

WĒKIU BUG BASELINE MONITORING

QUARTERLY REPORT
3rd QUARTER 2003

Prepared for

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

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WĒKIU BUG BASELINE MONITORING

QUARTERLY REPORT 3rd QUARTER 2003

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Wēkiu Bug Baseline Monitoring 3rd Quarter 2003 Report
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?

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Nondestructive sampling is one of the best approaches 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 3rd Quarter 2003 three-week sampling session was conducted from August 22, 2003 through September 15, 2003. During this sampling session a total of 451 Wēkiu bugs appeared in or near the live-traps. Four hundred and thirty-three were found on Pu'u Hau 'Oki, and eighteen on Pu'u Wēkiu. Trap capture rates ranged from zero to 17.6 Wēkiu bugs per trap per 3 days of sampling.

The average trap capture rate on Pu'u Hau 'Oki during the 3rd Quarter 2003

monitoring session was 12.37 Wēkiu bugs per trap per 3 days of sampling. This rate is about three times greater than the average capture rate measured on Pu'u Hau 'Oki during the 3rd Quarter 2002 baseline monitoring session.

The average trap capture rate on Pu'u Wēkiu during the 3rd Quarter 2003 monitoring session was 0.51 Wēkiu bugs per trap per 3 days of sampling. This rate is about 1.5 times greater than the average capture rate measured on Pu'u Wēkiu during the 3rd Quarter 2002 baseline monitoring session. These rates cannot be directly compared because trap locations changed on Pu'u Wēkiu in 2003.

Two hundred and fifty (55%) of the Wēkiu bugs captured during the 3rd Quarter 2003 monitoring session were juveniles, an indication that the population is breeding.

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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 seventh Quarterly Report of Baseline Monitoring. The results

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INTRODUCTION

of the sampling effort conducted August 22, 2003 through September 15, 2003 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.



Immature Wēkiu bug (left) and a mating pair (center) in a trap on Pu‘u Hau ‘Oki near the summit of Mauna Kea. Actual size of nymph 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 Wēkiu Bug 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.

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.



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

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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'ū Hau 'Ōki and Pu'ū 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 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 were wrapped around cap rocks, ten to fifteen

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METHODS

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 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, both 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 2003 3rd Quarter baseline monitoring session on August 22, 2003. The traps were checked every three days and were closed on September 15, 2003. An eighth 3-day sampling session was added because a hurricane passing on the southern end of the Island caused significant rain at the summit, flooding the traps.



Live-trap flooded with water during the September 1 – 3 sampling session.

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

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Weather Data

Daily weather data from the UKIRT Observatory on the summit of Mauna Kea is 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.

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.



Wēkiu bugs occur on many Mauna Kea cinder cones including Pu'u Mahoe, Pu'u Makanaka, Pu'u Hau Kea, Pu'u Kea, Pu'u Poliahu, Pu'u Ala, Pu'u Poepoe, and various other unnamed cinder cones. Wēkiu bugs have been collected on Pu'u Mahoe (above) in 1997, 1998, and 2002.

Photo taken on September 12, 2003.

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VI. RESULTS

SAMPLING INFORMATION

During the 2003 3rd Quarter baseline monitoring session there were a total of twenty-four sampling nights, making eight 3-day sampling periods. During the 3-day sampling session ending September 3rd, a hurricane passed the southern end of the Island and it rained heavily at the summit, flooding all traps. This 3-day sampling session was not included in the results and a replacement session ending September 15 was added. The results of seven 3-day trapping sessions are reported.

A total of four hundred and fifty-one Wēkiu bugs were captured, four hundred and thirty-three on Pu'u Hau 'Oki and eighteen on Pu'u Wēkiu. The trap capture rate (number of Wēkiu bugs per trap per 3-days) ranged from zero to 17.6 Wēkiu bugs. The overall trap capture rate during the 3rd Quarter

2003 sampling session was 12.37 Wēkiu bugs for Pu'u Hau 'Oki, and 0.51 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).

Overall mortality was less than 2% (8 of 451). Adult mortality was 3.0% (6 of 201) and juvenile mortality was less than 1% (2 of 250). The new live-traps appear to be successful at reducing mortality. Two other Wēkiu bugs died in the flooded traps, and are not included in the calculated mortality figures above. Further design changes may be necessary to make the modified live-traps more effective during rain (and snow).

TABLE 1.
3rd QUARTER 2003 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 2003 Baseline Monitoring.

Location	8/25/2003	8/28/2003	8/31/2003	9/6/2003	9/9/2003	9/12/2003	9/15/2003	AVERAGE
Pu'u Wēkiu	0.8	1.6	0.2	0.0	0.0	1.0	0.0	0.51
Pu'u Hau 'Oki	15.6	11.0	5.0	11.0	12.2	14.2	17.6	12.37

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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		4.97
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		40.41

* 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

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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 3rd Quarter 2003 sampling session the number of Wēkiu bugs varied with average temperature (Figure 1). Generally, as the average temperature for the three-day sampling sessions increased, the

number of Wēkiu bugs captured in live-traps increased. This was consistent with previous Baseline Monitoring sessions, that showed a general trend indicating the number of Wēkiu bugs captured increased as average temperature increased (Figure 2, Figure 3, Figure 4, Figure 5, Figure 6, and Figure 7).

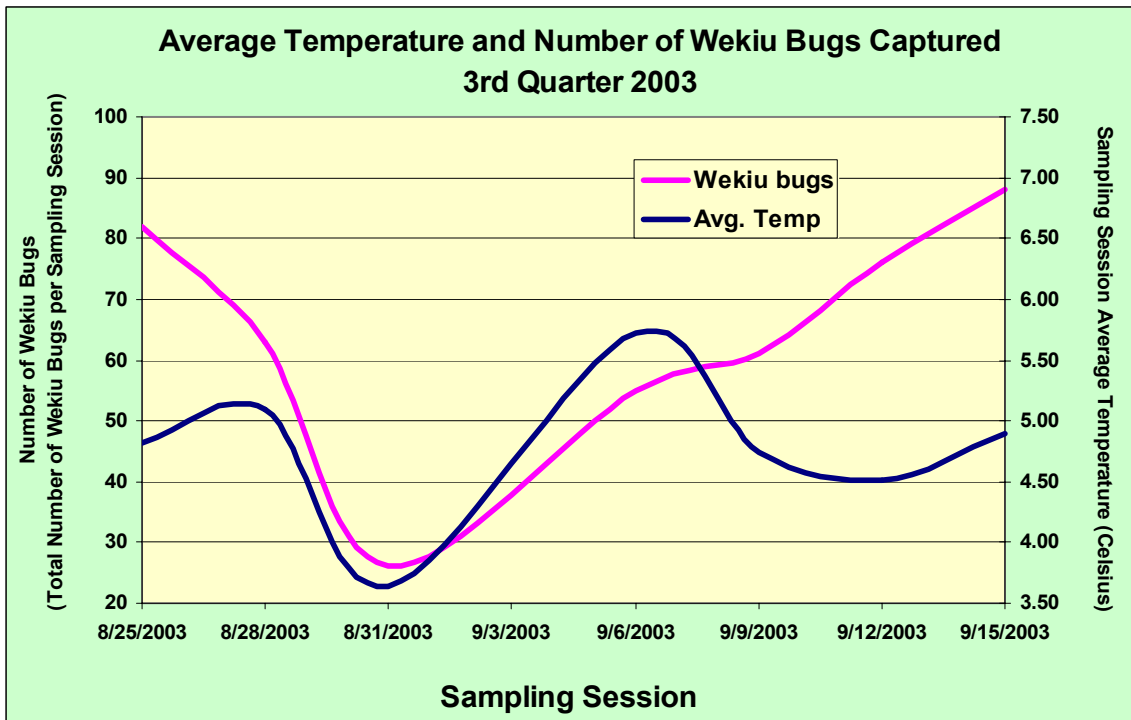


FIGURE 1. Plot of Average Temperature (Celsius) and Total Number of Wēkiu Bugs Captured for Seven Sampling Periods in the 3rd Quarter 2003 sampling session.

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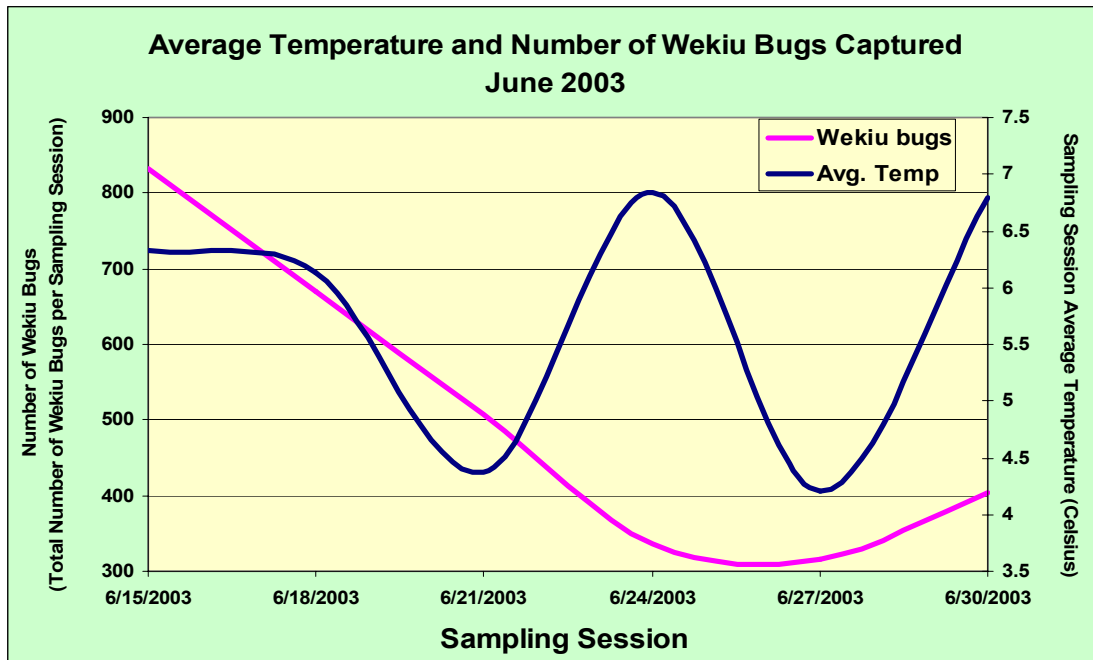


FIGURE 2. Plot of Average Temperature (Celsius) and Total Number of Wēkiu Bugs Captured for Seven Sampling Periods in the 2nd Quarter 2003 sampling session.

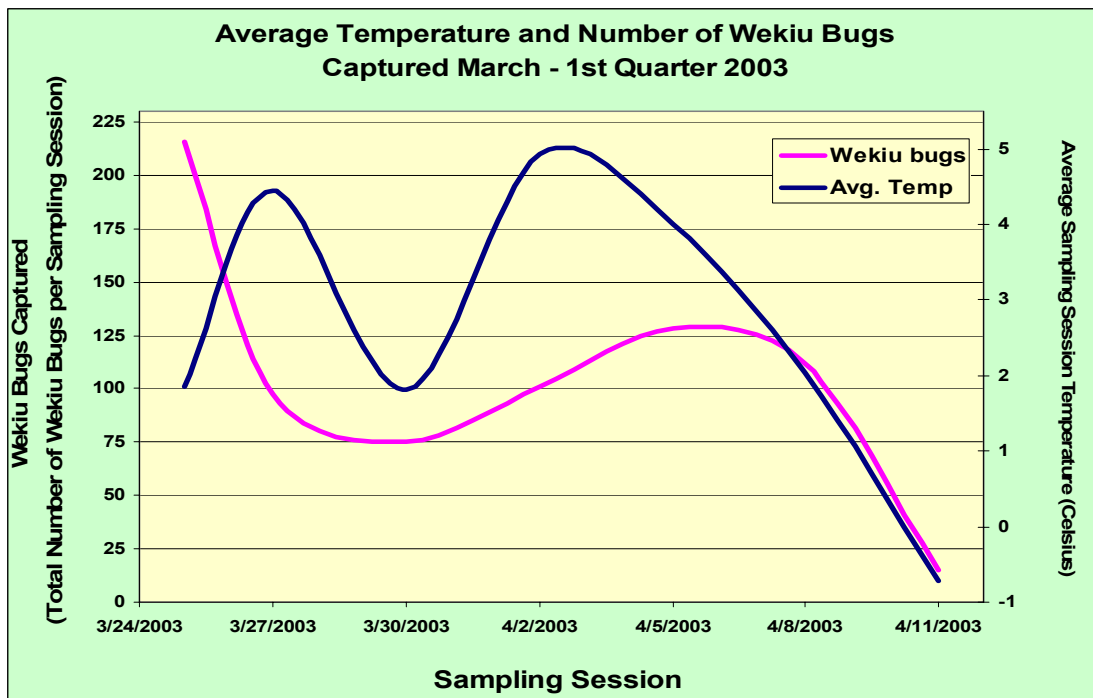


FIGURE 3. Plot of Average Temperature (Celsius) and Total Number of Wēkiu Bugs Captured for Seven Sampling Periods in the 1st Quarter 2003 sampling session.

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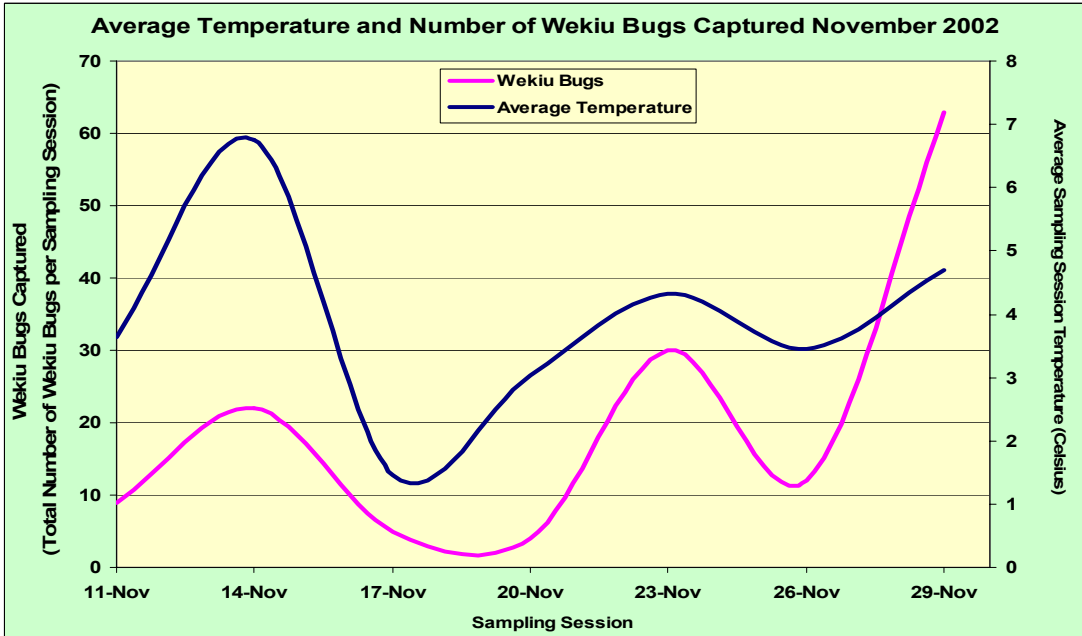


FIGURE 4. Plot of Average Temperature (Celsius) and Total Number of Wēkiu Bugs Captured for Seven Sampling Periods in the 4th Quarter 2002 sampling session.

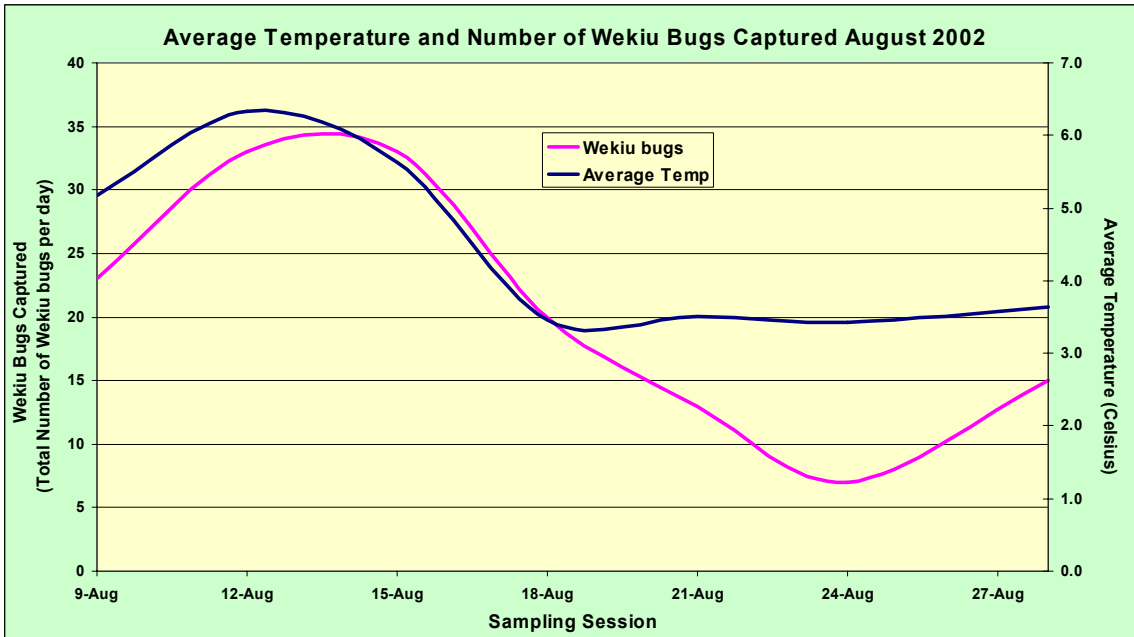


FIGURE 5. Plot of Average Temperature (Celsius) and Total Number of Wēkiu Bugs Captured for Seven Sampling Periods in 3rd Quarter 2002 sampling session.

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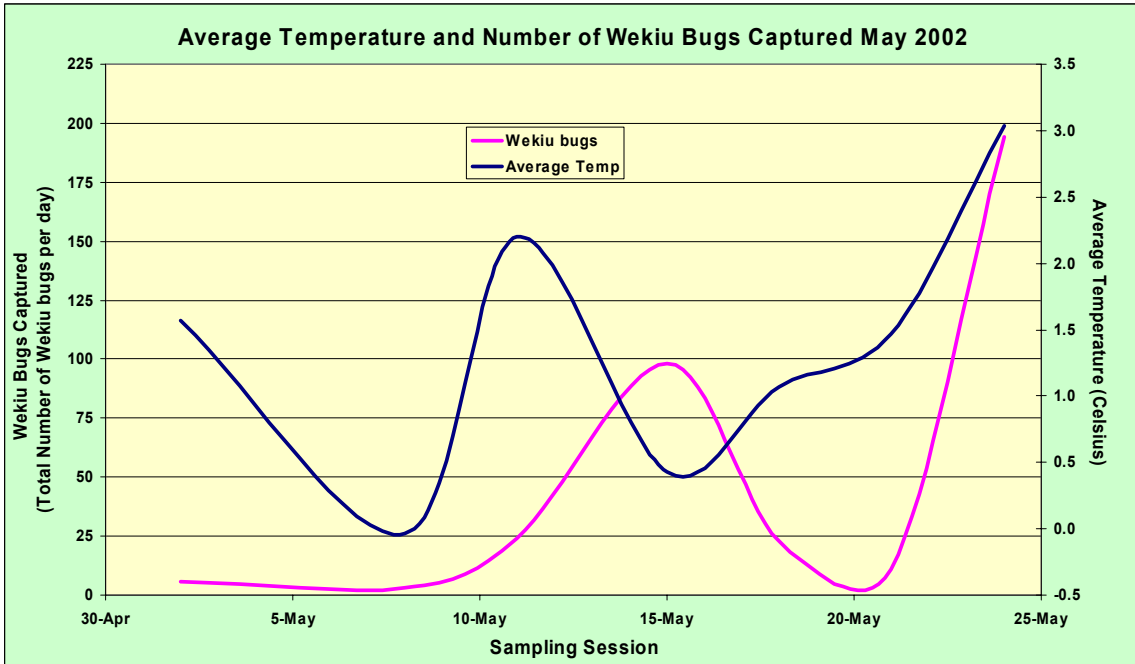


FIGURE 6. Plot of Average Temperature (Celsius) and Total Number of Wēkiu Bugs Captured for Seven Sampling Periods in the 2nd Quarter 2002 sampling session.

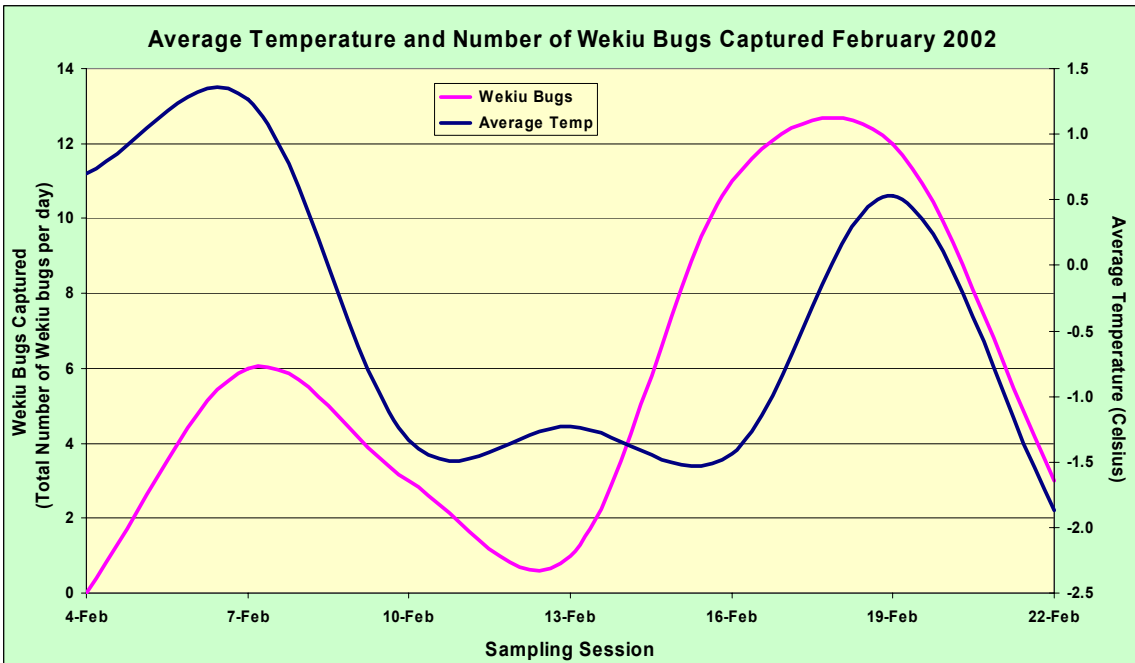


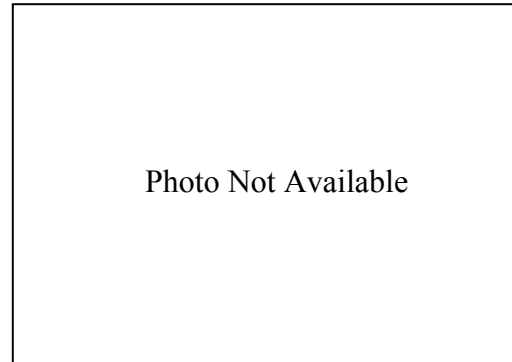
FIGURE 7. Plot of Average Temperature (Celsius) and Total Number of Wēkiu Bugs Captured for Seven Sampling Periods in the 1st Quarter 2002 sampling session.

Pu'u Hau 'Oki Inner Slope Photographic Archive

AUGUST - SEPTEMBER 2003



Pu'u Hau 'Oki inner slope
August 25, 2003



Pu'u Hau 'Oki inner slope
August 28, 2003



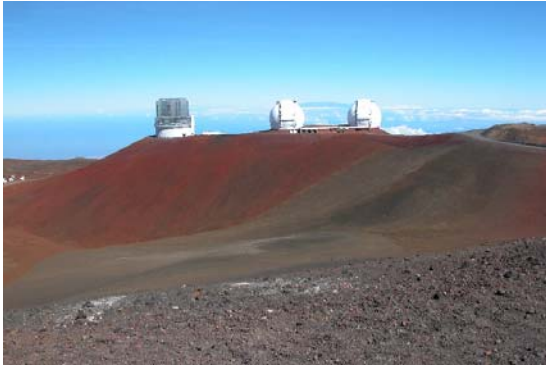
Pu'u Hau 'Oki inner slope
August 31, 2003



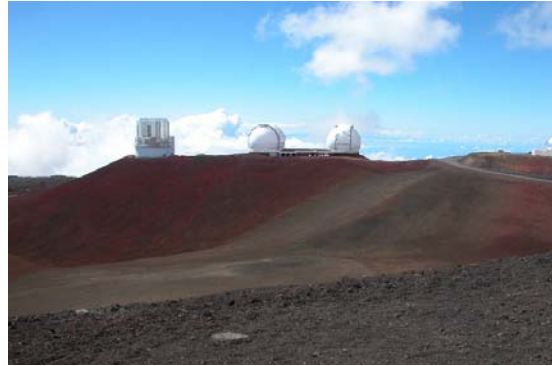
Pu'u Hau 'Oki inner slope
September 06, 2003

Pu'u Hau 'Oki Outer Slope Photographic Archive

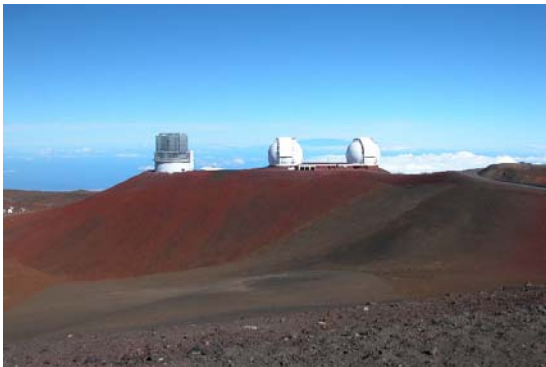
AUGUST - SEPTEMBER 2003



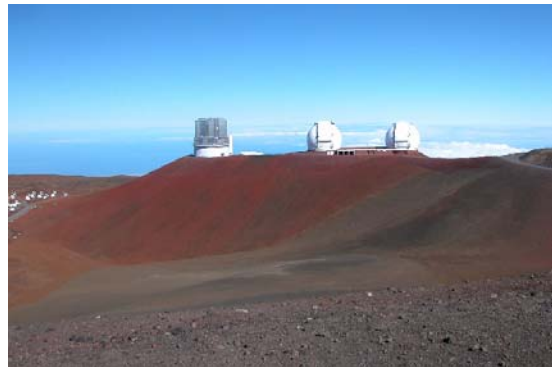
Pu'u Hau 'Oki outer slope
August 25, 2003



Pu'u Hau 'Oki outer slope
August 28, 2003

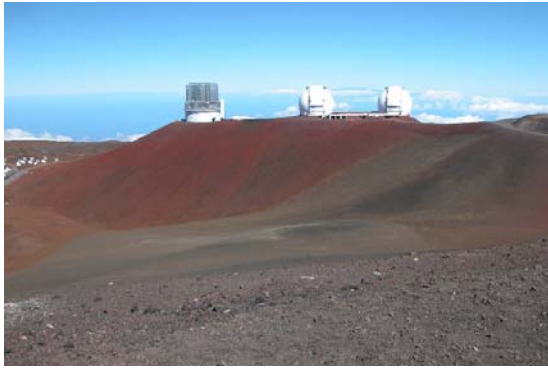


Pu'u Hau 'Oki outer slope
August 31, 2003

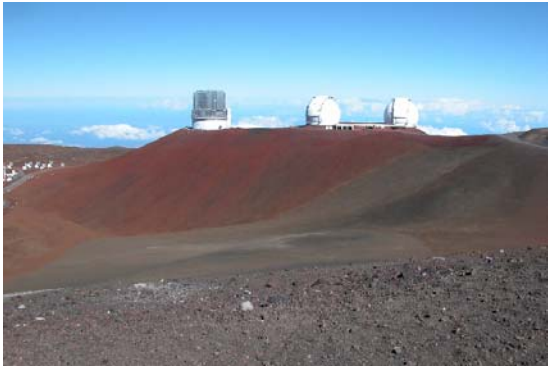


Pu'u Hau 'Oki outer slope
September 06, 2003

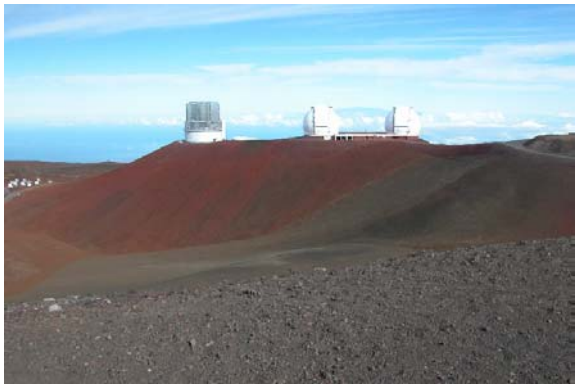
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Pu'u Hau 'Oki outer slope
September 09, 2003



Pu'u Hau 'Oki outer slope
September 12, 2003



Pu'u Hau 'Oki outer slope
September 15, 2003

Pu'u Wēkiu Photographic Archive

AUGUST - SEPTEMBER 2003



Pu'u Wēkiu inner slope
August 25, 2003



Pu'u Wēkiu inner slope
August 28, 2003



Pu'u Wēkiu inner slope
August 31, 2003



Pu'u Wēkiu inner slope
September 06, 2003

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DISCUSSION

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. 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 4.82 bugs per trap per 3-day trapping period on Pu'u Hau 'Oki, and 0.13 bugs per trap per 3-day trapping period on Pu'u Wēkiu.

During the 1st Quarter 2003 sampling session a total of seven hundred and twelve Wēkiu bugs appeared in or near the traps. The 1st Quarter 2003 average trap capture rate was 18.29 Wēkiu bugs per trap per 3 days of sampling on Pu'u Hau 'Oki and 2.87 on Pu'u Wēkiu (Table 2).

During the 2003 2nd Quarter sampling session a total of three thousand and sixty-three Wēkiu bugs appeared in or near the traps during the six trapping sessions. Average 2nd Quarter 2003 trap capture rate was 90.6 bugs per trap per 3-day trapping period on Pu'u Hau 'Oki and 11.5 bugs per trap per 3-day trapping period on Pu'u Wēkiu (Table 2).

During the 2003 3rd Quarter sampling session Wēkiu bugs appeared in all ten of the traps, and a total of four hundred and fifty-one Wēkiu bugs appeared in or near the traps during the seven trapping sessions. About ninety-six percent (433 Wēkiu bugs) of the Wēkiu bugs captured appeared in live-traps on Pu'u Hau 'Oki. Eighteen Wēkiu bugs appeared in live-traps on Pu'u Wēkiu. All live bugs were released back into their habitat.

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Average 3rd Quarter 2003 trap capture rate on Pu'u Hau 'Oki was 12.37 bugs per trap per 3-day trapping period. Average 3rd Quarter 2003 trap capture rate on Pu'u Wēkiu was 0.51 bugs per trap per 3-day trapping period. During the August 1997 sampling period of the 1997/98 Arthropod Assessment trap capture rates averaged 0.20 on Pu'u Hau 'Oki and 0.15 on Pu'u Wēkiu (Table 3). Overall trap capture rates in 2003 represented an increase of at least 45 times that measured in 1997/98. This evidence supports the hypothesis that Wēkiu bug populations have increased since 1998.

The Pu'u Hau 'Oki and Pu'u Wēkiu combined 3rd Quarter 2003 Wēkiu bug capture rate (6.44 bugs per trap per 3-day) was about three times the combined capture rate measured in the 3rd Quarter 2002 sampling session (2.15 bugs per trap per 3-day).

The average trap-capture rate for three quarters in 2003 is 22.71 bugs per trap per 3-day trapping period. That is almost 9 times greater than the rate measured through three quarters in 2002 (2.61 bugs per trap per 3-day trapping period).

The proportion of immature Wēkiu bugs captured in the 3rd Quarter 2003 sampling session (.55) was less than the proportion in the 2nd Quarter 2003

sampling session (.79). Immature Wēkiu bugs are apparently most active during June and July (the time of highest proportion of immature captures). This may be the season of dispersal after hatching, similar to other insects.

Unfortunately not all Wēkiu bugs survived in live-traps. In 2002 sampling, mortality averaged about 16%. In an effort to reduce mortality, a modification was made to the trap and tested during the 1st Quarter 2003 sampling session. The modification eliminated drain holes and reduced the amount of wick exposed in the trap cup. Trap mortality dropped to less than 9% in modified traps during that session. The modified live-traps were used exclusively during the 2nd Quarter 2003 sampling session and mortality decreased to less than 2%. Mortality remained low in the modified traps during the 3rd Quarter 2003 sampling session (less than 2%). The modified live-traps are apparently successful at reducing trap mortality and should be considered for all Wēkiu bug sampling.

Other Observations

During the 3rd Quarter 2003 monitoring session the site was free of loose trash and debris. Observatory vehicles parked near the

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WMKO were clean and free of mud and had no visible signs of alien arthropods.



Immature Wēkiu bug on a ruler.
Marks are millimeters.

In September 2003, W.M. Keck Observatory personnel attended a training session about Wēkiu bugs, their conservation and protection. The hour long training presented by Pacific Analytics briefed observatory workers on Wēkiu bug biology, and how workers and visitors at the summit can avoid disturbing Wēkiu bugs and their habitat. The W.M. Keck Observatory is committed to minimizing impact on Wēkiu bugs and plans to offer another training session in December 2003.