Number 147, 12 pages 12 June 2022

BISHOP MUSEUM
OCCASIONAL PAPERS

Range Extension of the Endemic Terrestrial Isopod *Hawaiioscia rapui* reveals the dispersal potential of the genus across the South Pacific

J. Judson Wynne, Stefano Taiti, Sebastían Yancovic Pakarati & Alma Carolina Castillo-Trujillo

Bishop Museum Press
Honolulu

Cover photo: *Hawaiioscia rapui* Taiti & Wynne, 2015 from Moto Motiro Hiva (top) and Rapa Nui (bottom).

RESEARCH PUBLICATIONS OF BISHOP MUSEUM

Bishop Museum Press has been publishing scholarly books on the natural and cultural history of Hawai‘i and the Pacific since 1892. The *Bishop Museum Occasional Papers* (eISSN 2376-3191) is a series of short papers describing original research in the natural and cultural sciences.

The Bishop Museum Press also published the *Bishop Museum Bulletin* series. It was begun in 1922 as a series of monographs presenting the results of research in many scientific fields throughout the Pacific. In 1987, the *Bulletin* series was superceded by the Museum's five current monographic series, issued irregularly:

Bishop Museum Bulletins in Anthropology	(eISSN 2376-3132)
Bishop Museum Bulletins in Botany	(eISSN 2376-3078)
Bishop Museum Bulletins in Entomology	(eISSN 2376-3124)
Bishop Museum Bulletins in Zoology	(eISSN 2376-3213)
Bishop Museum Bulletins in Cultural and Environmental Studies	(eISSN 2376-3159)

eISSN 2376-3191

BERNICE PAUAHI BISHOP MUSEUM
The State Museum of Natural and Cultural History
1525 Bernice Street
Honolulu, Hawai‘i 96817-2704, USA

Published online: 12 June 2022

Wynne, J.J. et al.. Range extension of the endemic terrestrial isopod *Hawaiioscia rapui* reveals the dispersal potential of the genus across the South Pacific. *Bishop Museum Occasional Papers* 147: 1–12 (2022).

ISSN (online) 2376-3191

lsid:zoobank.org:pub:9F338A49-545D-483B-ABBF-16C9BBED241B

Range extension of the endemic terrestrial isopod *Hawaiioscia rapui* reveals the dispersal potential of the genus across the South Pacific

J. Judson Wynne*

Department of Biological Sciences and Center for Adaptable Western Landscapes, Northern Arizona University, Flagstaff, Arizona, USA

Stefano Taiti

Istituto di Ricerca sugli Ecosistemi Terrestri CNR-IRET, Museo di Storia Naturale, Sezione di Zoologia, Sesto Fiorentino (Florence), Italy; Museo di Storia Naturale, Sezione di Zoologia, Florence, Italy

Sebastián Yancovic Pakarati

Laboratorio de Socioecosistemas, Departamento de Ecología, Universidad Autónoma de Madrid, Madrid, Spain; Consejo Asesor de Monumentos Nacionales de Chile - Rapa Nui, Chile; Manu Project, Rapa Nui, Chile

Alma Carolina Castillo-Trujillo

Woods Hole Oceanographic Institution, Falmouth, Massachusetts, USA

Abstract. *Hawaiioscia rapui* Taiti & Wynne, 2015 was first described from two caves on Rapa Nui and considered a potential island endemic and disturbance relict (i.e., an organism that becomes a relict species due to anthropogenic activities). As this species was not subterranean-adapted, it may have had an island-wide distribution prior to the arrival of the ancient Polynesians to Rapa Nui. We report new records for *Hawaiioscia rapui* beyond its type locality. These findings extend this animal's range to the closest neighboring island, Motu Motiro Hiva (MMH), 414 km east by northeast of Rapa Nui. We also report information on this animal's natural history, discuss potential dispersal mechanisms, identify research needs, and provide strategies for management. Our discovery further underscores that MMH likely harbors a unique and highly adapted halophilic endemic arthropod community. Conservation policies will be required to prevent alien species introductions; additionally, an inventory and monitoring program should be considered to develop science-based strategies to manage the island's ecosystem and species most effectively.

Keywords: Canoe Bug Hypothesis, rafting, marine littoral, Polynesia

INTRODUCTION

The genus *Hawaiioscia* (Family Philosciidae) was first described to accommodate four subterranean-adapted species discovered in caves on the Hawaiian Islands (Taiti & Howarth 1997). Each was a short-range endemic species with each species detected within an individual cave; these four species were described from coastal Kauai, Maui, Molokai, and Oahu. Nearly two decades later, *Hawaiioscia rapui* Taiti & Wynne, 2015 was described from two caves on Rapa Nui (Easter Island). Initially propounded as an

* Correspondence: jut.wynne@nau.edu

island endemic and disturbance relict (i.e., a species with a relictual distribution due to anthropogenic activities), this terrestrial isopod was believed to be restricted to caves due to extensive surface disturbance (Taiti & Wynne 2015; Wynne *et al.* 2014). As this species was not subterranean-adapted, the authors posited it may have had an island-wide distribution prior to the arrival of the ancient Polynesians to Rapa Nui (Wynne *et al.* 2014, 2016). Taiti *et al.* (2018) described the epigean *Hawaiioscia nicoyaensis* Taiti, Montesanto & Vargas 2018, from coastal Central America on Pita Playa, Costa Rica. These six species and the finding reported herein set the stage for exploring how their ancestral species may have colonized the South Pacific, as well as to postulate how closely these species may be related genetically to one another.

Here we report a range extension of *Hawaiioscia rapui* to Motu Motiro Hiva (MMH; Salas y Gómez Island), Chile, 414 km east by northeast of Rapa Nui (Fig. 1). These findings are based upon a morphological examination of specimens collected in August of 2016. Additionally, we disclose a new littoral location for *H. rapui* on Rapa Nui, provide some notes on its ecology, and investigate potential dispersal mechanisms leading to its arrival on MMH. Importantly, we also discuss research needs aimed toward collecting the information necessary to best manage *H. rapui* and the broader arthropod community on MMH, as well as to provide some recommendations to help ensure the long-term persistence of the arthropod community on the island.

METHODS AND FINDINGS

Methods

For arthropod sampling on Motu Motiro Hiva, on 23 August 2016, two individuals sampled two areas for approximately 30 minutes each (for a total of 2 person hours of searching). They examined vegetation, soil, and underneath rocks. Arthropods were hand collected with forceps and watercolor paintbrushes. Additional details on collection and curation may be found via Hershauer *et al.* (2020).

On Rapa Nui, rocky coasts and beaches were sampled from 5 July to 1 September 2016. Both the rocky coastline and beach cove of Ovahe were sampled. The sandy cove was sampled by examining detrital bands at the high tide boundary, examining decomposing algae and animals washed ashore, and by searching within the beach-vegetation boundary. In rocky areas, observers searched for and collected arthropods using a timed direct intuitive search approach within and beneath rocks and within rocky crevices. Observers used aspirators, watercolor paintbrushes, and forceps to collect arthropods. Refer to Wynne *et al.* (2016) for additional details.

For both locations, all specimens were placed directly into vials with 95% ethanol.

Range extension

In their paper chronicling the first arthropod survey on MMH, Hershauer *et al.* (2020) preliminarily identified two terrestrial isopods as different morphospecies (Halophilosciidae? sp. 1 and Halophilosciidae? sp. 2). At the time, a species level identification was not believed to be possible due to the poor preservation condition of most specimens. In email correspondence with the second author (ST), the lead author suggested one of the morphospecies was potentially *Hawaiioscia rapui*; however, upon examining images of one of the specimens, ST intimated the specimens probably represented at least one morphospecies of the family Halophilosciidae—as the specimens were collected in a halophilous

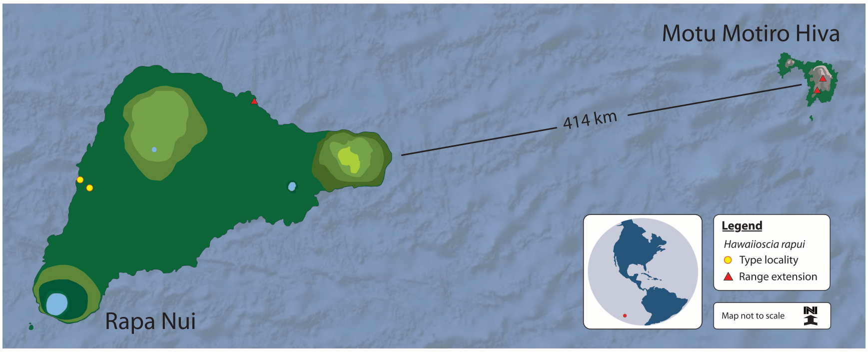

Figure 1. Present distribution of *Hawaiioscia rapui* Taiti & Wynne 2015 in the Easter Island Province, Chile. Yellow circles denote the locations where the species was first discovered (Taiti & Wynne 2014), while red triangles demarcate the range extensions to Ovahe Beach and Motu Motiro Hiva. Map is not to scale.

environment. ST recently examined all the terrestrial isopod specimens (n = 9) representing the potential two morphospecies identified by Hershauer *et al.* (2020). He determined all were *H. rapui.* While the authors referred to the morphospecies designations as questionable (denoted by question marks following the family name), this misidentification underscores why caution should be exercised when identifying certain taxonomic groups (in the case of terrestrial Isopoda) via photointerpretation. In most cases, important taxonomic characters cannot be sufficiently resolved resulting in questionable identifications.

All specimens were identified using the species description for *H. rapui* and the taxonomic key provided in Taiti & Wynne (2015). As the only character(s) requiring measurements was the length of the habitus, data for individuals from the MMH and Rapa Nui populations (Fig. 2) are provided. To date, only 19 specimens were available for this species. We acknowledge this represents a small number of specimens (nine for MMH, six individuals from Rapa Nui caves (Taiti & Wynne 2015), and four specimens from the north shore of Rapa Nui). However, because information is limited for this relatively new species, we felt it was incumbent upon us to present all the available data.

Of the nine specimens from MMH (1 male and 8 females), only three were fully adult. The remaining specimens were quite small (e.g., ≤4 mm); therefore, we did not include these measurements. For the adult MMH specimens, the length of the male was 4.5 mm, while the maximum length for female adults was 6.8 mm. For the six Rapa Nui cave specimens, maximum length was 7.5 mm for both males and females (Taiti & Wynne 2015).

Additionally, four individuals belonging to *Hawaiioscia rapui* (e.g., Fig. 3C) were collected from littoral habitats of Ovahe beach on the north shore of Rapa Nui. Maximum length for these specimens was comparable to those reported by Taiti & Wynne (2015); 4.5 mm (♂) and 6 mm (♀) in length with two individuals ≤ 4 mm in length. Incidentally, this species was not detected during the coastal cliff sampling effort (Wynne, unpublished data). Refer to Wynne *et al.* (2016) for details on coastal and cliff sampling, as well as the project's broader scope.

We emphasize that because isopods molt as they mature, these measurements may be relative.

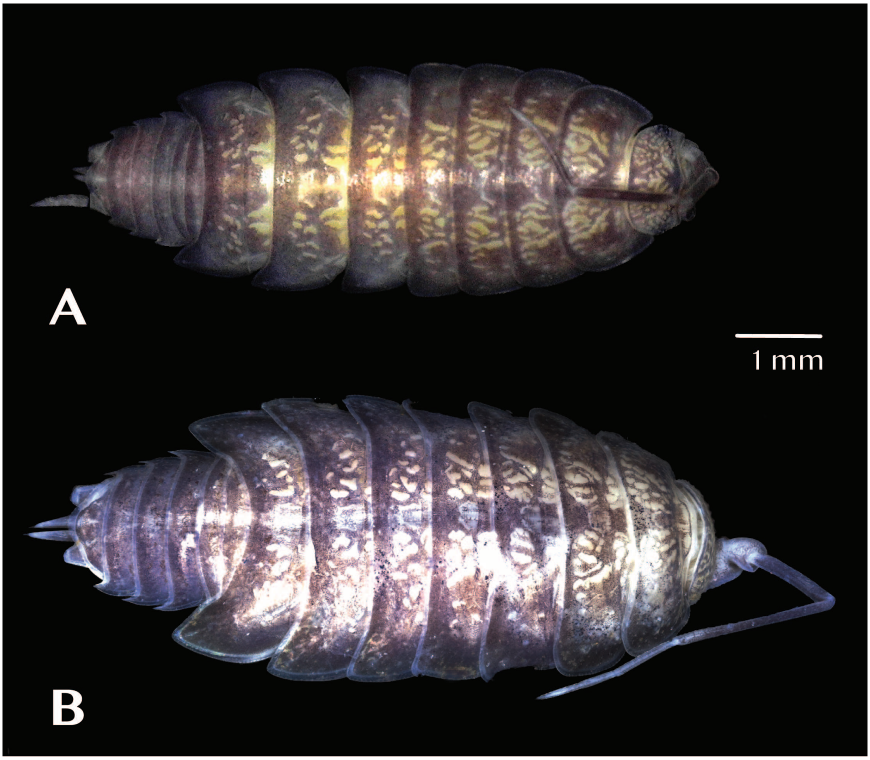

Figure 2. *Hawaiioscia rapui* Taiti & Wynne 2015. Dorsal views of female specimens from [**A**] Moto Motiro Hiva and [**B**] Rapa Nui, southeastern-most Polynesia, Chile. Scale bar is for both individuals.

A halophilic species

The discovery of *Hawaiioscia rapui* on MMH (Fig. 3A, B) and along the Rapa Nui coast (Fig. 3C) has yielded additional insights into its autecology. Moto Motiro Hiva is a small island (~2.5 km²) with the highest elevations reaching ~30 m above sea level; as a result, the entire island is incessantly showered by saltwater and salt spray. Additionally, Rapa Nui coastal beach habitats are subjected to the same littoral environmental conditions. Thus, *H. rapui* must be salt tolerant, and should be considered a littoral halophilic species. Prior to these findings, *H. nicoyaensis* was the only species in the genus considered a marine littoral species (Taiti *et al.* 2018). For the two caves where this species was initially discovered, one was a coastal cave, and the other cave was ~1.2 km from the coast (Wynne *et al.* 2014)—thus, both cave entrances are also exposed continuously to salt spray, while the deeper cave environments are expected to be more insulated from surface conditions (Fig. 3D, E).

DISCUSSION

Potential dispersal mechanisms

Concerning the arrival of *Hawaiioscia rapui* to MMH, we examined the most probable dispersal mechanisms: (1) rafting on flotsam (Thiel & Gutow 2005) from Rapa Nui to MMH (or perhaps the inverse) and (2) anthropogenic-assisted dispersal between the two islands. Importantly, terrestrial isopods are not known to disperse via phoresy on pelagic birds (Wynne *et al.* 2014), nor have they been observed dispersing by direct flotation on the open ocean (e.g., Peck 1994).

Dispersal of plants and animals across the open ocean in the direction of prevailing ocean currents is well-documented (de Queiroz 2005, Gillespie *et al.* 2012, Gressitt 1961, Jokiel 1990, Peck 1994). For this to occur, prevailing currents should flow in the general direction of the perceived dispersal route. Ocean circulation patterns between Rapa Nui and MMH are highly complex (Bertola *et al.* 2020, Chaigneau & Pizarro 2005, Moraga *et al.* 1999, Qiu & Chen 2004) and generally unfavorable for dispersal between Rapa Nui and MMH. The geostrophic flow pattern near Rapa Nui is predominantly north to northwesterly (Bertola *et al.* 2020; Chaigneau & Pizarro 2005). However, the Ekman currents are seasonally variable due to winds, and thus, could provide favorable eastward flow conditions for dispersal from Rapa Nui to MMH (Chaigneau & Pizarro 2005; Martinez *et al*. 2009; Thiel *et al*. 2021). Moreover, eastward current reversals can occur for days to weeks due to storm-generated swells originating off Antarctica (Snodgrass *et al*. 1966), local storms (e.g., Gressitt 1961), and potentially tsunamis (e.g., Carlton *et al*. 2017); these phenomena would produce shifts in ocean currents favoring dispersal from Rapa Nui to MMH.

If rafting did occur from Rapa Nui to MMH, this most likely transpired when the palm-dominated shrub forest on the island was largely intact (i.e., prior to or during the formative stages of Polynesian settlement; Wynne *et al.* 2014). During this time, palms and/or brambles of vegetation were available to be set adrift during intense inclement weather. Today, most of the vegetation on Rapa Nui is characterized as a low-lying invasive shrub-grassland association. Moreover, we deem dispersal via rafting from MMH to Rapa Nui to be improbable; in a historical sense, "rafting" is predicated upon plants and animals rafting on vegetation debris. Plant diversity on the MMH is limited to three succulent and one spleenwort species (Vilina & Gazitua 1999). Thus, as rafting material is largely absent on this island, dispersal to Rapa Nui via this mechanism seems unlikely.

Concerning human-assisted dispersal, alien arthropod species populations on Rapa Nui date back to some of the earliest natural history investigations (e.g., Fuentes 1914; Olalquiaga Faure 1946). The composition of the arthropod community, predominated by alien species, is attributed to a long history of merchant ship traffic to the island. In recent times, a steady influx of alien species continues to arrive on Rapa Nui as stowaways on supply ships primarily hailing from mainland Chile. While it is plausible *H. rapui* may have actively dispersed from Rapa Nui to MMH with contemporary mariners, MMH is a small uninhabited island and is not a safe harbor for maritime traffic. Thus, it is not a routine stopover point for merchant traffic between Rapa Nui and mainland Chile. We surmise that a contemporary human-assisted colonization event from Rapa Nui to MMH is possible, but not probable.

However, a growing body of evidence supports the idea that ancient Polynesians reached South America and/or interacted with South American indigenous groups. For example, contact with coastal Native American tribes in present-day Chile is inferred

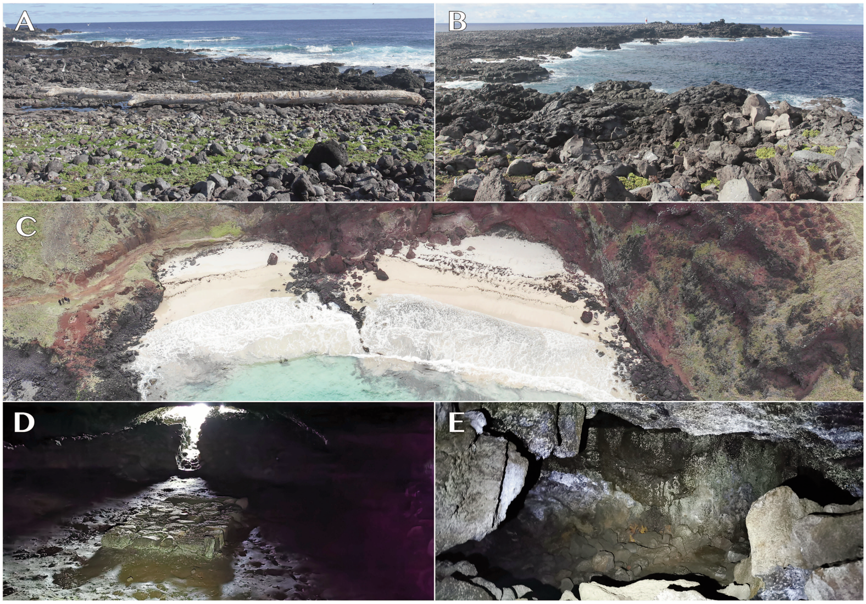

Figure 3. Surface and cave habitats where *Hawaiioscia rapui* was detected. Motu Motiro Hiva is represented in the top two panels—driftwood (i.e., potential rafting flotsam) featured in [**A**] and the lighthouse in the foreground of [**B**] provides scale. [**C**] Ovahe beach cove, north shore, Rapa Nui with four people at far-left center for scale. Cave habitats on Rapa Nui presently consist of the coastal cave (Q15-056 cave) [**D**] and a cave 1.2 km inland (Q15-076-078 cave) [**E**]; refer to Taiti & Wynne (2014) for details.

from the bones of the Polynesian chicken in the archaeological record (Storey *et al*. 2007). Additionally, next generation genetic analysis has revealed "pre-European contact" Native American ancestry in eastern Polynesian groups predating the settlement of Rapa Nui (Ioannidis *et al*. 2020).

As most endemic arthropod populations can be presumed to have been comparatively robust prior to the arrival of Europeans and during the formative years of the Rapanui civilization, *H. rapui* was likely far more common on the island historically. Thus, it could have been inadvertently collected in the soil of "canoe plants" (plants transported throughout the South Pacific in gourds for food, medicine, materials for dwellings and canoes, and other purposes; see Whistler 2009) and transported to MMH by the ancient Polynesians (Edwards 1928; Wynne *et al.* 2014). Wynne *et al.* (2014) referred to this concept as the "Canoe Bug Hypothesis".

Subsequently, both active and passive dispersal from Rapa Nui to MMH are possible. Because ocean currents are weak and variable between Rapa Nui and MMH, rafting would have been possible only when native vegetation was available as rafting material and weather conditions and current reversals favorably influenced ocean currents toward MMH. Additionally, the ancient Polynesians, European mariners, and contemporary

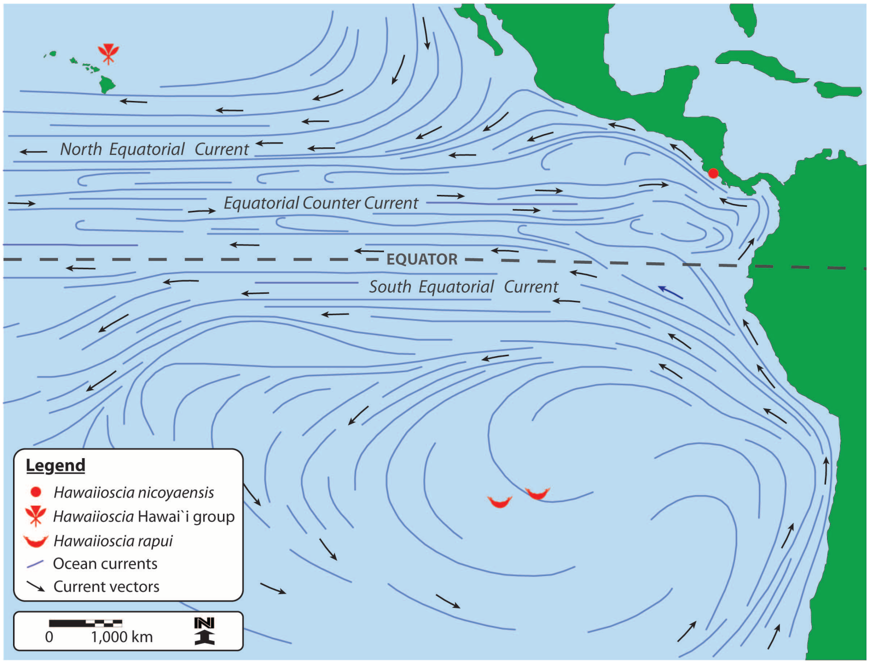

Figure 4. Known locations for the genus *Hawaiioscia*: *H. nicoyaensis* (Costa Rica), the Hawai‘i group, and *H. rapui* (Rapa Nui (western-most location) and Moto Motiro Hiva). A generalized representation of ocean currents modified from USASF (1943), Qiu and Chen (2004), and OSCAR data (Earth & Space Research 2021). Based on prevailing patterns of ocean currents, the rationale that representatives of the genus *Hawaiioscia* (or its ancestral lineage) may have originated from the Neotropics and dispersed, via rafting, to Hawai‘i, Rapa Nui, and possibly other littoral areas in the South Pacific stands to reason. Hawaiian Islands not to scale.

Chileans have traversed the waters between the two islands for centuries—with the aforementioned caveats provided. Subsequently, *H. rapui* likely dispersed to MMH via rafting or with the assistance of the ancient Polynesians (or perhaps historically by the Europeans).

Future research and conservation needs

We enumerate several research areas essential to advancing our knowledge of both *H. rapui* and the genus (and perhaps its allies). Firstly, what is the degree of genetic connectivity between the Rapa Nui and MMH populations? If there is evidence of divergence, can we establish a time when these two lineages began to diverge (i.e., when did *H. rapui* first colonize MMH—or perhaps Rapa Nui)? To address this question, additional specimens should be collected from both islands for genetic and molecular clock analysis.

More broadly, how are the six sibling species of *Hawaiioscia* phylogenetically related? As we have discussed, long-distance dispersal on prevailing ocean currents is well-established (Bertola *et a*l. 2020, de Queiroz 2005, Gillespie *et al.* 2012, Gressitt 1961, Jokiel 1990, Peck 1994). An examination of ocean currents (Martinez *et al*. 2009, Qiu & Chen 2004, USASF 1943) within the region where the six *Hawaiioscia* sibling species occur revealed a strong probability that *Hawaiioscia* (or its ancestral lineage) originated somewhere along the southern-most Central American (or perhaps the northern South American) coast, and then rafted to Hawaiʻi, Rapa Nui, and likely points in between. If correct, the Hawaiian and Rapanui/MMH species should be more closely related to the Costa Rican species than to each other. Genetic analysis revealed the four subterranean-adapted *Hawaiioscia* species from the Hawaiian Islands likely descended from one or more littoral epigean species either not yet discovered or extinct (refer to Rivera *et al*. 2002). COI sequences for these species are available on GenBank. Thus, to test this hypothesis and gain stronger inference regarding the phylogenetics of this group, sequence data would be required for the Rapa Nui/MMH and Costa Rica populations.

Another intriguing question relates to the overall distribution of this halophilic genus. In recent years, the distribution of *Hawaiioscia* has been expanded from the Hawaiian Islands to three additional localities in the tropical Pacific (coastal Costa Rica, Rapa Nui, and now Motu Motiro Hiva). Applying the rationale provided above, we hypothesize this marine littoral group has radiated throughout the tropical Pacific Ocean. This question may be addressed by conducting additional surveys along the Central and South American coasts within the region conducive to dispersal via the South Pacific Gyre and equatorial currents (refer to Fig. 4), including the coasts of the Desventuradas Islands, the Juan Fernandez Islands, the Galápagos Islands, and greater Polynesia. Interestingly, Taiti & Howarth (1997) considered dynamic boulder beaches, which were thought to represent the ancestral habitat of epigean *Hawaiioscia*, to be among the least sampled environments on oceanic islands largely due to the hazardous conditions. To ascertain how other *Hawaiioscia* species are placed phylogenetically within the genus, as well as to better chart the dispersal of this group across the southern Pacific Ocean, future workers should collect specimens in preparation for genetic studies (i.e., preserved in 100% non-denatured molecular grade ethanol and then appropriately stored).

Concerning the Rapa Nui population of *H. rapui*, this species was represented by low numbers compared to alien isopod species (refer to Taiti & Wynne 2015)—specifically *Porcellio scaber* Latreille, 1804, which was the most abundant terrestrial arthropod identified on Rapa Nui (Wynne *et al.* 2014). This was also the case when examining isopod specimens collected from Ovahe Beach. We posit that alien isopod species, in particular *P. scaber*, are likely exerting competitive pressure on native isopod populations (and native arthropod species writ large). Conversely, while arthropod sampling on MMH was limited (Hershauer *et al.* 2020), *P. scaber* is a rather conspicuous isopod and readily detectable; neither it, nor the other alien isopod species known from Rapa Nui [refer to Taiti & Wynne (2015) for the complete list] were detected during the 2016 sampling effort. Although these data were limited and thus the results should be interpreted carefully, the absence of alien isopod species (as well as other potential alien arthropod competitors) suggests the MMH population (and the broader arthropod community) represent a largely endemic and/or indigenous arthropod community.

As we now have two *Hawaiioscia rapui* populations on two distinct islands, we could repopulate one island with individuals from the other population—albeit once the question concerning genetic relatedness between the two island populations has been resolved. Specifically, should one population become imperiled, the other may serve as a source population for a captive breeding and reintroduction program (refer to Wynne *et al*. 2014). To prepare for this potentiality, both populations should undergo population viability analyses (Boyce 1992, Chaudhary & Oli 2020) to estimate both population sizes and extirpation risks. These results would equip resource managers and conservation biologists with the information required to make informed and measured decisions concerning a reintroduction program—should one become necessary. Given the Rapa Nui arthropod community is dominated by alien species, it is reasonable to infer this population is more likely to become imperiled than the MMH population.

Hawaiioscia rapui, previously known only from Rapa Nui, is now the second arthropod species also considered endemic to MMH (as both islands comprise the Easter Island Province). The first species, *Ariadna motumotirohiva* Giroti, Cotoras, Lazo & Brescovit, 2020, is a tube-web spider identified as a short-range endemic presently occurring solely on MMH (Giroti *et al*. 2020). Given the limited distributions of both species and the diminutive size of MMH, we recommend both taxa be considered species of management concern. Surveys should be conducted to gather the much-needed information concerning these species distributions and to obtain a baseline understanding of their population sizes. Once done, both species could be assessed using IUCN (International Union for the Conservation of Nature) Red List criteria (IUCN 2021) to determine their conservation significance.

This exciting discovery underscores that MMH may harbor a unique and highly adapted halophilic endemic arthropod community. However, before this can be established, additional research will be required. Although this community has not been thoroughly inventoried, precautionary policies should be established to reduce the likelihood of alien species introductions. One approach would be to regulate human visitation to the island—at least until the arthropod community on Motu Motiro Hiva can be sufficiently studied.

ACKNOWLEDGMENTS

For the Rapa Nui work, JJW extends his wholehearted gratitude to the field research team (Francisco Ika, Pedro Lazo Hucke, Sergio Manuheuroroa, Lazaro Pakarati, Drew Bristow, Rafael Rodríguez Brizuela, Eric Fies, Nicholas Glover, Walter Lynn Hicks, Dustin Kisner, Ivory Marinakis, Benjamin Shipley, and Byron Yeager). Logistical support and permitting was provided by CONAF-Parque Nacional Rapa Nui (Lillian Gonzales, Ninoska Hucke, Michel Pate, Katherine Moreira, Andrea Valdez Riroroko, Raul Palominos, Christophe Soon, Enrique Tucki, and Ramone Martinez Tepihe) and Consejo de Monumentos Nacionales (Jimena Ramirez and Merahi Atam López). Hostel Vai Here (Soraya Laharoa, Patricia Lillo Chinchilla, and Dale Simpson Jr.) and Hotel Tupa (Sergio Rapu Sr. and Sergio Rapu Jr.) provided accommodations for the research team. The Fulbright Visiting Scholars Program, CONAF-Parque Nacional Rapa Nui, and the National Speleological Society's International Exploration grant program supported this research. Sponsors included Yale Cordage (Sarah Burr and Jamie Goddard) for rope, Act Safe (Britt Trude Christensen) for the power ascender, and Rock Exotica (Brandon Lane) for climbing gear. Rapa Nui fieldwork was recognized as an Explorers Club Flag Expedition. For the Moto Motiro Hiva field research, SYP acknowledges: Edgardo Quezada V. from Servicio Agricola y Ganadero (SAG), Oficina de Rapa Nui; Pedro Lazo Hucke with CONAF, Rapa Nui; Violeta Producciones of Rapa Nui; the Chilean Navy and the AP 41 Aquiles crew;

Consejo Asesor de Monumentos Nacionales (CAMN), Secretaria Tecnica de Patrimonio (STP) on Rapa Nui; and Sebastián Pakarati Trengove. We also thank Francis G. Howarth, Jeremy Vandenberg and two anonymous reviewers for comments leading to the improvement of this manuscript.

REFERENCES

Bertola, **L.D.**, **Boehm**, **J.T.**, **Putman**, **N.F.**, **Xue**, **A.T.**, **Robinson**, **J.D.**, **Harris**, **S.**, **Baldwin**, **C.C.**, **Overcast**, **I.**, **& Hickerson**, **M.J**. 2020. Asymmetrical gene flow in five co-distributed syngnathids explained by ocean currents and rafting propensity. *Proceedings of the Royal Society B*. **287**: 20200657. https://doi.org/10.1098/rspb.2020.0657

Boyce, **M.S**. 1992. Population viability analysis. *Annual Review of Ecology and Systematics* **23**: 481–497.

Carlton, **J.T.**, **Chapman**, **J.W.**, **Geller**, **J.B.**, **Miller**, **J.A.**, **Carlton**, **D.A.**, **McCuller**, **M.I.**, **Treneman**, **N.C.**, **Steves**, **B.P.**, **& Ruiz**, **G.M**. 2017. Tsunami-driven rafting: transoceanic species dispersal and implications for marine biogeography. *Science* **357**: 1402–1406. https://doi.org/10.1126/science.aao1498

Chaigneau, **A. & Pizarro**, **O**. 2005. Surface circulation and fronts of the South Pacific Ocean, east of 120º W. *Geophysical Research Letters* **32**: L08605. https://doi.org/10.1029/2004GL022070

Chaudhary, **V. & Oli**, **M.K**. 2020. A critical appraisal of population viability analysis. *Conservation Biology* **34**: 26–40. https://doi.org/10.1111/cobi.13414

de Queiroz, **A**. 2005. The resurrection of oceanic dispersal in historical biogeography. *Trends in Ecology and Evolution* **20**: 68–73. https://doi.org/10.1016/j.tree.2004.11.006

Earth & Space Research. 2021. OSCAR Surface Currents, OSCAR v2.0. Avilable at: https://www.esr.org/research/oscar/overview/ (Accessed 19 October 2022).

Edwards, **F.W**. 1928. Diptera, Nematocera. *Insects of Samoa and Other Samoan Terrestrial Arthropoda* **2**: 23–102.

Fuentes, **F**. 1914. Contribución al studio de la fauna de Isla de Pascua. *Boletín del Museo Nacional de Historia Natural de Santiago, Chile* **7**: 285–318.

Gillespie, **R.G.**, **Baldwin**, **B.G.**, **Waters**, **J.M.**, **Fraser**, **C.I.**, **Nikula**, **R.**, **& Roderick**, **G.K**. 2012. Long-distance dispersal: a framework for hypothesis testing. *Trends in Ecology and Evolution* **27**: 47–56. https://doi.org/10.1016/j.tree.2011.08.009

Giroti, **A.M.**, **Cotoras**, **D.D.**, **Lazo**, **P.**, **& Brescovit**, **A.D**. 2020. First endemic arachnid from Isla Sala y Gómez (Motu Motiro Hiva), Chile. *European Journal of Taxonomy* **722**: 97–105. https://doi.org/10.5852/ejt.2020.722.1137

Gressitt. **J.L**. 1961. Problems in the zoogeography of Pacific and Antarctic insects. *Pacific Insects Monograph* **2**: 1–94.

Hershauer, **S.N.**, **Pakarati**, **S.Y.**, **& Wynne**, **J.J**. 2020. Notes on the arthropod fauna of Salas y Gómez island, Chile. *Revista Chilena de Historia Natural* **93**: 4. https://doi.org/10.1186/s40693-020-00093-w

[IUCN] International Union for the Conservation of Nature (**IUCN**). 2021. The IUCN Red List of Threatened Species. Version 2021-3. Available at: https://www.iucnredlist.org (Accessed 11 June 2022).

Ioannidis, **A**.**G**., **Blanco-Portillo**, **J**., **Sandoval**, **K**., **Hagelberg**, **E**., **Miquel-Poblete**, **J**.**F**., **Moreno-Mayar**, **J**.**V**., **Rodríguez-Rodríguez**, **J**.**E**., **Quinto-Cortés**, **C**.**D**., **Auckland**, **K**., **Parks**, **T**., **& Robson**, **K**. 2020. Native American gene flow into Polynesia predating Easter Island settlement. *Nature* **583**: 572–577. https://doi.org/10.1038/s41586-020-2487-2

Jokiel, **P**.**L**. 1990. Long-distance dispersal by rafting: reemergence of an old hypothesis. *Endeavour* **14**: 66–73.

Martinez, **E**., **Maamaatuaiahutapu**, **K**., **& Taillandier**, **V**. 2009. Floating marine debris surface drift: convergence and accumulation toward the South Pacific subtropical gyre. *Marine Pollution Bulletin* **58**: 1347–1355. https://doi.org/10.1016/j.marpolbul.2009.04.022

Moraga, **J**., **Valle-Levinson**, **A**., **& Olivares**, **J**. 1999. Hydrography and geostrophy around Easter Island. *Deep Sea Research Part I: Oceanographic Research Papers* **46**: 715–731.

Olalquiaga Faure, **G**. 1946. Anotaciones entomológicas: insectos y otros artrópodos colectados en Isla de Pascua. *Agricultura Técnica* **7**: 231–233.

Peck, **S**.**B**. 1994. Sea-surface (Pleuston) transport of insects between islands in the Galápagos archipelago, Ecuador. *Annals of the Entomological Society of America* **87**: 576–582.

Qiu, **B**. **& Chen**, **S**. 2004. Seasonal modulations in the eddy field of the South Pacific Ocean. *Journal of Physical Oceanography* **34**: 1515–1527. https://doi.org/10.1175/1520-0485(2004)034<1515:SMITEF>2.0.CO;2

Rivera, **M**.**A**.**J**., **Howarth**, **F**.**G**., **Taiti**, **S**., **& Roderick**, **G**.**K**. 2002. Evolution in Hawaiian cave-adapted isopods (Oniscidea: Philosciidae): vicariant speciation or adaptive shifts? *Molecular Phylogenetics and Evolution* **25**: 1–9. https://doi.org/10.1016/S1055-7903(02)00353-6

Snodgrass, **F**.**E**., **Hasselmann**, **K**.**F**., **Miller**, **G**.**R**., **Munk**, **W**.**H**., **& Powers**, **W**.**H**. 1966. Propagation of ocean swell across the Pacific. *Philosophical Transactions of the Royal Society of London. Series A, Mathematical and Physical Sciences* **259**: 431–497.

Storey, **A**.**A**., **Ramirez**, **J**.**M**., **Quiroz**, **D**., **Burley**, **D**.**V**., **Addison**, **D**.**J**., **Walter**, **R**., **Anderson**, **A**.**J**., **Hunt**, **T**.**L**., **Athens**, **J**.**S**., **Huynen**, **L**., **& Matisoo-Smith**, **E**.**A**. 2007. Radiocarbon and DNA evidence for a pre-Columbian introduction of Polynesian chickens to Chile. *Proceedings of the National Academy of Science* **104**: 10335–10339. https://doi.org/10.1073/pnas.0703993104

Taiti, **S**. **& Howarth**, **F**.**G**. 1997. Terrestrial isopods (Crustacea, Oniscidea) from Hawaiian caves. *Mémoires de Biospéologie* **24**: 97–118.

Taiti, **S**. **& Wynne**, **J**.**J**. 2015. The terrestrial Isopoda (Crustacea, Oniscidea) of Rapa Nui (Easter Island), with descriptions of two new species. *ZooKeys* **515**: 27–49. http://doi.org/10.3897/zookeys.515.9477

Taiti, **S**., **Montesanto**, **G**., **& Vargas**, **J**.**A**. 2018. Terrestrial Isopoda (Crustacea, Oniscidea) from the coasts of Costa Rica, with descriptions of three new species. *Revista de Biologia Tropical* **66** (Suppl. 1): S187–S210. https://doi.org/10.15517/RBT.V66I1.33296

Thiel, **M**. **& Gutow**, **L**. 2005. The ecology of rafting in the marine environment. II. The rafting organisms and community. *Oceanography and Marine Biology* 43: 279–418. https://doi.org/10.1016/j.marpolbul.2021.112535

Thiel, **M**., **Lorca**, **B**.**B**., **Bravo**, **L**., **Hinojosa**, **I**.**A**., **& Meneses**, **H**.**Z**. 2021. Daily accumulation rates of marine litter on the shores of Rapa Nui (Easter Island) in the South Pacific Ocean. *Marine Pollution Bulletin* **169**: 112535.

[**USASF**] **U**.**S**. **Army Service Forces**. 1943. Ocean currents and sea ice from atlas of world maps. USASF, Army Specialized Training Division. Army Service Forces, Manual no. M-101.

Vilina, **Y**.**A**. **& Gazitua**, **F**.**J**. 1999. The birds of Sala y Gómez island, Chile. *Waterbirds* **22**: 459–62.

Whistler, **W**.**A**. 2009. *Plants of the canoe people: an ethnobotanical voyage through Polynesia*. University of Hawaii Press, Honolulu. 252 pp.

Wynne, **J**.**J**., **Bernard**, **E**.**C**., **Howarth**, **F**.**G**., **Sommer**, **S**., **Soto-Adames**, **F**.**N**., **Taiti**, **S**., **Mockford**, **E**.**L**., **Horrocks**, **M**., **Pakarati**, **L**., **& Pakarati-Hotus**, **V**. 2014. Disturbance relicts in a rapidly changing world: the Rapa Nui (Easter Island) factor. *BioScience* **64**: 711–718. https://doi.org/10.1093/biosci/biu090

Wynne, **J**.**J**., **Ika**, **F**., **Yancovic Pakarati**, **S**., **Gonzales**, **L**., **Hucke**, **P**.**L**., **Manuheuroroa**, **S**., **Pakarati**, **L**., **Bristow**, **D**., **Rodríguez Brizuela**, **R**., **Fies**, **E**., **Glover**, **N**., **Hicks**, **W**.**L**., **Kisner**, **D**., **Marinakis**, **I**., **Shipley**, **B**., **Yeager**, **B**., **Villagra**, **C**., **Tucki**, **E**., **& Scherson**, **R**. 2016. Island-wide inventory for endemic ground-dwelling arthropods in extreme environments of Rapa Nui, Explorers Club flag report flag # 139. The Explorers Club, New York. 28 pp.