Technical Report HCSU-088

HAWAIIAN HOARY BAT (*LASIURUS CINEREUS SEMOTUS*) ACTIVITY AND PREY AVAILABILITY AT KALOKO-HONŌKOHAU NATIONAL HISTORICAL PARK

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Abstract

We examined habitat use and foraging activity of the endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*), as well as nocturnal aerial insect abundance at Kaloko-Honōkohau National Historical Park located in the coastal region of Kailua-Kona, Hawai'i Island. We evaluated bat activity in two habitat types, wooded shorelines beside brackish water fishponds and xeric lava fields dominated by two invasive plant species: white leadwood (*Leucaena leucocephala*, Fabaceae), and fountain grass (*Cenchrus setaceus*, Poaceae). We recorded bat echolocation calls at seven acoustic stations that operated nightly from November 2013 through February 2015. Additionally, three UV light traps were used to collect insects at three locations from dusk to dawn in January, April, July, and November 2014. Bat acoustic activity showed seasonal patterns in pulse counts, call-events, feeding buzzes, and frequency of occurrence with three major peaks in bat echolocation activity in November–December 2013, April–May 2014, and August–December 2014. Overall, bat acoustic activity was greatest at the shoreline of Kaloko Fishpond. Although there were no significant differences in insect biomass among collection stations, Hawaiian hoary bats use the Park as an important foraging habitat.

Introduction

The Hawaiian hoary bat (*Lasiurus cinereus semotus*), a federally and state listed endangered subspecies, is the only extant, native terrestrial mammal in the Hawaiian archipelago. The U.S. Fish and Wildlife Service (USFWS) published a recovery plan for this species in 1998 (USFWS 1998). Also known as the 'Ōpe'ape'a, the species is the official state land mammal of Hawai'i. A seasonal (May through July) survey (Fraser *et al.* 2007) detected Hawaiian hoary bats in Kaloko-Honokōhau National Historical Park (hereafter, Park) in March and April, 2005. While subsequent bimonthly acoustic surveys (Pinzari *et al.* 2014) demonstrated the seasonal occurrence of Hawaiian hoary bats in the Park and bat foraging activity was detected in January, May, September, and October but not in March or July. Although studies on Hawaiian hoary bat diet (Whitaker & Tomich 1983; Jacobs 1999; Todd 2012), foraging, home range movements (Bonaccorso *et al.* 2015), prey abundance, seasonal distribution (Jacobs 1994; Todd 2012), and occupancy (Gorresen *et al.* 2013) have been published for other areas, the biology of this species and its potential nocturnal insect prey base and diet in the coastal dry plains of leeward Hawai'i Island is poorly understood.

Our objectives for this study were to document seasonal patterns of bat presence by recording bat echolocation calls and to sample nocturnal aerial insects as an index of potential bat prey. This report summarizes the seasonal presence of the Hawaiian hoary bat and nocturnal, aerial insect prey at the Park over a 15-month period from November 2013 to February 2015. From these data we draw inferences about foraging activity, prey availability and habitat use by Hawaiian hoary bats in the Park.

Methods

Study Area

Our study was conducted at Kaloko-Honokōhau National Historical Park on the leeward side of Hawai'i Island. The Park covers approximately 486 ha of marine waters and terrestrial coastal plains. Habitat in the Park includes lowland coastal vegetation, xeric lava fields with and without vegetation, wetlands, and large brackish fishponds (Figure 1).

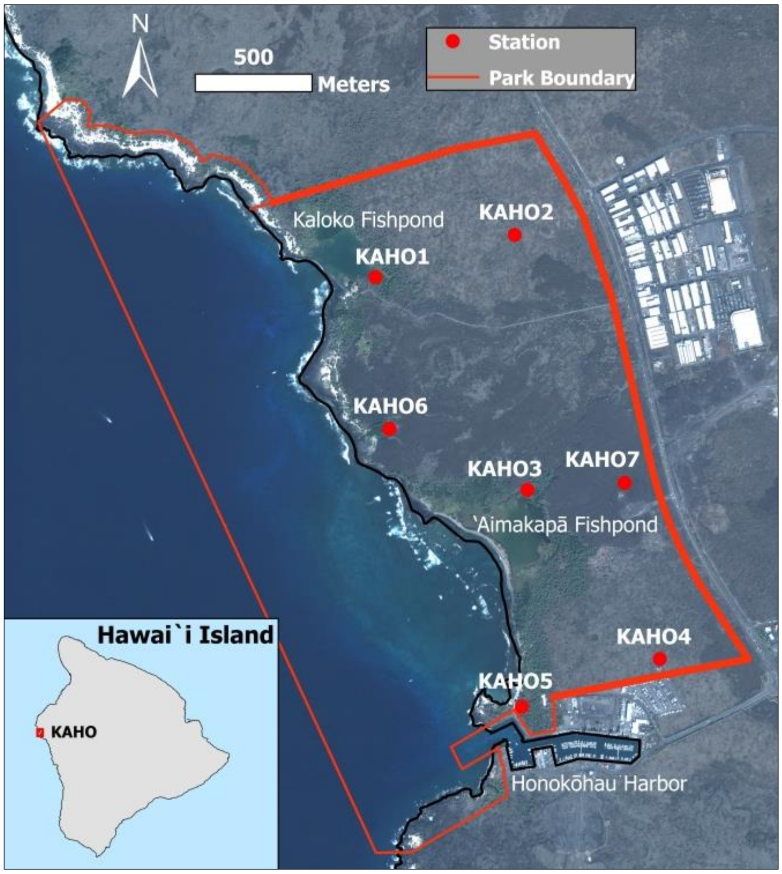

Figure 1. Sample station locations within Kaloko-Honokōhau National Historical Park.

We recorded Hawaiian hoary bat vocalizations at seven sampling stations between 1 and 10 m above sea level. These stations were designated as KAHO1–KAHO7 (Table 1, Figures 1 and 2). Stations KAHO1 and KAHO3 were established along wooded shorelines of brackish fishponds dominated by an invasive species of mesquite tree known locally as kīawe (*Prosopis pallida*, Fabaceae). Stations KAHO2, KAHO4, and KAHO6 were placed in xeric lava fields dominated by another invasive species of tree known locally as haole koa or white leadwood (*Leucaena leucocephala*, Fabaceae) and fountain grass (*Cenchrus setaceus*, Poaceae). Station KAHO5 was located in coastal wetland habitat at ʻAiʻōpio Fishtrap near the southern Park boundary adjacent to Honokōhau Harbor. Station KAHO7 was located in a nearly barren, xeric lava field near the Park's Visitor Contact station.

Table 1. List of station names, Universal Transverse Mercator (UTM) coordinates, location, habitat and sample type (bat acoustic, “A”; insect collection, “I”).

Station	Easting, Northing (UTM)	Location	Habitat	Sample type
KAHO1	810930, 2179841	Kaloko Fishpond	Wooded shoreline	A, I
KAHO2	811824, 2179779	Māmalahoa Trail	Xeric, vegetated lava field	A
KAHO3	811877, 2178674	ʽAimakapā Fishpond	Wooded shoreline	A, I
KAHO4	812450, 2177902	South Boundary	Xeric, vegetated lava field	A, I
KAHO5	811860, 2177758	ʻAiʻōpio Fishtrap	Coastal wetland	A
KAHO6	811293, 2178944	Ala Hele Huʽe Huʽe Trail	Xeric, vegetated lava field	A
KAHO7	812300, 2178714	Visitor Contact station	Xeric, barren lava field	A

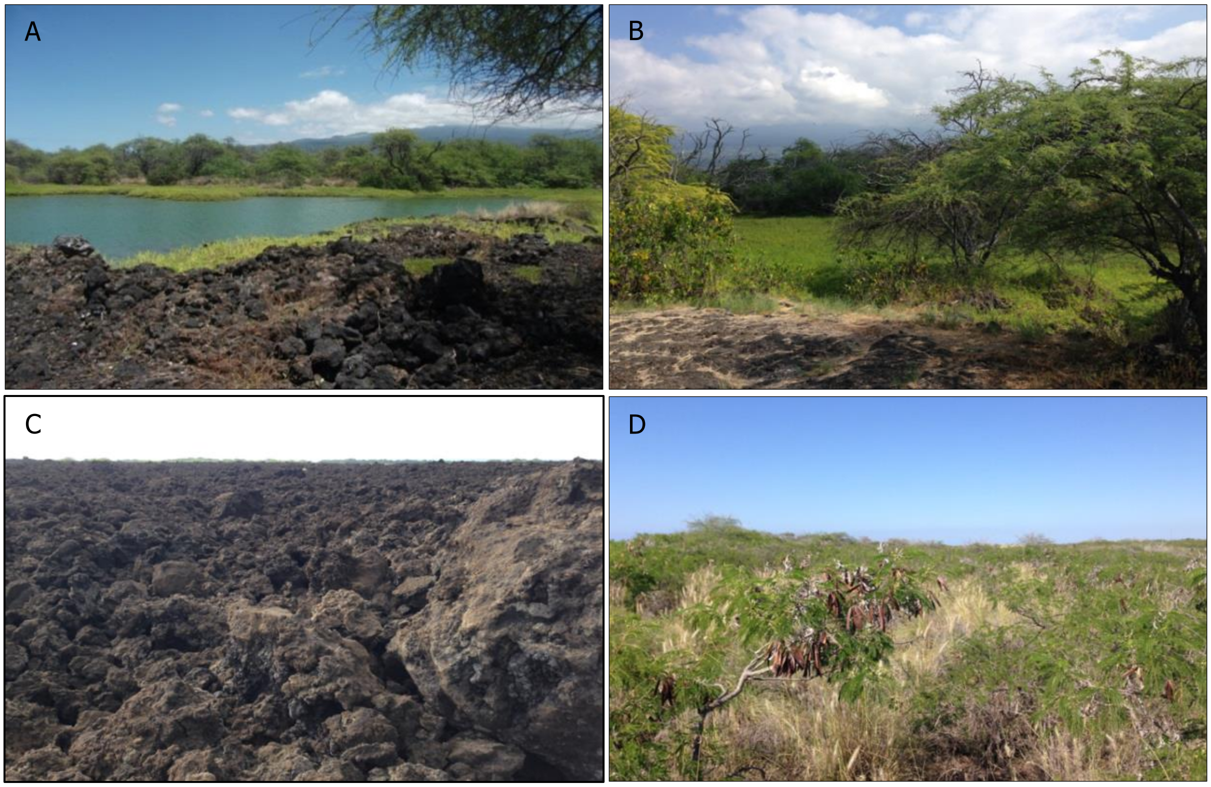

Figure 2. Habitat and vegetation types: A) wooded shoreline at Kaloko Fishpond (KAHO1) B) coastal wetland at ʻAiʻōpio Fishtrap (KAHO5) C) xeric, barren lava field (KAHO7) D) xeric, vegetated lava field with invasive trees and grasses (KAHO4).

Survey Techniques

Bat Acoustic Detection

Ultrasonic vocalizations used for echolocation by Hawaiian hoary bats, including call-events with search phase and terminal phase calls (Griffin *et al.* 1960), were recorded nightly from November 2013 through February 2015. Call-events (also referred to as "bat passes" in the literature) are hereby defined as a sequence of ultrasonic pulses over a span of milliseconds (ms) that can be detected by an ultrasonic microphone as an individual bat flies past the effective range of the microphone. Call-events may contain search phase calls made by a bat moving about an area often for the purpose of searching for prey, and may end with a feeding buzz (also referred to as "terminal phase calls"). Feeding buzzes, indicative of foraging activity, are characterized by a rapid series of pulses made by a bat closely approaching a prey item (Figure 3). The presence of multiple bats was determined when more than one echolocation call event occurred simultaneously at different frequencies in a single echolocation call file (Figure 4).

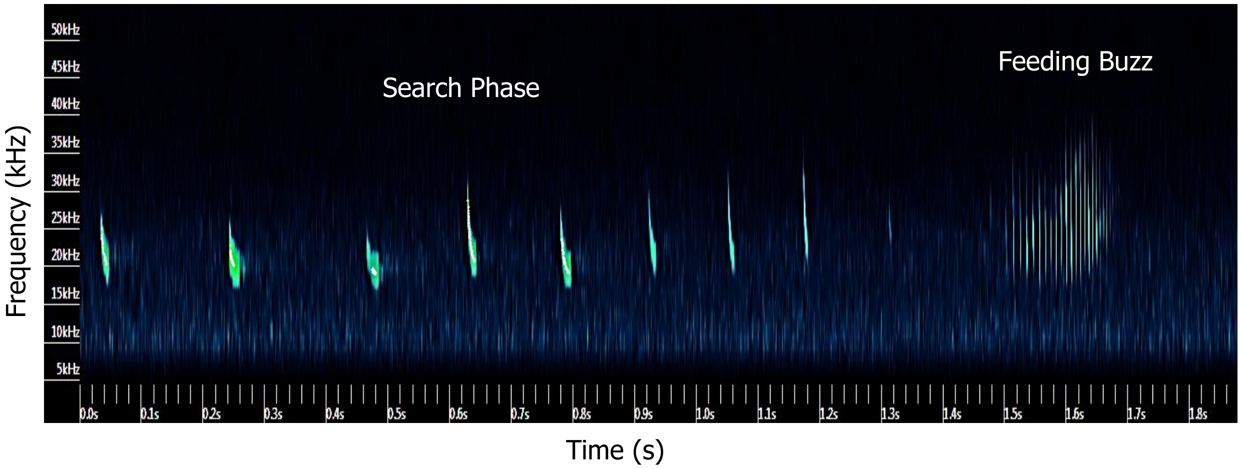

Figure 3. Spectrogram of a Hawaiian hoary bat echolocation call-event with search phase echolocation pulses (left and center) followed by a feeding buzz (far right).

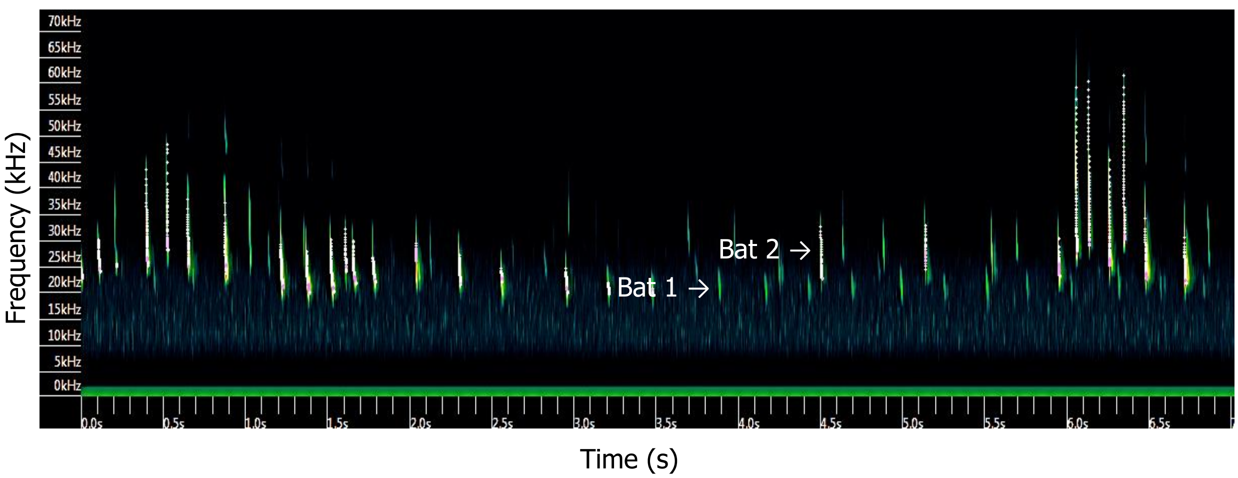

Figure 4. Spectrogram of a Hawaiian hoary bat echolocation call file containing multiple bats where each arrow points to a series of echolocation pulses from different bats.

From November 2013 through February 2015, Hawaiian hoary bat echolocation calls were recorded at each of the seven stations (KAHO1–KAHO7) using an acoustic recording unit (SM2Bat+ Song Meter Digital Field Recorder, Wildlife Acoustics, Concord, MA) programmed to record between 10 and 100 kHz. Each recording unit was deployed in a waterproof housing and powered by a 6 V external battery with solar panel for recharging. An ultrasonic microphone (SMX-US, Wildlife Acoustics, Concord, MA) was mounted on a pole 2 to 3 m above the ground and connected by cable to the recording unit (Figure 5). Microphones were omnidirectional and capable of recording bats at distances up to 25 m under ideal conditions (Adams *et al.* 2012). However, the range of call detection varies with weather conditions, vegetative clutter, and orientation of the bat's head relative to the microphone. Upon detection of a vocalizing bat, recording was triggered, and a call file was stored with the corresponding date and time on a secure digital (SD) memory card. SD memory cards were replaced every two months during which quality checks on microphones were also made. Each recording unit was programmed to operate from one hour before local sunset until one hour after local sunrise.

Figure 5. Acoustic monitoring station (left), and insect light trap (right) at the shoreline of ʽAimakapā Fishpond (KAHO3).

Hawaiian hoary bat vocalizations were organized into call-events by night using Kaleidoscope software (version 4.1.0, Wildlife Acoustics, Concord, MA). All echolocation pulses, call-events, feeding buzzes, and files with multiple bats were counted and verified by audio and visual inspection. We discarded triggered events that did not conform to standard Hawaiian hoary bat vocalization parameters (Gorresen *et al.* 2017). At each station, echolocation pulses, call-events, feeding buzzes, and occurrences of multiple bats were summed and standardized across sampling nights within each month. Echolocation pulse counts included search phase calls and feeding buzzes. Timing of nightly Hawaiian hoary bat vocalizations was determined by the time-stamp of proofed positive triggered echolocation events. Some acoustic monitoring stations had equipment malfunctions that resulted in nights where no recording occurred as shown in Appendix I. Acoustic data are available at https://doi.org/10.5066/P9S0DY53 (Montoya-Aiona *et al*. 2019).

Insect Collection

Nocturnal aerial insects were collected using a 22 W UV light placed above a funnel and bucket trap (Model #2851M, Bioquip Products Inc., Rancho Dominguez, CA) and powered by a 12 V marine deep cycle battery (Figure 5). In 2014, insect collection occurred in January and April (2 or 3 nights each) and in July and November (1 or 2 nights each). Insect traps were placed near (~10 m) KAHO1 and KAHO3 (wooded shorelines) and KAHO4 (xeric, vegetated lava field). Timers turned the lights on at approximately one hour before local sunset and off at approximately one hour after local sunrise. Insects were removed from the traps at approximately 00:00 and 06:00, and preserved in ethyl alcohol (EtOH) for later sorting.

Insect samples were counted and identified to taxonomic order under a dissecting microscope (Leica MS5, Leica Microsystems Inc., Wetzlar, DE). Samples were dried in a drying oven for approximately 48 hours at 65 °C and weighed on an analytical scale to obtain dry-biomass. Insect dry-biomass and relative abundance at each station were calculated and standardized across sampling nights within each month. Relative abundance of insect orders by station was based on frequency of occurrence of individuals. Insect capture data are available at https://doi.org/10.5066/P9S0DY53 (Montoya-Aiona *et al*. 2019).

Bat Capture Efforts

Efforts to capture bats in the Park were met with limited success and are reported in Appendix II.

Statistical Analyses

Acoustic recordings of bats were used to produce an index of occurrence, defined as the proportion of nightly samples with at least one bat echolocation detection for each one-month sample period. To capture spatial and temporal variability, the occurrence index was produced for each sample station separately for each period. A threshold for detection of at least one confirmed call-event with ≥3 echolocation pulses per night was applied to all data. Feeding buzzes were the number of individual feeding buzzes counted within a corresponding triggered event. Multiple bat occurrence was the number of occurrences of multiple bats counted within a corresponding triggered recording file. Frequency of occurrence equal to 1.0 is equivalent to recording bat calls at a station every night of the month. Zero represents no verifiable bat calls during the one-month sampling period.

ANOVA was used to assess the difference among stations (KAHO1–KAHO7) for two types of data: echolocation pulses and feeding buzzes. Tukey's post hoc analysis was used to control multi-comparison error variances.

A Mann-Whitney-Wilcoxon test was used to evaluate the difference in feeding activity, as indicated by feeding buzz detections, between reproductive (May–October) and non-reproductive (November–April) seasons. The Hawaiian hoary bat reproductive or "breeding" season (as adapted from Menard 2001) includes a pregnancy (May–June), a lactation (July–August), and a fledging/post-lactation/mating period (September–October). The remainder of the year comprises a pre-pregnancy period (November–April), which is considered the "non-breeding" period. To ensure comparability, only data for KAHO1, KAHO3, and KAHO4 were used in the analyses as these sites were sampled continuously from (November 2013 to October 2014). We report p-values adjusted for multiple comparisons using the Bonferonni method.

Additionally, ANOVA was used to assess the difference in insect "bat prey" dry-biomass among stations KAHO1, KAHO3, KAHO4. Insects classified as "bat prey" were defined as likely prey items based on insect taxa (Coleoptera, Diptera, Isoptera, Lepidoptera) previously found to be included most often in the diet of Hawaiian hoary bats (Whitaker & Tomich 1983, Jacobs 1999, Todd 2012). A Kruskal-Wallis test was used to evaluate the seasonal differences in insect "bat prey" dry-biomass among January, April, July, and November at KAHO1, KAHO3, and KAHO4. All statistical analyses were conducted with the program R (Version 3.4.3, R Development Core Team, 2016). Statistical significance was set *a priori* at alpha=0.05.

RESULTS

Bat Acoustic Activity

Echolocation calls of Hawaiian hoary bats were detected at all seven stations monitored at the Park during 2,531 detector-nights. Mean counts of echolocation pulses (Figure 6) and mean call-events (Figure 7) at the KAHO1 station were greatest in November 2014 and far exceeded those of all other stations in all months with the caveat that during January and February 2015 recording equipment at KAHO1 malfunctioned.

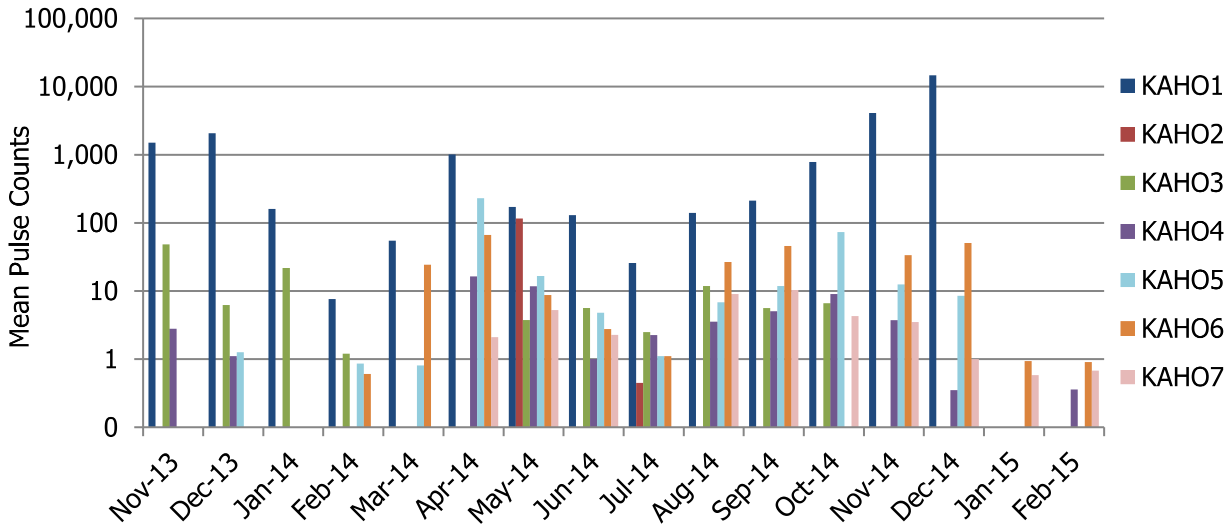

Figure 6. Mean bat echolocation pulses at acoustic detection stations by month from November 2013 to February 2015. See Appendix I for details on start-end dates of monthly acoustic counts and standard deviation (SD).

An ANOVA of the differences of bat echolocation pulses by station showed statistically significant differences among the number of echolocation pulses recorded at the seven stations (KAHO1–KAHO7) ($p<0.001$, $F=6.52$, $df=6$). A Tukey's post hoc analysis only revealed significant differences between KAHO1 and all other stations (Appendix III, Table A).

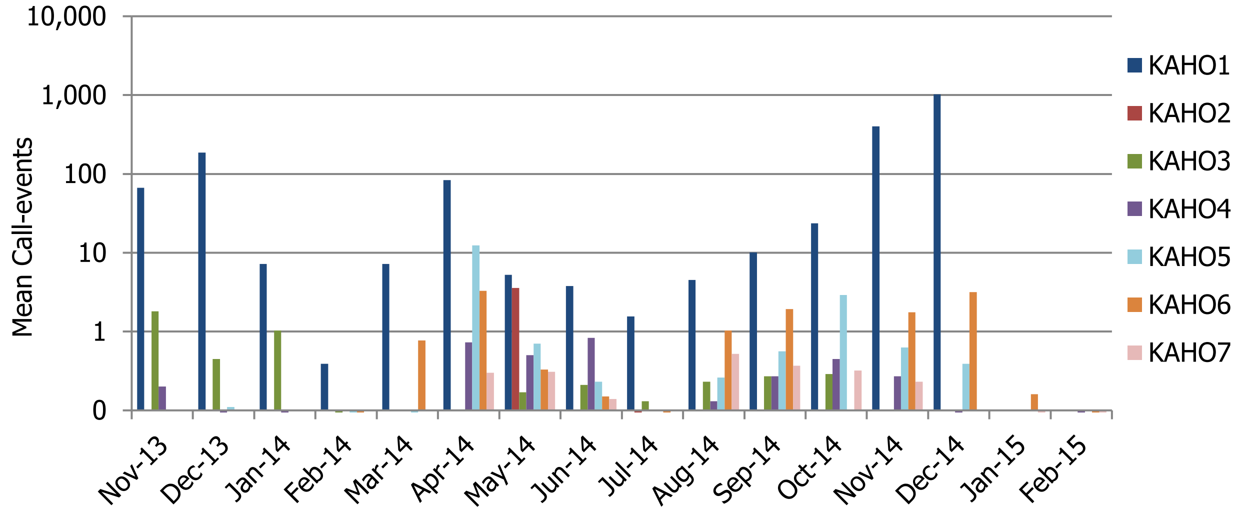

Figure 7. Mean bat call-events at acoustic detection stations by month from November 2013 to February 2015. See Appendix I for details on start-end dates of monthly acoustic counts and standard deviation (SD).

Within each month of our study, the greatest number of feeding buzzes occurred at KAHO1 (Figure 8). The maximum numbers of feeding buzzes at KAHO1 were measured in April 2014 (5,600 feeding buzzes) and November 2014 (11,434 feeding buzzes; Appendix I). At all other stations, feeding buzzes peaked in April or May 2014 and no feeding buzzes were recorded at any station in January or February 2015.

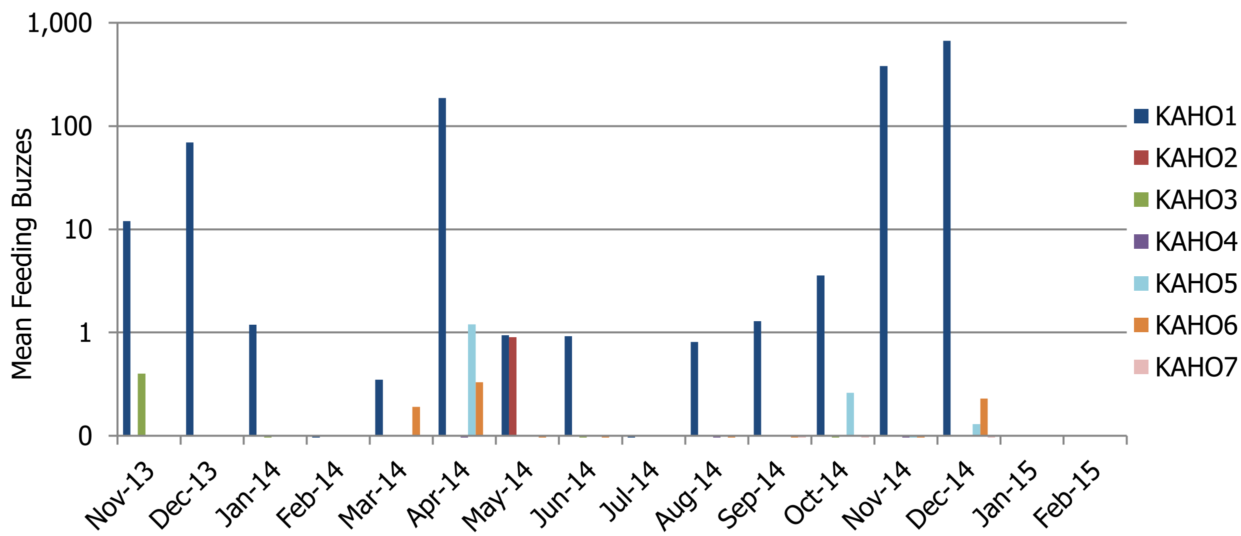

Figure 8. Mean bat feeding buzzes recorded at acoustic detection stations by month from November 2013 to February 2015. See Appendix I for details on start-end dates of monthly acoustic counts and standard deviation (SD).

An ANOVA of the differences among the number of bat feeding buzzes by station (KAHO1–KAHO7) showed statistically significant differences among the number of feeding buzzes recorded at the seven stations (KAHO1–KAHO7; p=0.005, F=3.35, df=6). A Tukey's post hoc analysis revealed a significant difference between KAHO1 and all other stations (Appendix III, Table B). Station KAHO1 had the most feeding buzz activity among all stations. There were no feeding buzzes detected in January or February 2015 due to equipment malfunction at KAHO1 and there was an absence of feeding buzzes at all other sites during those months. A Mann-Whitney-Wilcoxon test was used to test the seasonal differences in feeding buzzes between Hawaiian hoary bat reproductive (May–October) and non-reproductive (November–April) seasons at sites KAHO1, KAHO3, and KAHO4 individually. There were no significant seasonal differences at KAHO1 (W=23, p=0.471, padj=1), KAHO3 (W=17, p=0.929, padj=1) and KAHO4 (W=18.5, p=1, padj=1).

Occurrences of multiple bats were a rare event and not found at all stations. Station KAHO1 had the most occurrences of multiple bats with a peak in November and December 2014 (Figure 9). Stations KAHO2 and KAHO5 were the only other stations that had any multiple bat activity.

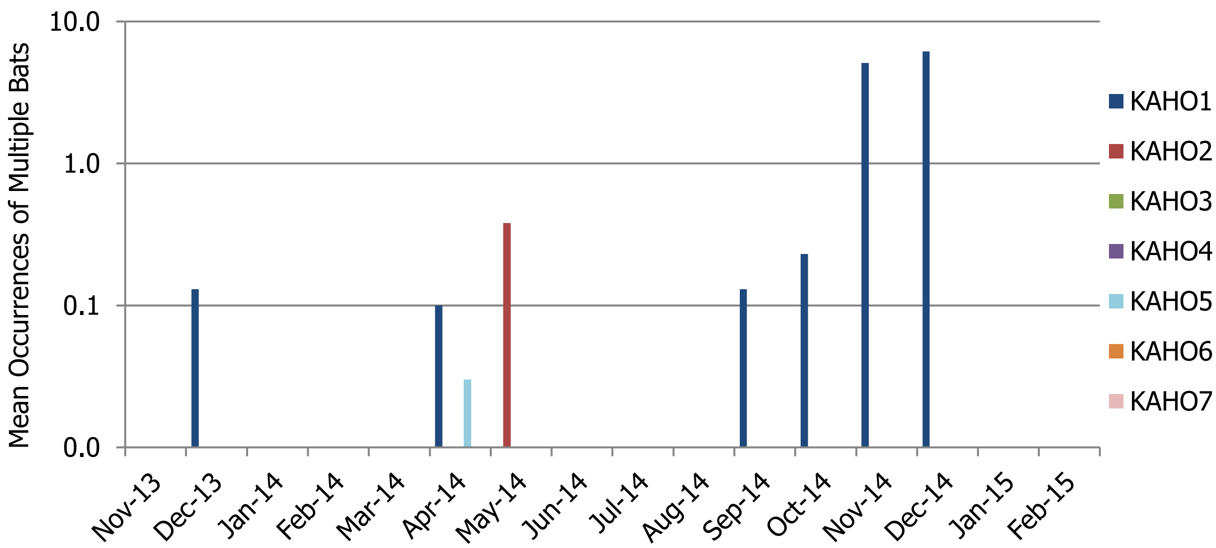

Figure 9. Mean occurrences of multiple bats recorded at acoustic detection stations by month from November 2013 to February 2015. See Appendix I for details on start-end dates of monthly acoustic counts and standard deviation (SD).

We detected three peaks in frequency of occurrence of echolocation calls across all stations: November 2013, March–May 2014, and August–December 2014 (Figure 10). The highest frequency of occurrence values in every month of our study were found at KAHO1. The timing of nightly Hawaiian hoary bat vocalizations at stations KAHO1, KAHO3, and KAHO4 from November 2013 to December 2014 was determined by analyzing time-stamps from proofed positive triggered echolocation events (Figure 11).

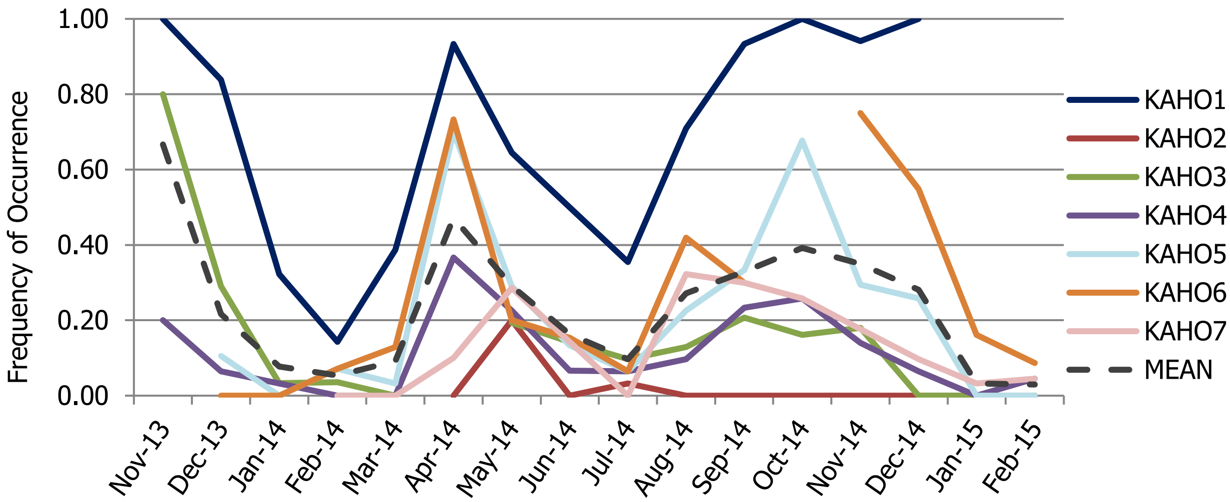

Figure 10. Monthly bat echolocation frequency of occurrence by station from November 2013 to February 2015. Dashed line is the mean of all stations. See Appendix I for details on start-end dates of monthly acoustic counts.

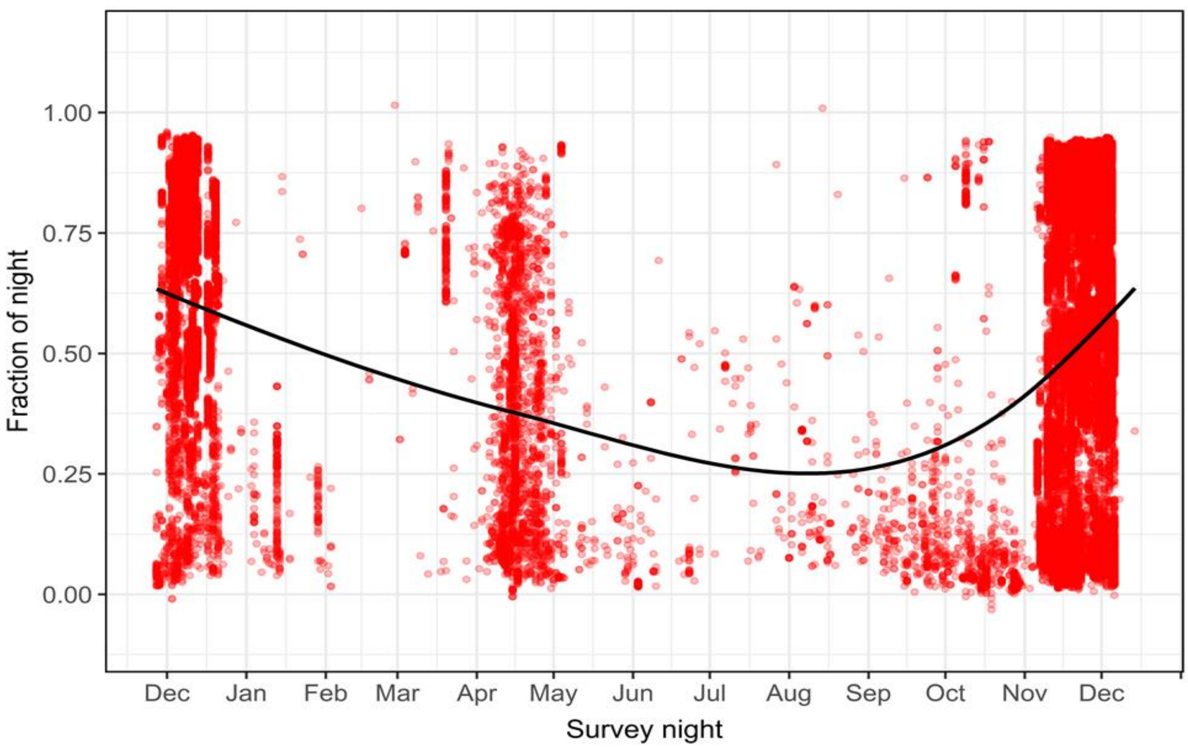

Figure 11. Detections of bat vocalization at stations KAHO1, KAHO3, KAHO4 from November 26, 2013, to December 14, 2014. Points depict bat detections by date relative to time of night. To account for seasonal differences in night length, the time of detection is standardized as a fraction of night length where 0 and 1 indicates sunset and sunrise, respectively. A loess curve fit to detections shows the trend over the survey period, and values below 0.5 indicates a greater proportion of detections in the first half of the night.

In reproductive months (May–October) nightly echolocation activity begins at or shortly after local sunset and quickly decreases as the night progresses especially during fledging/post-lactation/mating period (September–October). While in the non-reproductive season (November–April) nightly echolocation activity begins at sunset and persists through the night until nearly sunrise.

Prey Biomass and Relative Abundance

We collected 16,581 individual insects representing seven arthropod orders over 23 station-nights of light trapping at KAHO1, KAHO3, KAHO4 (Appendix IV). During January 2014, Hymenoptera had the greatest relative abundance among insect orders at all three stations followed by Lepidoptera (Figure 12). Hymenoptera and Lepidoptera represented approximately 80% of the mean dry-biomass of insects collected during January across all stations (Figure 13). During April 2014, all three stations had very similar compositions of relative abundance with Lepidoptera representing over 50% of the relative abundance among insect orders across all stations (Figure 12). Lepidoptera represented the greatest mean dry-biomass with 1.14 g and 2.42 g at each of the two fishpond stations, (KAH01 and KAH03, respectively), while Coleoptera had the greatest mean dry-biomass at KAH04 with 0.90 g (Figure 13). During July 2014, the relative abundance of insects was similar at KAHO1 and KAHO3, with Lepidoptera representing >55% of the relative abundance of insects at these stations (Figure 12). At KAHO4, Diptera had the greatest relative abundance of insects at 38% (Figure 12). However, Coleoptera represented the greatest mean dry-biomass at KAHO4 (0.97 g) while Lepidoptera had the greatest mean dry-biomass at KAHO1 (0.76 g) and KAHO3 (1.30 g) (Figure 13). In November 2014, stations KAHO1 and KAHO3 had similar relative abundances with Lepidoptera representing >70% of the relative abundance (Figure 12). At KAHO4, Diptera had the greatest relative abundance (40%) followed by Lepidoptera (37%) (Figure 12). During November 2014, Lepidoptera had the greatest mean dry-biomass with 6.10 g, 2.78 g and 1.93 g at KAHO1, KAHO3, and KAHO4 respectively (Figure 13).

Overall, Lepidopterans represented the greatest mean dry-biomass of "bat prey" insect resource across all stations in all months except at KAHO4 in July as discussed above. Moreover, Lepidoptera had the greatest mean dry-biomass across all stations in April and November 2014. Total mean insect dry-biomass across all stations was smallest in July with 1.98 g, and peaked in November at 6.57 g.

An ANOVA of insect dry-biomass by station showed no statistically significant differences (p=0.921, F=0.083, df=2). Additionally, an ANOVA of only "bat prey" insect dry-biomass by station also showed no statistically significant differences among stations (p=0.501, F=0.748, df=2). A Kruskal-Wallis test was used to evaluate the seasonal differences in insect "bat prey" dry-biomass among January, April, July, and November collection times at KAHO1, KAHO3, and KAHO4. There was no statistically significant difference in seasonal "bat prey" dry-biomass at these collection sites (p=0.086, X^2=6.590, df=3).

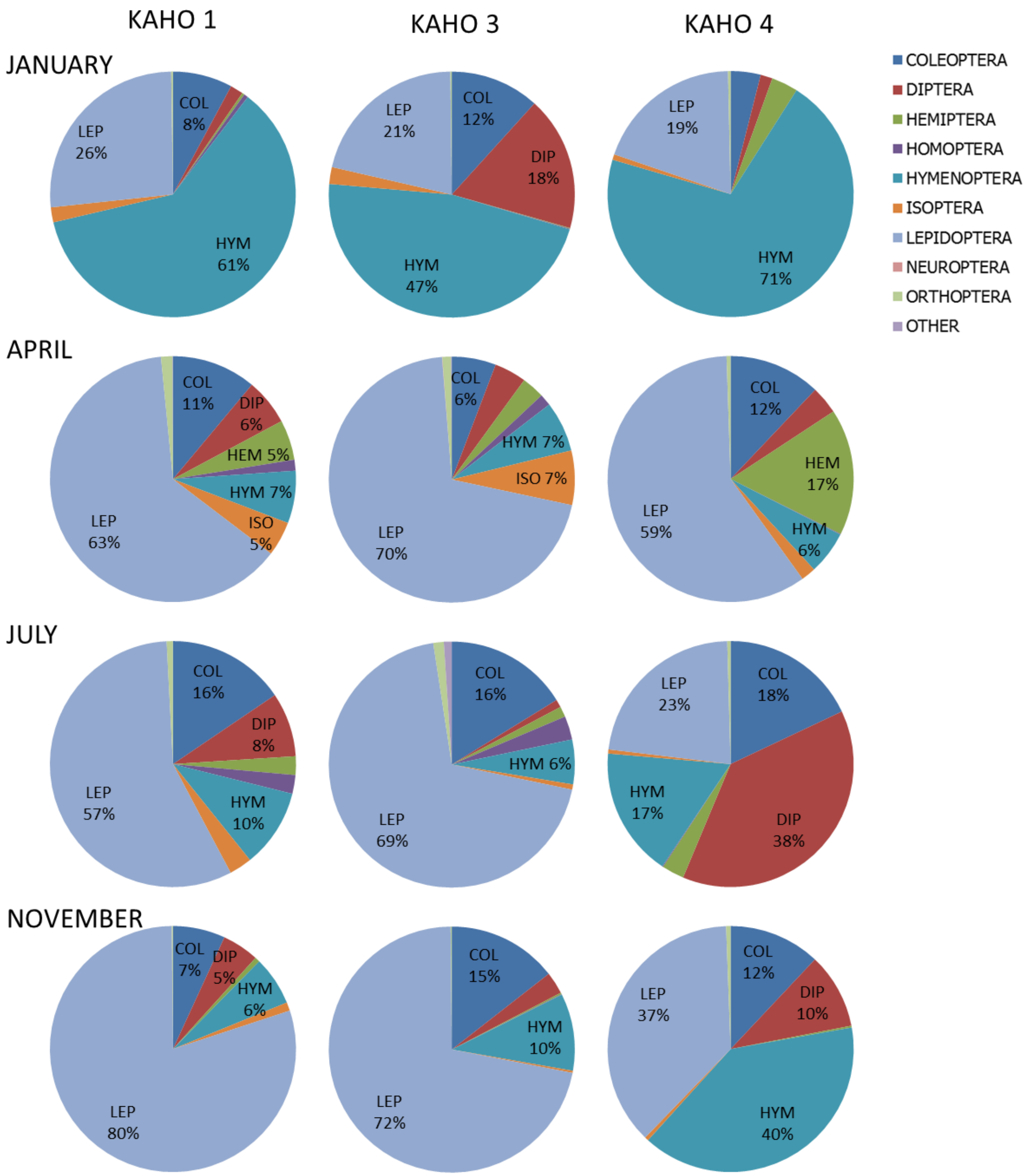

Figure 12. Relative abundance by insect order for stations KAHO1, KAHO3, KAHO4 sampled in January, April, July, and November 2014. Abundance values <5% are not labeled. Primary "bat prey" include Coleoptera, Diptera, Isoptera, and Lepidoptera. See Appendix IV for details.

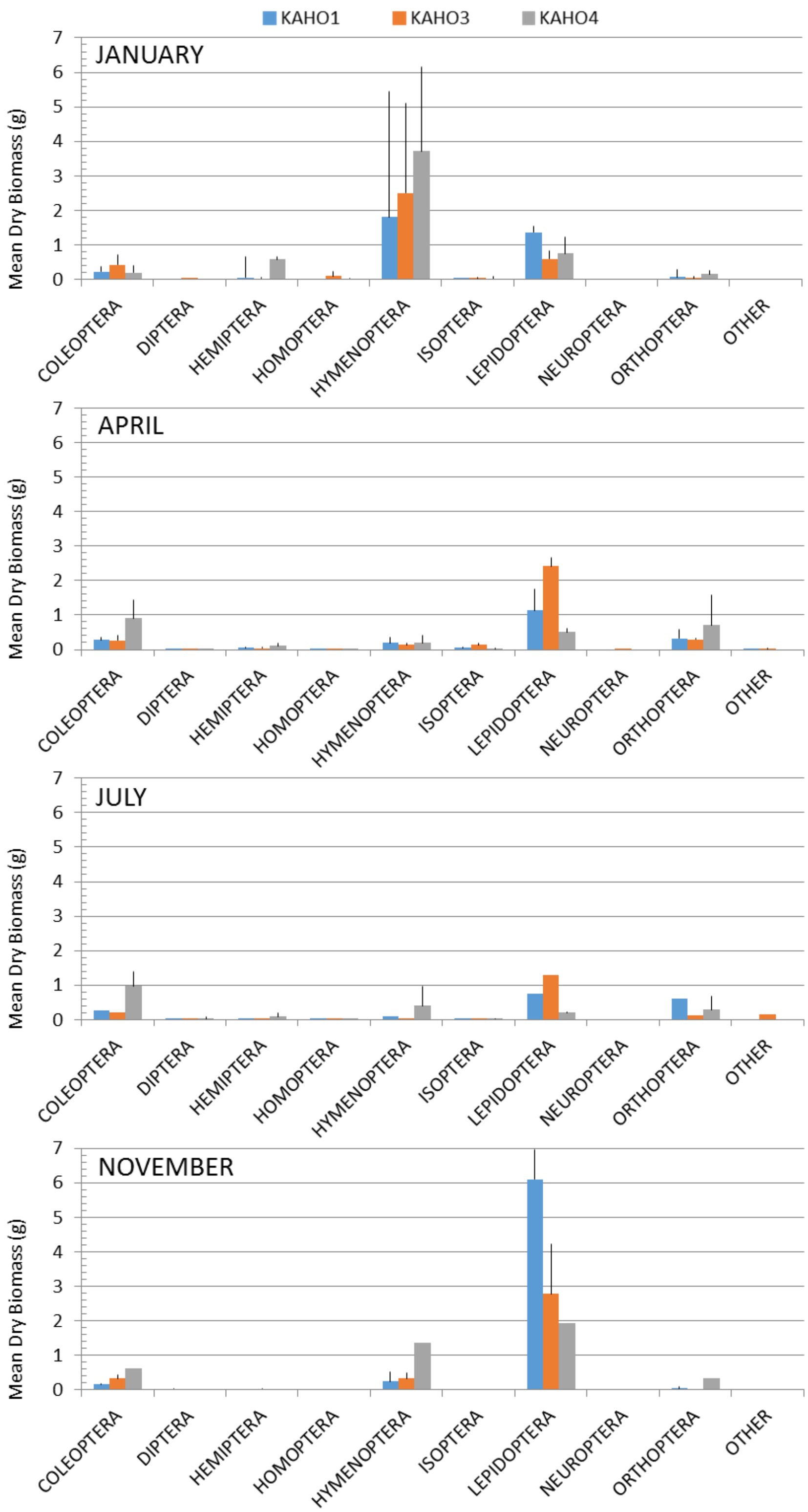

Figure 13. Mean dry-biomass (g) by insect order for stations KAHO1, KAHO3, KAHO4 sampled in January, April, July and November 2014. Primary "bat prey" include Coleoptera, Diptera, Isoptera, and Lepidoptera. Standard deviation (SD) error bars are shown for stations sampled >1 night per sampling period. See Appendix IV for details.

Discussion

Bat echolocation activity in the Park showed seasonal patterns in pulse counts, call-events, feeding buzzes, and frequency of occurrence. Seasonal variation of bat activity levels was evident from the cyclic patterns in frequency of occurrence. There were three major peaks in bat echolocation activity during our study: November–December 2013, April–May 2014, and August–December 2014. Gorresen *et al*. (2013) also reported consistent annual peaks in bat activity over five years in lowland regions of Hawai'i during summer and autumn (June–August and September–November, respectively). Menard (2001), Gorresen *et al*. (2013), and Bonaccorso *et al*. (2015) all suggested that on the island of Hawai'i, hoary bats concentrate foraging activity in the coastal lowlands during pupping and fledgling, and move to interior highlands during the winter, especially between January and March. This pattern of seasonal movement between lowlands and highlands on Hawai'i when superimposed over the reproductive seasonality is supported by our current acoustic data. The peak in bat activity in the Park from August to December 2014, most notably at KAHO1 and KAHO5, corresponds with annual fledging and mother-pup group foraging for hoary bats. Occurrences of multiple bats, while rare, were most abundant at KAHO1 especially in November and December 2014. During the fledging period the total Hawaiian hoary bat population theoretically should be at its annual maximum, thus contributing to increased bat activity (Gorresen *et al*. 2013). We visually observed up to three bats flying together above Kaloko Fishpond (KAHO1) at dusk during the fledging season, possibly representing an adult female foraging with twin offspring (twin pups are typical in this species). Although there are rare occurrences of multiple bats in the park, particularly at KAHO1, demographics such as age, sex, reproductive status and diet cannot be identified with acoustic methods.

Gorresen *et al*. (2013) suggested that additional variables including localized population irruptions of insect prey and weather conditions such as prolonged or intensified weather events or stationary fronts may contribute to complex patterns in bat activity. Ongoing restoration and invasive plant species removal at the Park fishponds near KAHO1 and KAHO3 may have contributed to localized habitat changes during our study that may have influenced prey availability and bat activity.

Levels of bat activity, as measured by recordings of echolocation calls, may be associated with proximity to both prey abundance and drinking resources in the semi-arid region of leeward Hawai'i Island. Several studies have found relationships between high bat activity and pond habitats. Siebold *et al.* (2013) found echolocation activity was higher around ponds than meadows and clear-cuts in Germany. Gruenstein (2014) found a positive association between insectivorous bat foraging activity at lakes stocked with trout compared to lakes without trout in the Sierra Nevada Mountains of North America. In coastal wetlands of South Carolina, the abundance and diversity of insects were not related to levels of bat activity (Moore & Best 2018); however, there was significantly less activity where vegetation covered water surfaces compared to open-water, and freshwater habitats had greater activity by bats than brackish or saltwater habitats. Distinct echolocation 'drinking buzzes' that guide aerial drinking maneuvers have been identified in some bat species (Russo *et al*. 2015). Thus, potential overestimation of foraging activity where surface water is present may occur, if 'drinking buzzes' are not considered. Although we did not attempt to distinguish drinking calls from foraging calls, the high salt content of the fish ponds in the Park make it unlikely that Hawaiian hoary bats drink in this habitat, particularly at Kaloko Fishpond, which has surface exchange with the ocean.

We found that bat acoustic activity was greater near fishponds, particularly KAHO1, compared to xeric habitats. While mean insect biomass was not significantly different among the three stations, Kaloko Fishpond (KAHO1) had by far the greatest amount of bat echolocation activity compared to all other stations and high moth abundance throughout the study including select species that are ideal prey size for Hawaiian hoary bats. Our data suggest that the Kaloko Fishpond (KAHO1) is a foraging area of importance for Hawaiian hoary bats, especially during the latter part of the reproductive season. It was the only area where we visually identified multiple bats flying together and the only station where we were able to capture a bat with mist-nets. Pinzari *et al.* (2014) also found that bats were active primarily along the wooded shorelines adjacent to the Park's fishponds; whereas little activity was observed over the inland xeric habitats of barren lava and scattered shrubs in the Park. With the possible exception of coconut palms there are virtually no large shade trees in the Park like those observed to be used by Hawaiian hoary bats as day roosts elsewhere on the island of Hawai'i. Nevertheless, bats do use the Park as a foraging area that may be particularly important when food resources are scarce elsewhere (Pinzari *et al*. 2014). These results represent a baseline for assessing bat activity and prey availability in a habitat that had not previously been intensively studied. Additional studies that include genetic barcoding of insects and identification of insect taxa in fecal pellet content from bats would provide a more thorough understanding of Hawaiian hoary bat diets at the Park and elsewhere.

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LITERATURE CITED

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Appendix I. Bat Acoustic Data

Ultrasonic vocalizations used for echolocation by Hawaiian hoary bats, including call-events with search phase and terminal phase calls, and occurrences with multiple bats were recorded nightly from November 2013 through February 2015. Total counts (T-Count), mean counts (M-Count) with standard deviation (SD), and total number of sample nights (S-Nights) are shown by station and month. Note that "–"is indicative of a period where equipment malfunctioned or acoustic recording was otherwise not available.

Pulses

Station		Nov-13	Dec-13	Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15
KAHO1	T-Count	7506	63716	4972	212	1705	60140	5331	3083	800	4372	6394	24184	121668	87539	-	-
	M-Count	1501.20	2055.36	160.38	7.57	55.00	1004.66	171.97	128.46	25.81	141.03	213.13	780.13	4055.60	14589.83	-	-
	SD	698.86	2069.48	585.52	18.90	186.66	2163.63	328.55	356.06	56.45	173.67	211.13	839.36	3477.22	6767.80	-	-
	S-Nights	5	31	31	28	31	30	31	24	31	31	30	31	30	6	0	0
KAHO2	T-Count	-	-	-	-	-	-	2436	0	14	0	0	0	0	0	0	0
	M-Count	-	-	-	-	-	-	116.00	0	0.45	0	0	0	0	0	0	0
	SD	-	-	-	-	-	-	324.14	0	2.51	0	0	0	0	0	0	0
	S-Nights	0	0	0	0	0	0	21	19	31	31	30	31	30	31	31	22
KAHO3	T-Count	241	194	659	34	0	-	113	158	77	367	167	205	0	0	0	0
	M-Count	48.20	6.26	21.97	1.21	0	-	3.77	5.64	2.48	11.84	5.57	6.61	0	0	0	0
	SD	36.40	14.14	88.02	6.43	0	-	7.37	15.68	7.42	55.99	14.59	17.58	0	0	0	0
	S-Nights	5	31	30	28	9	0	30	28	31	31	30	31	30	31	31	22
KAHO4	T-Count	14	34	3	0	0	489	350	15	70	110	151	280	111	11	0	8
	M-Count	2.80	1.10	0.10	0	0	16.30	11.67	1.00	2.26	3.55	5.03	9.03	3.70	0.35	0	0.36
	SD	6.26	5.41	0.54	0	0	33.46	27.23	3.87	9.67	13.35	11.57	30.13	8.78	1.42	0	1.71
	S-Nights	5	31	31	28	31	30	30	15	31	31	30	31	30	31	31	22
KAHO5	T-Count	-	24	0	24	25	6880	499	144	34	211	356	2260	374	266	0	0
	M-Count	-	1.26	0	0.86	0.81	229.33	16.63	4.80	1.10	6.81	11.87	72.90	12.47	8.58	0	0
	SD	-	4.01	0	3.14	4.49	311.41	31.68	14.20	4.46	14.97	22.62	198.51	22.35	21.41	0	0
	S-Nights	0	19	2	28	31	30	30	30	31	31	30	31	30	31	31	22
KAHO6	T-Count	-	0	0	17	759	2008	261	36	34	828	550	-	402	1565	29	21
	M-Count	-	0	0	0.61	24.48	66.93	8.70	2.77	1.10	26.71	45.83	-	33.50	50.48	0.94	0.91
	SD	-	0	0	2.33	119.50	86.20	21.77	7.34	4.28	48.09	53.07	-	53.43	82.72	2.19	3.03
	S-Nights	0	20	2	28	31	30	30	13	31	31	12	0	12	31	31	23
KAHO7	T-Count	-	0	-	0	0	21	68	32	0	280	312	132	106	31	18	15
	M-Count	-	0	-	0	0	2.10	5.23	2.29	0	9.03	10.40	4.26	3.53	1.00	0.58	0.68
	SD	-	0	-	0	0	3.48	9.05	6.02	0	27.79	32.96	9.99	11.29	3.88	3.23	3.20
	S-Nights	0	15	0	10	17	10	13	14	31	31	30	31	30	31	31	22

Call-events

Station		Nov-13	Dec-13	Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15
KAHO1	T-Count	332	5784	224	11	223	2495	163	91	48	140	302	731	12081	6139	-	-
	M-Count	66.40	186.58	7.23	0.39	7.19	83.17	5.25	3.79	1.55	4.52	10.07	23.58	402.70	1023.17	-	-
	SD	38.32	190.29	26.77	0.99	27.29	85.26	9.99	8.34	2.68	5.08	10.16	24.27	310.05	359.55	-	-
	S-Nights	5	31	31	28	31	30	31	24	31	31	30	31	30	6	0	0
KAHO2	T-Count	-	-	-	-	-	-	75	0	1	0	0	0	0	0	0	0
	M-Count	-	-	-	-	-	-	3.57	0	0.03	0	0	0	0	0	0	0
	SD	-	-	-	-	-	-	10.63	0	0.18	0	0	0	0	0	0	0
	S-Nights	0	0	0	0	0	0	21	19	31	31	30	31	30	31	31	22
KAHO3	T-Count	9	14	31	2	0	-	6	6	4	7	8	9	0	0	0	0
	M-Count	1.80	0.45	1.03	0.07	0	-	0.17	0.21	0.13	0.23	0.27	0.29	0	0	0	0
	SD	1.30	0.81	3.68	0.38	0	-	0.38	0.63	0.34	0.80	0.64	0.74	0	0	0	0
	S-Nights	5	31	30	28	9	0	30	28	31	31	30	31	30	31	31	22
KAHO4	T-Count	1	2	1	0	0	22	15	1	3	4	8	14	8	2	0	1
	M-Count	0.20	0.06	0.03	0	0	0.73	0.50	0.83	0.10	0.13	0.27	0.45	0.27	0.06	0	0.05
	SD	0.45	0.25	0.18	0	0	1.14	1.20	0.26	0.40	0.43	0.52	1.15	0.52	0.25	0	0.21
	S-Nights	5	31	31	28	31	30	30	15	31	31	30	31	30	31	31	22
KAHO5	T-Count	-	2	0	2	1	373	21	7	3	8	15	90	19	12	0	0
	M-Count	-	0.11	0	0.07	0.03	12.43	0.70	0.23	0.10	0.26	0.56	2.90	0.63	0.39	0	0
	SD	-	0.32	0	0.26	0.18	15.75	1.21	0.63	0.30	0.51	0.86	7.37	1.00	0.67	0	0
	S-Nights	0	19	2	28	31	30	30	30	31	31	30	31	30	31	31	22
KAHO6	T-Count	-	0	0	2	24	99	10	2	2	32	23	-	21	98	5	2
	M-Count	-	0	0	0.07	0.77	3.30	0.33	0.15	0.06	1.03	1.92	-	1.75	3.16	0.16	0.09
	SD	-	0	0	0.26	3.41	3.88	0.76	0.38	0.25	1.56	2.43	-	1.66	4.88	0.37	0.29
	S-Nights	0	20	2	28	31	30	30	13	31	31	12	0	12	31	31	23
KAHO7	T-Count	-	0	-	0	0	3	4	2	0	16	11	10	7	3	1	1
	M-Count	-	0	-	0	0	0.30	0.31	0.14	0	0.52	0.37	0.32	0.23	0.10	0.03	0.05
	SD	-	0	-	0	0	0.48	0.48	0.36	0	1.03	0.61	0.60	0.50	0.30	0.18	0.21
	S-Nights	0	15	0	10	17	10	13	14	31	31	30	31	30	31	31	22

Feeding Buzzes

Station		Nov-13	Dec-13	Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15
KAHO1	T-Count	60	2150	37	1	11	5600	29	22	2	25	36	111	11434	4024	-	-
	M-Count	12.00	69.35	1.19	0.04	0.35	186.67	0.94	0.92	0.06	0.81	1.29	3.58	381.13	670.67	-	-
	SD	9.13	75.54	4.41	0.19	1.98	217.68	2.63	3.87	0.25	1.56	1.21	5.97	408.65	376.91	-	-
	S-Nights	5	31	31	28	31	30	31	24	31	31	30	31	30	6	0	0
KAHO2	T-Count	-	-	-	-	-	-	19	0	0	0	0	0	0	0	0	0
	M-Count	-	-	-	-	-	-	0.90	0	0	0	0	0	0	0	0	0
	SD	-	-	-	-	-	-	2.30	0	0	0	0	0	0	0	0	0
	S-Nights	0	0	0	0	0	0	21	19	31	31	30	31	30	31	31	22
KAHO3	T-Count	2	0	2	0	0	-	0	1	0	3	0	1	0	0	0	0
	M-Count	0.40	0	0.07	0	0	-	0	0.04	0	0.10	0	0.03	0	0	0	0
	SD	0.89	0	0.37	0	0	-	0	0.19	0	0.55	0	0.18	0	0	0	0
	S-Nights	5	31	30	28	9	0	30	28	31	31	30	31	30	31	31	22
KAHO4	T-Count	0	0	0	0	0	2	0	0	0	1	0	0	1	0	0	0
	M-Count	0	0	0	0	0	0.07	0	0	0	0.03	0	0	0.03	0	0	0
	SD	0	0	0	0	0	0.37	0	0	0	0.18	0	0	0.19	0	0	0
	S-Nights	5	31	31	28	31	30	30	15	31	31	30	31	30	31	31	22
KAHO5	T-Count	-	0	0	0	0	36	0	0	0	0	0	8	1	4	0	0
	M-Count	-	0	0	0	0	1.20	0	0	0	0	0	0.26	0.03	0.13	0	0
	SD	-	0	0	0	0	2.02	0	0	0	0	0	0.68	0.18	0.43	0	0
	S-Nights	0	19	2	28	31	30	30	30	31	31	30	31	30	31	31	22
KAHO6	T-Count	-	0	0	0	6	10	1	1	0	1	1	-	1	7	0	0
	M-Count	-	0	0	0	0.19	0.33	0.03	0.08	0	0.03	0.08	-	0.08	0.23	0	0
	SD	-	0	0	0	0.75	0.71	0.18	0.28	0	0.18	0.29	-	0.29	0.50	0	0
	S-Nights	0	20	2	28	31	30	30	13	31	31	12	0	12	31	31	23
KAHO7	T-Count	-	0	-	0	0	0	0	0	0	0	2	1	0	1	0	0
	M-Count	-	0	-	0	0	0	0	0	0	0	0.07	0.03	0	0.03	0	0
	SD	-	0	-	0	0	0	0	0	0	0	0.37	0.18	0	0.18	0	0
	S-Nights	0	15	0	10	17	10	13	14	31	31	30	31	30	31	31	22

Occurrences of Multiple Bats

Station		Nov-13	Dec-13	Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15
KAHO1	T-Count	0	4	0	0	0	3	0	0	0	0	4	7	153	37	-	-
	M-Count	0	0.13	0	0	0	0.10	0	0	0	0	0.13	0.23	5.10	6.17	-	-
	SD	0	0.42	0	0	0	0.55	0	0	0	0	0.57	0.67	6.92	2.99	-	-
	S-Nights	5	31	31	28	31	30	31	24	31	31	30	31	30	6	0	0
KAHO2	T-Count	-	-	-	-	-	-	8	0	0	0	0	0	0	0	0	0
	M-Count	-	-	-	-	-	-	0.38	0	0	0	0	0	0	0	0	0
	SD	-	-	-	-	-	-	1.32	0	0	0	0	0	0	0	0	0
	S-Nights	0	0	0	0	0	0	21	19	31	31	30	31	30	31	31	22
KAHO3	T-Count	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	0
	M-Count	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	0
	SD	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	0
	S-Nights	5	31	30	28	9	0	30	28	31	31	30	31	30	31	31	22
KAHO4	T-Count	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	M-Count	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	S-Nights	5	31	31	28	31	30	30	15	31	31	30	31	30	31	31	22
KAHO5	T-Count	-	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
	M-Count	-	0	0	0	0	0.03	0	0	0	0	0	0	0	0	0	0
	SD	-	0	0	0	0	0.18	0	0	0	0	0	0	0	0	0	0
	S-Nights	0	19	2	28	31	30	30	30	31	31	30	31	30	31	31	22
KAHO6	T-Count	-	0	0	0	0	0	0	0	0	0	0	-	0	0	0	0
	M-Count	-	0	0	0	0	0	0	0	0	0	0	-	0	0	0	0
	SD	-	0	0	0	0	0	0	0	0	0	0	-	0	0	0	0
	S-Nights	0	20	2	28	31	30	30	13	31	31	12	0	12	31	31	23
KAHO7	T-Count	-	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0
	M-Count	-	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0
	SD	-	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0
	S-Nights	0	15	0	10	17	10	13	14	31	31	30	31	30	31	31	22

APPENDIX II. BAT CAPTURE EFFORTS

To determine the demographics of Hawaiian hoary bats in the Park we attempted to capture bats within the Park's boundaries (Figure 1). We operated 6 and 9 m length mist-nets with an UltraSoundGate Player BL Light acoustic lure (Avisoft Bioacoustics, Glienicke, DE) from sunset to midnight near KAHO1 and KAHO3 on nine nights during 2014. Netting was conducted in tandem with insect light trapping in January, April, July and November for a total of 460 net-hours. One adult male bat was captured on 17 November, 2014 (Figure 14). We recorded reproductive condition, age class (adult), sex (male), weight (12.5 g), forearm length (46.5 mm), and collected wing tissue biopsies, guano samples, and hair clippings. The protocol for handling bats was approved by the Institutional Animal Care and Use Committee (IACUC #04-039-12) through the University of Hawai'i at Hilo following guidelines of the American Society of Mammalogists. Biological samples were collected under permits USFWS TE003483-31 and Hawai'i DLNR-DOFAW WL16-04. The protocol for handling bats was approved by the Institutional Animal Care and Use Committee (IACUC #04-039-12) through the University of Hawai'i at Hilo following guidelines of the American Society of Mammalogists (Sikes & Gannon 2011).

Figure 14. Photo of adult male captured at Kaloko Fishpond (KAHO1) on 17 November 2014.

Additionally, NPS field crew observed a bat swimming from the center towards the southern shoreline in Kaloko Fishpond at approximately 8:15 am on 13 January, 2014. The bat became entangled in pickleweed along the shoreline and a field crew member retrieved it and placed it on a nearby tree where it hung for a time before flying toward the SE and was not observed again (Tyler Paikuli-Campbell, NPS, pers comm).

APPENDIX III. SUMMARY STATISTICS

ANOVA were used to assess the difference in number of echolocation pulses, call-events, and feeding buzzes between acoustic recording stations (KAHO1-KAHO7). Tukey's post hoc analysis was used to verify differences by groups when statistically significant differences among stations were determined through ANOVA. Summary statistics are presented below.

Appendix III Table A. Tukey's post hoc comparison of differences in total number of echolocation pulses among seven monitoring stations. P-value adjustment using Tukey method for comparing a family of seven estimates, significant level of alpha = 0.05.

Station	ls mean	SE	df	Lower CI	Upper CI	Group
KAHO 7	92.272	4599.226	86	-12547.24	12731.78	a
KAHO 4	102.875	3813.477	86	-10377.25	10583.00	a
KAHO 3	138.437	3813.477	86	-10341.69	10618.56	a
KAHO 2	245.000	4823.709	86	-13011.43	13501.43	a
KAHO 6	542.500	4403.424	86	-11558.91	12643.91	a
KAHO 5	792.642	4076.778	86	-10411.08	11996.37	a
KAHO 1	27973.000	4079.778	86	16769.27	39176.73	b

Appendix III Table B. Tukey's post hoc comparison of differences in echolocation feeding buzzes among seven monitoring stations. P-value adjustment using Tukey method for comparing a family of seven estimates, significant level of alpha = 0.05.

Station	ls mean	SE	df	Lower CI	Upper CI	Group
KAHO 7	0.363	389.267	86	-1069.414	1070.141	a
KAHO 3	1.875	322.763	86	-885.137	888.887	a
KAHO 2	1.900	408.267	86	-1120.092	1123.892	a
KAHO 6	2.333	372.695	86	-1021.900	1026.567	a
KAHO 5	3.500	345.048	86	-944.756	951.756	a
KAHO 4	0.250	322.763	86	-886.762	887.262	a
KAHO 1	1681.571	493.745	86	323.881	3039.261	b

APPENDIX IV. INSECT DATA

Nocturnal aerial insects were collected for 1 to 3 nights during January, April, July and November, 2014 at stations KAHO1, KAHO3, KAHO4. Total dry-biomass (T-Biomass), mean dry-biomass (M-Biomass), total counts (T-counts) and mean counts (M-Count) are shown below with standard deviation (SD) and count data proportions (Prop) relative to all taxa. Insect taxa sampled include Coleoptera (COL)*, Diptera (DIP)*, Hemiptera (HEM), Homoptera (HOM), Hymenoptera (HYM), Isoptera (ISO)*, Lepidoptera (LEP)*, Neuroptera (NEU), Orthoptera (ORT). Asterisk denotes primary "bat prey".

January

Station	Nights		COL*	DIP*	HEM	HOM	HYM	ISO*	LEP*	NEU	ORT	OTHER	TOTAL
KAHO1	2	T-Biomass (g)	0.4611	0.0163	0.1135	0.0263	3.6234	0.1018	2.7320	0.0000	0.1425	0.0000	7.2169
		M-Biomass (g)	0.2306	0.0082	0.0568	0.0132	1.8117	0.0509	1.3660	0.0000	0.0713	0.0000	3.6085
		SD	0.1978	0.0108	0.0800	0.0186	2.4266	0.0588	0.4748	0.0000	0.1010	0.0000	
		T-Count	171	37	7	12	1326	43	576	0	5	0	2177
		M-Count	86	19	4	6	663	22	288	0	3	0	1089
		SD	21	18	4	8	875	25	91	0	4	0	
		Prop.	7.9%	1.7%	0.3%	0.6%	60.9%	2.0%	26.5%	0.0%	0.2%	0.0%	100.0%
KAHO3	2	T-Biomass (g)	0.8397	0.0667	0.0473	0.1912	5.0164	0.0671	1.1795	0.0000	0.0795	0.0000	7.4874
		M-Biomass (g)	0.4199	0.0334	0.0237	0.0956	2.5082	0.0336	0.5898	0.0000	0.0398	0.0000	3.7437
		SD	0.2862	0.0110	0.0335	0.1352	2.6074	0.0354	0.2286	0.0000	0.0562	0.0000	
		T-Count	132	199	1	1	527	25	239	0	2	0	1126
		M-Count	66	100	1	1	264	13	120	0	1	0	563
		SD	37	23	1	1	173	13	33	0	1	0	
		Prop.	11.7%	17.7%	0.1%	0.1%	46.8%	2.2%	21.2%	0.0%	0.2%	0.0%	100.0%
KAHO4	2	T-Biomass (g)	0.3970	0.0129	1.1665	0.0000	7.4374	0.0332	1.5052	0.0000	0.2939	0.0000	10.8461
		M-Biomass (g)	0.1985	0.0065	0.5833	0.0000	3.7187	0.0166	0.7526	0.0000	0.1470	0.0000	5.4231
		SD	0.1346	0.0066	0.5987	0.0000	3.6293	0.0096	0.1709	0.0000	0.2078	0.0000	
		T-Count	70	28	62	0	1252	13	345	0	6	0	1776
		M-Count	35	14	31	0	626	7	173	0	3	0	888
		SD	25	10	25	0	27	4	11	0	4	0	
		Prop.	3.9%	1.6%	3.5%	0.0%	70.5%	0.7%	19.4%	0.0%	0.3%	0.0%	100.0%

April

Station	Nights		COL*	DIP*	HEM	HOM	HYM	ISO*	LEP*	NEU	ORT	OTHER	TOTAL
KAHO1	3	T-Biomass (g)	0.8535	0.1055	0.1500	0.0387	0.5805	0.1399	3.4088	0.0000	0.9823	0.0064	6.2655
		M-Biomass (g)	0.2845	0.0352	0.0500	0.0129	0.1935	0.0466	1.1363	0.0000	0.3274	0.0021	2.0885
		SD	0.0857	0.0186	0.0198	0.0153	0.1545	0.0274	0.6078	0.0000	0.2479	0.0037	
		T-Count	185	102	88	24	115	76	1053	0	25	1	1669
		M-Count	62	34	29	8	38	25	351	0	8	0	556
		SD	30	20	11	8	21	17	204	0	4	1	
		Prop.	11.1%	6.1%	5.3%	1.4%	6.9%	4.6%	63.1%	0.0%	1.5%	0.1%	100.0%
KAHO3	3	T-Biomass (g)	0.8032	0.0975	0.1094	0.0388	0.4016	0.3905	7.2566	0.0017	0.8626	0.0361	9.9979
		M-Biomass (g)	0.2677	0.0325	0.0365	0.0129	0.1339	0.1302	2.4189	0.0006	0.2875	0.0120	3.3326
		SD	0.1366	0.0236	0.0322	0.0008	0.0645	0.0667	0.2485	0.0010	0.0416	0.0209	
		T-Count	146	106	75	39	167	180	1770	1	29	2	2515
		M-Count	49	35	25	13	56	60	590	0	10	1	838
		SD	6	19	18	5	35	29	129	1	3	1	
		Prop.	5.8%	4.2%	3.0%	1.6%	6.6%	7.2%	70.4%	0.0%	1.2%	0.1%	
KAHO4	2	T-Biomass (g)	1.8053	0.0058	0.2227	0.0002	0.3725	0.0445	1.0223	0.0000	1.4152	0.0000	4.8886
		M-Biomass (g)	0.9027	0.0029	0.1114	0.0001	0.1863	0.0223	0.5112	0.0000	0.7076	0.0000	2.4443
		SD	0.5308	0.0012	0.0843	0.0002	0.2267	0.0108	0.0911	0.0000	0.8753	0.0000	
		T-Count	138	42	190	1	65	22	679	0	6	0	1143
		M-Count	69	21	95	1	33	11	340	0	3	0	572
		SD	6	0	81	1	23	6	19	0	3	0	
		Prop.	12.1%	3.7%	16.6%	0.1%	5.7%	1.9%	59.4%	0.0%	0.5%	0.0%	100.0%

July

Station	Nights		COL*	DIP*	HEM	HOM	HYM	ISO*	LEP*	NEU	ORT	OTHER	TOTAL
KAHO1	1	T-Biomass (g)	0.2561	0.0205	0.0227	0.0160	0.0880	0.0216	0.7571	0.0000	0.5983	0.0000	1.7802
		M-Biomass (g)	-	-	-	-	-	-	-	-	-	-	
		SD	-	-	-	-	-	-	-	-	-	-	
		T-Count	57	31	9	9	38	11	209	0	3	0	367
		M-Count	-	-	-	-	-	-	-	-	-	-	
		SD	-	-	-	-	-	-	-	-	-	-	
		Prop.	15.5%	8.4%	2.5%	2.5%	10.4%	3.0%	56.9%	0.0%	0.8%	0.0%	100.0%
KAHO3	1	T-Biomass (g)	0.2050	0.0007	0.0014	0.0150	0.0158	0.0028	1.3014	0.0000	0.1350	0.1577	1.8347
		M-Biomass (g)	-	-	-	-	-	-	-	-	-	-	
		SD	-	-	-	-	-	-	-	-	-	-	
		T-Count	47	3	4	9	17	2	201	0	4	3	290
		M-Count	-	-	-	-	-	-	-	-	-	-	
		SD	-	-	-	-	-	-	-	-	-	-	
		Prop.	16.2%	1.0%	1.4%	3.1%	5.9%	0.7%	69.3%	0.0%	1.4%	1.0%	100.0%
KAHO4	2	T-Biomass (g)	1.9417	0.0657	0.1670	0.0023	0.8082	0.0124	0.3931	0.0000	0.5708	0.0000	3.9612
		M-Biomass (g)	0.9709	0.0329	0.0835	0.0011	0.4041	0.0062	0.1966	0.0000	0.2854	0.0000	1.9806
		SD	0.4085	0.0442	0.1105	0.0016	0.5692	0.0056	0.0163	0.0000	0.4036	0.0000	
		T-Count	165	352	27	1	156	5	208	0	4	0	918
		M-Count	83	176	14	1	78	3	104	0	2	0	459
		SD	56	238	15	1	109	2	34	0	3	0	
		Prop.	18.0%	38.3%	2.9%	0.1%	17.0%	0.5%	22.7%	0.0%	0.4%	0.0%	100.0%

November

Station	Nights	Metric	COL*	DIP*	HEM	HOM	HYM	ISO*	LEP*	NEU	ORT	OTHER	TOTAL
KAHO1	2	T-Biomass (g)	0.3134	0.0279	0.0060	0.0000	0.4882	0.0366	12.1924	0.0000	0.0837	0.0000	13.1482
		M-Biomass (g)	0.1567	0.0140	0.0030	0.0000	0.2441	0.0183	6.0962	0.0000	0.0419	0.0000	6.5741
		SD	0.0111	0.0163	0.0013	0.0000	0.2855	0.0015	0.8552	0.0000	0.0592	0.0000	
		T-Count	136	96	13	0	128	22	1583	0	3	0	1981
		M-Count	68	48	7	0	64	11	792	0	2	0	991
		SD	41	34	1	0	20	4	25	0	2	0	
		Prop.	6.9%	4.8%	0.7%	0.0%	6.5%	1.1%	79.9%	0.0%	0.2%	0.0%	
KAHO3	2	T-Biomass (g)	0.6481	0.0116	0.0277	0.0020	0.6583	0.0065	5.5534	0.0000	0.0576	0.0000	6.9652
		M-Biomass (g)	0.3241	0.0058	0.0139	0.0010	0.3292	0.0033	2.7767	0.0000	0.0288	0.0000	3.4826
		SD	0.1221	0.0054	0.0196	0.0014	0.1586	0.0007	1.4581	0.0000	0.0115	0.0000	
		T-Count	204	41	3	1	143	4	1014	0	2	0	1412
		M-Count	102	21	2	1	72	2	507	0	1	0	706
		SD	4	25	2	1	23	0	355	0	0	0	
		Prop.	14.4%	2.9%	0.2%	0.1%	10.1%	0.3%	71.8%	0.0%	0.1%	0.0%	100.0%
KAHO4	1	T-Biomass (g)	0.6289	0.0022	0.0045	0.0000	1.3734	0.0101	1.9316	0.0000	0.3361	0.0000	4.2868
		M-Biomass (g)	-	-	-	-	-	-	-	-	-	-	
		SD	-	-	-	-	-	-	-	-	-	-	
		T-Count	145	120	3	0	477	6	449	0	7	0	1207
		M-Count	-	-	-	-	-	-	-	-	-	-	
		SD	-	-	-	-	-	-	-	-	-	-	
		Prop.	12.0%	9.9%	0.2%	0.0%	39.5%	0.5%	37.2%	0.0%	0.6%	0.0%	100.0%