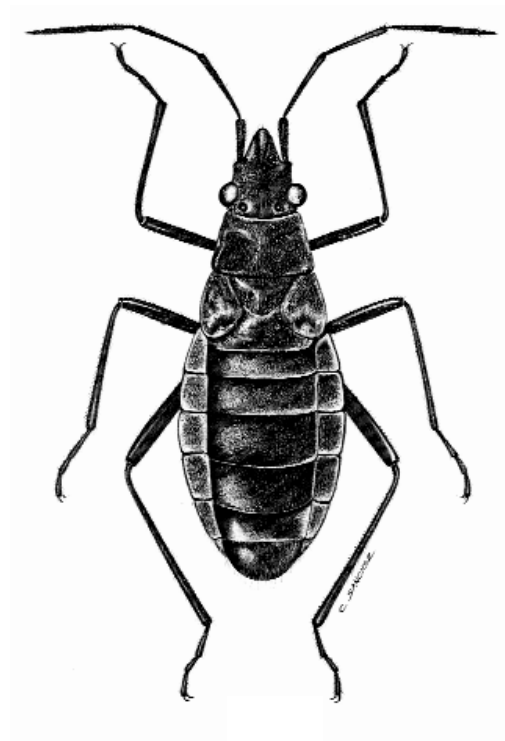


WĒKIU BUG BASELINE MONITORING

3RD QUARTER 2002
QUARTERLY REPORT



Revised April 2004



Pacific Analytics, L.L.C.

Cover : Wēkiu Bug drawn by Mr. C. Sanchez of the University of the Philippines
College of Science and Humanities.

WĒKIU BUG BASELINE MONITORING

3RD QUARTER 2002
QUARTERLY REPORT

Prepared for

The Outrigger Telescopes Project
WM Keck Observatory
Kamuela, Hawai'i

Revised April 2004



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WĒKIU BUG BASELINE MONITORING

3rd QUARTER 2002 QUARTERLY REPORT

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Wēkiu Bug Baseline Monitoring
EXECUTIVE SUMMARY

II. EXECUTIVE SUMMARY

The Mauna Kea Science Reserve (MKSr) is located on the summit of Mauna Kea, the tallest mountain in Hawai'i. Within the reserve are the world's two largest optical telescopes, constituting the W.M. Keck Observatory (WMKO). The slopes of Pu'u Hau 'Oki directly adjacent to and below the WMKO are part of a unique natural environment that supports the Wēkiu bug, a rare insect. Wēkiu bug habitat generally encompasses an estimated 300 acres (121 hectares) of the summit of Mauna Kea. Populations of Wēkiu bugs also occur on other cinder cones near the summit.

The National Aeronautics and Space Administration (NASA), together with the California Institute of Technology (CalTech)/Jet Propulsion Laboratory (JPL), the California Association for Research in Astronomy (CARA) and the University of Hawai'i (UH), have proposed to protect and enhance Wēkiu bug habitat on Pu'u Hau 'Oki to mitigate disturbance by on-site construction and installation of the Outrigger Telescopes Project. To that end these participants have prepared the Wēkiu Bug Mitigation Plan and Wēkiu Bug Monitoring Plan. They are also the participants in this Wēkiu Bug Baseline Monitoring Plan.

Sampling of Wēkiu bug habitat was approved to establish baseline population estimates of the Wēkiu bug in the area surrounding the site of the proposed Outrigger Telescopes Project and at a control site on Pu'u Wēkiu. The intended purpose of this activity is to gather reliable scientific information about population trends in both areas that can be used to determine the effectiveness of habitat protection and restoration, and the impacts, if any, due to construction of the Outrigger Telescopes Project.

Sampling of Wēkiu bugs is being conducted to answer two main Questions of Interest. They are:

- 1) How, where and when are the Wēkiu bug populations changing? Locations of interest include current habitat on Pu'u Hau 'Oki crater and undisturbed Wēkiu bug habitat at Pu'u Wēkiu (for comparison).
- 2) Are weather phenomena, human activities, and/or other factors associated with Wēkiu bug and/or other resident arthropod population change?

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## Wēkiu Bug Baseline Monitoring EXECUTIVE SUMMARY

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Nondestructive sampling is the best approach to monitoring rare and sensitive invertebrate species. Special live-traps were developed and tested during the 1997-98 MKSR arthropod assessment and are being deployed during Baseline Monitoring. Ten live-traps are installed at the summit of Mauna Kea at designated locations, five on Pu'u Hau 'Oki and five on Pu'u Wēkiu.

The first quarter three-week sampling session was conducted from February 1, 2002 through February 22, 2002. All live bugs were released back into their habitat. The trap capture rate during this Baseline Monitoring session ranged from 0 to 2.4 Wēkiu bugs per trap per 3 days of sampling. Thirty-four of the thirty-five Wēkiu bugs captured appeared in live-traps on Pu'u Hau 'Oki. The average trap capture rate on Pu'u Hau 'Oki was 0.99 Wēkiu bugs per trap per 3 days of sampling.

The second quarter three-week sampling session was conducted from April 29, 2002 through May 24, 2002. All of the 359 Wēkiu bugs appeared in or near traps on Pu'u Hau 'Oki. The capture rate during the second quarter session ranged from 0 to 38.8 Wēkiu bugs per trap per 3 days of sampling. The average trap capture rate on Pu'u Hau 'Oki in May 2002 was 9.56 Wēkiu bugs per trap per 3 days of sampling.

The third quarter three-week sampling session was conducted from August 6, 2002 through August 28, 2002. During that time a total of 154 Wēkiu bugs appeared in or near the live-traps. One hundred and forty-four were found on Pu'u Hau 'Oki, and ten on Pu'u Wēkiu. Trap capture rates ranged from 0.0 to 6.6 Wēkiu bugs per trap per 3 days of sampling.

The average trap capture rate on Pu'u Hau 'Oki in August 2002 was 4.01 (± 0.78) Wēkiu bugs per trap per 3 days of sampling. This rate is about four times greater than the average capture rate measured on Pu'u Hau 'Oki during the first quarter baseline monitoring session in February 2002, and about forty percent of the rate measured during the second quarter baseline monitoring session in May 2002.

The average August trap capture rate was about four times greater than the average capture rate (1.10 Wēkiu bugs per trap per 3 days of sampling) measured in the same area during a comparable period of the 1997/98 Arthropod Assessment (Howarth et al. 1999). Thirty-five of the Wēkiu bugs captured during August were juveniles, an indication that the population is breeding.

Wēkiu Bug Baseline Monitoring
EXECUTIVE SUMMARY



Adult Wēkiu bug found in live-traps on Pu‘u Hau ‘Oki.
Actual size is about ¼ inch (~5 mm).

Wēkiu Bug Baseline Monitoring
INTRODUCTION

III. INTRODUCTION

The Mauna Kea Science Reserve is located on the summit of Mauna Kea, the tallest mountain in Hawai'i. Within the reserve are the world's two largest optical telescopes, constituting the W.M. Keck Observatory (WMKO). The slopes of Pu'u Hau 'Oki directly adjacent to and below the WMKO are part of a unique natural environment that supports the Wēkiu bug, a rare insect. Wēkiu bugs generally occupy habitat encompassing an estimated 300 acres (121 hectares) of the summit of Mauna Kea. Populations of Wēkiu bugs also occur on other cinder cones near the summit.

Current plans call for adding four to six Outrigger Telescopes on the WMKO site. The Outrigger Telescopes would be placed strategically around the existing Keck Telescopes.

The National Aeronautics and Space Administration (NASA), together with the California Institute of Technology (CalTech)/Jet Propulsion Laboratory (JPL), the California Association for Research in Astronomy (CARA) and the University of Hawai'i (UH), have proposed to protect and enhance Wēkiu bug habitat on Pu'u Hau 'Oki to mitigate disturbance by on-site construction and installation of the

Outrigger Telescopes Project. To that end these participants have prepared the Wēkiu Bug Mitigation Plan and Wēkiu Bug Monitoring Plan. They are also the participants in this Wēkiu Bug Baseline Monitoring Plan.

Sampling of Wēkiu bug habitat was approved to establish baseline population estimates of the Wēkiu bug in the area surrounding the site of the proposed Outrigger Telescopes Project and at a control site on Pu'u Wēkiu. The populations of Wēkiu bugs were last measured at these sites in 1998 during an arthropod assessment conducted as part of the Environmental Impact Statement prepared for the Mauna Kea Master Plan approved in 2000 by the UH Board of Regents. This new monitoring activity will update that information.

The intended purpose of the current activity is to gather reliable scientific information about population trends in both areas that can be used to determine the effectiveness of habitat protection and restoration, and the impacts, if any, due to construction of the Outrigger Telescopes Project.

Wēkiu Bug Baseline Monitoring
INTRODUCTION

This is the third Quarterly Report of Baseline Monitoring. The results of the sampling effort conducted August 6 through August 28 are reported. Comparisons to previously collected

data will be presented, along with new analysis and interpretations of correlations of changes in Wēkiu bug populations with weather related phenomena.



Photo by Jeffrey C. Miller

**Immature Wēkiu bugs found on Pu‘u Hau ‘Oki near the summit of Mauna Kea.
Actual size is less than ¼ inch (~3 mm).**

IV. QUESTIONS OF INTEREST

Important Questions of Interest are those with answers that can be efficiently estimated and that yield the information necessary for management decision-making. The following Questions of Interest were developed in the Baseline Monitoring Plan and are the focus of this report.

Question 1

How, where and when are the Wēkiu bug populations changing? Locations of interest include current habitat on Pu’u Hau ‘Oki crater and undisturbed Wēkiu bug habitat at Pu’u Wēkiu (for comparison).

Justification:

Baseline monitoring of Wēkiu bugs will yield reliable scientific information about the current status of Wēkiu bugs, and trends in their population. The information will be useful to compare to status and trends during construction of the proposed Outrigger Telescopes.

Monitoring goals:

- 1) To provide historical records of change in Wēkiu bug population attributes, and characteristics,
- 2) To detect trends, periodicities, cycles, and/or other patterns in those changes, and
- 3) To associate auxiliary phenomena, attributes, and characteristics with trends and patterns of change in Wēkiu bug population attributes, and characteristics

Wēkiu Bug Baseline Monitoring
QUESTIONS OF INTEREST

Question 2

Are weather phenomena, human activities, and/or other factors associated with Wēkiu bug and/or other resident arthropod population change?

Justification:

Snow, rain, day/night temperatures, and other weather phenomena may be associated with Wēkiu Bug population change. Monitoring these indirect factors will aid in understanding trends in Wēkiu Bug population change.

Monitoring goals:

To associate environmental phenomena and attributes, and characteristics of human activities with trends and patterns of change in Wēkiu Bug populations.



Photo by Jeffrey C. Miller

**Lycosid spider found in Live Trap on Pu‘u Wēkiu.
Actual size is about 1 ½ inches (~40 mm).**

Wēkiu Bug Baseline Monitoring
METHODS

were wrapped around cap rocks, ten to fifteen inches in diameter. The cap rocks were then placed over each trap such that the entire trap was shaded from sunlight (Step 8).

Traps were checked for Wēkiu bugs every three days during the sampling session. During each live-trap check, an area about 20 cm in diameter around the live-trap was checked for the presence of Wēkiu bugs. The cap rock was also inspected for the presence of Wēkiu bugs. The trap cups were then removed and carefully inspected for Wēkiu bugs. Live Wēkiu bugs were counted and released to cinder habitat at least one to two meters away from the live-trap. Dead

bugs were collected in vials filled with alcohol.

Live-traps were reset by topping off the water reservoir, and by placing new bait and chum in and around the live-traps. When the 3-week sampling session was complete, trap cups were removed, and cap rocks placed over the wire tubes. Small identification tags containing contact information were attached to the flag wires. The same locations will be used for future sampling.

Traps were opened for the third baseline monitoring session on August 6, 2002. The traps were checked every three days and were closed on August 28, 2002.



OMKM Rangers patrol the MKSR, offering assistance to visitors. Protective clothing and eyewear are necessary at the summit because of intense ultraviolet radiation.

Wēkiu Bug Baseline Monitoring
METHODS

Weather Data

Daily weather data from the UKIRT Observatory on the summit of Mauna Kea was downloaded from the Internet/World Wide Web at *www.maunakeaweather.hawaii.edu*. The UKIRT Observatory is located on Pu‘u Kea adjacent to the Pu‘u Wēkiu sampling sites, and is less than one-half mile away from the Pu‘u Hau ‘Oki sampling sites.

Average temperature, average wind-chill temperature, average barometric pressure, and average humidity were

calculated for each 3-day sampling session from the UKIRT Observatory weather data. Minimum and maximum temperatures for the 3-day sampling sessions were also noted from the data.

Archive photographs were taken from fixed points on Pu‘u Hau ‘Oki and on Pu‘u Wēkiu. Photographs were taken at the beginning of each sampling period to record snow coverage and changes in Wēkiu bug habitats through time.



Pu‘u Kea Observatories. A view of Pu‘u Kea from Pu‘u Hau ‘Oki. UKIRT Observatory, where weather data were collected, is the last building on the right. IRTF Observatory on Pu‘u Hau ‘Oki is in the foreground on the left. Photo taken February 2002.

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Wēkiu Bug Baseline Monitoring
RESULTS
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VI. RESULTS

SAMPLING INFORMATION

During the third quarter baseline monitoring session there were a total of twenty-two sampling nights, making seven 3-day sampling periods. A total of one hundred and fifty-four Wēkiu bugs were captured, one hundred and forty-four on Pu’u Hau ‘Oki and ten on Pu’u Wēkiu. The trap capture rate (number of Wēkiu bugs per trap per 3-days) ranged from zero to 6.6 Wēkiu bugs. The overall

trap capture rate during the 3-week sampling session was 4.01 (± 0.78) Wēkiu bugs for Pu’u Hau ‘Oki, and 0.26 (± 0.11) Wēkiu bugs for Pu’u Wēkiu (Table 1). For comparison, average trap capture rates from previous baseline monitoring sessions in 2002 and the 1997/98 Arthropod Assessment are provided (Table 2 and Table 3).

TABLE 1.
AUGUST SAMPLING PERIOD AVERAGE TRAP CAPTURE RATES
The average number of Wēkiu bugs per trap per 3-days
for each 3-day sampling period for 3rd Quarter 2002 Baseline Monitoring.

Location	8/9/2002	8/12/2002	8/15/2002	8/18/2002	8/21/2002	8/24/2002	8/28/2002
Pu’u Wēkiu	0.0	0.0	0.8	0.2	0.0	0.4	0.45
Pu’u Hau Oki	4.6	6.6	6.6	4.0	2.6	1.4	2.3

**Wēkiu Bug Baseline Monitoring
RESULTS**

TABLE 2.

**2002 BASELINE MONITORING
AVERAGE QUARTERLY TRAP CAPTURE RATES**

The average number of Wēkiu bugs per trap per 3-days for each of the 2002 Quarterly Baseline Monitoring Sampling Sessions. Average trap capture rates for the 2002 Baseline Monitoring are in **RED**.

Location	1 st Q 2002	2 nd Q 2002	3 rd Q 2002	Avg. 2002
Pu'u Wekiu	0.03	0.03	0.26	0.11 (±0.08)
Pu'u Hau Oki	0.99	9.56	4.01	4.85 (±2.51)

TABLE 3.

SAMPLING PERIOD AVERAGE TRAP CAPTURE RATES

The average number of Wēkiu bugs per trap per 3-days for each sampling period during the 1997/98 Arthropod Assessment. Average trap capture rates for the 1997/98 Arthropod Assessment are in **RED**.

Location	Aug. 1997	Jan. 1998	Apr-98	Jul-98	Avg. 1997/98
Pu'u Wekiu	0.15	0	0.07	0.15	0.11
Pu'u Hau Oki	0.2	0	0.2	1.1	0.38

OTHER ARTHROPODS CAPTURED IN LIVE TRAPS

During the third quarter baseline monitoring session several other arthropods were found in or near the live traps. These specimens are still being identified and must be compared to museum specimens to confirm taxonomic identification. These arthropods include spiders such as *Lycosa* sp. (Family Lycosidae) and *Leptyphantos* sp. (Family Linyphiidae), True Bugs (Order Heteroptera), Flies (Order Diptera,

Families Sciaridae, Sepsidae, Chloropidae, and others), Beetles (Order Coleoptera, Families Chrysomelidae, Coccinellidae, and Staphylinidae), wasps (Order Hymenoptera, Families Brachonidae and Ichneumonidae), and caterpillars (Order Lepidoptera, Family Noctuidae). Some of these Arthropods may be prey of Wēkiu bugs.

Wēkiu Bug Baseline Monitoring
RESULTS

WEATHER INFORMATION

The number of Wēkiu bugs found in traps on Pu'u Hau 'Oki were plotted with average temperature during the 3-day sampling periods. The pattern reveals that during the August sampling session the number of Wēkiu bugs is correlated with average temperature.

As average temperature increases, the number of Wēkiu bugs captured also increases. This is the same general pattern found during the February and May Baseline Monitoring sampling sessions (Figure 2 and Figure 3).

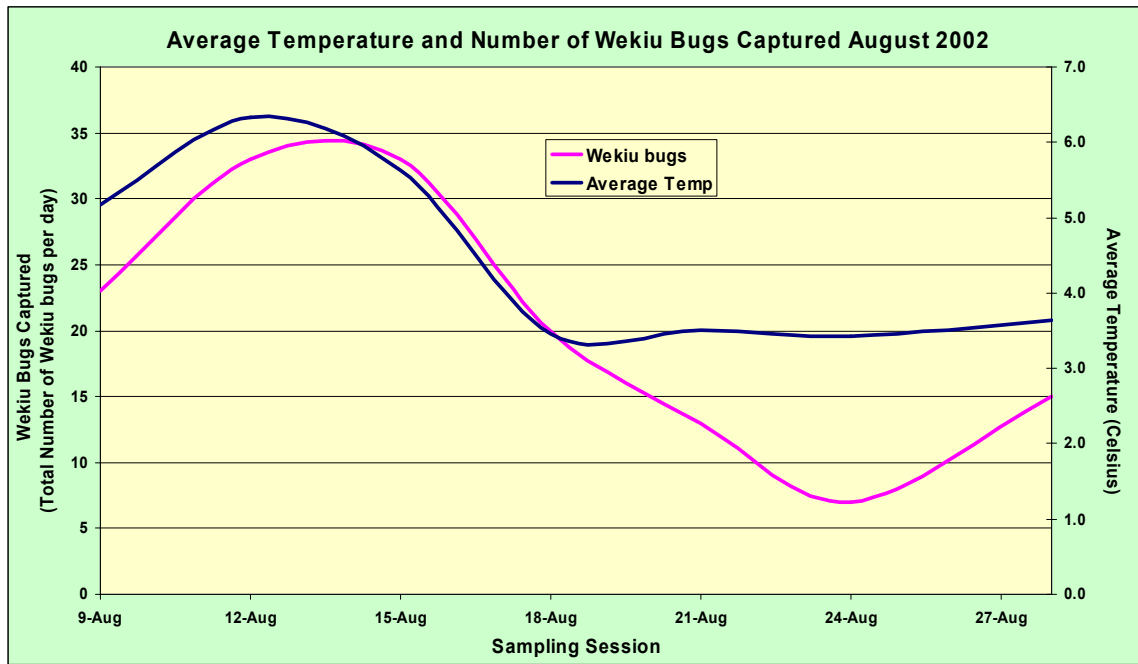


FIGURE 1. Plot of Average Temperature (Celsius) and Total Number of Wēkiu Bugs Captured for Seven Sampling Periods in 3rd Quarter 2002.

Wēkiu Bug Baseline Monitoring
RESULTS

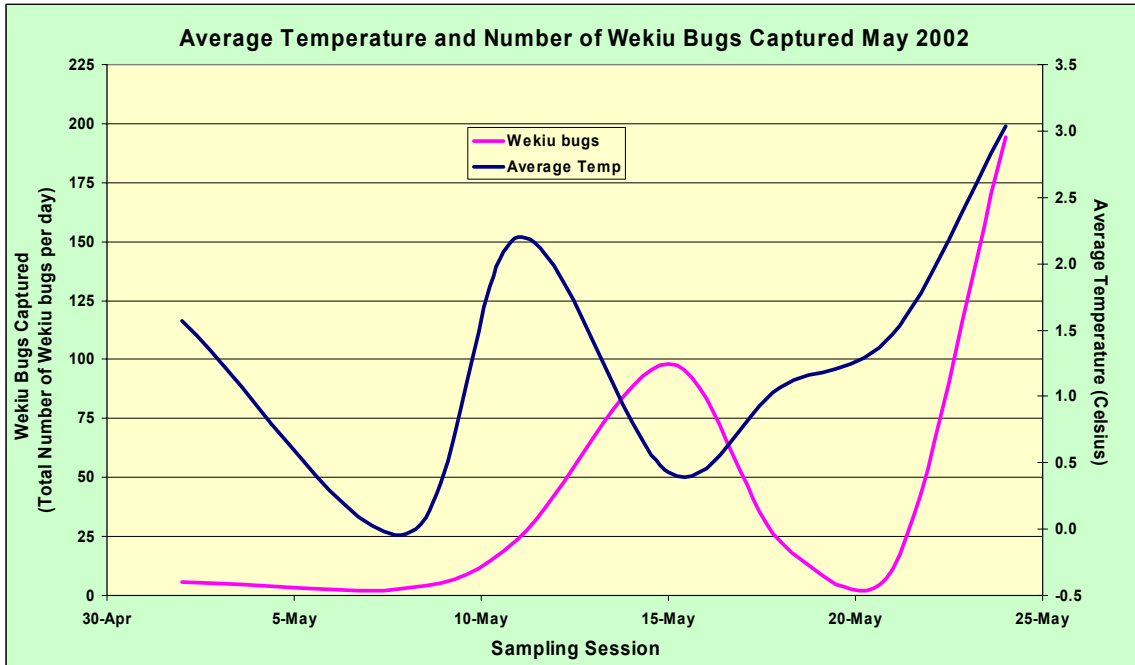


FIGURE 2. Plot of Average Temperature (Celsius) and Total Number of Wēkiu Bugs Captured for Seven Sampling Periods in 2nd Quarter 2002.

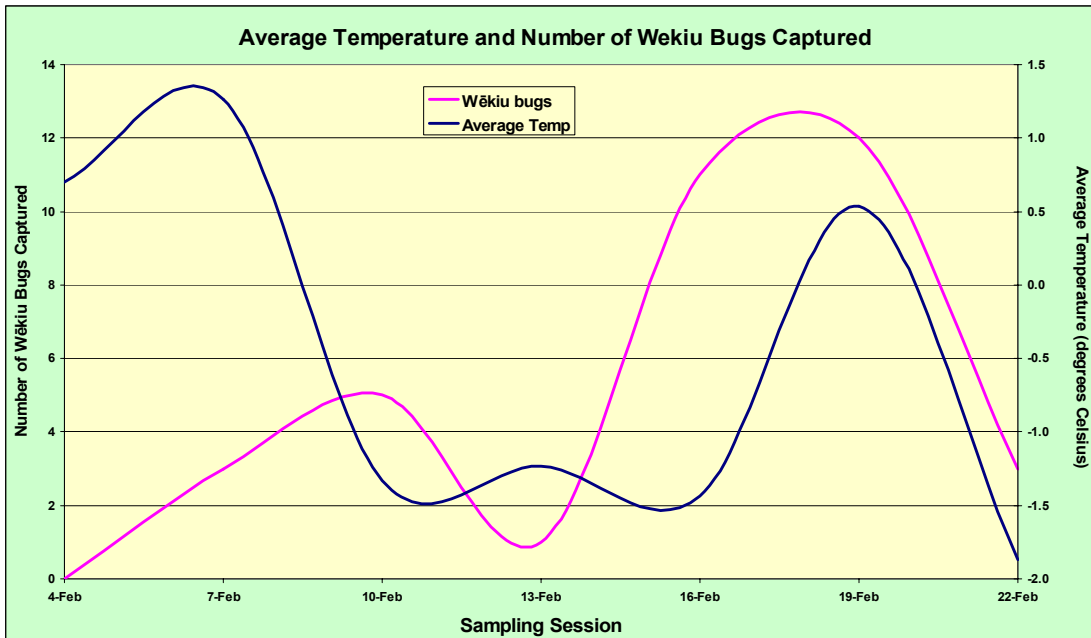


FIGURE 3. Plot of Average Temperature (Celsius) and Total Number of Wēkiu Bugs Captured for Seven Sampling Periods in 1st Quarter 2002.

Wēkiu Bug Baseline Monitoring
RESULTS

Pu'u Hau 'Oki Inner Slope Photographic Archive

AUGUST 2002



Pu'u Hau 'Oki inner slope
August 06, 2002



Pu'u Hau 'Oki inner slope
August 09, 2002

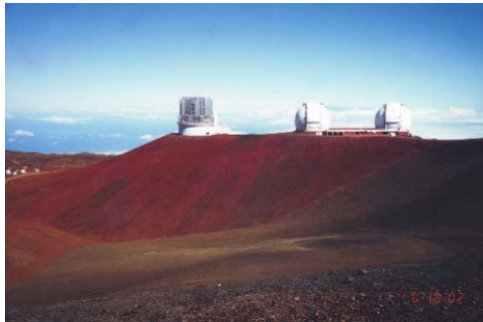


Pu'u Hau 'Oki inner slope
August 12, 2002



Pu'u Hau 'Oki inner slope
August 15, 2002

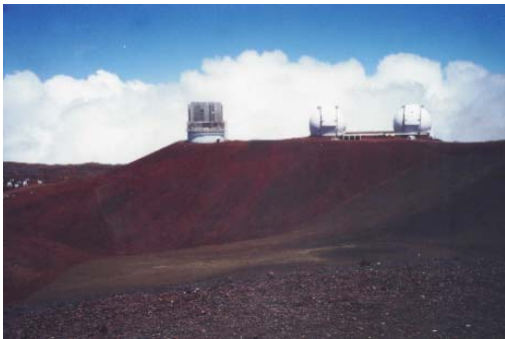
Wēkiu Bug Baseline Monitoring
RESULTS



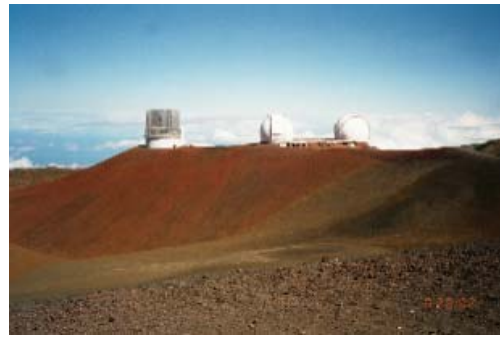
**Pu'u Hau 'Oki outer slope
August 18, 2002**



**Pu'u Hau 'Oki outer slope
August 21, 2002**



**Pu'u Hau 'Oki outer slope
August 24, 2002**



**Pu'u Hau 'Oki outer slope
August 28, 2002**

Wēkiu Bug Baseline Monitoring
RESULTS

Pu'u Wēkiu Photographic Archive

AUGUST 2002



Pu'u Wēkiu inner slope
August 06, 2002



Pu'u Wēkiu inner slope
August 09, 2002



Pu'u Wēkiu inner slope
August 12, 2002



Pu'u Wēkiu inner slope
August 15, 2002

Wēkiu Bug Baseline Monitoring
RESULTS



**Pu'u Wēkiu inner slope
August 18, 2002**



**Pu'u Wēkiu inner slope
August 21, 2002**



**Pu'u Wēkiu inner slope
August 24, 2002**



**Pu'u Wēkiu inner slope
August 28, 2002**

Wēkiu Bug Baseline Monitoring
RESULTS

Pu'u Wēkiu and Hau Kea Photographic Archive

AUGUST 2002



Pu'u Wēkiu and Hau Kea
August 06, 2002



Pu'u Wēkiu and Hau Kea
August 09, 2002



Pu'u Wēkiu and Hau Kea
August 12, 2002



Pu'u Wēkiu and Hau Kea
August 15, 2002

VII. DISCUSSION

Trapping Data

Permission to begin Baseline Wēkiu bug Monitoring was received on January 21, 2002. On January 28, Pacific Analytics personnel installed 10 live-traps in designated areas, five on the inner slopes of Pu‘u Hau ‘Oki and five on the slopes of Pu‘u Wēkiu. After a few days to allow the traps to settle in, the traps were baited and set. The first 3-week sampling session was conducted from February 1, 2002 to February 22, 2002 with samples acquired every three days (seven samples per trap). The second 3-week sampling session began on April 30, 2002, and sampling occurred every third day thereafter until May 24 (seven samples per trap). Traps were set for the third sampling session on August 6, 2002 and checked every third day beginning August 9 through August 28 (seven samples per trap).

Wēkiu bugs appeared in nine of the ten traps. During the 3-week sampling session a total of one hundred and fifty-four Wēkiu bugs appeared in or near the traps. That represents a more than four-fold increase over trap captures in February 2002 and about 42% of the May 2002 capture rate. About ninety-three percent of the

Wēkiu bugs captured appeared in live-traps on Pu‘u Hau ‘Oki. Only ten appeared in live-traps on Pu‘u Wēkiu (compared to only one Wēkiu bug captured on Pu‘u Wēkiu in the February and May sampling sessions combined). All live bugs were released back into their habitat.

During the 1997/98 Mauna Kea Science Reserve Arthropod Assessment prepared for the 2000 Mauna Kea Master Plan, a standard was established to compare trap capture rates between various studies. The standard unit of measurement is the number of Wēkiu bugs per trap per 3 days of sampling.

The trap capture rate on Pu‘u Hau ‘Oki during the August 2002 Baseline Monitoring session ranged from 2.6 to 6.6 Wēkiu bugs per trap per 3-days (Table 1). The trap capture rate in February and May 2002 the ranged from 0 to 2.4 and 1.2 to 38.8, respectively. During the 1997/98 MKSR Arthropod Assessment, average trap capture rates on Pu‘u Hau ‘Oki ranged from 0 to 1.1 Wēkiu bugs (Table 3). On Pu‘u Wēkiu, the trap capture rate ranged from 0 to 0.8 Wēkiu bugs. During the 1997/98

Wēkiu Bug Baseline Monitoring
DISCUSSION

study trap capture rates ranged from 0 to 0.15 Wēkiu bugs.

The average trap capture rate in Pu‘u Hau ‘Oki was 4.01 Wēkiu bugs per trap per 3 days of sampling (Table 2). This average was about four times greater than the average capture rate (1.10 Wēkiu bugs per trap per 3 days of sampling) measured in the same area during a comparable period of the 1997/98 Arthropod Assessment. The August Wēkiu bug capture rate was about four times greater than in February, and less than one-half the capture rate measured in May. It appears that Wēkiu bugs were more active in May 2002 than in February or August 2002.

The average trap capture rate on Pu‘u Wēkiu was 0.26 Wēkiu bugs per trap per 3 days of sampling (Table 3). This is ten times the rate measured in February or May 2002. During the 1997/98 study the rate was 0.11 Wēkiu bugs per trap per 3 days of sampling. It was noted during February and May 2002 Baseline Monitoring that the cinder slopes of Pu‘u Wēkiu remained frozen longer than those on Pu‘u Hau ‘Oki. Snow persisted longer on Pu‘u Wēkiu as well (see Photographic Archive). It is possible that the snow and frozen cinder hindered Wēkiu bug activity and that once the cinder thawed, Wēkiu bug activity increased.

The Wēkiu bug population has apparently increased since 1998. The number of Wēkiu bugs captured during the 3-week sampling session (155 Wēkiu bugs in ten traps over seven 3-day trap periods) was more than five times the number collected during the five one-week sampling sessions over 18 months of sampling for the 1997/98 Arthropod Assessment (30 Wēkiu bugs in one hundred fifty-five 3-day trap periods) on Pu‘u Hau ‘Oki and Pu‘u Wēkiu.

Unfortunately not all Wēkiu bugs survived in the live-traps. About 71% of the captured Wēkiu bugs survived and were released. The August mortality rate was almost three times greater than the mortality rate observed in the February sampling session. Higher temperatures and decreased precipitation may have contributed to the increase in mortality. Live traps were set exactly as they were in February, according to established protocols. It may be necessary to check live-traps more frequently during months with less precipitation.

More immature Wēkiu bugs were captured during the August sampling session than during the February and May sampling sessions. Almost twenty-three percent of all Wēkiu bugs captured were nymphs, compared to ten percent in the February sampling

Wēkiu Bug Baseline Monitoring
DISCUSSION

The tractor and trailer were pressure-washed before advancing up the Mauna Kea Access Road. The tractor and trailer were inspected for alien arthropods by a Pacific Analytics entomologist and found to be free of any signs of ants and spiders.

During the Second Quarter Baseline Monitoring a truck sent to retrieve waste packaging products from the DEIMOS camera shipping container was inspected for non-indigenous arthropods. The truck had apparently been pressure-washed because the undercarriage was clean and free of any alien arthropods. Also during this period solid trash was removed from the WMKO site in this container. An inspection of the truck and trash container found them clean and free of any arthropods.



Trash and debris are removed from the WMKO in covered waste containers.

The WMKO septic tank was serviced during Baseline Monitoring in August. The process was monitored, and it was observed that workers were careful to limit their activity to the immediate

area of the septic tank opening. The activity occurred at least seventy-five feet from the nearest Wēkiu bug habitat.



Septic tank at WMKO is pumped periodically by septic tank professionals.

The pumping truck was inspected and found to be very clean, and was free of alien arthropods and mud.

Inspection of the WMKO site found the area free of loose trash and debris. Observatory vehicles parked near the WMKO were clean and free of mud and had no visible signs of alien arthropods.



Wheel wells and undercarriage of the pumping truck were inspected and found to be free of alien arthropods.