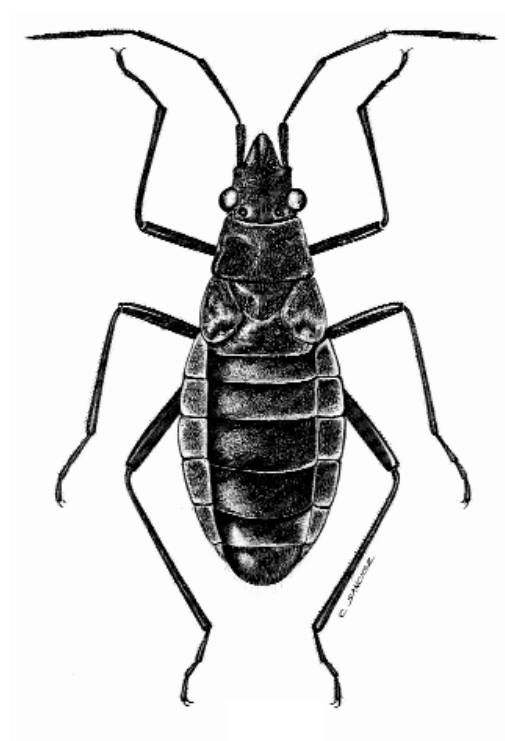


WĒKIU BUG BASELINE MONITORING

QUARTERLY REPORT
1ST QUARTER 2004



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

QUARTERLY REPORT 1ST QUARTER 2004

Prepared for

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

Revised April 2004



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WĒKIU BUG BASELINE MONITORING

QUARTERLY REPORT 1ST QUARTER 2004

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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 occurs on the upper elevations of Mauna Kea. Populations of Wēkiu bugs also occur on other cinder cones above 11,700' (3,570 m) elevation.

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 potential 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?

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 bug habitat generally occurs on the upper elevations of Mauna Kea. Populations of Wēkiu bugs also occur on other cinder cones above 11,700' (3,570 m) elevation.

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 potential 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 which became part of the Environmental Impact Statement prepared for the Mauna Kea Science Reserve Master Plan approved in 2000 by the UH Board of Regents. This new monitoring activity will provide current 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.

This is the ninth Quarterly Report of Baseline Monitoring. The results of

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.



Snow on Mauna Kea as seen from about 7,000 ft elevation on Mauna Loa.
Picture taken on March 8, 2004.

Wēkiu Bug Baseline Monitoring
METHODS

V. METHODS

Live Traps

Nondestructive sampling is one of the best approaches to monitoring rare and sensitive invertebrate species. Data on relative abundance can be collected with specially designed live-traps that cause minimal disturbance to species and their habitats. Non-destructive live-traps for Wēkiu bugs were developed and tested during the 1997-98 MKSR arthropod assessment. These live-traps provide Wēkiu bugs with food, moisture, and protection from predators and changing weather conditions, and can sustain captured individuals for several days.

Ten live-traps were set on Pu'u Hau 'Oki and Pu'u Wēkiu at the same locations where traps were installed during the previous sampling session.

Protocol for Setting Live-Traps

The sampled habitat was accessed with a minimum of disturbance to the habitat and cinder slopes. Care was taken to avoid creation of new trails or evidence of foot traffic.

Traps were previously installed at each sampling station by carefully digging into the cinder, disturbing

only the amount of cinder necessary to set up the trap (Step 1). A hardware cloth tube was inserted into the holes so that the top of the tube was slightly below the existing surface (Step 2). The hole around the tube was refilled with the cinder that was removed from the hole and a 4-inch apron of local ash and small-sized cinder was created around each trap (Step 3). The apron allows Wēkiu bugs to easily walk into the traps.

Traps were set by placing reservoir cups into the wire tubes and pouring about 15 ml of purified water into the reservoir (Step 4). About a teaspoon of shrimp paste was spread on the coffee filter wick in the trap cups and two to three pieces of re-hydrated shrimp were added to each cup (Step 5). Four to five pieces of native cinder, 1/2" to 1" in diameter were added and the trap cups were placed into the reservoir cups such that the coffee-filter wicks made contact with the water reservoirs (Step 6).

Chum, consisting of pureed pre-moistened shrimp, was distributed around the traps and a teaspoon of shrimp paste was spread on the bottom of the cap rocks (Step 7). Irrigation flags to mark the locations

Wēkiu Bug Baseline Monitoring
METHODS

Setting a Wēkiu Bug Live-Trap



Step 1
Dig Trap Hole



Step 2
Install Wire Tube



Step 3
Create Trap Apron



Step 4
Fill Reservoir



Step 5
Bait Trap



Step 6
Add Cinder Habitat



Step 7
Distribute Chum Bait



Step 8
Emplace Cap Rock

Wēkiu Bug Baseline Monitoring
METHODS

Weather Data

Daily weather data from the UKIRT Observatory on the summit of Mauna Kea is usually downloaded from the Internet/World Wide Web at <http://hokukea.soest.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.

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.



Snow drifts reach up to six feet in some locations on Mauna Kea during the 1st Quarter 2004 sampling session. Photo taken on March 5, 2004.

Wēkiu Bug Baseline Monitoring
RESULTS

VI. RESULTS

SAMPLING INFORMATION

During the 2004 1st Quarter baseline monitoring session there were a total of twenty-three sampling nights, making six 3-day sampling periods and one five-day sampling period.

A total of eighty-seven Wēkiu bugs were captured, all on Pu'u Hau 'Oki. The trap capture rate (number of Wēkiu bugs per trap per 3-days) ranged from zero to 10.2 Wēkiu bugs. The overall trap capture rate during the 3-week sampling session was 2.13 (± 1.5) Wēkiu bugs for Pu'u Hau 'Oki and 0.00 Wēkiu bugs for Pu'u Wēkiu

(Table 1). For comparison, average trap capture rates from previous baseline monitoring sessions in 2002, 2003 (Table 2), and the 1997/98 Arthropod Assessment are provided (Table 3).

Overall mortality was 4.6% (4 of 87). All mortality occurred in the second sampling period, extended to five days because the summit access road was closed due to unsafe conditions. All Wēkiu bugs survived in the other sampling periods.

TABLE 1.
1st QUARTER 2004 SAMPLING PERIOD
AVERAGE TRAP CAPTURE RATES
 The average number of Wēkiu bugs per trap per 3-days
 for each 3-day sampling period during 1st Quarter 2004 Baseline Monitoring.

Location	03/08/2004	03/13/2004	03/16/2004	03/19/2004	03/22/2004	03/25/2004	03/28/2004	AVERAGE
Pu'u Wēkiu	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
Pu'u Hau 'Oki	10.4	3.7	0.0	0.0	0.0	0.0	0.8	2.13 (± 1.5)

Wēkiu Bug Baseline Monitoring
RESULTS

TABLE 2.
QUARTERLY BASELINE MONITORING
AVERAGE TRAP CAPTURE RATES
 The average number of Wēkiu bugs per trap per 3-days
 for each of the Quarterly Baseline Monitoring Sampling Sessions.
 Yearly average trap capture rates for Baseline Monitoring are in **RED**.

Location	1 st Quarter	2 nd Quarter	3 rd Quarter	4 th Quarter	Year Avg.
Pu'u Wēkiu 2002	0.03	0.03	0.26	0.17	0.12
Pu'u Wēkiu 2003*	2.87	11.5	0.51	0.00	3.73
Pu'u Wēkiu 2004	0.00				0.00
Pu'u Hau 'Oki 2002	0.99	9.56	4.01	3.97	4.63
Pu'u Hau 'Oki 2003	18.29	90.6	12.37	0.83	30.51
Pu'u Hau 'Oki 2004	2.13				2.13

* Different trap locations on Pu'u Wēkiu in 2003

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	April 1998	July 1998	Avg. 1997/98
Pu'u Wēkiu	0.15	0.0	0.07	0.15	0.11
Pu'u Hau 'Oki	0.20	0.0	0.20	1.10	0.38

**Wēkiu Bug Baseline Monitoring
RESULTS**

WEATHER INFORMATION

The number of Wēkiu bugs found in traps was plotted with average temperature during the 3-day sampling periods. The pattern reveals that during the 1st Quarter 2004 sampling session the number of Wēkiu bugs varies with average temperature (Figure 1).

In previous Baseline Monitoring sessions, there was a general trend that indicated the number of Wēkiu bugs captured increased as average temperature increased (Figure 2). It appears from Figure 1 that C Wēkiu bugs may not be active below an average temperature of about -2°C.

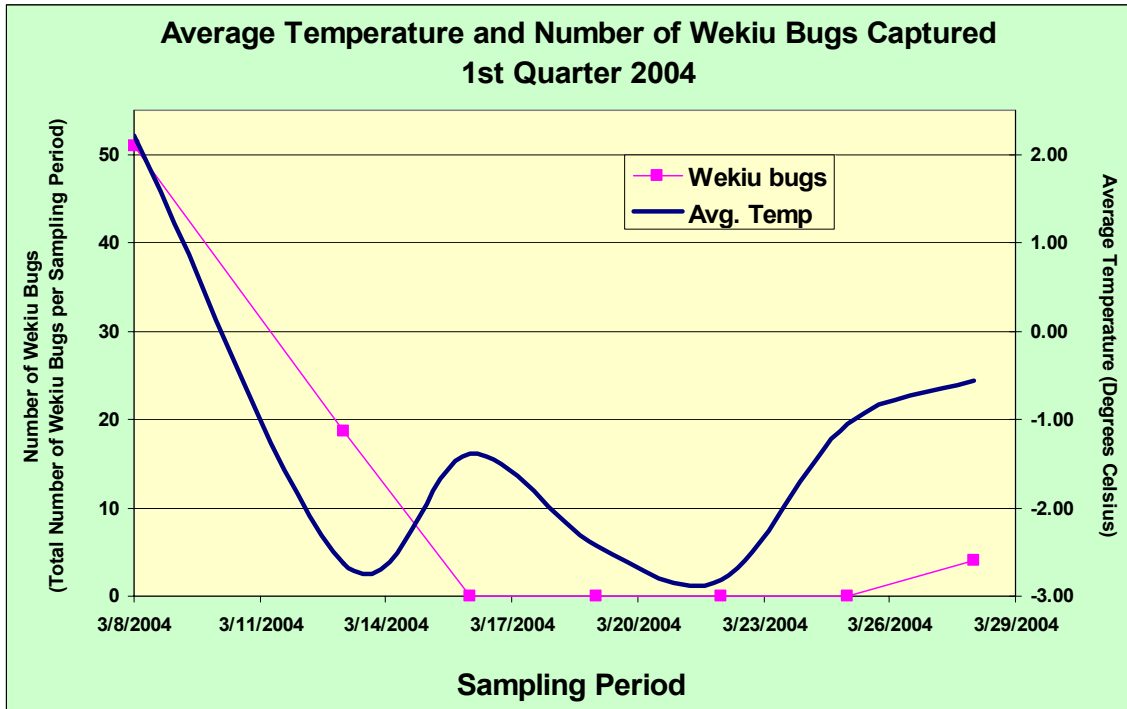


FIGURE 1. Plot of Average Temperature (Celsius) and Total Number of Wēkiu Bugs Captured per Sampling Period during the 1st Quarter 2004 sampling session.

Wēkiu Bug Baseline Monitoring
RESULTS

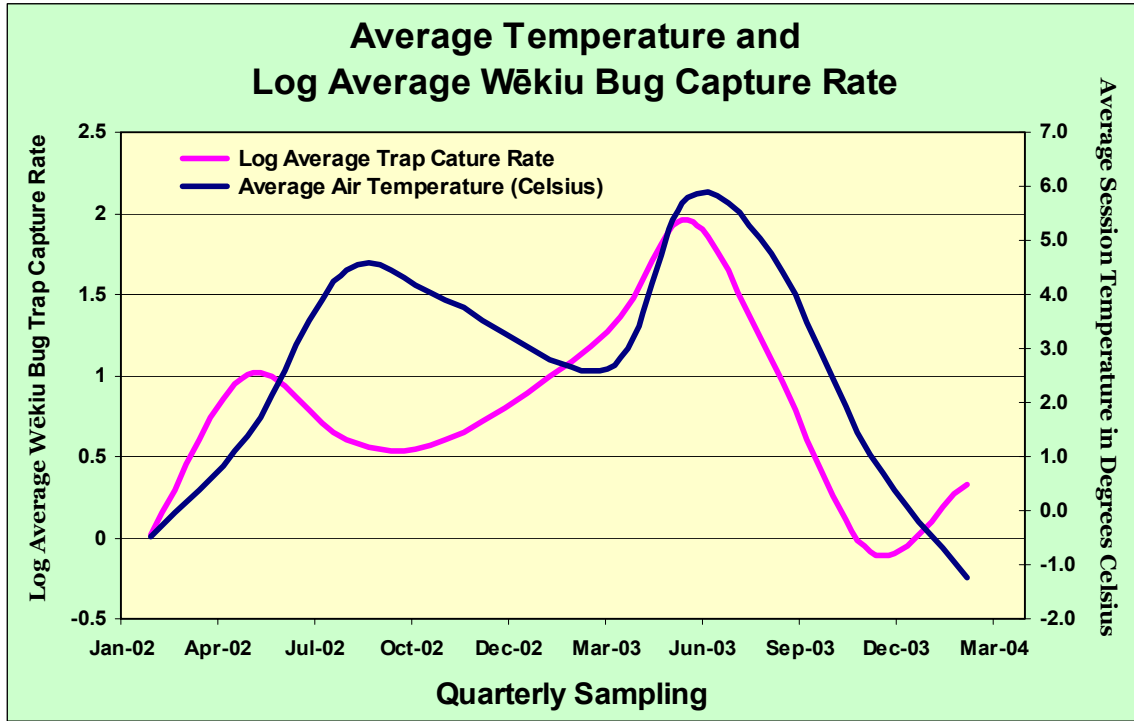


FIGURE 2. Plot of Baseline Monitoring Quarterly Average Temperature (Celsius) and Natural Log Average Wēkiu Bug Quarterly Trap Capture Rate.

Wēkiu Bug Baseline Monitoring
RESULTS

Pu'u Hau 'Oki Inner Slope Photographic Archive

MARCH 2004



**Pu'u Hau 'Oki inner slope
March 5, 2004**



**Pu'u Hau 'Oki inner slope
March 8, 2004**



**Pu'u Hau 'Oki inner slope
March 13, 2004**



**Pu'u Hau 'Oki inner slope
March 16, 2004**

**Wēkiu Bug Baseline Monitoring
RESULTS**



Pu'u Hau 'Oki inner slope
March 19, 2004



Pu'u Hau 'Oki inner slope
March 22, 2004

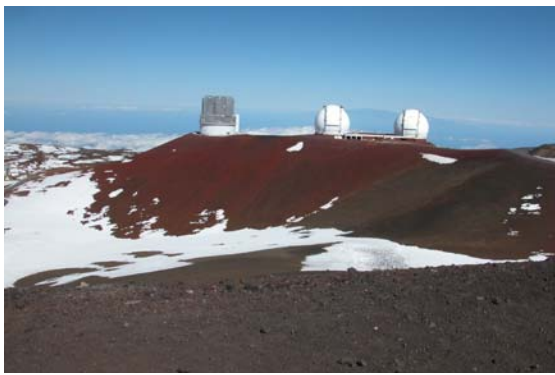


Pu'u Hau 'Oki inner slope
March 25, 2004

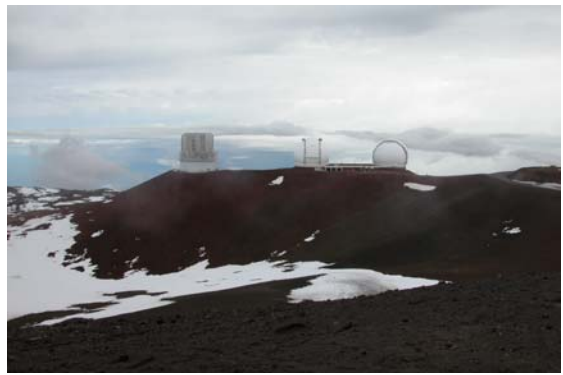


Pu'u Hau 'Oki inner slope
March 28, 2004

Wēkiu Bug Baseline Monitoring
RESULTS



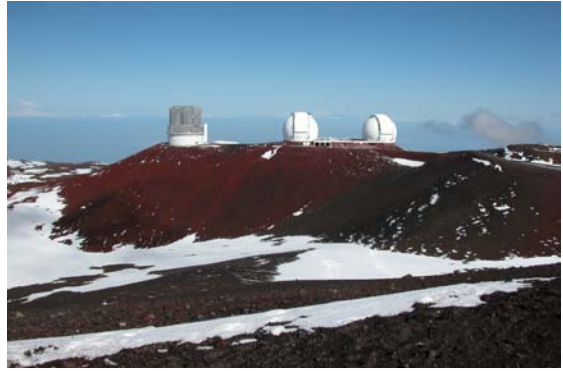
Pu'u Hau 'Oki outer slope
March 19, 2004



Pu'u Hau 'Oki outer slope
March 22, 2004



Pu'u Hau 'Oki outer slope
March 25, 2004



Pu'u Hau 'Oki outer slope
March 28, 2004

Wēkiu Bug Baseline Monitoring
RESULTS

Pu'u Wēkiu Photographic Archive

MARCH 2004



**Pu'u Wēkiu inner slope
March 5, 2004**



**Pu'u Wēkiu inner slope
March 8, 2004**



**Pu'u Wēkiu inner slope
March 13, 2004**



**Pu'u Wēkiu inner slope
March 16, 2004**

Wēkiu Bug Baseline Monitoring
 RESULTS



Pu'u Wēkiu inner slope
 March 19, 2004



Pu'u Wēkiu inner slope
 March 22, 2004



Pu'u Wēkiu inner slope
 March 25, 2004



Pu'u Wēkiu inner slope
 March 28, 2004

Pu'ū Wēkiu and Hau Kea Photographic Archive

MARCH 2004



**Pu'ū Wēkiu and Hau Kea
March 5, 2004**



**Pu'ū Wēkiu and Hau Kea
March 8, 2004**



**Pu'ū Wēkiu and Hau Kea
March 13, 2004**



**Pu'ū Wēkiu and Hau Kea
March 16, 2004**

Wēkiu Bug Baseline Monitoring
DISCUSSION

VII. DISCUSSION

Trapping Data

Permission to begin Baseline Wēkiu bug monitoring was received on January 21, 2002. On January 28, 2002 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. Sampling began in February 2002.



Adult Wēkiu bug on cinder near a live-trap.

Over the four quarters of monitoring during 2002, 696 Wēkiu bugs were captured in live-traps, and Wēkiu bug trap capture rates averaged 4.63 bugs per trap per 3-day trapping period on Pu'u Hau 'Oki, and 0.12 bugs per trap per 3-day trapping period on Pu'u Wēkiu.

Over the four quarters of monitoring during 2003, 4,237 Wēkiu bugs were captured in live-traps. Wēkiu bug trap capture rates averaged 30.51 bugs per trap per 3-day trapping period on Pu'u Hau 'Oki, and 3.73 bugs per trap per 3-day trapping period on Pu'u Wēkiu.

During the 1st Quarter 2004 sampling session Wēkiu bugs appeared in all five of the traps on Pu'u Hau 'Oki but none appeared in traps on Pu'u Wēkiu. A total of eighty-seven Wēkiu bugs appeared in or near the traps during the seven trapping sessions. All live bugs were released back into their habitat.

Average 1st Quarter 2004 trap capture rate on Pu'u Hau 'Oki was 2.13 bugs per trap per 3-day trapping period. Average 1st Quarter 2004 trap capture rate on Pu'u Wēkiu was 0.00 bugs per trap per 3-day trapping period. During the April 1998 sampling period of the 1997/98 Arthropod Assessment (the closest equivalent to the March 2004 sampling period) trap capture rates averaged 0.20 on Pu'u Hau 'Oki and 0.07 on Pu'u Wēkiu (Table 3).

The 1st Quarter 2004 Wēkiu bug capture rate was about twice the capture rate measured in the 1st

Wēkiu Bug Baseline Monitoring
DISCUSSION

Quarter 2002 sampling session, and about one ninth the capture rate measured in the 1st Quarter 2003 sampling session.

No immature Wēkiu bugs were captured in the 1st Quarter 2004 sampling session. Immature Wēkiu bugs may not be active during the cold winter months. They have been most active during June and July (the time of highest proportion of immatures) of previous years of Baseline Monitoring.

About 4.7% of the Wēkiu bugs (4/86) captured during the 1st Quarter 2004 sampling session did not survive. The summit of Mauna Kea experienced severe storms, high winds, extreme cold, and snow and rain events during this sampling session.

Mortality occurred when trap checking was delayed. Live-traps may need special modifications to ensure Wēkiu bugs survival during delayed sampling and severe storms. The modifications to live-traps made in 2003 appear to be successful at reducing mortality during less severe conditions. The mortality measured in 2004 is a great reduction from the 16% measured in 2002 sampling using unmodified live-traps. The modified live-traps are apparently successful at reducing trap mortality and should be considered for all Wēkiu bug sampling.



A view of Puu Hau Kea with Mauna Loa in the distance.
Picture taken on March 5, 2004

Wēkiu Bug Baseline Monitoring
DISCUSSION

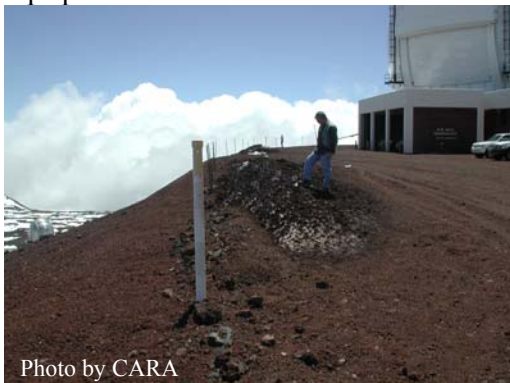
Other Observations

During the 1st Quarter 2004 monitoring session the WMKO site was free of loose trash and debris. Observatory vehicles parked near the WMKO were clean. No vehicles had any visible signs of alien arthropods.



Cinder and snow accumulated on the outer slope break of Pu'u Hau 'Oki at the edge of the W. M. Keck Observatory parking area. Picture taken on March 5, 2004.

A large amount of cinder was piled up with snow removed from the W. M. Keck Observatory parking area. There was also a large gouge in the parking area where the snow-removing equipment excavated cinder.



Melted snow and cinder away from slope break. Picture taken on March 29, 2004.

The snow and cinder were placed away from the slope break such that it would be unlikely cinder would fall into Wēkiu bug habitat. After the snow has melted the cinder will be returned to the parking area.

The W. M. Keck Observatory summit crew received Natural Resource Awareness training on March 9, 2004. The training presented by Dr. Gregory Brenner of Pacific Analytics included information about the flora and fauna of Mauna Kea above 11,700 ft elevation. The training session lasted about 45 minutes and was attended by the entire summit crew.



Photo by Gary Fujihara, IfA
Dr. Brenner delivering a public lecture at UH Hilo on March 12, 2004.

On March 12, 2004, Dr. Brenner delivered a public lecture about Wēkiu bug ecology and conservation in Hilo. The lecture was sponsored by the UH

