INSECTA MUNDI

A Journal of World Insect Systematics

0532

Southeast Farallon Island arthropod survey

Jeffrey Honda
San Jose State University, Department of Entomology San Jose,
CA 95192 USA

Bret Robinson
San Jose State University, Department of Entomology San Jose,
CA 95192 USA

Michael Valainis
San Jose State University, Department of Entomology San Jose,
CA 95192 USA

Rick Vetter
University of California Riverside, Department of Entomology Riverside,
CA 92521 USA

Jaime Jahncke
Point Blue Conservation Science 3820
Cypress Drive #11 Petaluma, CA
94954 USA

Date of Issue: March 31, 2017

Center for Systematic Entomology, Inc., Gainesville, FL

Jeffrey Honda, Bret Robinson, Michael Valainis, Rick Vetter, and Jaime Jahncke
Southeast Farallon Island arthropod survey
Insecta Mundi 0532: 1–15

ZooBank Registered: urn:lsid:zoobank.org:pub:516A503A-78B9-4D2A-9B16-477DD2D6A58E

Published in 2017 by
Center for Systematic Entomology, Inc.
P. O. Box 141874
Gainesville, FL 32614-1874 USA
http://centerforsystematicentomology.org/

Insecta Mundi is a journal primarily devoted to insect systematics, but articles can be published on any non-marine arthropod. Topics considered for publication include systematics, taxonomy, nomenclature, checklists, faunal works, and natural history. **Insecta Mundi** will not consider works in the applied sciences (i.e. medical entomology, pest control research, etc.), and no longer publishes book reviews or editorials. Insecta Mundi publishes original research or discoveries in an inexpensive and timely manner, distributing them free via open access on the internet on the date of publication.

Insecta Mundi is referenced or abstracted by several sources including the Zoological Record, CAB Abstracts, etc. **Insecta Mundi** is published irregularly throughout the year, with completed manuscripts assigned an individual number. Manuscripts must be peer reviewed prior to submission, after which they are reviewed by the editorial board to ensure quality. One author of each submitted manuscript must be a current member of the Center for Systematic Entomology.

Manuscript Preparation Guidelines and **Submission Requirements** available on the Insecta Mundi webpage at: http://centerforsystematicentomology.org/insectamundi/

Printed copies (ISSN 0749-6737) annually deposited in libraries:
CSIRO, Canberra, ACT, Australia
Museu de Zoologia, São Paulo, Brazil
Agriculture and Agrifood Canada, Ottawa, ON, Canada
The Natural History Museum, London, UK
Muzeum i Instytut Zoologii PAN, Warsaw, Poland
National Taiwan University, Taipei, Taiwan
California Academy of Sciences, San Francisco, CA, USA
Florida Department of Agriculture and Consumer Services, Gainesville, FL, USA
Field Museum of Natural History, Chicago, IL, USA
National Museum of Natural History, Smithsonian Institution, Washington, DC, USA
Zoological Institute of Russian Academy of Sciences, Saint-Petersburg, Russia

Electronic copies (Online ISSN 1942-1354, CDROM ISSN 1942-1362) in PDF format:
Printed CD or DVD mailed to all members at end of year. Archived digitally by Portico.
Florida Virtual Campus: http://purl.fcla.edu/fcla/insectamundi
University of Nebraska-Lincoln, Digital Commons: http://digitalcommons.unl.edu/insectamundi/
Goethe-Universität, Frankfurt am Main: http://nbn-resolving.de/urn/resolver.pl?urn:nbn:de:hebis:30:3-135240

Layout Editor for this article: Eugenio H. Nearns

INSECTA MUNDI 0532: 1–15 2017

Southeast Farallon Island arthropod survey

Jeffrey Honda
San Jose State University, Department of Entomology
San Jose, CA 95192 USA
(408) 924-4877
Jeffrey.honda@sjsu.edu

Bret Robinson
San Jose State University, Department of Entomology
San Jose, CA 95192 USA

Michael Valainis
San Jose State University, Department of Entomology
San Jose, CA 95192 USA

Rick Vetter
University of California Riverside, Department of Entomology
Riverside, CA 92521 USA

Jaime Jahncke
Point Blue Conservation Science
3820 Cypress Drive #11
Petaluma, CA 94954 USA

Abstract. Effective island conservation depends on thorough biodiversity surveys and species assessment. The U.S. Fish and Wildlife Service in coordination with Point Blue Conservation Science undertook a two-year insect survey of the Farallon Islands, California, in order to catalog current insect and spider species on the island and to gather information that will be used to examine prey dynamics to aid in the conservation of the endemic salamander *Aneides lugubris* (Hallowell). The report lists 11 insect orders representing 60 families, 107 genera and 112 insect species on Southeast Farallon Island. Holometabolous orders were the most represented on the island with Coleoptera and Diptera being the most abundant, followed by Lepidoptera and Diptera. One spider order was identified, representing six genera and six species.

Key Words. Insect diversity, island ecology, insect catalog, California

Introduction

Insects are a diverse group with over 1 million described species (May 2002) and estimates show that there could be as many as 30 million insect species still undescribed (Erwin 1982). They play crucial roles in food chains, decomposition, pollination, and other direct/indirect species interactions within their ecosystems (Chua et al. 2007). It is crucial that insects are catalogued and described in order to further study the intricacies of their role and interactions in the ecosystem and to better understand their biodiversity and their importance in conservation strategies.

An insect survey is a necessary component for any investigative island assessment in examining biodiversity. For example, island studies have occurred around the world from the Socotra Archipelago in Africa (Batelka 2012), Borrow Island in Australia (Callan et al. 2011), to Yeonpyeong-do Island in Korea (Park et al. 2012), and the Channel Islands in the United States (Rubinoff and Powell 2004).

Island ecosystems are greatly influenced by a number of factors. For example, human induced plant and animal introductions are common for islands that are close to a mainland, and may negatively impact populations of native island flora and fauna. For example, ant invasions on the Galapagos Islands (Herrera et al. 2013) and Cocos Islands (Neville et al. 2008) decimated native vegetation while Rubinoff and Powell (2004) observed that human introduced non-native grasses on the Channel Islands quickly displaced endemic plant species.

Furthermore, an island's proximity and size are important factors when looking at diversity and colonization (MacArthur and Wilson 2001). Along with the human action of intentional and accidental species introduction, proximity allows for natural insect immigration (Rubinoff and Powell 2004). The size of an island also correlates to species diversity as larger islands can support a higher level of diversity (MacArthur and Wilson 2001). Rates of succession mean that smaller islands may have more species turnover than larger islands (MacArthur and Wilson 2001).

Island ecosystems are influenced by geology including soil type and rock cover as well as cave structures and a diversity of other microhabitats that accommodate specific species. Geologic factors such as these can be informative as to the types of insects that may be collected (Batelka 2012), including cave or ground insects that require rock cover for shelter. Hence, geological diversity and vegetation community habitats together may greatly affect biodiversity.

The Farallon National Wildlife Refuge, a granite island chain that is part of the Salinian Block (Harden 1998), is located approximately 48 km off the coast of San Francisco, California. The chain is made up of small islands that stretch over roughly 8 km with a total land area of 0.41 km^2. Southeast Farallon Island is the largest at 0.31 km^2. It is the only human inhabited island and therefore the only island in the chain that allows easy access and a high degree of safety to conduct research. The climate is Mediterranean with mild wet winters and dry summers. The human history of the island dates back over 175 years and is well documented (White 1995). Since the 1800s the islands were an economic resource for humans (White 1995). The impact of killing native species, like the northern fur seal, collection of common murre eggs, and constructed buildings on nesting habitat, drastically changed the island's ecological dynamics. Multiple boats came and went from the port of San Francisco to resupply and sell goods increasing the likelihood of transporting invasive species. Mice and rabbits were introduced to the island as well as many plant species. After the fur traders and eggers left, a lighthouse was built and required families to live on the island in order to maintain and operate it since the 1880s (U.S. Fish and Wildlife Service 2014). The U.S. Coast Guard took over managing the lighthouse and the U.S. Army also occupied the island (White 1995). Researchers form Point Blue Conservation Science, formerly Point Reyes Bird Observatory, began working on the island in the late 1960s and continue to study island wildlife year round.

The U.S. Fish and Wildlife Service has documented invasive plant species on the Farallon Islands (U.S. Fish and Wildlife Service 2014). For instance, New Zealand spinach *Tetragonia tetragonioides* (Pallas) Kuntze was brought as a food source while tree mallow *Lavatera arborea* (L.) may have been accidentally introduced. Both species have had an invasive impact (Simberloff and Von Holle 1999) on the island's ecology by pushing out native vegetation and preventing ground nesting for endemic seabirds. Common mallow, *Malva neglecta* (Wallr.) is an invasive weed found on many islands including the Farallon Islands. Invasive plants now benefit and sustain non-island colonizers.

The Farallon Islands are likely home to insect species that have yet to be identified and catalogued. Only the endemic cricket, *Farallonophilus cavernicolus* Rentz and research on bird ectoparasites (Marshall and Nelson 1967) have been conducted on the islands. The islands also provide a wealth of research opportunities for seabird, sharks, plant, and pinnipeds, leading biologists to engage in numerous conservation efforts. An insect study would complement existing research performed on the island. The objectives of this study were to create a baseline reference catalogue of terrestrial insects and spiders found on the island, to determine an effective sampling protocol for continued collection, and to provide a foundation that can impact future conservation efforts. These baseline data will also provide some information on the insect prey available for the endemic salamander, *Aneides lugubris* Hallowell, and document insect diversity on the island prior to an anticipated eradication project that plans to remove both invasive plants and the introduced house mouse population that pose a threat to nesting birds.

Materials and Methods

Study Site

The site for the baseline study was the Southeast Farallon Island in the Pacific Ocean (coordinates 37.7249303°N 123.0302779°W), located 40 km west of the coast of San Francisco, California. It is a

National Wildlife Refuge for seabird and pinniped breeding, and is part of San Francisco County. The southeast island is the largest and only accessible island in the chain. It is managed and maintained through collaborative efforts between U.S. Fish and Wildlife Service and Point Blue Conservation Science. Oceanic influences impact the climate, which is characterized as temperate with cool, foggy summers and mild rainy winters. Winter and spring are typically the wettest seasons, while fall tends to be the driest. The islands are an important breeding sanctuary for seabirds, hosting the largest breeding colony in the contiguous United States, as well as significant populations of 5 species of seals and California sea lions.

Insect Diversity Survey

Variety in plant diversity, abundance, terrain and microclimates were crucial in establishing survey areas, and factors in determining the areas for collecting and identifying unique microhabitats. Figure 1 shows representative views of the island topography and vegetation and how vastly the vegetation density changes from season to season. The island was broken into six microhabitats (Figure 2) based on distinctive geologic areas, microclimates, and vegetation plots determined by researchers from San Francisco State University (Barbara Holzman, unpublished data) and described below. All areas were accessible via man-made paths and the two old lighthouse family houses provided living quarters and lab spaces. Other areas on the island were not searched due to limited access, and in some areas the terrain was too difficult to navigate. There were 9 collecting trips between February 2013 and October 2014. Each trip lasted roughly 12 continuous days.

Microhabitat zone descriptions

North Landing

Located at the northern end of the island, North Landing is windy and wet. The wind regularly blows from the northwest and the area is often in shade keeping it cool and moist. This area is dense with seaside goldfields, *Lasthenia maritima* (A. Gray) Ornduff, and in bloom during the winter and spring months.

West Marine Terrace

This area is an open, generally flat, rocky zone with little plant diversity. It contains *Spergularia macrotheca* (Hornem. Ex Cham. & Schltdl.) Heynh, *T. tetragoniodes* and *L. maritima*. This area is fairly windy, with some protection from adjacent rocky hillsides. There is little shade and it is dry.

Marine Terrace

Marine Terrace contains the highest amount of plant diversity mainly consisting of *L. maritime*, *S. macrotheca*, *Plantago coronopus* (L.), *Claytonia perfoliata* (Donn ex Willd.), *Pseudabutilon umbellatum* (L.) Fryxell, *T. tetragonioides*, *Hordeum murinum* (L.) and *Bromus diandrus* (Roth). It is an open, generally flat zone with mixed terrain consisting of soil and rock. There is little to no shade. This area retains a lot of moisture due to an abundance of plants.

Shubrick

Shubrick is located along the eastern side of the island and is generally warmer since it is protected from strong northwesterly winds by Lighthouse Hill and there is no shade. Shubrick is similar to West Marine Terrace with its rocky terrain. There is little plant diversity and abundance, except for *L. maritima* that blooms in the winter months.

Lighthouse Hill Base

This is a small thin zone encompassed by Shubrick, Marine Terrace and Lighthouse Hill. It is at the base of the hill and very rocky. Sections of this area are comprised of sandy soil providing a growing medium for the invasive *T. tetragonioides*. Seabird activity is noticeable and burrows and crevices are visible in the rock base wall as well as in the sandy ground. This is also the location of the two research houses, two Monterey cypress trees and invasive *L. maritima*.

Lighthouse Hill

The Lighthouse is centrally located on the island and sits atop a solid granite base covered in scree. Plant diversity is abundant in this area with most of the vegetation found along the paths being *L. maritima*, *S. macrotheca*, *P. coronopus*, *T. tetragonioides*, and *B. diandrus*. Lighthouse Hill is also a nesting place for various seabird species.

Collection

The island's geography and plant assemblages provided six zones for the survey. Insect communities were located within each zone. It was important to have a basic knowledge of the island's plants and geology in order to facilitate optimal trap placement and type. Aerial nets, and aspirators were used to collect insects, while larger specimens were hand collected. Pitfall traps, malaise traps, yellow pan traps, mercury vapor and black lights, and aspirators were used to collect insects. Insects collected were killed in either ethyl acetate jars, or vials containing 70% ethanol. Once specimens were collected they were either pinned or stored in a vial of 70% ethanol. Vials were labeled and dated. Labels were prepared and contained information such as order and family, trap or collecting device, where it was located, and any other notes such as habitat. Specimens were catalogued to species when possible with the aid of expert taxonomists or by comparing them to specimens located at the California Academy of Sciences. Specimens were identified to family/genus. Voucher specimens were stored at the California Academy in San Francisco and the J. Gordon Edwards Entomology Museum at San Jose State University.

Results and Discussion

Many collecting methods were used with limited success during sampling in order to optimize the collection process. Some of the traps were not successful due to the conditions on the island. Malaise traps did not withstand the wind on the island and were blown out to sea. Yellow pan traps and pitfall traps worked well until they were flipped by Western gulls during the summer breeding season when adults are fighting and curious chicks roamed the sampling areas. An insect vacuum was used, although this proved too destructive to the specimens. However using a 175 Watt mercury vapor light set up at night to collect moths and winged insects drew in many nocturnal insects. This trap was set up at the lighthouse, which was the highest point on the island.

Table 1 lists the insects and spiders that were collected on the island. We found 11 orders of insects represented by 60 families, 107 genera and 112 species. One spider order was identified represented by 6 genera and 6 species. A brief overview of some of the insects and spiders is discussed below. It was not surprising that the Coleoptera were the most represented followed by the Diptera, Lepidoptera, and Hymenoptera.

While some insect species are found throughout the island, (i.e. tenebrionid beetles, calliphorids (blow flies) and the anthomyiid, *Fucellia thinobi*a [Thompson]), some microhabitats with more vegetation were more diverse. Areas with invasive and native plants had large aphid populations and other herbivorous insects (including Lepidoptera, and Diptera), which in turn, had more specialized predator and parasitoid species. For example, tenebrionid beetles, carabid beetles, and homopterans can be directly linked to feeding on *L. arborea* or predating other insects utilizing the plant (Hawke and Clark 2010). Specifically, the aphid species found on the island were observed preying upon by syrphid and lacewing larvae, coccinellids, and parasitoids including the braconid, *Lysiphlebus* sp., and the ichneumonid, *Diplazon laetatorius* (F.), an aphid specialist. Pteromalid species found, along with the two species of eulophids, utilized leaf-mining flies (Agromyzidae) as hosts, as these files were abundantly collected around *M. neglecta.* Other parasitoids include *Scambus brevicornis* (Gravenhorst), a coleopteran parasite that may be using the abundant tenebrionid or carrion beetles found on the island, while the pteromalids (*Trichomalopsis* sp.) and diapriids (one of which may be a new species) possibly seek muscid fly hosts.

In areas with high concentrations of marine birds and pinnipeds as in the entire Marine Terrace, North Landing and Lighthouse Hill, detritivores and carrion feeding insects were very abundant. The two largest feeding guilds of insects collected were detritivores and herbivores, followed by predators.

Among the predators, many spiders inhabit the island. Some species on the island may have ballooned over via their webbing carried by the wind from the coast. This event was witnessed while on the island but no specimens were obtained when ballooning. A genus found on the island that may have used this technique is *Xysticus*. The trap door spiders *Aptostichus* hunt ground insects and are found throughout Marine Terrace and North Landing. There are species found in the caves and crevices that catch moths and crickets, which become entangled in their webs. There are active hunting spiders, *Phanias albeolus* (Chamberlin and Ivie) and *Pardosa ramulosa* (McCook), which have been observed stalking and catching various flies, most commonly, *F. thinobia*. Some species found were continuously located in one or two specific areas of the island. For example, the salpingid beetle, *Aegialites farallonensis* Zerche, was found on the lighthouse in a group of around 30 individuals in a 0.5 m^2 patch and similarly only on a few granite faces along the path between Marine Terrace and the North Landing. They were generally only observed at night, where they were moving around the walls and mating.

A second beetle, *Sibinia maculata* (F.), was found only on Marine Terrace in the flowers of *S. macrotheca*. This weevil has a unique scale pattern seen only on the Farallon Islands (personal communication L. Chamorro, USDA Systematic Entomology Laboratory). It was thought to be a new species but further identification of the male genitalia confirmed it is *S. maculata*.

The previously described endemic Farallon cricket, *F. cavernicolus*, appears to be the only endemic insect on the island and is found primarily in caves.

Almost all of the insects collected on the island either colonized the island or are windblown strays commonly found on the West Coast, which is only 48 km west of San Francisco. Most of the insects collected are winged insects capable of flight, or are small enough to use the prevailing northwesterly winds, which could easily carry insects from the mainland to the island. Odonata, for example, were commonly seen on the island, but there is no standing water for immature development to sustain populations. The small number of flightless insects such as tenebrionid and carabid beetles may have been introduced from infested soil or vegetation from the mainland. Determining which species are established on the islands is difficult (Table 1); however, we used the specimen collection criteria year round, and/or finding of larval or pupal forms (for holometabolous insects) as indicators of successful colonists.

A number of these introduced species may play key roles in the island's ecosystems dynamics. A salamander foraging study found through isotope analysis that the endemic *A. lugubris* feeds primarily on five different prey items, beetles, crickets, jumping bristletails, sowbugs, and spiders (Polito and Bradley 2014). *Coniontis* sp. beetles serve as a food source for the migrating burrowing owl and their exoskeletons have been recovered in owl pellets. In contrast, the other tenebrionid beetle, *Eleodes (Blaphylis) parvicollis* Eschscholtz has a noxious odor that may be unappetizing to the owl. It is still unknown as to whether this noxious odor deters the salamander since no active predation was observed on *E. parvicollis* adults.

Current eradication projects continue to remove a number of invasive plants such as *T. tetragonioides, P. coronopus*, *P. umbellatum*, *L. arborea* and *B. diandrus*. Some of these are food sources for many Lepidoptera species as we have found both larval and pupal forms on the islands. Mallow is a known larval food for painted lady butterflies and host for the aphids found on the islands.

A number of introduced insects (i.e., tenebrionid beetles, jumping bristletails, and isopods) on the island appear to serve as prey for the salamander population based on salamander isotope samples. Their seasonable availability and evaluating these potential prey is the subject of another study. Management of invasive plant species while desirable for habitat restoration may have a large impact on insect herbivore and predator species on the island. For example, eliminating mallow on the island may impact painted lady butterfly numbers when herbicides are used.

This survey is the most comprehensive study of the insects and spiders of the Farallon Islands to date, and demonstrates that even small islands located proximally close to the mainland and heavily impacted by humans can yield interesting data. This study also represents a pre- invasive plant and mouse eradication survey. Due to limited island access for sampling, this list is not complete. Additional surveys will be carried out on the island by Point Blue researchers with increased regularity to add to our survey, which will ensure a long-term record of the insect diversity on the island both pre- and post-eradication. We recommend that other trapping methods be used to sample the area more thoroughly including sampling animals for parasites, and soil (i.e., use of Berlese traps) for small, soft-bodied insects. Additionally, we advocate for more thorough sampling to determine if there are undiscovered/undescribed species on the island. Any identification indicating possibly new species (such as the recently undetermined diapriid) merit further examination.

Acknowledgments

We thank Drs. Silvia Rondon (Oregon State University) and Raul Medina (Texas A&M University) for their comments and review of an earlier version of this manuscript. We thank all the Farallon research leaders and assistants for their assistance in carrying out this research. The authors thank the Bently Foundation, Campini Foundation, Elinor Paterson Baker Trust, Kimball Foundation, Marisla Foundation, Mead Foundation and the many Point Blue donors who have helped fund Farallones research over the years. Thanks to Point Blue Conservation, U.S. Fish and Wildlife Service, Farallon Patrol, Friends of the Farallones for collection permits, access, lodging, and transportation to the island, and to Dr. Barbara Holtzman and her team from San Francisco State University for aiding our research. We thank California Academy of Sciences and the Essig Museum at the University of California, Berkeley, for allowing us to reference their entomology collections. We extend special acknowledgment to all the taxonomists that provided Farallon insect identifications: Dr. M. Lourdes Chamorro, Systematic Entomology Laboratory, ARS, USDA; Dr. Brian Fisher, California Academy of Sciences; Dr. Dave Kavanaugh, California Academy of Sciences; Dr. Peter Kerr, Plant Pest Diagnostics Branch, California Department of Food & Agriculture; Dr. Lynn Kimsey, Bohart Museum of Entomology, University of California, Davis; Dr. Robert Kimsey, Department of Entomology and Nematology, University of California, Davis; Dr. Norm Penny, California Academy of Sciences; Dr. Jerry Powell, Essig Museum of Entomology, University of California, Berkeley; Dr. F. Christian Thompson Department of Entomology, Smithsonian Institute; Dr. Charles Triplehorn, Museum of Biological Diversity, Department of Entomology, Ohio State University; and Dr. Norman E. Woodley, SEL, ARS, USDA.

This is Point Blue Conservation Science contribution number 2111.

Literature Cited

Batelka, J. 2012. Socotra Archipelago - A lifeboat in the sea of changes: advancement in Socotran insect biodiversity survey. Acta Entomologica Musei Nationalis Pragae 52 (suppl. 2): 1–26.

Callan, S. K., J. D. Majer, K. Edwards, and D. Moro. 2011. Documenting the terrestrial invertebrate fauna of Barrow Island, Western Australia. Australian Journal of Entomology 50(4): 323–343.

Chua, L. S. L., L. G. Kirton, and L. G. Saw. (eds.). 2007. Status of biological diversity in Malaysia and threat assessment of plant species in Malaysia: Proceedings of the seminar and workshop, 28–30 June 2005. Forest Research Institute Malaysia (FRIM), Kuala Lumpur, Malaysia. 290 p.

Erwin, T. L. 1982. Tropical Forests: Their richness in Coleoptera and other arthropod species. The Coleopterists Bulletin 36(1): 74–75.

Harden, D. R. 1998. California Geology. Prentice Hall. 479 p.

Hawke, D. J., and J. M. Clark. 2010. Incorporation of the invasive mallow *Lavatera arborea* into the food web of an active seabird island. Biological Invasions 12(6): 1805–1814.

Herrera, C. M., M. Medrano, and P. Bazaga. 2013. Epigenetic differentiation persists after male gametogenesis in natural populations of the perennial herb *Helleborus foetidus* (Ranunculaceae). PLoS ONE 8(7): e70730.

MacArthur, R. H., and E. O. Wilson. 2001. The theory of island biogeography. Princeton Landmarks in Biology. 224 p.

May, R. 2002. Biological Diversity in a Crowded World: Past, Present and Likely Future. Essay. (Available at ~ http://www.zoo.ox.ac.uk/newsite/groups/mathbiol/essay.html. Last accessed February 2017.)

Marshall, A. G., and B. C. Nelson. 1967. Bird ectoparasites from South Farallon Island, California. Journal of Medical Entomology 4: 335–338.

Neville, P. J., D. J. O'Dowd, and A. L. Yen. 2008. Issues and implications for research on disturbed oceanic islands illustrated through an ant survey of the Cocos (Keeling) Islands. Journal of Insect Conservation 12: 313–323.

Park, S. J., H. M. Lim, E. J. Hong, Y. L. Jeon, and B. J. Kim. 2012. Survey on Insect Diversity of Yeonpyeong-do Island, Korea. Journal of Korean Nature 5: 17–26.

Polito, M. J., and R. W. Bradley. 2014. A stable isotope investigation of the diets and ecosystem impacts of the introduced house mice on Southeast Farallon Island, California. USFWS unpublished.

Rubinoff, D., and J. A. Powell. 2004. Conservation of fragmented small populations: endemic species persistence on California's smallest channel island. Biodiversity and Conservation 13: 2537–2550.

Simberloff, D., and B. Von Holle. 1999. Positive interactions of nonindigenous species: invasion meltdown? Biological Invasions 1: 21–32.

U.S. Fish and Wildlife Service. 2014. History of the Farallon Islands. (Available at ~ http://www.fws.gov/refuge/farallon/about/history.html. Last accessed February 2017.)

White, P. 1995. The Farallon Islands: Sentinels of the Golden Gate. Scottwall Associates. 133 p.

Received February 19, 2017; Accepted March 5, 2017.
Review Editor Julieta Brambila.

Figure 1. Southeast Farallon Island Fall 2013 (Photo B. Robinson). Looking out from atop the granite peak of Light House Hill down to the Western Marine Terrace and out to the West Side Hill. The figure shows the drastic change in seasonal vegetation. The left picture was taken February 2013 and the right was taken August 2013.

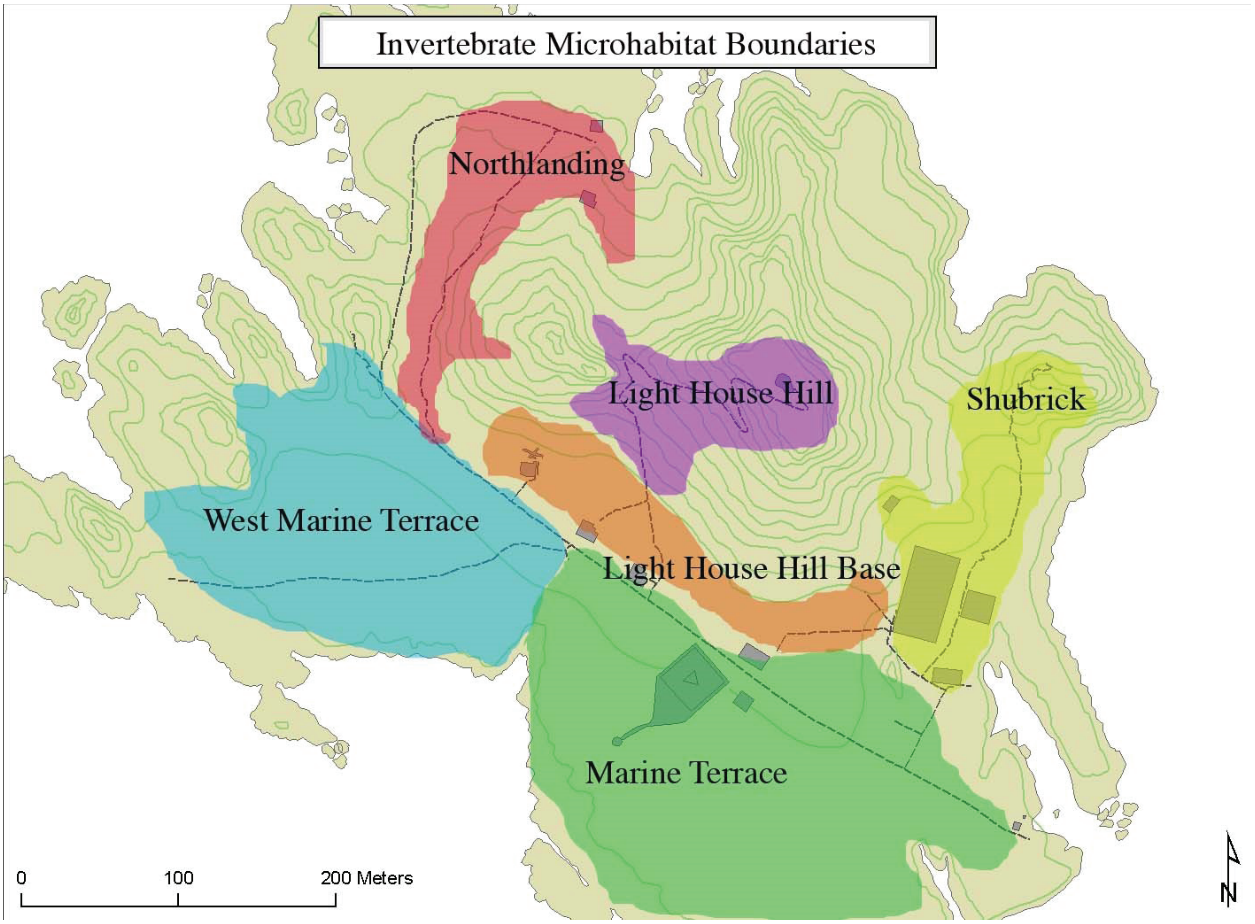

Figure 2. Topographic map of Southeast Farallon Island with marked survey microhabitat zones.

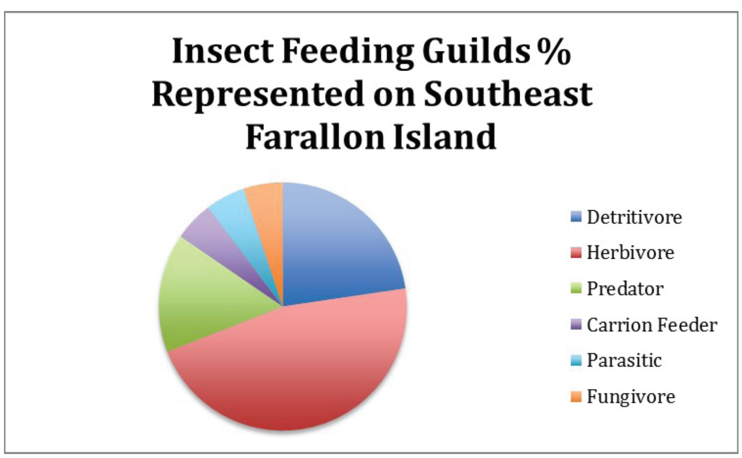

Figure 3. Insect feeding guild distribution for the Southeast Farallon Island.

Table 1. List of insects and spiders collected on the Southeast Farallon Island during February 2013- September 2014. Location Key: Marine Terrace (M), Marine Terrace West (W), Lighthouse Hill (L), Lighthouse Hill Base (B), Shubrick (S), Northlanding (N), House Structures (H), and Caves(C).

Order: Family	**Genus**	**Species**	**Location**	**Reference**
Microcoryphia: Machilidae	*Pedetontus*		M, W, L, B, S, N	
Odonata: Aeshnidae	*Aeshna*	*multicolor*	M, L, B	
Odonata: Coenagrionidae	*Enallagma*	*cyathigerum*	M, L, B	
Odonata: Libellulidae	*Sympetrum*	*corruptum*	M, L, B	
Orthoptera: Rhaphidophoridae	*Farallonophilus*	*cavernicolus*	C	David C. Rentz (1972)
Hemiptera: Aphidae	*Macrosiphum*	*euphorbiae*	M, W, L	Dr. Peter Kerr (CDFA)
Hemiptera: Aphidae	*Metopolophium*	spp.	M, W, L	Dr. Peter Kerr (CDFA)
Hemiptera: Coreidae	*Leptoglossus*	*zonatus*	M, B	Dr. Jeffrey Honda (San Jose State University)
Hemiptera: Miridae	*Lygus*	*shulli*	M, W	(CAS)
Hemiptera: Pentatomidae	*Holcostethus*	*limbolarius*	M, W	(CAS)
Psocoptera			M	
Coleoptera: Bostrichidae			H	
Coleoptera: Carabidae	*Amaria*	*californicus*	M, W	Dr. Dave Kavanaugh (CAS)
Coleoptera: Carabidae	*Anisodactylus*	*californicus*	M, W	Dr. Dave Kavanaugh (CAS)
Coleoptera: Coccinellidae	*Coccinella*	*californicus*	M	Dr. Jeffrey Honda (San Jose State University)
Coleoptera: Coccinellidae	*Coccinella*	*septempunctata*	M, W, L	Dr. Jeffrey Honda (San Jose State University)
Coleoptera: Coccinellidae	*Hippodamia*	*convergens*	M, W, L	Dr. Jeffrey Honda (San Jose State University)
Coleoptera: Curculionidae	*Listroderes*	*costirostris*	W, N	Dr. M. Lourdes Chamorro (USDA)

Order: Family	Genus	Species	Location	Reference
Coleoptera: Curculionidae	*Sibinia*	*maculata*	M, W,	Dr. M. Lourdes Chamorro (USDA)
Coleoptera: Dermestidae			M, W, L, B, S, N	
Coleoptera: Elateridae	*Conoderus*	spp.	N	(USDA)
Coleoptera: Histeridae	*Gnathoncus*	*rotundatus*	M, W, L, B, S, N	(USDA)
Coleoptera: Melyridae	*Endeodes*	*collaris*	M	(USDA)
Coleoptera: Salpingidae	*Aegialites*	*farallonensis*	L, N	Dr. Alexey Tishechkin (USDA)
Coleoptera: Staphylinidae			M	
Coleoptera: Tenebrionidae	*Coniontis*	spp.	M, W, L, B, S, N	Dr. Charles A. Triplehorn (Ohio State University)
Coleoptera: Tenebrionidae	*Eleodes*	*parvicollis*	M, W, L, B, S, N	Dr. Charles A. Triplehorn (Ohio State University)
Neuroptera: Chrysopidae	*Chrysopidae*	*plorabunda*	M, L	Dr. Norm Penny (CAS)
Neuroptera: Hemerobiidae	*Hemerobius*		M, L	Dr. Norm Penny (CAS)
Hymenoptera: Braconidae	*Lysiphlebus*	sp.	M	Dr. Lynn Kimsey (University of California, Davis)
Hymenoptera: Diapriidae	*Aneuropria*	*New species*	M	Dr. Lynn Kimsey (University of California, Davis)
Hymenoptera: Diapriidae	*Trichopria*	sp.	M	Dr. Lynn Kimsey (University of California, Davis)
Hymenoptera: Encyrtidae	*Lamennaisia*	*ambigua*	M	Dr. Lynn Kimsey (University of California, Davis)
Hymenoptera: Eulophidae	*Diglyphus*	*begini*	M	Dr. Lynn Kimsey (University of California, Davis)
Hymenoptera: Eulophidae	*Diaulinopsis*	sp.	M	Dr. Lynn Kimsey (University of California, Davis)
Hymenoptera: Formicidae	*Tapinoma*	*sessile*	M, W	Dr. Brian Fisher (CAS)

Order: Family	**Genus**	**Species**	**Location**	**Reference**
Hymenoptera: Ichneumonidae	*Diplazon*	*laetorius*	M	Dr. Lynn Kimsey (University of California, Davis)
Hymenoptera: Ichneumonidae	*Scambus*	*brevicornis*	M	Dr. Lynn Kimsey (University of California, Davis)
Hymenoptera: Pteromalidae	*Halticoptera*	sp.	M	Dr. Lynn Kimsey (University of California, Davis)
Hymenoptera: Pteromalidae	*Pachyneuron*	*aphidis*	M	Dr. Lynn Kimsey (University of California, Davis)
Hymenoptera: Pteromalidae	*Trichomalopsis*	sp.	M	Dr. Lynn Kimsey (University of California, Davis)
Lepidoptera: Crambidae	*Achyra*	*Occidentalis*	L	Dr. Jerry Powell (University of California, Berkeley
Lepidoptera: Crambidae	*Euchromius*	*ocelleus*	L	Dr. Jerry Powell (University of California, Berkeley
Lepidoptera: Crambidae	*Hellula*	*Rogatalis*	L	Dr. Jerry Powell (University of California, Berkeley
Lepidoptera: Crambidae	*Nomophila*	*nearctica*	L	Dr. Jerry Powell (University of California, Berkeley
Lepidoptera: Crambidae	*Uresiphita*	*Reversalis*	L	Dr. Jerry Powell (University of California, Berkeley
Lepidoptera: Geometridae	*Eupithecia*	*Misturata*	L	Dr. Jerry Powell (University of California, Berkeley
Lepidoptera: Geometridae	*Triphosa*	*Haesitata*	L	Dr. Jerry Powell (University of California, Berkeley
Lepidoptera: Geometridae	*Xanthorhoe*	*Defensaria*	L	Dr. Jerry Powell (University of California, Berkeley
Lepidoptera: Noctuidae	*Autographa*	*californica*	M, L, B	Dr. Jerry Powell (University of California, Berkeley
Lepidoptera: Noctuidae	*Euxoa*	spp.	L	Dr. Jerry Powell (University of California, Berkeley
Lepidoptera: Noctuidae	*Helicoverpa*	*zea*	L	Dr. Jerry Powell (University of California, Berkeley
Lepidoptera: Noctuidae	*Heliothis*	*phloxiphaga*	M, W	Dr. Jerry Powell (University of California, Berkeley
Lepidoptera: Noctuidae	*Leucania*	*oregona*	L	Dr. Jerry Powell (University of California, Berkeley

Order: Family	**Genus**	**Species**	**Location**	**Reference**
Lepidoptera: Noctuidae	*Lithophane*	*georgii*	L	Dr. Jerry Powell (University of California, Berkeley
Lepidoptera: Noctuidae	*Lithophane*	*pertorrida*	L	Dr. Jerry Powell (University of California, Berkeley
Lepidoptera: Noctuidae	*Mythimna*	*unipuncta*	L	Dr. Jerry Powell (University of California, Berkeley
Lepidoptera: Noctuidae	*Noctua*	*pronuba*	M, W, L,	Dr. Jerry Powell (University of California, Berkeley
Lepidoptera: Noctuidae	*Orthosia*	spp.	L	Dr. Jerry Powell (University of California, Berkeley
Lepidoptera: Noctuidae	*Peridroma*	*saucia*	M, L	Dr. Jerry Powell (University of California, Berkeley
Lepidoptera: Noctuidae	*Spodoptera*	*exigua*	L	Dr. Jerry Powell (University of California, Berkeley
Lepidoptera: Nymphalidae	*Vanessa*	*annabella*	M, W, L	Dr. Jeffrey Honda (San Jose State University)
Lepidoptera: Nymphalidae	*Vanessa*	*cardui*	M, W, L	Dr. Jeffrey Honda (San Jose State University)
Lepidoptera: Oecophoridae	*Edromis*	*sarcitrella*	M, W, L, B, S, N	Dr. Jerry Powell (University of California, Berkeley
Lepidoptera: Oecophoridae	*Hoffmanophila*	*pseudospretella*	M, W, L, B, S, N	Dr. Jerry Powell (University of California, Berkeley
Lepidoptera: Plutellidae	*Plutella*	*albidorsella*	M, W, L, B, S, N	Dr. Jerry Powell (University of California, Berkeley
Lepidoptera: Plutellidae	*Plutella*	*xylostella*	M, W, L, B, S, N	Dr. Jerry Powell (University of California, Berkeley
Lepidoptera: Pterophoridae	*Platypilia*	*williamsii*	M, W, L, B, S, N	Dr. Jerry Powell (University of California, Berkeley
Lepidoptera: Sphyngidae	*Hyles*	*lineata*	M, L,	Dr. Jerry Powell (University of California, Berkeley
Lepidoptera: Tineidae	*Monopis*	*crocicapitella*	C	Dr. Jerry Powell (University of California, Berkeley
Lepidoptera: Tineidae	*Tinea*	*pallescentella*	C	Dr. Jerry Powell (University of California, Berkeley
Lepidoptera: Tortricidae	*Bactra*	*verutana*	M, W, L, B, S, N	Dr. Jerry Powell (University of California, Berkeley

Order: Family	Genus	Species	Location	Reference
Lepidoptera: Tortricidae	*Cydia*	*pomonella*	M, W, L, B, S, N	Dr. Jerry Powell (University of California, Berkeley
Siphonoptera Pulicidae	*Nosopsyllus*	*fasciatus*	M, W, L, B, S, N	Santa Clara Vector Control
Diptera: Agromyzidae	*Liriomyza*		M	
Diptera: Anthomyiidae	*Fucillia*	*thinobia*	M, W, L, B, S, N	Dr. Robert Kimsey (University of California, Davis)
Diptera: Calliphoridae	*Calliphora*	*latifrans*	M, W, L, B, S, N	Dr. Jeffrey Honda (San Jose State University)
Diptera: Calliphoridae	*Lucillia*	*sericata*	M, W, L, B, S, N	Dr. Jeffrey Honda (San Jose State University)
Diptera: Canacidae	*Nocticanace*		M	
Diptera: Chironomidae			M	
Diptera: Dolichopodidae	*Paraphrosylus*	*nigripennis*	M	Dr. Norman E. Woodley (USDA)
Diptera: Dolichopodidae	*Paraphrosylus*	*praedator*	M	Dr. Norman E. Woodley (USDA)
Diptera: Drosophilidae	*Drosophila*		M, L	
Diptera: Ephydridae	*Parydra*		M	
Diptera: Heleomyzidae	*Trixoscelis*		M, L	
Diptera: Mycetophilidae	*Orfelia*	*augustata*	M, W, L, N	Dr. Jeffrey Honda (San Jose State University)
Diptera: Phoridae	*Pericyclocera*		M	
Diptera: Piophilidae			M	
Diptera: Psychodidae	*Psychoda*		M, H	
Diptera: Sciaridae	*Lycoriella*		M	

Order: Family	Genus	Species	Location	Reference
Diptera: Syrphidae	*Eupeodes*	*fumipennis*	M	Dr. F. Christian Thompson (Smithsonian)
Diptera: Syrphidae	*Eupeodes*	*volucris*	M	Dr. F. Christian Thompson (Smithsonian)
Diptera: Syrphidae	*Ocyptamus*	*lemur*	M	Dr. F. Christian Thompson (Smithsonian)
Diptera: Syrphidae	*Paragus*	*haemorrhous*	M	Dr. F. Christian Thompson (Smithsonian)
Diptera: Syrphidae	*Scaeva*	*pyrastri*	M	Dr. F. Christian Thompson (Smithsonian)
Diptera: Syrphidae	*Sphaerophoria*	*sulphuripes*	M	Dr. F. Christian Thompson (Smithsonian)
Diptera: Syrphidae	*Syrphus*	*opinator*	M	Dr. F. Christian Thompson (Smithsonian)
Diptera: Syrphidae	*Toxomerus*	*occidentalis*	M	Dr. F. Christian Thompson (Smithsonian)
Diptera: Tethinidae	*Neopelomyia*		M	
Diptera: Tipulidae, Limoniinae	*Limonia*	*marmorata*	M, W, L, N	(Osten-Sacken, 1861)
Araneae: Dictynidae	*Blabomma*		M, W, L, B, S, N	Richard S. Vetter (University of California, Riverside)
Araneae: Euctenizidae	*Aptostichus*		M, W, B, N	Richard S. Vetter (University of California, Riverside)
Araneae: Lycosidae	*Pardosa*	*ramulosa*	M, C	Richard S. Vetter (University of California, Riverside)
Araneae: Salticidae	*Phanias*	*albeolus*	M, W, L, B, S, N	Richard S. Vetter (University of California, Riverside)
Araneae: Theridiidae	*Steatoda*	*grossa*	H, C	Richard S. Vetter (University of California, Riverside)
Araneae: Thomisidae	*Xysticus*	*punctulatus*	M	Richard S. Vetter (University of California, Riverside)