RANGE, HABITAT, AND ECOLOGY OF THE WEKIU BUG (*NYSIUS WEKIUICOLA*), A RARE INSECT SPECIES UNIQUE TO MAUNA KEA, HAWAI'I ISLAND

FINAL REPORT

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EXECUTIVE SUMMARY

The Hawaii Biological Survey of the Bishop Museum was contracted by the Office of Mauna Kea Management (OMKM) to assess the distribution and habitat use of the wēkiu bug (*Nysius wekiuicola* Ashlock, and Gagné), endemic to Mauna Kea. This project arose after a preliminary study conducted by the Smithsonian Institution found relatively high numbers of wēkiu bugs on Pu'u Hau Kea in June 2001, in contrast to other similar studies which had indicated population declines. Because of these findings, OMKM was interested in obtaining further information regarding the distribution and status of wēkiu bugs in the alpine zone of Mauna Kea.

The three major objectives of this study were to 1) survey for the presence or absence of wēkiu bugs at the summits of various pu'u's (cinder cones) located in the alpine zone of Mauna Kea, 2) determine the elevational distribution of wēkiu bugs on Mauna Kea, and 3) assess whether different pitfall trapping methods used in earlier Bishop Museum surveys provide comparable data in regard to wēkiu bug capture rates.

Wēkiu bug surveys for this study occurred in April and May 2002, with additional sampling of Pu'u Hau Kea in September 2002. The current study assessed the presence or absence of wēkiu bugs in the alpine zone of Mauna Kea as a whole, and provided valuable new information that will help better conserve and manage this rare species.

Wēkiu bugs were infrequently collected, occurring preferentially along the upper rim areas of suitable cinder cones within the alpine zone of Mauna Kea. Evidence for the rarity of wēkiu bugs is demonstrated by the fact that despite 398 total trap days of effort during this study, only 47 wēkiu bugs were captured. Wēkiu bugs were found at lower elevations than previously recorded, being present in pitfall traps, although in low numbers, to elevations as low as 11,715 ft (3,572 m). A pronounced pattern was observed of wēkiu bugs becoming increasingly more common in pitfall traps as elevations increased, with the greatest numbers captured on Pu'u Hau Kea. Substrate types were also determined to be of critical importance in assessing whether a particular habitat was suitable or not for wēkiu bugs.

Bishop Museum wēkiu bug studies conducted in the early 1980s have been implicated by some for the demise and current rarity of the wēkiu bug. On the contrary, our findings indicate there is no evidence that ethylene glycol trapping in the early 1980s was responsible for this decline, nor is there is any quantitative evidence available to actually show there has been a decline or increase in the population. This is because: 1) valid population studies have not been conducted, 2) methodologies used in the 1982 study with one exception have not been used since that time and, 3) past sampling measured wēkiu bug foraging activity. Because there are no reliable data comparable to the 1982 study, and because valid population studies are not being currently conducted, any conclusions that wēkiu bug populations are currently increasing or decreasing are invalid.

Although much controversy has been generated recently over whether wēkiu bug populations are increasing or decreasing, alternatives exist that could provide quantitative information regarding the population status of this species. Wēkiu bugs collected in the 1982 study could be compared to wēkiu bugs preserved from the more recent studies conducted since 1997. This would provide quantitative information as to whether the wēkiu bug populations have actually declined. Molecular markers could be used to quantitatively state whether wēkiu bugs have undergone a genetic bottleneck, and also examine gene flow between the core populations around the high observatory summit areas and smaller outlying populations in the lower alpine zone of Mauna Kea, such as at Pu'u Makanaka.

To further understand the entire range of potential habitats that can be utilized by this species, it is recommended that wēkiu bug surveys be continued in the outlying alpine zone areas of Mauna Kea that have not yet been sampled. Although further testing of pitfall trap methodology is warranted, our study has shown that shrimp pitfall traps have several major drawbacks, with 56% mortality recorded during this study compared to 55% recorded in previous Bishop Museum studies. This clearly cannot be considered a non-lethal sampling methodology. Additionally, large predators such as lycosid (wolf) spiders consume items within these traps, and thus traps with negative wēkiu bug results may not necessarily have had zero wēkiu bugs within them. Thus, it is concluded that because both native and alien insects cannot escape from ethylene glycol traps, they are a better measure of wēkiu bug presence.

insects were captured near the inner and outer rim of each cone, generally within approximately 150 ft (50 m) vertical elevation of each individual cinder cone lip (Table 5). Pu'u Makanaka was the one notable exception. An individual wēkiu bug was collected at pitfall Trap #2, which was the second to lowest in the transect of 15 pitfall traps up this large cinder cone.

At Pu'u Ala and the unnamed Pu'u near the VLBA observatory, shrimp pitfall traps were rebaited and allowed to run for longer times than in other sampled areas (Table 7). No additional wēkiu bugs were collected in either of these cinder cones after rebaiting. Two possibilities may explain this observed lack of additional captures after rebaiting. First, weather deteriorated during the last few days of the study in late April, and the snow and freezing rain may have led to reduced wēkiu bug activity. The other plausible explanation is that these two cinder cones contain only marginal wēkiu bug habitat, and thus have low numbers of these insects in these areas as reflected by the low total numbers captured in the traps.

Table 3. Summary of sample effort and results of Mauna Kea cinder cones surveyed for Wēkiu bugs using both shrimp pitfall and ethylene glycol pitfall traps in April/May 2002, and September 2002.

Cinder Cone	Highest Elevation	Total Traps	Wēkiu bugs in traps	Wēkiu bugs observed only	Trap Dates	Total Trap Days[3]
Pu'u Hau Kea	13,441 ft	16	9	4	17-20 Sept	48
Pu'u Māhoe	13,154 ft	-	n/a	1	24 Apr	-
Pu'u Poepoe	12,679 ft	10	33	0	26-29 Apr	30
Pu'u Ala	12,610 ft	9	3	0	24 Apr-May 1	63
Pu'u Makanaka	12,414 ft	15	1	0	22-24 Apr	30
Unnamed Pu'u 1W[1]	12,100 ft	10	0	0	22-28 Apr	60
Unnamed Pu'u near VLBA	11,920 ft	13	1	0	25-30 Apr	65
Transit Area[2]	11,850 ft	3	0	0	22-28 Apr	30
Pu'u Keonehehe'e	11,600 ft	10	0	0	22-28 Apr	60
Unnamed Pu'u 2W[3]	11,600 ft	2	0	0	22-28 Apr	12
Totals		88	47	5		398

[1]Located at 19°47'34.6"N, 155°27'42.8"W; [2]Located at 19°47'52.7"N, 155°26'35.4"W; [3]Located at 19°47'08.5"N 155°27'34.0"W; [3]Trap days = total nights x total traps per cinder cone

Ethylene Glycol versus Shrimp Pitfall Trapping Test

The results of the test between shrimp pitfall traps and ethylene glycol traps on Pu'u Hau Kea in September 2002 were statistically even (Table 4), with 4 wēkiu bugs collected in the ethylene glycol pitfall traps versus

5 collected in the shrimp pitfall traps. Statistical tests are obviously not needed to conclude there were no significant differences in wēkiu bug catch rates between these two types of traps. By contrast, far greater numbers of wēkiu bugs were captured in June 2001, with 473 wēkiu bugs (Polhemus 2001) collected on Pu'u Hau Kea in exactly the same trapping localities as compared to nine wēkiu bugs in September 2002, and with 8 fewer traps than used during the present study. During the preliminary June 2001 Polhemus study, only ethylene glycol traps were used. Seasonal abiotic factors such as air temperature, humidity, soil moisture, and substrate temperature were quite different in September 2002 than in June 2001, and undoubtedly influenced wēkiu bug activity and likely accounted for the wide disparity in results between 2001 and 2002 on Pu'u Hau Kea. Additionally, a massive aeolian drift event of the small seed bug *Nysius palor* Ashlock from the lower grasslands into the Mauna Kea alpine zones may have also had some influence on wēkiu bug activity (see Discussion section).

Table 4. Summary of results of Pu'u Hau Kea paired ethylene glycol and shrimp pitfall traps for each trap used during surveys for wēkiu bugs during September 2002.

Trap Type	Trap #	# wēkiu bugs collected in trap	# wēkiu bugs observed on caprock[1]	wēkiu Mortality (shrimp traps)
Ethylene Glycol	1 A	0	0	n/a
Shrimp Pitfall	1 B	0	1	0
Ethylene Glycol	2 A	0	0	n/a
Shrimp Pitfall	2 B	0	1	0
Ethylene Glycol	3 A	0	0	n/a
Shrimp Pitfall	3 B	1	0	1
Ethylene Glycol	4 A	1	0	n/a
Shrimp Pitfall	4 B	1	0	1
Ethylene Glycol	5 A	2	0	n/a
Shrimp Pitfall	5 B	0	0	0
Ethylene Glycol	6 A	0	0	n/a
Shrimp Pitfall	6 B	0	0	0
Ethylene Glycol	7 A	0	0	n/a
Shrimp Pitfall	7 B	0	0	0
Ethylene Glycol	8 A	1	0	n/a
Shrimp Pitfall	8 B	3	0	0
Total Glycol		4	0	n/a
Total Shrimp		5	2	2

[1] Wēkiu bugs not collected within trap, but observed near underneath caprock near shrimp paste

Wēkiu Bug and Mortality and Daily Catch Rates in Pitfall Traps

Although originally designed to prevent wēkiu bug mortality during sampling, shrimp pitfall traps did not prove to be an effective method for the live capture and release of wēkiu bugs. Twenty-four of 43 insects captured in such traps during this study were found dead or dying, for a mortality rate of 56% (Table 5). Mortality appeared to be primarily caused when wēkiu bugs became stuck to the shrimp paste in the interior cup section of these shrimp pitfall traps. During the wet and moist conditions brought on by snow or rain, the Kum Lum Lee® shrimp paste becomes wet and sticky, so that wēkiu bugs become ensnared and weakened, subsequently dying from exposure to low night-time temperatures. Those wēkiu bugs that remain alive in the shrimp pitfall traps are generally found in the shelter of the small gravel or pebbles placed in the bottom of the plastic cups.

Table 5. Complete results, including wēkiu bug mortalities, of shrimp pitfall trap results for each trap that captured wēkiu bugs during April-May 2002, and September 2002 (see Table 1 for each trap GPS coordinates). Only traps collecting wēkiu bugs were included in this table.

Cinder Cone	Trap #	Trap Elevation	Trap Run Dates[1]	# wēkiu collected	wēkiu mortality
Pu'u Hau Kea	3B	13,437 ft	17-20 Sept	1	1
Pu'u Hau Kea	4B	13,441 ft	17-20 Sept	1	1
Pu'u Hau Kea	8B	13,407 ft	17-20 Sept	3	0
Pu'u Ala	4	12,270 ft	24-27 Apr	1	1
Pu'u Ala	5	12,390 ft	24-27 Apr	1	0
Pu'u Ala	7	12,350 ft	24-27 Apr	1	0
Pu'u Makanaka	2	11,920 ft	22-24 Apr	1	0
Pu'u Poepoe	4	12,500 ft	26-29 Apr	4	3
Pu'u Poepoe	5	12,560 ft	26-29 Apr	9	5
Pu'u Poepoe	6	12,580 ft	26-29 Apr	8	2
Pu'u Poepoe	7	12,560 ft	26-29 Apr	3	3
Pu'u Poepoe	8	12,510 ft	26-29 Apr	6	6
Pu'u Poepoe	9	12,540 ft	26-29 Apr	2	1
Pu'u Poepoe	10	12,560 ft	26-29 Apr	1	1
Unnamed Pu'u near VLBA	3	11,715 ft	25-28 Apr	1	0
Totals				43	24

[1]This date indicates the total time a trap had run when the first wēkiu bug was caught, although traps ran longer, no additional wēkiu bugs were captured in the traps.

With the exception of Pu'u Poepoe, daily wēkiu bug capture rates using a three-day standardized average were low for all cinder cones examined during this study. When only cinder cones with wēkiu bugs present were averaged (Table 6 and Table 7), the three-day capture rate ranged from 0.04 to 2.5 wēkiu bugs/trap

using shrimp pitfall traps. In June 2001, by contrast, a capture rate of 47.3 wēkiu bugs/trap for four days of trapping was obtained at the summit of Pu'u Hau Kea (Polhemus 2001). The trap results observed on Pu'u Hau Kea for September 2002 are likely a result of seasonal differences due to changes in abiotic factors such as increased temperatures and decreased soil moisture, or perhaps the mass windblown migration of *Nysius palor*. Overall, a pattern of an increasing wēkiu bug capture as elevation increases was apparent during this study (Table 6), particularly when the high wēkiu bug captures from Pu'u Hau Kea in June 2001 (Polhemus 2001) were taken into account.

Table 6. Summary of mean wēkiu bugs/trap for three days of trapping using shrimp pitfall traps, all other pu'us had 0 wēkiu bugs.

Cinder Cone	Maximum Elevation	Mean # trap/3 days	Std. Dev.
Pu'u Hau Kea – June 2001[1]	13,441 ft	47.3	58.6
Pu'u Hau Kea – September 2002	13,441 ft	0.63	1.1
Pu'u Poepoe – April 2002	12,679 ft	2.5	3.3
Pu'u Ala – April 2002	12,610 ft	0.17	0.38
Pu'u Makanaka[2]- April 2002	12,414 ft	0.07	0.28
Unnamed Pu'u near VLBA[3]- April 2002	11,920 ft	0.04	0.19

[1]Ethylene glycol traps used for four days[2]Traps on Pu'u Makanaka ran for two nights instead of three; [3]Traps ran for 5 nights instead of 6

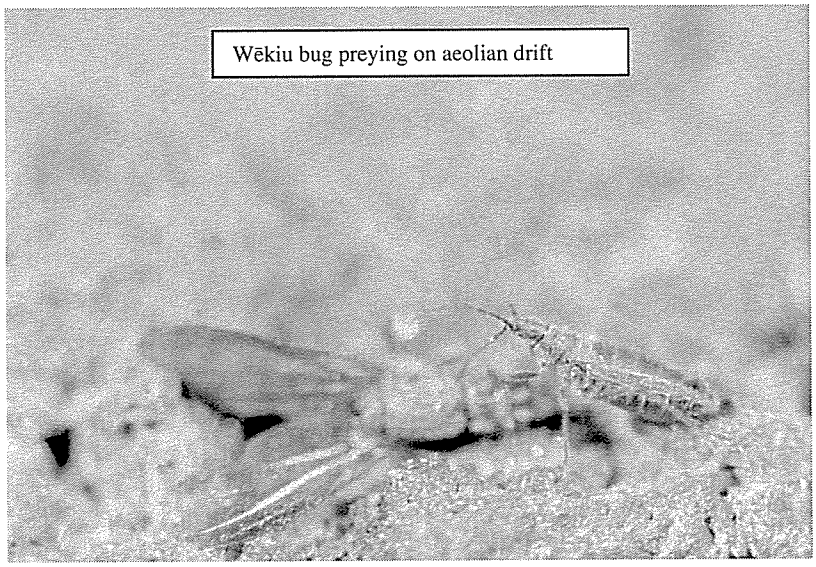
Wēkiu bug preying on aeolian drift

Table 7. Total wēkiu bug numbers in each shrimp pitfall trap for every three days.

Pu'u Hau Kea	17-20 Sept
Trap 1	0
Trap 2	0
Trap 3	1
Trap 4	1
Trap 5	0
Trap 6	0
Trap 7	0
Trap 8	3
Totals:	5

Pu'u Ala	24-27 Apr	27 Apr-1 May
Trap 1	0	0
Trap 2	0	0
Trap 3	0	0
Trap 4	1	0
Trap 5	1	0
Trap 6	0	0
Trap 7	1	0
Trap 8	0	0
Trap 9	0	0
Totals:	3	0

Unnamed Pu'u near VLBA	25-28 Apr	28-30 Apr
Trap 1	0	0
Trap 2	0	0
Trap 3	1	0
Trap 4	0	0
Trap 5	0	0
Trap 6	0	0
Trap 7	0	0
Trap 8	0	0
Trap 9	0	0
Trap 10	0	0
Trap 11	0	0
Trap 12	0	0
Trap 13	0	0
Totals	1	0

Pu'u Poepoe	26-29 Apr
Trap 1	0
Trap 2	0
Trap 3	0
Trap 4	4
Trap 5	9
Trap 6	8
Trap 7	3
Trap 8	6
Trap 9	2
Trap 10	1
Trap 11	0
Trap 12	0
Trap 13	0
Totals:	33

Pu'u Makanaka	Apr 22-24
Trap 1	0
Trap 2	1
Trap 3	0
Trap 4	0
Trap 5	0
Trap 6	0
Trap 7	0
Trap 8	0
Trap 9	0
Trap 10	0
Trap 11	0
Trap 12	0
Trap 13	0
Trap 14	0
Trap 15	0