lei of the ʻākōlea fern)" (Sato et al., 2018, p. 324). When Pahulu returns with fish and tries to embrace her, she transforms into a stone. Sato et al. (2018, p. 324) say, "like the shifting movement of a kāhuli shell, Hi'iaka shifts her form to escape Pahulu's advance." It is

this figure of kāhuli, as shifting or transforming embodied, that I now wish to follow in pursuit of *Euglandina*. If lovers of snails are to avoid the embrace of extinction in pursuit of a future full of snail-song, as Hi'iaka evaded Pahulu, then conventional views of *Euglandina* must similarly be transmuted. A decolonial multispecies commitment demands such an approach, caring about *Euglandina* in all its complexity, such that a Hawaiian ecological future can be sung full of hope.

Reckonings: Knowing unloved others

When Polynesian peoples first journeyed to Hawai'i millennia ago, they took with them wauke (paper-mulberry) root shoots, used to make bark cloth and bark paper, and established the plant in close association with agricultural settlements. When, in the mele following Lauka'ie'ie, her friend the pūpūkanioi seeks assistance in its journey to find her a male companion, the pūpūkanioi calls upon all members of the leaf family, endemic and introduced, in addition to the snails across Hawaiian lands and seas. What would it mean for the pūpūkanioi to call upon *Euglandina*, and what might *Euglandina* respond? This is also to ask, where is *Euglandina* in the family of things and in the world? What does it mean to become with another on islands whose natures slip from under themselves? These are the questions, through the lens of introduced mollusks, to which the remainder of this paper attends.

Snails tumbled into snails: Biological control and knowing *Euglandina*

This story begins firstly with forced removal and relocation. In 1936, an individual sent young of the giant African land snail *Lissachatina fulica* to Hawai'i from Japan, to be cultivated in hatcheries as a potential human food source. It was not until 1938 that its presence in the archipelago, and its taste for the valuable crop sugarcane, came to the attention of territorial authorities (Davis & Butler, 1964). By 1951, it became clear that methods of controlling the so-called pestiferous mollusk were untenable, and methods of biological control would likely need to be implemented. The turn towards considering mollusks for the biological control of other mollusks happened around the same time in multiple places, transcending scientific literature and entering public discourses where invertebrate biological control was heralded as an agricultural savior (e.g., *Life*, 16 Apr 1956; *Time*, 9 Jan 1956). In 1955, *Euglandina* were collected from a citrus grove in Leesburg, Florida and shipped to Hawai'i; one of thirty molluscan predators imported for biological control between 1948–1961 (Cowie, 1998; Meyer et al., 2017). In the world of molluscan introduction, control, and invasion, it is snails tumbled into snails (Lien, 2015). *Euglandina* increased in abundance rapidly, outpacing threats from native flatworms, other snails, and *L. fulica*-aimed poisons, allowing for subsequent distribution to other areas in islands infested with *L. fulica*. From the 1950s through the 1970s, *Euglandina* was cast far and wide (Barker, 2004; Gerlach et al., 2021). Despite limited evidence on the efficacy of *Euglandina* as a biological control agent for *L. fulica*, more purposeful and accidental local introductions took place in the following decades. The mid-century fervor for the global circulation and introduction of predators for agriculturally pestiferous organisms could not always, if even often,

be relied upon to uniformly enact neo-colonial projects of environmental management. It can be hard to predict whether relocated bodies will live according to plan in new environments, however comparable new places are to old places (Cowie, 2001). It can be harder still to know what to do when proliferations run feral.

While scientists have noted the paucity of data on *Euglandina*, especially relative to its preferred prey species, projects examining feeding behavior or movement through space map the two main histories of knowing Euglandinid life history in the traditions of professional biological science and, as I show below, non-professional natural history (see Figure 2). Researchers in Mauritius were the first to explore the possibility that *Euglandina* might selectively predate on species, finding significant preferences for native species and a total distaste for *L. fulica* (Griffiths et al., 1993). In Hawai'i, *Euglandina* preferred to follow a slime trail more than 90% of the time, and while showing no preferences for feeding on *L. fulica* versus the also-introduced *Bradybaena similaris*, or between *B. similaris* and *Achatinellids*, *Euglandina* strongly preferred *Achatinella* to *L. fulica* (Holland et al., 2012).

Figure 2. *Euglandina rosea* consuming prey while grasping other snails to be consumed. *Source*: Bill Frank.

Meyer and Cowie (2010) tracked individual *Euglandina* in Waianae Gulch using mark-recapture, mapping distances individuals travelled, their growth rates, and lengths of time between sightings. They found that *Euglandina*, though sometimes crisscrossing ridges, preferred to remain within gulches, meaning that even in areas of very high predation pressure from *Euglandina* there are likely discrete areas in which native species can persist. This claim continues to be born out in subsequent work on the snails (Gerlach, 2014; Gerlach et al., 2021). Still, echoing Meyer and Cowie (2010, 2011), much remains unknown, including, for example, how *Euglandina* use ground relative to arboreal space, or the relationship between leaf litter density on the forest floor and snail persistence, or how *Euglandina* interact with other introduced predators like rats. These questions hold significant consequences for the future of island snail survival (Cook, 1989; Meyer & Cowie, 2010, 2011).

Even in its endemic home, the opportunity for naturalists to find robust local populations of Floridian *Euglandina* is uncommon. Bill Frank, a member of the Jacksonville Shell Club in Florida and creator of jaxshells.org, encountered one such population by accident several years ago between Jacksonville and St. Augustine (Frank, 2021). After periodic checking, Frank began visiting every other day and marking living snails — not for mark-recapture studies of individuals, but to gauge the size of the viable population (see Figure 3). Low recapture rates, combined with the persistence of individuals in the area from the first tagged cohort, indicate that while new snails migrate to the habitat, not all older snails stick around.

Figure 3. A large, previously marked, recently cannibalized *Euglandina* found at Bill Frank's field site. *Source*: Bill Frank.

Feeding behavior is an outstanding question, as the density and diversity of prey species seems untenable for such a large population of large individuals (the only terrestrial molluscan prey available appears to be *Polygyra septemvolva*), leading Frank to suspect that cannibalism plays a critical role in supporting the community. From observational study in home terraria, Frank (2021) asserts that what happens when similarly sized *Euglandina* are made to interact is non-obvious, with the consequences ranging from mating to cannibalism to nothing at all. Frank has also recently examined other populations of *Euglandina* found in unlikely habitats, like isolated oceanside dunes where no other live snails are found. Frank's multi-year interaction with populations and individuals of *Euglandina* on roadsides, in unlikely wilds, and in home terraria is an instantiation of the sort of careful, committed attention required of snail-love. Questions and answers generated by this natural-historical work can, I contend, contribute to knowing *Euglandina* in other contexts, especially where it takes on the identity of 'invasive alien'.

One more way of knowing *Euglandina* might be in a molecular register. Since both feeding and mating commence with trail following, tracking the chemical traces of other snails is an activity which *Euglandina* spends an estimated 80% of its time doing, carving the environment

into a landscape of chemical signals on a sensory register out of range to human sensation. Behavioral neurobiologists engaged with invertebrate sensory learning and conservation biologists alike have sought to work out how snails and slugs use chemical cues to know their worlds (Clifford et al., 2003). *Euglandina* can follow the trails of both prey and other *Euglandina*, though in lab settings directionally track only conspecifics, while in the wild they also directionally follow prey. *Euglandina* follow trails even if they have no interest in feeding, pursuing prey snails even if they do not ultimately consume them. When following prey, they exhibit a strong bias for turning left, a choice made for no clear reason. Researchers amputated the lip extensions of *Euglandina* and found that they were no longer able to effectively follow prey trails, suggesting that the sensory systems implicated in distance olfaction and those of slime-trail tracking, which can be altered or inhibited by chemical species like nitric oxide synthase inhibitors, are separate. *Euglandina* are excellent associative learners, and quickly learn to follow novel compounds associated with prey or a potential mate. After a single feeding of a prey species combined with a novel compound, *Euglandina* will remarkably follow trails composed of only that compound (Davis-Berg, 2011; Patel et al., 2014; Shaheen et al., 2005). Working with such knowledge furthermore extends our ability to understand other introduced predators in the Hawaiian ecology, like the flatworm *Platydemus manokwari* (see Figure 4). *P. manokwari* has its own distinct preferences and varied ability to directionally pursue trails (Iwai et al., 2010).

Figure 4. *Platydemus manokwari* in situ, Ogasawara Islands, Japan. *Source*: Shinji Sugiura.

Opportunities abound for multispecies encounters at the level of slime cues and sensory apparatuses. We might, perhaps, come to understand the landscape through the presence and absence of a broad diversity of small volatile and non-volatile molecules washing out of slime trails on trees and in leaf litter. Indeed, this view might be particularly urgent given that flatworms don't leave traces of marked and recaptured shells for surveying. That snails learn, that chemosensory cues for recognizing prey and conspecifics are species-specific, and that slime trails are diverse assemblages of multivalent molecules are contentions that each invite new cross-taxal engagements. Mucous contains possibilities of expanding and operationalizing tactics of snail-love beyond native prey and toward introduced predators, along chemical snail trails.

More than half a century of knowing *Euglandina* in heterogeneous localities has revealed that *Euglandina* populations do not materialize in identical ways with predictable consequences. Rather, they are contingent becomings dependent on a multitude of snail (and other) preferences for living. Marianne Lien (2015) reminds that no animal is an island, and natural historical and biological laboratory practice with *Euglandina* reveals the resonances of this assertion. What projects might transpire from loving *Euglandina* will vary around their ethics and politics of engagement. Maybe, as in the case of invasive species biologists on Guadalupe Island, Mexico, "care for the pest" (Wanderer, 2020) might resemble tracking individuals as they reveal hidden conspecifics for collective extermination or getting to know pests to better orient killing practices. Perhaps, by drawing on a wide genealogy of snail-love tactics that I have begun to articulate, Euglandinid habits and preferences might be sufficiently parsed, and *Euglandina* might be productively enfolded into their novel island ecosystems (Hill & Hadly, 2018). In any case, loving *Euglandina* might be a path forward toward a future becoming where both *Euglandina* and Achatinellids share a world with each other while encountering other arriving organisms like *Platydemus*, whose biology and ecology are even harder to grasp.

Reconciliations: Righteousness with snails

In the story of the princess Lā'ieikawai, kāhuli song precedes a wedding, signalling important coming events. Aimee Sato and colleagues (2018) characterize the song and the physical form of the kāhuli as a hō'ailona, a symbol or an omen in the Hawaiian culture and literature that signals the import of an event or person. Hō'ailona take many forms in animal presence and song, especially of birds like i'iwi, but kāhuli are the only land invertebrates known to act as hō'ailona. In the chant 'Pa Ka makani', the presence of the rooster god brings with him pouring rains and great winds that are signaled by the trilling of the kāhuli. According to Sato et al. (2018, p. 326), the singing of the kāhuli "foreshadowed positive events or offered affirmative signs that proper action had been taken. In Hawaiian literature, all was pono (righteous) again when the kāhuli sang." And now, given all that has been done to alter the physical and affective terrain of the Hawaiian forest, work must be done to ensure that future generations can experience the "sights, sounds and smells" (Wilcox, 2019) of a Hawaiian forest once thriving with snails. What partnerships, between which humans and which invertebrates, will need to be created and sustained in this effort? How might we become with native and introduced snails in Hawai'i, open to a plurality of island futures, and hopeful for the pono experience of snail-song?

Working conclusions toward future snail-song

The Hawaiian landscape is a world of snails tumbled into snails, wherein mollusks introduced to perform desired kinds of consumption became unruly organisms by enacting unforeseen and undesirable preferences. Humans who might eat *Lissachatina fulica* are surprised to find them eating sugarcane and introduce *Euglandina*, who surprise again by preferring other native and nonnative snails and are in turn combatted through the manufacture of poisons using yet more

pestiferous *Pomacea* snail bodies (Wittenberg & Cock, 2001). The life history characteristics of invertebrates cause biological control to run up against its limits and control with, of, for mollusks, might never be tenable (Cowie, 2001; Gerlach et al., 2021). In the Anthropocene's patchy landscapes, where lifeways of some island communities continue to rush asymptotically toward disappearance while others settle into and fill the niches of novel ecosystems, a politic of just engagement depends on remaining open to the gamut of possibility around the becomings of archipelagic life, movement, and relation (Kirksey et al., 2013). Doing so requires drawing on a wide genealogy to cultivate methods of snail-love. Such engagement hedges situated practices of care and hope against circulations of capital and colony's human and nonhuman companions. In turn, discursive space is opened with Achatinellid radiations to theorize the situated self-making of islanders, and with Euglandinid introductions for considering views on species movement in the islanded Anthropocene. As Donna Haraway (Hadfield & Haraway, 2019, p. S233) writes, "the contact zones of allies are formed from the intersections, and the healing arts of living on a damaged planet require all the players."

I have argued that one player is *Euglandina*, and I have advocated loving the introduced predator. Radical hope, for Anna Tsing and colleagues (2019, p. S192), accompanies "collaboration — open and curious — across multiple registers of knowledge and being," and, if radical hope works to acknowledge catastrophe while imagining possibility, as Jonathan Lear (2006) contends, then one articulation of its characteristic pragmatism must be to love that which we have forcibly moved and introduced to new ecologies the world over. For the most part, *Euglandina* has been treated as a disappointing artefact of misguided biological control strategies. But *Euglandina* are established in dozens of island groups; they will endure, and we cannot afford to flatten what *Euglandina* is or was or might be, just as we cannot accept the disappearance of kāhuli.

With Hawaiian snails, the work of snail-love in making futures will be realized in the material-symbolic space among leaf litter and 'ohi'a branches, gulches and peaks, stories and sciences, snail-songs and songs-of-snail. All that snails leave in their path, far-traveling and sweet songs or empty shells or small molecules in mucosal suspension, or another snail somewhere down the line in pursuit of prey or kin, teach us that making and sustaining the bonds of multispecies relationality requires epistemological openness and methodological creativity. In the Hawaiian Islands, this claim carries several critical implications. Firstly, snail-love is as much a claim on the limits and boundaries of ecological epistemologies as it is one on human-snail relations. Kānaka maoli and Western epistemological linkages rest on foundations of unequal power relations, whereby the latter has benefitted over historical time and continues to benefit from the former in a frequently unidirectional relationship. This is trackable in the circulation of specimens through historical collections, in the work of Indigenous interlocutors gone historically unacknowledged, and in the travels of Hawaiian language sources on kāhuli in the text of Western scientific monographs (Wang, 2020). However, the genealogy of snail-love offered here traces the limits and potentials of both Western natural-historical and biological methods and Hawaiian snail knowledges to envision careful and complementary collaboration. Mele and mo'olelo communicate the embodiment of place in kāhuli and the experience of kāhuli in place, complementing other ecological visions' taxonomies, toponyms, and theories, to the end of

survival through snail-love (Sato et al., 2018). What this paper ultimately tracks, across destabilized space and time, is the storiation of histories and knowledges of neo-imperial environmental dispossession and alteration. I have passed native mollusks and their introduced predator through patches of Kānaka maoli and Western storyscapes and landscapes to demonstrate the ways that snails can be and have been partners in multispecies becoming. Elaborating this alliance will be important if we hope to one day hear kāhuli sing.

Looking back toward the northern Key Largo roadside where I began by surveying the *Liguus* recently evacuated by *Platydemus*, what strikes me is the dearth of epistemological and other resources available for contending with this circumstance. Unlike kāhuli, these *Liguus* (and the *Euglandina* here, too) lack a diversity of extant, articulated perspectives on their lifeways, whether complementary or contestatory, from which futures could be imagined and enacted. Meanwhile, up the Floridian coast, Bill Frank watches tagged *Euglandina* crawl along Little Talbot Island. Meanwhile, the SEPP rehomes laboratory-born *Partulina* on Moloka'i. Snail-love, working to stem the tide of loss with dissimilar species across disparate landscapes, attests to the available range of opportunities for humans and snails to become together on many kinds of islands, sung alive in shifting seas.

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