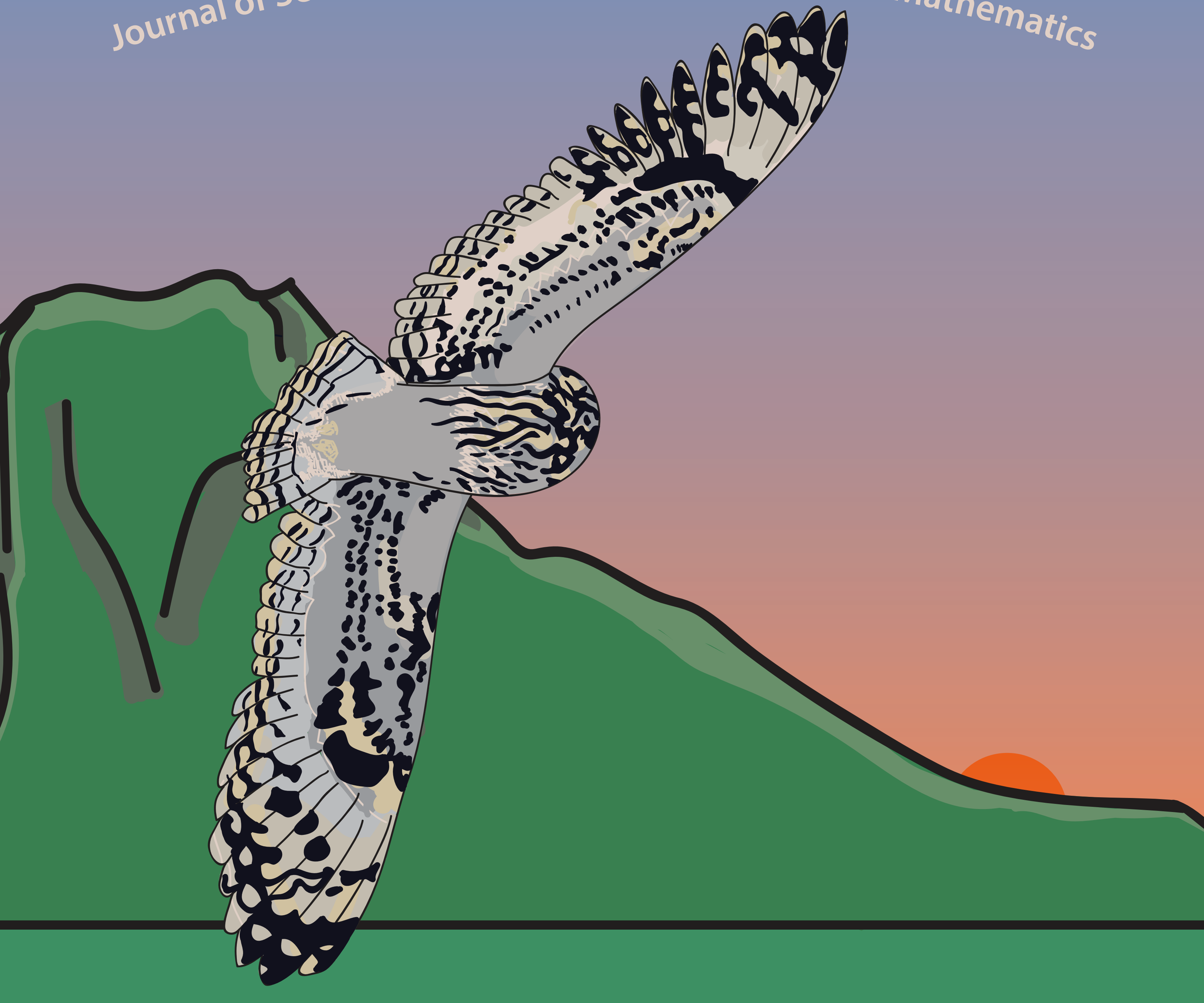
Pueo O Kū

Journal of Science, Technology, Engineering, and Mathematics



Kapi‘olani Community College
STEM Program & Board of Student Publications
Spring 2016

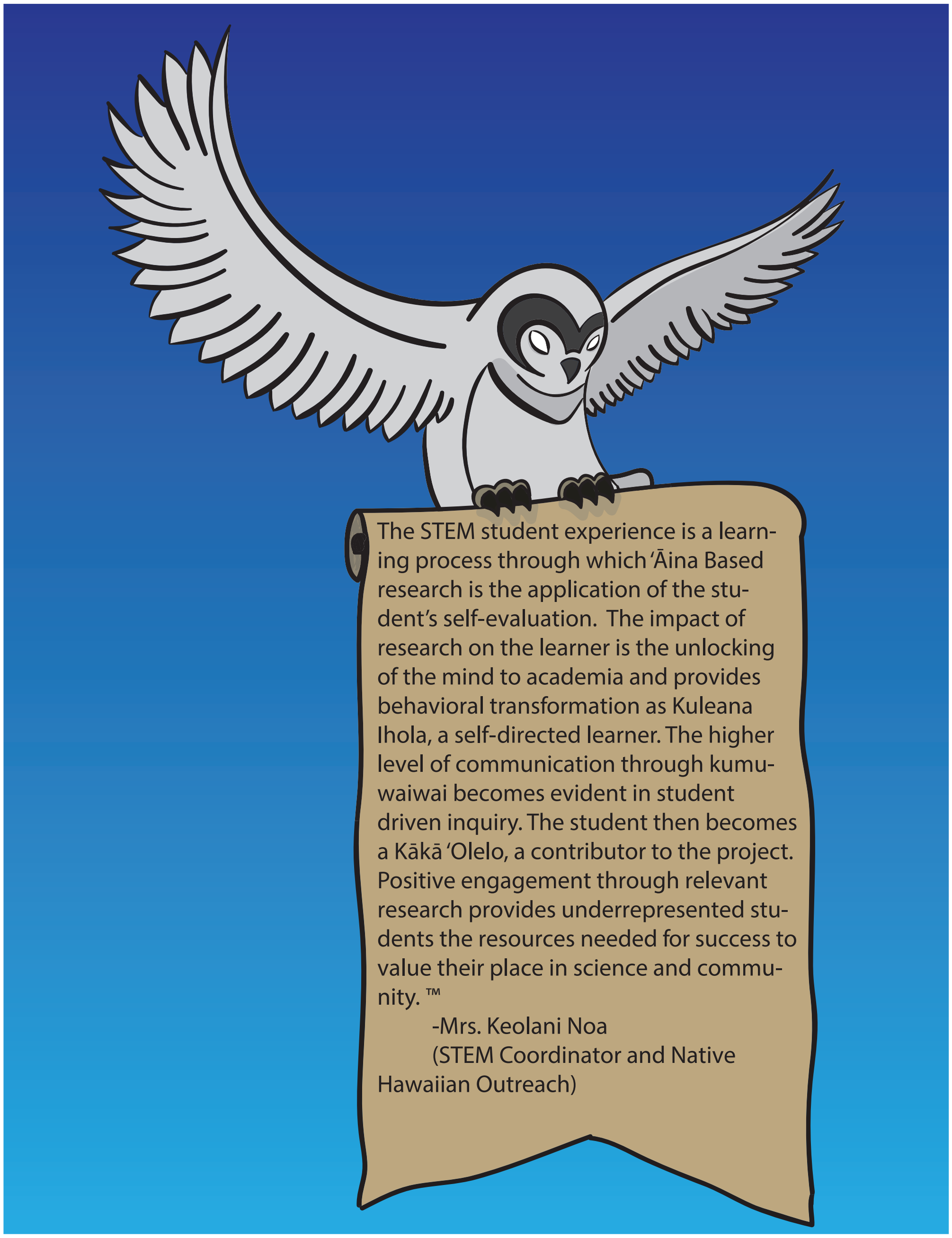
Pueo o Kū

Journal of Science, Technology, Engineering, and Mathematics

Spring 2016

University of Hawaiʻi
Kapiʻolani Community College

Board of Student Publications
4303 Diamond Head Road
Honolulu, Hawaiʻi 96816



Pueo o Kū ("Net of Kū") features the research writing of Kapiʻolani Community College's Science, Technology, Engineering and Mathematics (STEM) program. Established in August of 2005 the STEM program aims to improve the quality of education in the fields of STEM through various initiatives, including undergraduate research projects, peer mentoring, and summer bridge programs. The effort has increased the number of KCC students transfering to four-year degree programs to prepare for careers in one of the STEM disciplines. For more about KCC's STEM program, visit its website at <http://stem.kcc.hawaii.edu/>.

Pueo Art: Andrew Chang

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By Maria Petelo and Tiffanee Pahia (*Faculty Advisers*: Keolani Noa and Dr. Hervé Collin)

INTRODUCTION

In the Kanaka Maoli (Hawaiian) culture, Kūkaniloko is one of Hawaiʻi's most sacred places. This location is designated as the birthplace for all Aliʻi, or Chiefs, dating back to the 12th century (Hawaiʻi Forum, 2013), and, as such, represents the Piko, or source of life, of the island of Oʻahu. Kūkaniloko was chosen for this purpose because of the vast amount of mana (spiritual power) that it contained; the Aliʻi wanted their children to be born here for spiritual power (Mililani High School, 2001). The child was usually set to be born in the month of August because it was believed to be the time when Kūkaniloko was filled with mana. (Mililani High School, 2001). Kūkaniloko means to "Anchor the cry from within" (Mililani High School, 2001); which the Hawaiians believed the pohaku (stones) contained the power to ease the pain of childbirth, coupled with a strict diet and exercise regimen for the mother.

Figure 1. Piko of Kukaniloko

Kūkaniloko contains many different stones, some of which were calendrical markers noting the dates of conception and predicted birthdates of chiefs. In attendance of the birth of the new Ali'i, 36 chiefs were present because paper documentation was not available; they served as witnesses to welcome the new Ali' i (Kareninhonolulu, 2011). Today, there are 36 stones that guard the entrance to Kūkaniloko; although not the originals, they were placed there by the State to

Figure 2. The 36 stones lined up to Kūkaniloko

represent the 36 chiefs (Hawaii Forum, 2013).

The main pohaku or stones were in the shape of a diamond which had various ridges along the sides which were used along with the sun for time purposes. The birthing stone which is called Kūkaniloko (Sterling & Summers, 1978), has indentations in them which served as footholds for leverage (Hawaii Forum, 2013). The mother did not actually touch the stone, because she was an Aliʻi; she had to be carried by four men, two in the back two in the front, accompanied by the Kahuna (doctor) who was there to deliver the child (Sterling & Summers, 1978). Gravity was expected to do most of the work.

Figure 3. Birthstone of Kūkaniloko

Today, the stones are scattered around the site of Kūkaniloko, but are easily recognized by their bowl-like shapes and petroglyphic circles (Hawai‘i Forum, 2013) representing the piko or center, symbolizing the reference point of everything else; where it all started. The connection between Kanaka Maoli and the ‘āina, or land, is ancestral and, because of this, Kūkaniloko is particularly sacred in the Hawaiian culture as it signifies the center from which life springs forth.

PURPOSE

The purpose of this research is to confirm the location of Kūkaniloko as the piko or the center of mass of the island of O‘ahu using the scientific method.

Figure 4. First grid used to calculate the C.O.M.

METHOD

Grid references, Global Positioning System (GPS), and the center of mass (COM) formula were applied to validate that Hawaiians have an understanding of the scientific concept of mass and applied this knowledge in designating Kūkaniloko as the piko of O‘ahu, both literally and culturally. First, a coordinate system was established over the island of Oahu, and the origin was set to the following GPS coordinates (21°11’57.18”N, 21° 11’57.18”N). The size of the grid was 82.906 km along in the x axis, and 67.355 km along in the y axis as shown in Figure 4. Five different grids were used in this project. The first grid had a unit rectangle with dimensions of 20.726 km by 22.452 km. The second grid had a unit rectangle of half the dimensions of the first grid, and so on. We then used the website http://www. movable-type.co .uk/scripts/latlong.html to calculate the x distance and the corresponding y distance to each GPS coordinate of the center of each rectangle. The elevation was measured at that point using Google Earth. These data points were then used in the center of mass formula.

Its original form given in equations (1) was slightly modified for this research:

$$\bar{X} = \frac{\sum_{i=1}^{N} X_i m_i}{\sum_{i=1}^{N} m_i} \qquad \bar{Y} = \frac{\sum_{i=1}^{N} Y_i m_i}{\sum_{i=1}^{N} m_i} \tag{1}$$

Assuming the earth’s density ρ to be an invariant quantity, the mass term was substituted with $m = \rho V$, and the volume ρV was expressed in terms of the surface area A (of the unit rectangle of the grid) and the elevation e such as $m = \rho Ae$. Hence, equation (1) was modified by canceling the constant terms ρ and A from both the numerator and denominator:

$$\bar{X} = \frac{\sum_{i=1}^{N} X_i e_i}{\sum_{i=1}^{N} e_i} \qquad \bar{Y} = \frac{\sum_{i=1}^{N} Y_i e_i}{\sum_{i=1}^{N} e_i} \tag{2}$$

RESULTS

A Center of Mass of the island of O‘ahu was obtained for each grid. As the grids have smaller unit rectangles, the accuracy of the COM with respect to the actual location of Kūkaniloko was expected to increase. Figure 5 shows the position of the COM calculated for each grid. All COMs are located within 7 km of Kūkaniloko. When the 5th calculation (grid) was done, the x coordinate was slightly further than the 4th calculation, but the y coordinate was the closest of all the grids used in this research.

Furthermore, the radial distances (in polar coordinate) of the five C.O.M. calculated in this project

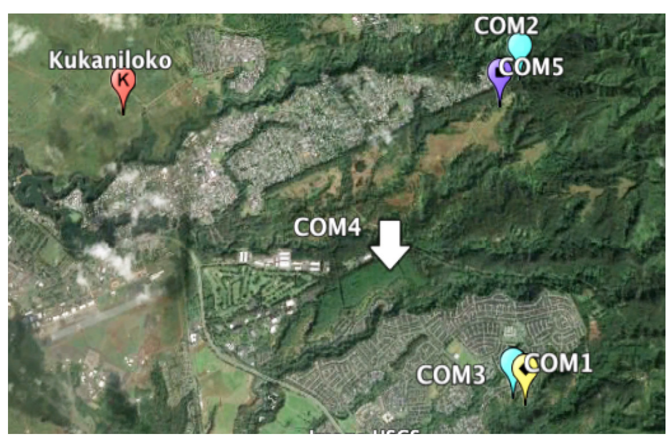
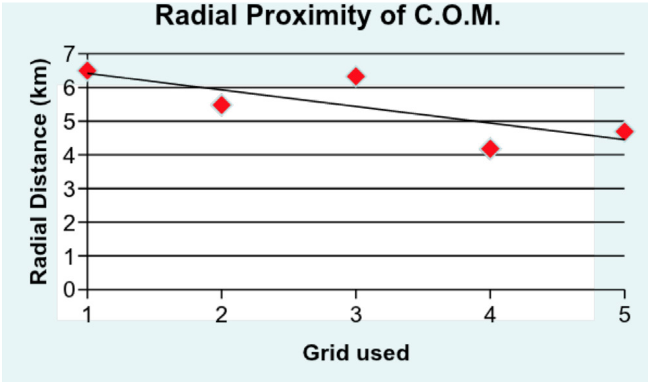


Figure 5. C.O.M. location for each grid

seems to converge towards the actual location of Kūkaniloko as shown in Graph1.



Graph 1. Radial distances of the C.O.M.

The extrapolation of the radial distances of the COM around Kūkaniloko performed by a linear regression, suggests that accuracy of the COM keeps increasing as finer grids are used. The x intercept value suggests that the Center of Mass will match the exact location of Kūkaniloko at grid 14.

CONCLUSION AND FURTHER RESEARCH

This research suggests that selecting smaller and smaller unit rectangles in the chosen grids increases the accuracy of the COM calculation. Specifically, further research should include an additional 15 grids to improve significantly the outcome of this project and to confirm that grid 14 is the COM. In addition, the variations in the density of surrounding mountains should be considered in the future, rather than assuming a constant density in the COM calculation.

Finally, further research should be conducted on the purposes of the stones of Kūkaniloko, and how they have also been used for navigational astronomy and calendar marking. Like many indigenous cultures, Hawaiians have a deep understanding and connection to their land and natural resources. Their astronomical knowledge led them to be exceptional nautical explorers, perfecting the art of navigation over the years. Additional indigenous knowledge also assisted in sustaining life on the islands through the engineering of sustainable fishponds (unique to the islands of Hawai‘i), planting of crops and manipulation of the land. Today, locations such as Kūkaniloko serve the purpose of understanding the ancient culture of Hawai‘i and provides an opportunity to pass that knowledge down through the generations; thus it is valuable for native STEM students to learn and explore its existence.

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ACKNOWLEDGMENTS

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Summer Wind Patterns on KCC Campus

By Tatiana Oje (*Advisors*: Aaron Hanai and Bradley Hughes)

INTRODUCTION

This is an analysis of surface winds on the KCC campus during the summer months. The inspiration for this project is an interest in creating a wind map that traces surface wind vectors as they travel over campus. The wind is a powerful energy and effects our daily lives in countless ways. In contemporary meteorology, global winds are the movement of the molecules in the earth's atmosphere driven by heat from the sun and five physical forces: Pressure Gradients, Gravity, Coriolis Effect, Centrifugal Force, Friction.

PURPOSE/OBJECTIVE

- Test the accuracy of Maunuunu Weather Station's wind
- sensors.
- Analyze the weather's influence on wind patterns.

PRACTICAL APPLICATIONS

- Weather modeling
- Storm damage prevention
- Bike ridding, Surfing, Paddling, etc

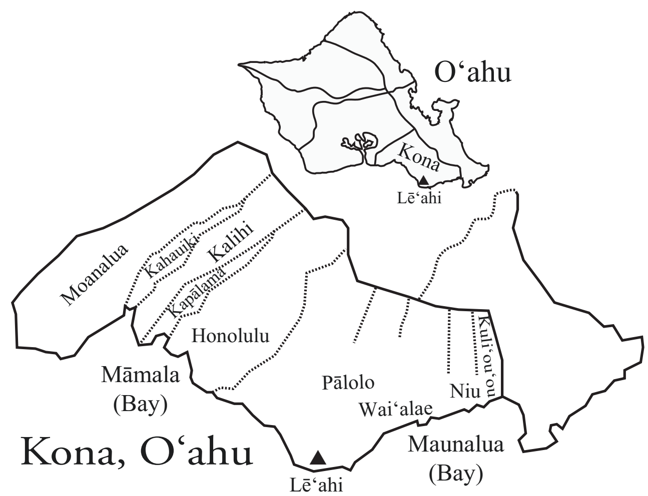
HYPOTHETICAL WIND MAP

This map attempts to trace where campus wind runs originate. It is based off of observations and the definitions of downslope, valley, land and sea winds.

CONSULTING HAWAIIAN SCIENCE

In The Wind Gourd of La'amaomao, Moses Nakuina gives a complete version of Kuapaka'a calling all the winds of the Hawaiian Islands. In the area around KCC there are seven unique winds, if you count the description of Le'ahi's wind.

> Holouha is of Kekaha,
> Maunuunu is of Wai'alae,
> The wind of Le'ahi turns here and there,
> ʻOlauniu is of Kahaloa,
> Wai'oma'o is of Palolo,
> Kuehu-lepo is of Kahua,
> Kukalahale is of Honolulu.



The vocabulary of wind names can tell us behaviors, traits and direction. It also reveals a deep understanding of the interaction between the land, the sea and the atmosphere. The name for the prevailing Trade winds varied by locale and are often referred to using the root a'e, meaning diagonal. This corresponds with the contemporary NE trade winds that blow at a 45 degree angle.

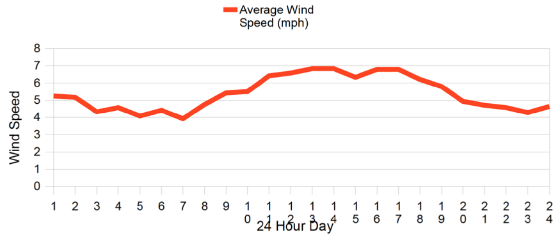
TIMELINE

A steady stream of data was recorded in 30 minute intervals from May 13 to June 14, 2013.

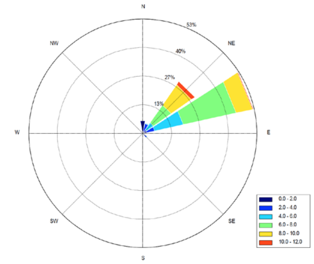
Week One (May13-19, 2013)

Diurnal Wind Speed

(Average of May 13-19, 2013)



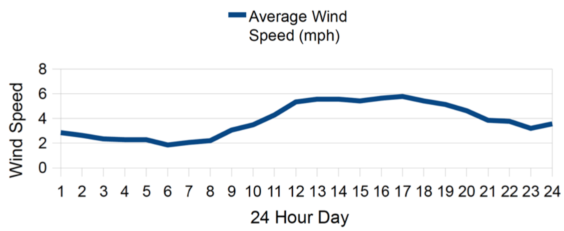
Frequency of Wind Direction
(May13-19, 2013)



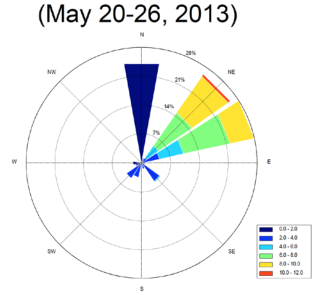
Week Two (May 20-26, 2013)

Diurnal Wind Speed

(Average of May 20-27, 2013)



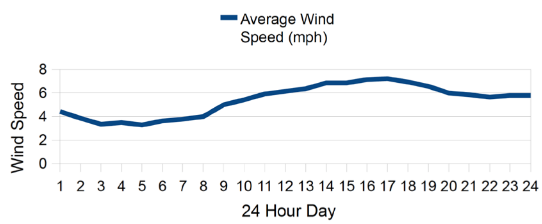
Frequency of Wind Direction
(May 20-26, 2013)



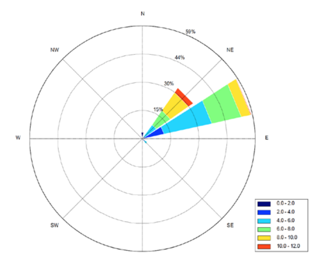
Week Three (May27-June 2, 2013)

Diurnal Wind Speed

(Average of May 27-June 2, 2013)



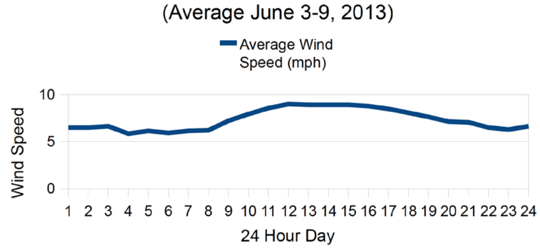
Frequency of Wind Direction
(May 27-June 2, 2013)



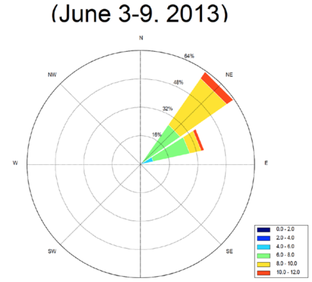
Week Four (June 3-9, 2013)

Diurnal Wind Speed

(Average June 3-9, 2013)



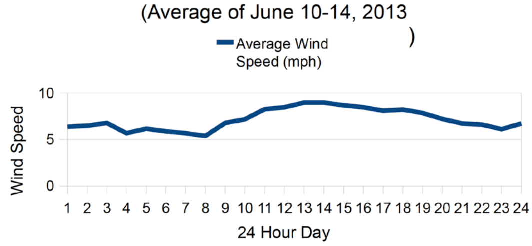
Frequency of Wind Direction
(June 3-9, 2013)



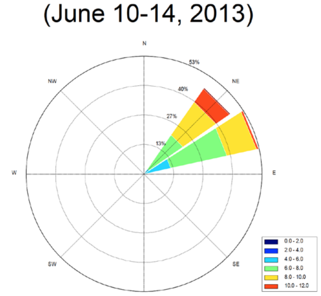
Week Five (June 10-14, 2013)

Diurnal Wind Speed

(Average of June 10-14, 2013
)



Frequency of Wind Direction
(June 10-14, 2013)



METHOD

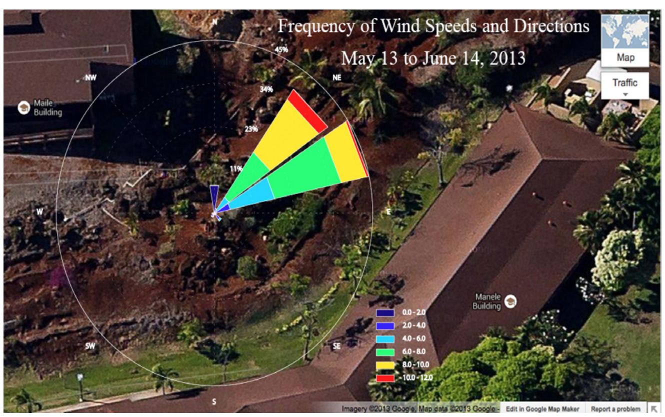
- Measured direction wind blows from and wind speed (mph) with an anemometer.
- Record any observations about the weather using my senses.
- Check current weather data on NOAA website
- Review published literature for any relevant writings.
- Repeat data collection timeline in May 2014.

POSSIBLE ERRORS IN THE EXPERIMENT

Anemometer height and lack of comparable weather station wind data in immediate area.

DISCUSSION

The 31-day collection period showed two trends in wind patterns corresponding to the behavior of pressure systems over the Northeast Pacific Ocean. During periods when ENE and NE wind directions dominate, the Pacific High Pressure system drives the Trade Winds. A low pressure trough passed over Oahu causing Kona weather for about six days. This weather event correlated with low wind speeds and more frequent winds blowing from S and SW of the island. When a Kona low passes over the island "the wind direction over the ocean tends to change to south or southwest preceding the pressure trough, and veering to westerly in the area behind the trough" (Leopold 1948). Leopold's description corresponds to the data collected for this period of time.



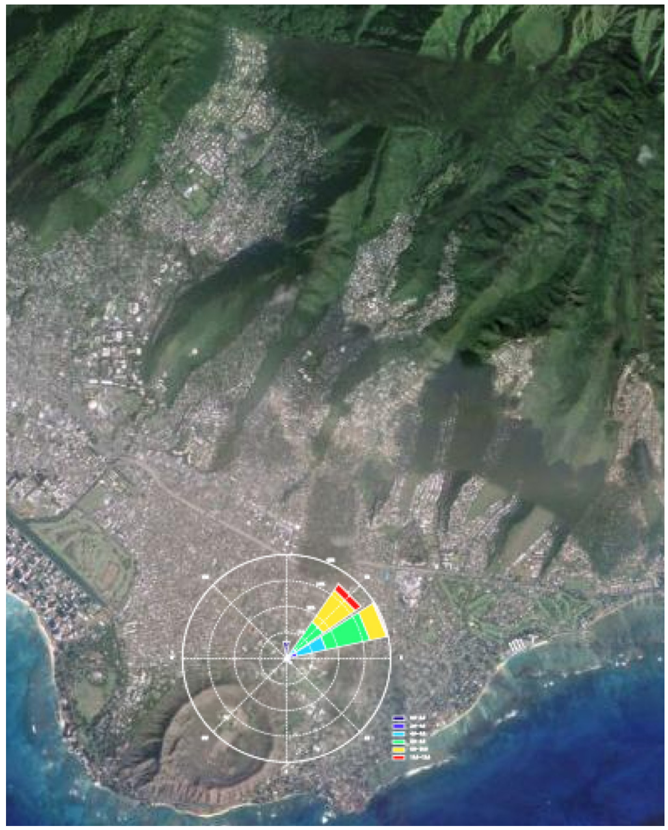
CONCLUSION

Hawai'i has a long history with the wind. The wind has played a key role in populating the islands with people, plants and birds. Some winds are gentle and others are associated with storms. The wind brings rain. It drives the waves we surf and the breezes that offers relief on a hot day.

Seasonal temperatures rose in the months of May and June. There was little rainfall over the collection period. ENE and NE winds between 4 and 8 mph were the most frequent and prevailing wind.

During the Kona storm, the weather was hot and humid and the sky was filled with Vog. The leaves of trees turned slightly, though the wind was not strong enough for the branches to sway. It was in this period that .29 inches of rain fell over campus.

There was a definite diurnal trend in wind speeds. Wind speeds tended to pick up at sun rise and decline after sun set.



FUTURE WORKS

The intent of this analysis was to create a starting point for the study of wind patterns on campus. I would like to continue this study by firstly improving the siting of the anemometer and repeating the experiment in the winter months and in the summer of 2014. I will continue to review academic papers about atmospheric science and exploring more Hawaiian place-based sources and newspapers.

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The Velocity of a Jackson's Chameleon's Tongue

By Kimberly Kahaleua (*Faculty Mentor*: Dennis Perusse)

INTRODUCTION

Jackson's Chameleons (Trioceros jacksonii) hunt and spy on predators without moving their heads or bodies. With the use of their individually operated eyes, they search for prey. Once a prey is spotted, their eyes converge and gauge the distance to the target.[2] Jackson's Chameleons have the ability to capture their prey from a distance of about one and a half times the length of their body with the use of their tongue, at a speed the human eye cannot naturally observe.[3] The three primary components of the tongue include the sticky tip, retractor muscles, and accelerator muscles.

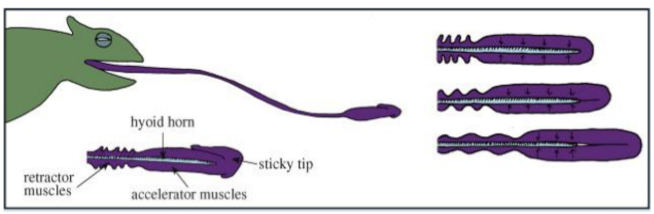


Figure 1. Sketch of a Chameleon with a projected tongue (upper left), the structure of a Chameleon's tongue (lower left), and the launch of a Chameleon's tongue in three movements (right).[4]

To prepare to strike the prey, the Chameleon would first open it's mouth, move their tongue towards the front, activate the retractor muscles, and then finally fire towards the target.[1][2] Jackson's Chameleons use ballistic tongue projection to catch their prey. Ballistic projection involves muscles contracting at high firing rates and force over a brief time.[5] The purpose of this study is to determine, with the use of mathematics, the magnitude of the velocity of a Jackson's Chameleon's tongue while capturing prey.

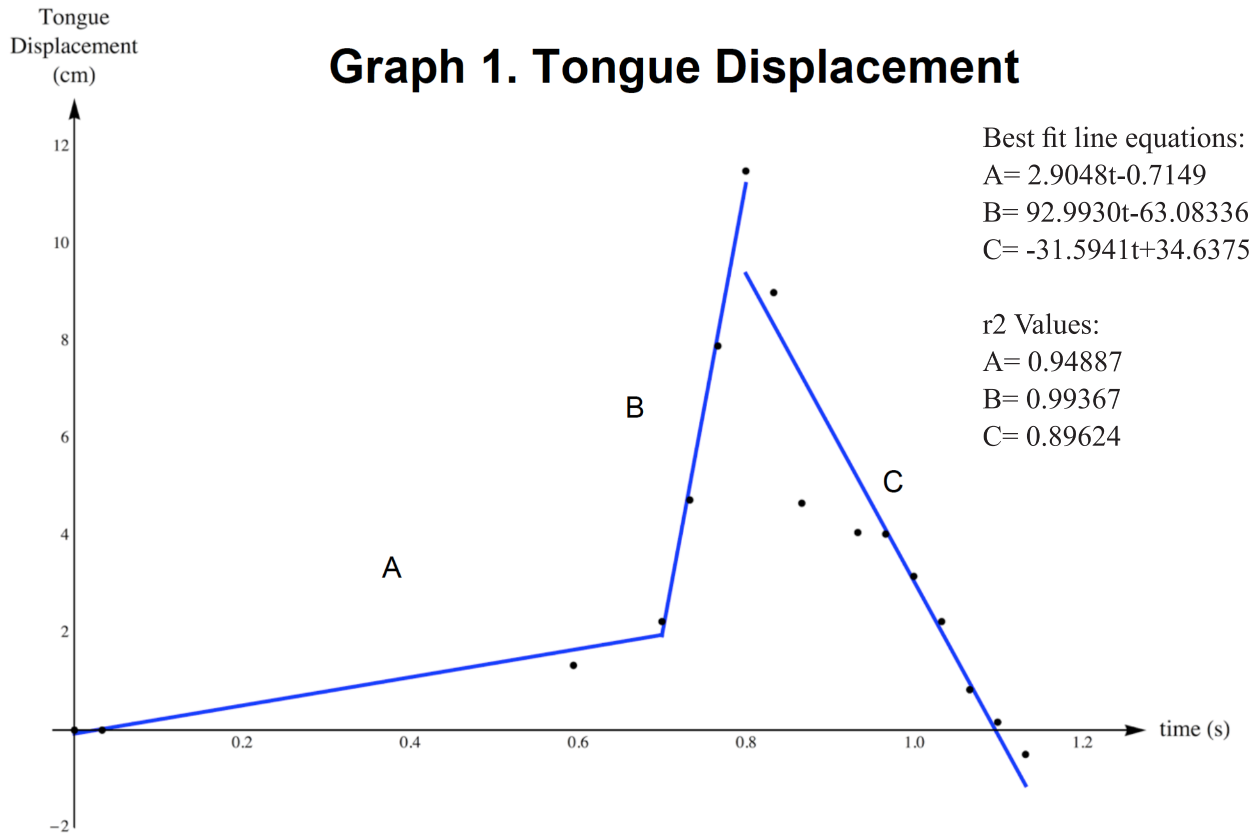
METHODS

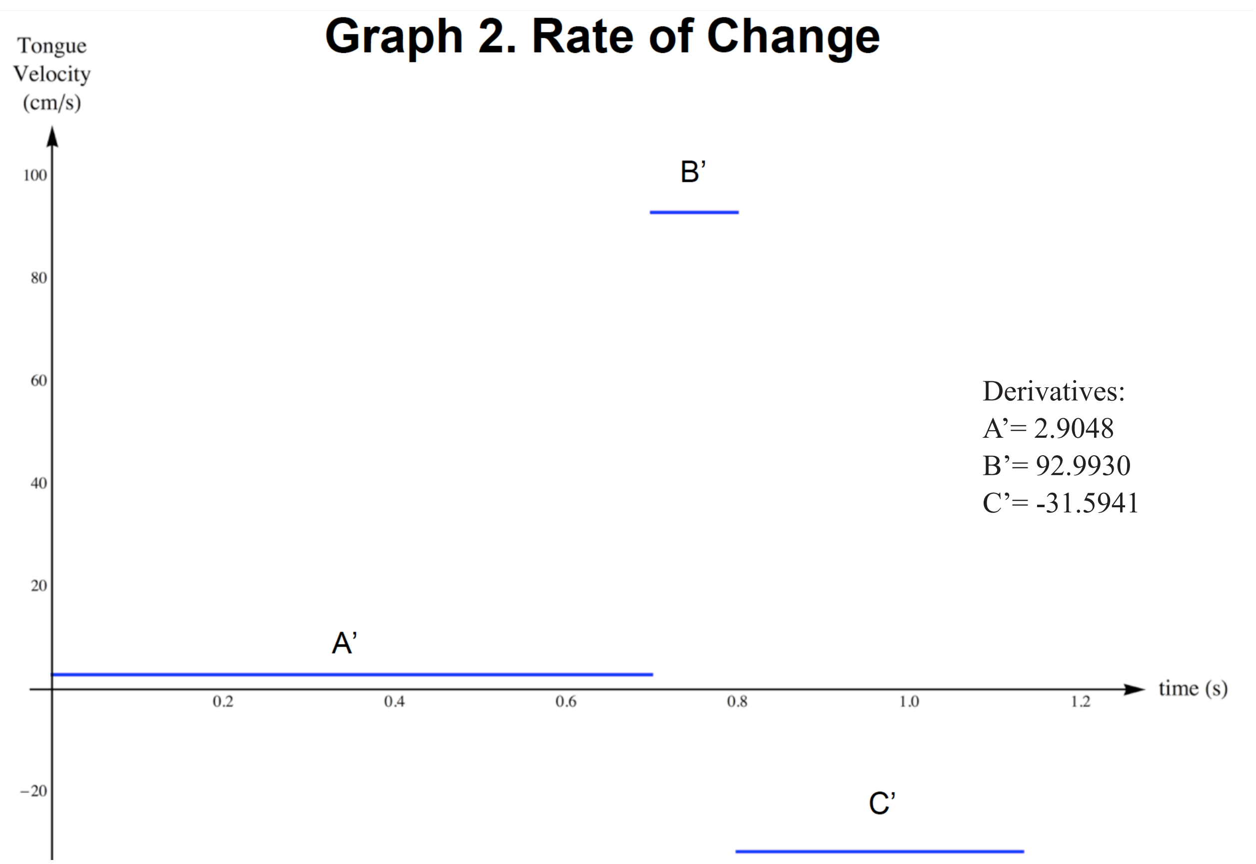
Data was collected using a ruler attached to a feeding jar and video recordings were taken at a rate of 30 frames per second. Video software, QuickTime Player, was used to record and capture the projection and retraction of the Jackson's chameleon's tongue movement. Each frame was counted and the corresponding measurement was recorded. Using three different videos, the average of each distance at a certain time was calculated. A Computer Algebra System (CAS), Mathematica, was then used to plot the data points. Each stage was calculated separately and a best fit line was generated. CAS was also used to plot the derivatives of the best fit lines to determine the rate of change.

Figure 2. The test subject, Argo the Jackson's Chameleon

Figure 3. Argo eating a cricket from the feeding jar with ruler attached.

RESULTS


Tongue Displacement (cm)
Graph 1. Tongue Displacement
Best fit line equations:
A= 2.9048t-0.7149
B= 92.9930t-63.08336
C= -31.5941t+34.6375
r2 Values:
A= 0.94887
B= 0.99367
C= 0.89624
A
B
C
12
10
8
6
4
2
−2
0.2
0.4
0.6
0.8
1.0
1.2
time (s)


Tongue Velocity (cm/s)
Graph 2. Rate of Change
B’
Derivatives:
A’= 2.9048
B’= 92.9930
C’= -31.5941
A’
C’
100
80
60
40
20
−20
0.2
0.4
0.6
0.8
1.0
1.2
time (s)

CONCLUSION

According to the results, since there were three different lines, there were also three different velocities over the total of 1.1 seconds. It can be observed that there are different tongue displacement stages: projection, acceleration, and retraction. The projection stage is represented by line A, which has a velocity of 2.9 cm/s. The acceleration stage is represented by line B, which shows an exponential increase with a velocity of 93 cm/s. The retraction stage is represented by line C, which shows the exponential decrease with a velocity of -31.6 cm/s.

Projection stage (A) = 2.9 cm/s
Acceleration stage (B) = 93 cm/s
Retraction stage (C) = -31.6 cm/s

The acceleration stage, line B, represents the fastest rate of change. In 2/15 of a second, the Jackson's Chameleon's tongue traveled 9.3 cm at a velocity of 93 cm/s.

To improve this project, a camera with a higher frame-rate and better resolution is suggested. Higher frames per second will increase available data points, thus improving the accuracy of this study and its r2 value. Additional exploration of exponential models for position and velocity of a Jackson's Chameleon's tongue should also be explored.

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ACKNOWLEDGMENTS

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Project Olonā: ‘Uhaloa Growth Rate Comparison

By Andrew Chang (*Faculty Mentors*: Kathleen Ogata, Dennis Perusse, Mike Ross)

INTRODUCTION

Project Olonā contextualizes the undergraduate research experience within the knowledge of Hawaiian culture and the natural environment, in order to discover the potential for combining traditional Hawaiian practices with modern scientific research. The project is focused on a comparative study of common Hawaiian medicinal plants (Lā‘au Lapa‘au) grown in soil media or hydroponic solutions.[1] With the use of Lā‘au Lapa‘au, healing was done with these herbal remedies made by indigenous Native Hawaiians. Hawaiian plants that contained medicinal properties were sought out for the use of creating these herbal medicine. With the known plant uses done by Hawaiians, comparisons of western medicine and the traditional uses will be made.

‘Uhaloa is an endemic plant to Hawai‘i that is used in the healing process of Lā‘au Lapa‘au. *Waltheria indica* also known as ‘Uhaloa in Hawai‘i is a shrub that is able to grow to be 2 m in height and is found in elevations of 1220 m high and prefers to grow in dry climates.[2] ‘Uhaloa was mainly known to cure conditions such as coughing, congestion, thrush in infants,sore throat and to lower blood pressure.[3] The root of ‘Uhaloa was chewed or made into a tea with the addition of leaves and flowers to relieve symptoms.[4]

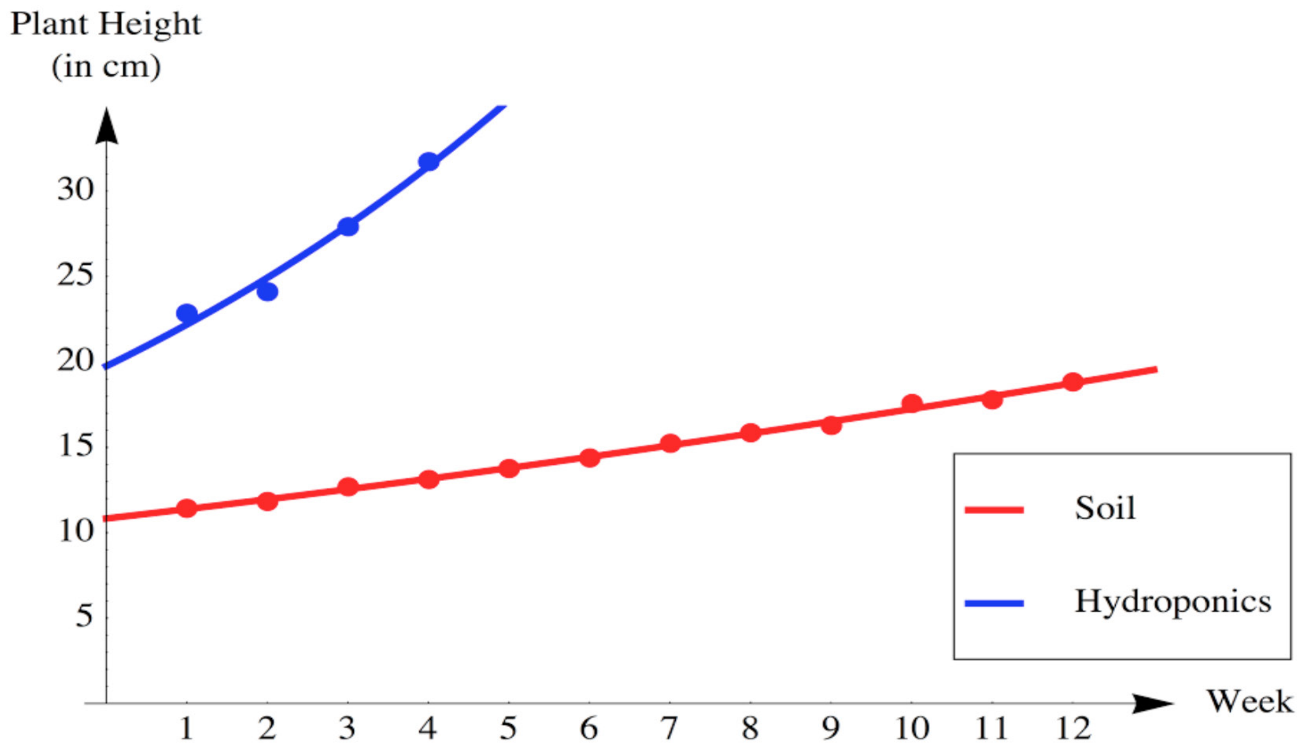
‘Uhaloa was grown using two different methods, hydroponics and traditional soil. A comparison of growth in soil and hydroponics was analyzed to find which growing method will produce a taller plant. In hydroponics, plants were measured weekly for a total of four weeks compared to soil which was measured in a 12 week period. After the fitted growth functions were determined, the growth rates were calculated from the first derivative of each function with respect to time (t). When comparing the growth rates a non-pooled t-test of the difference between the means of the two data sets were performed.

METHODS

‘Uhaloa was grown by cuttings and was transplanted into a raised soil bed and a hydroponic setup. Plant height was then measured weekly. Two sites were prepared for cuttings; soil and a hydroponic system. Cuttings were gathered, prepared and then transplanted to each site. Using a metric ruler, measurements of plant height were taken weekly for 12 weeks (Soil) and 4 weeks (Hydroponics). Data was then inputted into a spreadsheet and Mathematica was used to fit a logistic curve and plot plant heights per week. After determining the proper best-fit logistic curve, the

Figure 1. Hydroponic ‘Uhaloa Week 1

Figure 2. Soil ‘Uhaloa Week 2



Soil function:

$$y = \frac{56.50005783}{1+4.210071351e^{-0.06161889198t}} \qquad y' = \frac{14.62097442e^{-0.0616189198t}}{(1+4.210071351e^{-0.06161889198t})^2}$$

Hydroponic function:

$$y = \frac{9.308181346\times 10^{14}}{1+4.70779172\times 10^{13}e^{-0.1162926234t}} \qquad y' = \frac{-5.096031023\times 10^{27}}{(1+4.70779172\times 10^{13}e^{-0.1162926234t})^2}$$

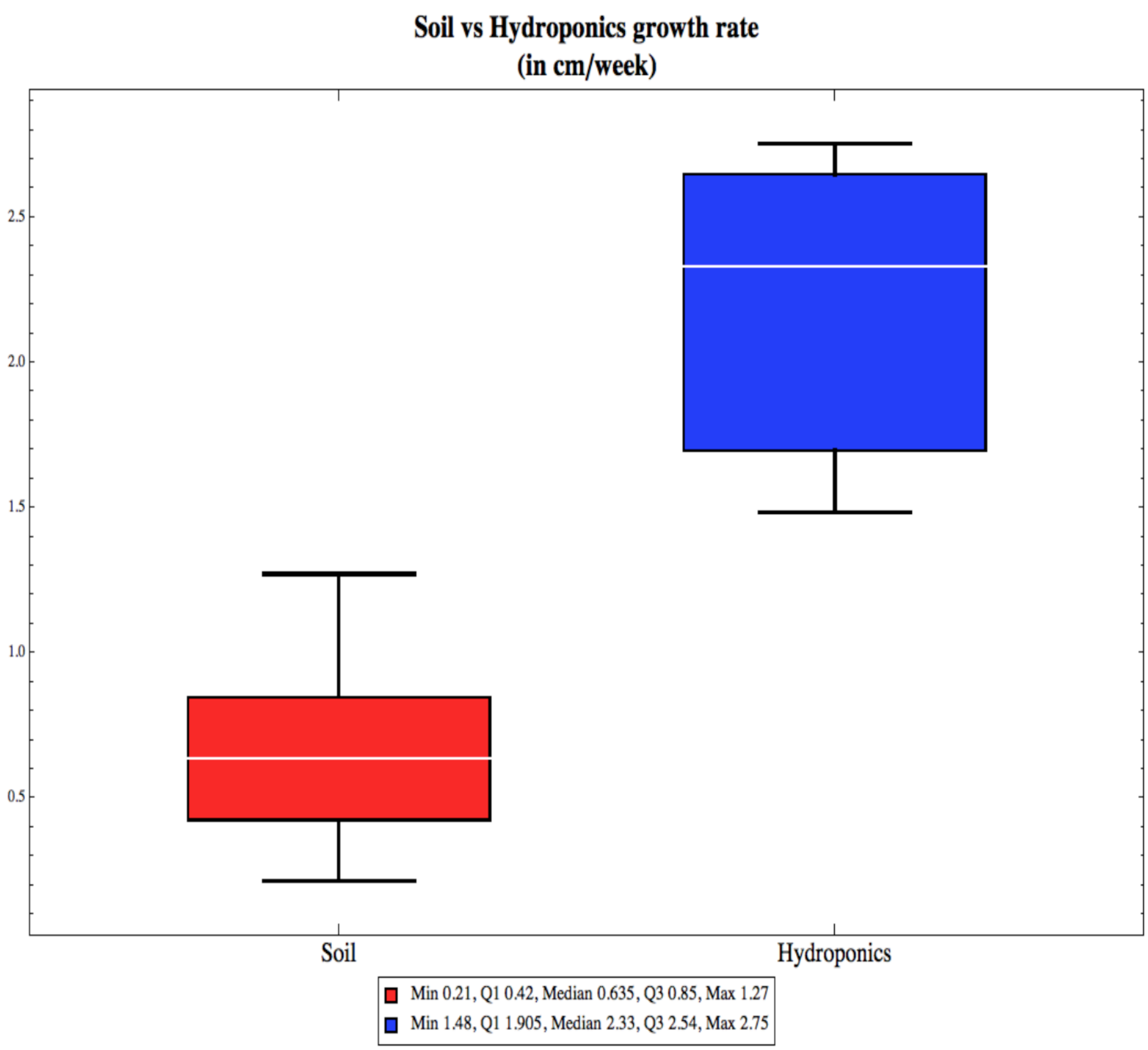
growth rates were calculated using the first derivative with respect to time(t). Values of the first derivative were then used to compare growth rates. Subsequently, a statistical approach was used, with changes in plant height then calculated, and the mean and the standard deviation of the plant growths found. A hypothesis test was then conducted to compare the mean growth rates of the soil and hydroponic plants, using a non-pooled t-test of the difference between the means of the two data sets. A level of significance of $\alpha = 0.05$ was then used to compare the two growth samples, with a null hypothesis (H_0) $\mu soil = \mu_{hydroponics}$ and an alternate hypothesis (H_a) of $\mu_{soil} < \mu_{hydroponics}$.

CONCLUSION

With the use of calculus the rate of change of the maximum plant height growth was found. The soil grown plant's maximum growth rate over a 12 week period was shown to be approximately 0.772 cm/week, whereas the hydroponic maximum growth rate over a four week period was approximately 3.66 cm/week. The finding of this study suggest that hydroponics produces a taller plant in a shorter time frame when compared to soil. The p value of the t-test was found to be $0.02411 < 0.05 = p$. Since $p < \alpha$ thus the null hypothesis (H_0) is rejected. Therefore the data provide significant evidence to suggest that soil mean growth rate is less than the mean hydroponic growth rate. With the understanding that hydroponics produces a taller and faster growing plant. Future studies will include the comparison of the medicinal properties of ‘Uhaloa when grown in soil and hydroponic media.

Figure 3. Hydroponic ‘Uhaloa Week 4

Figure 4. Soil ‘Uhaloa Week 12



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ACKNOWLEDGMENTS

Hidden Power of ‘Uhaloa

By Andrew Chang (*Faculty Mentors*: Kathleen Ogata and Keolani Noa)

INTRODUCTION

‘Uhaloa (Fig.a), also known as *Waltheria indica*, is an endemic shrub that is used as a traditional medicine (la’au lapa’au) plant in Hawai‘i [1]. As a medicinal plant, ‘uhaloa is found to have healing properties that help relieve the symptoms of sore throat, cough, congestion, and oral thrush. Traditionally the root of ‘Uhaloa was chewed or made into a tea with the addition of leaves and flowers as treatment [2]. Due to the medicinal versatility of ‘uhaloa, it is important to study the chemical compounds to identify the compound that is responsible within the plant that gave ‘uhaloa its healing property that was used in la’au lapa’au. Quercetin (Fig.b) is a known flavonoid within *Waltheria indica* and contains antibacterial properties. With the use of chemistry, isolation of quercetin within ‘uhaloa will help validate why it was used in la’au lapa’au.

Figure a. ‘Uhaloa

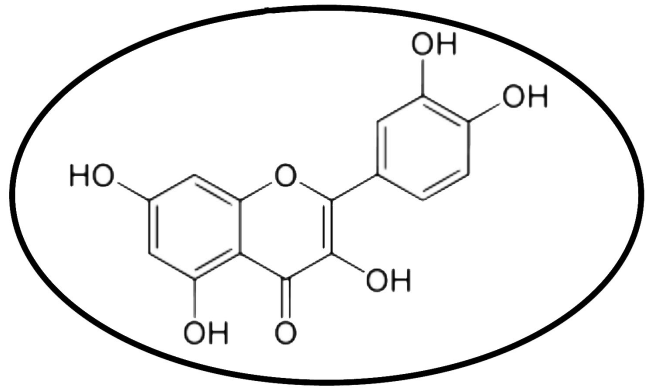
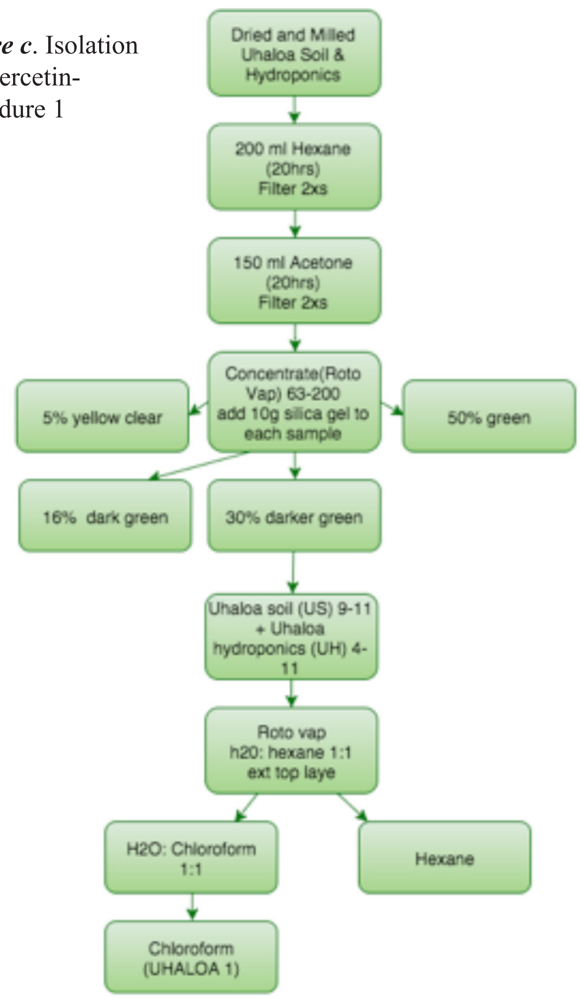


Figure b. Quercetin

METHODS

Isolation of quercetin was done using two different procedures. [3,4] (See figures c and d.)

Figure c. Isolation of Quercetin-Procedure 1



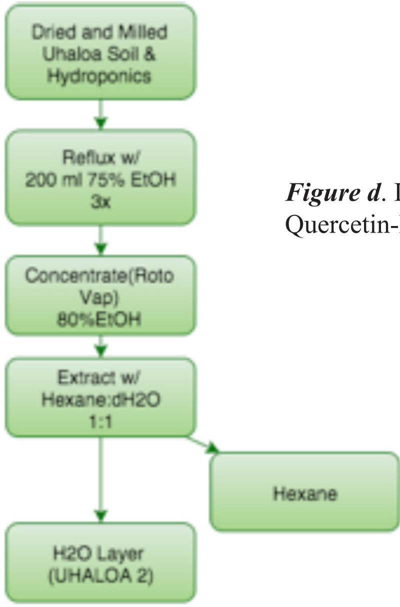


Figure d. Isolation of Quercetin-Procedure 2

After Quercetin was isolated using procedure 1 and 2, TLC was performed. [5]

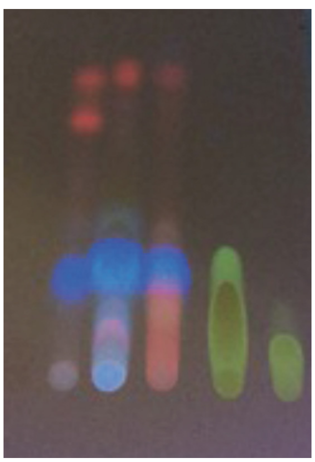


Figure e. Uhaloa 1 TLC
5%,16%,30%,50%
Ethyl Acetate,
Quercetin 8ug, 0.8 ug

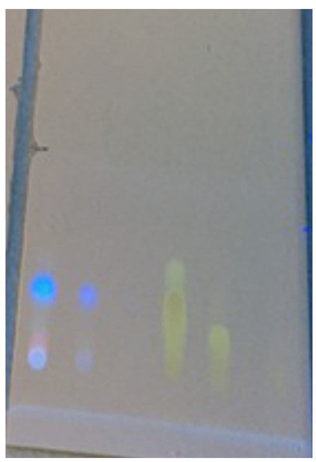


Figure f. 'Uhaloa 2 TLC
10 ug,1 ug
Quercetin 11 ug, 1.1 ug

Antibacterial activity was tested with *Stapholococcus Areus*.

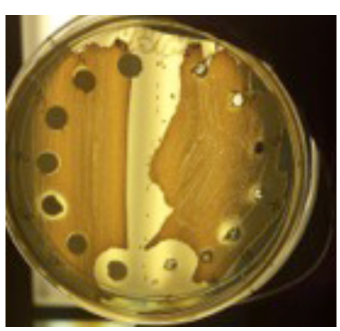


Figure g.
Antibacterial plate

Sample	**Rf**
'Uhaloa 2-1	0.35
'Uhaloa 2-2 (diluted)	0.33
Quercetin 1	0.32, 0.45
Quercetin 2 (diluted)	0.29

Table 1. TLC Rf Values

RESULTS

Quercetin was isolated according to procedures 1 and 2 (3,4) shown in the Figures(c,d). Procedure 1 was a modification of Rao's procedure which used acetone instead of methanol and also used a chromatography step followed by extraction with solvents to yield the 'uhaloa 1 sample. The second procedure involved extraction with solvents only, which produced the 'uhaloa 2 sample. The semi purified samples extracts were then tested with thin layer chromatography (TLC) and compared with a sigma quercetin standard. The results showed that quercetin standard gave a yellow fluorescent color compared to both 'uhaloa samples which fluoresced blue. From the TLC pattern of a acetone extract of milled 'uhaloa, quercetin accounts for a very small percentage of the fluorescence while the another compound that yields blue fluorescence is about 40%. Therefore, it was easier to extract the blue fluorescence compound using the procedures which extracts flavonoids. Bacterial effect inhibition of the growth of *Staphylococcus aureus* by quercetin and the 'uhaloa samples is shown in Figures (g,h). 'Uhaloa 2 had a bigger zone of inhibition than 'uhaloa 1 and quercetin. Therefore it is likely that the blue-fluorescent compound also has bactericidal activity or the compound works synergistically with quercetin. A very rough estimate of the amount of the blue compound using intensity of fluorescence of quercetin as a standard shown that we may have 20 micrograms of the blue fluorescent compound from sixty grams of 'uhaloa.

CONCLUSIONS

The amount of quercetin may be masked by the blue fluorescent compound of the 'uhaloa 2 sample. According to the bacterial test the 'uhaloa 2 sample shows more inhibition of Staphylococcus aureus better than quercetin and 'uhaloa 1. In the 'uhaloa 2 sample

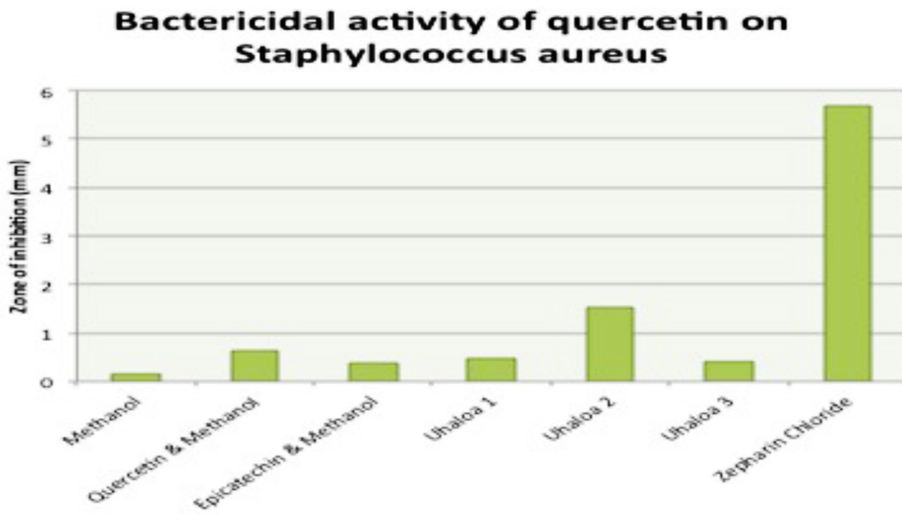


Figure h. Bacterial inhibition

a synergy of multiple flavonoids could have a better bactericidal effect. HPLC testing along with a mass spectroscopy analysis of the ʻuhaloa sample will then clarify if the quercetin is in ʻuhaloa and also may lead us to find out what is making the ʻuhaloa have better bacterial inhibition.

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Nelda Quensell, Mike Ross, Project Olonā Members, Kamehameha Schools

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Stressed Out Streams: The Effects of Agriculture on Stream Nutrient Cycling

By Jennifer A. Wong-Ala, and Aaron Stoler, Ph. D., Rensselaer Polytechnic Institute

ABSTRACT

The conversion of forest into agricultural land is known to dramatically affect stream characteristics, including increased water temperature and reductions in organic matter inputs (e.g., woody debris). This study sought to assess the effects of reduced organic matter input on nutrient cycling in streams as mediated by microbial activity. We hypothesized that reductions in woody debris inputs associated with agricultural activity would decrease the cycling of nutrients, such as oxygen and nitrogen. Specifically, we predicted that decreases in organic matter inputs would decrease microbial activity. To test this prediction, we conducted a controlled experiment using streamside flow-through mesocosms within the secondary forest of the Las Cruces Biological Station in Coto Brus, Costa Rica. Treatments consisted of rock substrate or rock substrate with organic material including leaf litter and woody debris, which simulated agricultural and forested stream substrates, respectively. We estimated microbial activity by measuring the amounts of dissolved oxygen (DO) in each stream channel.

Our results show that decreases in organic matter decreased microbial activity, but only when microbial activity on both rock and organic substrate is considered. Our findings may also indicate that microbial communities may acclimate to disturbances in a short amount of time and this may be of interest to further work in agriculture and even urbanized streams.

Figure 1. Agricultural Stream

Figure 2. Map of Costa Rica with Las Cruces Biological Station indicated with a red circle.

INTRODUCTION

- Anthropogenic stressors such as, the conversion of land to pasture or agricultural land can cause e.g. raised water temperature, decreased organic matter, nutrient enrichment, and increased sediment input.[3,4]
- Inputs of woody debris and leaf litter in small streams serve as substrate for the colonization and growth of microbial communities (i.e. bacteria and fungi).[1]
- Bacteria and fungi play a major role in nutrient cycling by converting organic matter into available nutrients for the stream ecosystem.
- We hypothesized that reductions in organic matter inputs associated with agricultural impacts will

decrease rates of in-stream nutrient cycling.

- Specifically, we predicted that a reduction in organic matter within streams would decrease microbial growth and activity, which ultimately lead to a reduction in nutrient cycling.

METHODS

Study System

- Study site is located at a second order stream in the secondary forest of Las Cruces. We siphoned water from an upstream tributary located that funnels water into the stream.
- Eight 1-m stream channel mesocosm system (Figure 5) used to simulate natural systems.

Treatments

- **Rock Only Treatments**: four (4) replicates to simulate agricultural stream.
- **Rocks + Organic matter input Treatments (leaf litter and woody debris)**: four (4) replicates to simulate a forested stream.

Microbial Measurements

Measured **Biological Oxygen Demand (BOD)** to measure microbial activity by using two (2) rock samples from every stream channel (Figure 4) to perform a modified Winkler Method.

Figure 3. Conducting research in the field

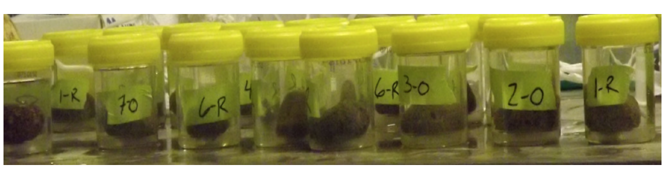

Figure 4. Rocks taken from each stream channel to test for BOD

Figure 5. Eight stream channel mesocosm system

RESULTS

See figures 6 and 7 at the top of page 19.

DISCUSSION

The results from this study support our hypothesis that streams with less organic matter will have a lower rate of nutrient cycling.[2] However, BOD of microbial communities on rocks in the Rock + Organic treatment was lower than that in the Rock only treatment (Figure 6). Because of these results, we considered the chemical leaching of leaves which has been shown to inhibit bacteria growth (Figure 8). We also tested for BOD of microbial communities on woody debris, and this showed the potential for microbial transfer from rocks to woody debris (Figure 9). The results from this study shows a relationship between substrate type and microbial activity in streams.

Further work could aim to better understand

Figure 8. Leaching of leaves

Results

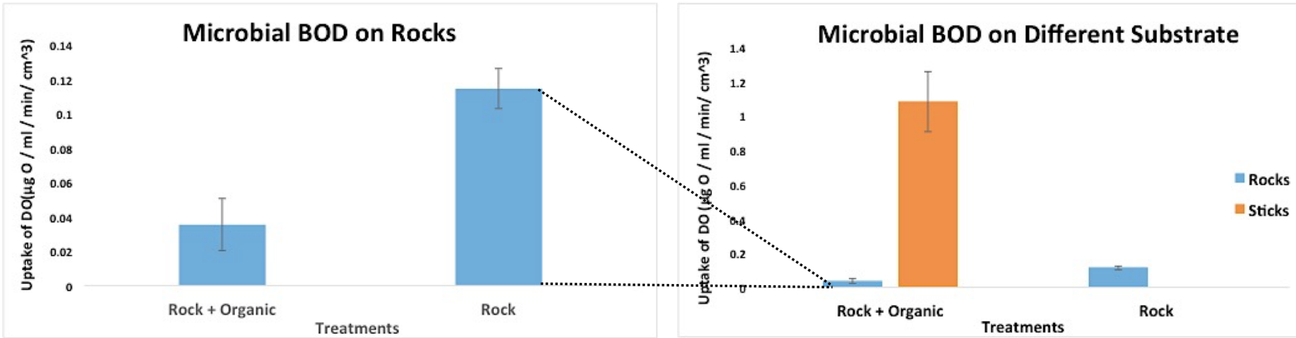

Figure 6: Average uptake of dissolved oxygen per treatment.

Figure 7: Comparison of uptake of dissolved oxygen per substrate type.

the effects of land-use change on stream ecosystem functioning by examining more complex streams and how microbial communities acclimate over long periods of time.[5,6]

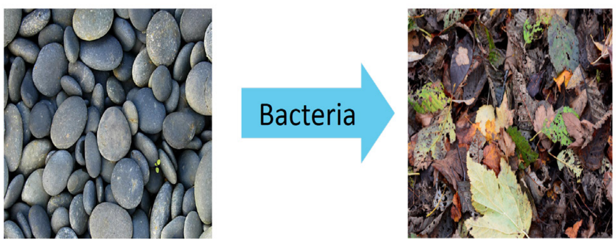

Figure 9. Movement of bacteria from one substrate to another..

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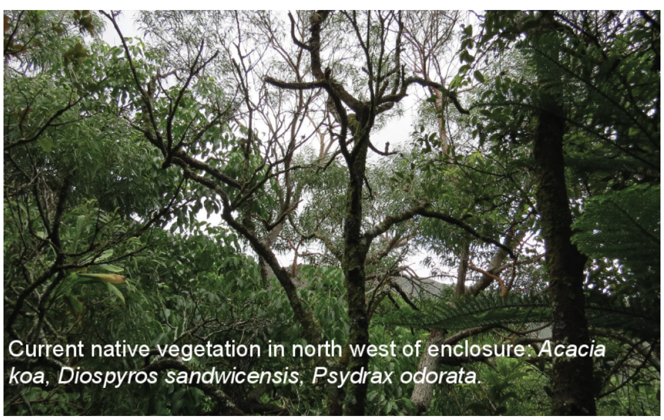
A Community-based Project to Restore a Hawaiian Mesic Forest in Wailupe, O‘ahu

By Miles Thomas[1], Shaun Wriston[1], Wendy Kuntz[1], Mike Ross[1], Jason Misaki[2]
([1]Kapi‘olani Community College, [2]HI Division of Forestry and Wildlife)

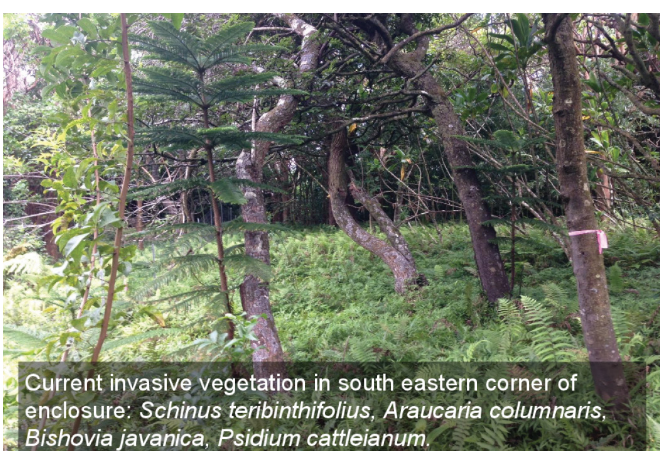
ABSTRACT

Community partnerships can be one effective way to focus attention and resources towards restoration efforts and revitalizing Mālama ‘Āina. Kapi’olani Commu÷nity College (KCC) has partnered with the Hawai‘i Division of Forestry and Wildlife (DOFAW) and the local community to establish a mesic forest restoration project. In 2013, DOFAW fenced a small exclosure in Wailupe Valley to remove herbivore ingress, primarily feral pigs. Restoration goals include providing habitat for native plants and an endemic endangered bird, the O‘ahu ‘Elepaio (Chasiempis ibidis). In Spring 2014, KCC students set up a transect grid for the exclosure and began monitoring current vegetation composition. In 2015, collaborating with local community members, KCC students continued monitoring and began removing invasive vegetation in select 10x10m plots. These plots will be monitored to determine native plant resiliency. Early monitoring has shown that Strawberry guava (Psidium cattleianum) is the main invasive species within the enclosure and the primary target for removal. This project will serve to educate local college students about Hawaiian forest ecology, aid in the rehabilitation of the exclosure habitat, and establish a relationship with community volunteers. These types of community-based projects can help initiate broader restoration efforts across the state and potentially world-wide.

O‘ahu ‘Elepaio (*Chasiempis ibidis)*
Photo: Tim Kroessig



Current native vegetation in north west of enclosure: *Acacia koa, Diospyros sandwicensis, Psydrax odorata.*



Current invasive vegetation in south eastern corner of enclosure: *Schinus teribinthifolius, Araucaria columnaris, Bishovia javanica, Psidium cattleianum.*

INTRODUCTION

Working closely with the Hawai‘i Division of Forestry and Wildlife (DOFAW), we have built a partnership that allows for Kapi ‘olani Community College (KCC) students to work alongside community members in the initiation of a two hectare habitat restoration enclosure. constructed by DOFAW in November 2014 (***fig. 1***).

Enclosure Site, Wailupe..

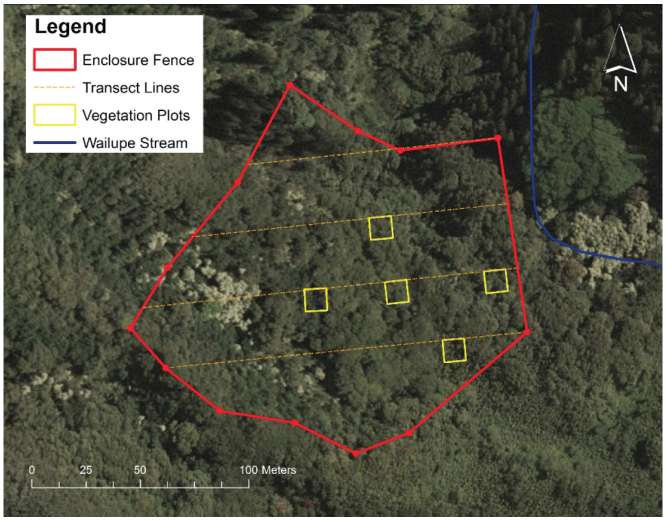
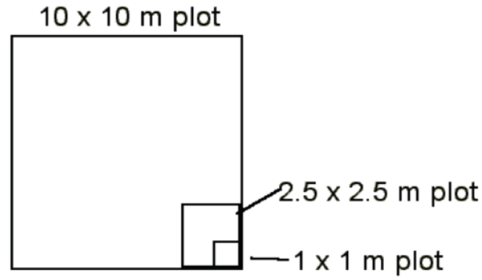


Figure 1: Map of enclosure

This student opportunity allowed for first hand experience with establishing a restoration site in its beginning stages and the complex factors involved with field work ecology. Our goals were to establish a transect grid and to document current forest composition as a baseline for comparison prior to invasive species removal. The primary target monitoring species was Strawberry Guava (*Psidium cattleianum*), but all native and introduced species were recorded. Removal of invasive species was initiated through the help of community partnerships.

METHODS

We used GPS to map the perimeter of the enclosure and established four transects running east to west (fig. 1). From the transects, we set up five 10x10 meter vegetation monitoring plots, which contained 2.5x2.5 meter and 1x1 meter sub-plots in the southeast corner (***fig. 2***). Monitoring plots were randomly placed within the enclosure. The native/invasive species in each plot were measured to determine the basal area, allowing us to calculate species density in plots. In the 10x10m plots, trees with a circumference of 10 cm (DBH of 3.18 cm) and above were measured. Within the 2.5x2.5m sub-plots, we measured trees with a circumference of 2.0-9.9 cm (DBH of 0.63-3.15 cm). In the 1x1m sub-plots, individual saplings/ seedlings were counted. We then calculated the Basal Area [BA=Pi(DBH/2)²] of the tree species within the monitored plots. Invasive removal was done only in the monitored plots with weed wrenches provided



- **10 x10m transects**
  - Measure DBH of trees 3.18cm and above.
- **2.5 x 2.5m subplots**
  - Measure DBH of trees 0.63-3.15cm.
- **1 x 1m subplots**
  - Count individual saplings/seedlings.

Figure 2. Documenting Plot

by DOFAW. All non-native species that were of manageable size were taken out of the plots and removed from the enclosure, placing them outside the fencing. Larger trees will be taken out in the future with herbicide or chainsaw. Community volunteers have participated in a majority of the removal.

BASELINE DATA RESULTS

From our initial monitoring, we have found that in the 10x10m plots Strawberry Guava was the dominant species (54%) followed by the indigenous Psydrax odorata (30%). For smaller trees in the 2.5x2.5 m plots, Strawberry Guava has the highest basal area, suggesting a high germination rate and the capacity for this species to turn diverse areas into monotypic stands of these trees. It is also quite possible that some of these seedlings were formed from the underground lateral roots of parent trees. In the 1x1 m plots the dominant species was Cook Pine (Araucaria columnaris) (***Fig. 3***).

Through community help, restoration of this enclosure was conducted within five vegetation monitoring plots. ***Table 1*** refers to the total amount of individual invasive trees that were removed by volunteers. The bulk of the removal consisted of strawberry guava, which corresponds our vegetation monitoring plot data in indicating that this species is the most abundant within the total area of these selected plots. When these species are removed, we will monitor what species regenerate in response to the increased light penetration upon the forest floor.

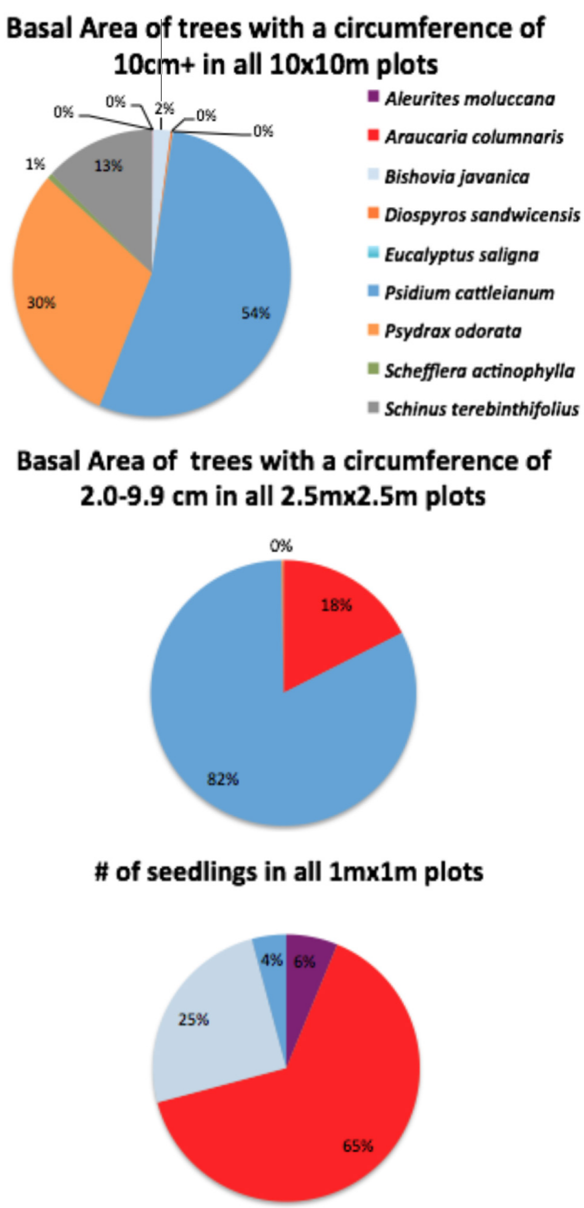


Figure 3: Species density pre-removal

DISCUSSION

Removal of the vegetation plots was a hard task, but with the help of community volunteers, we were able to work more efficiently. Within the plots, we removed as much invasive tree species as possible. This included small trees all the way to seedlings on the forest floor. We did not remove bigger trees due to the small size of the weed wrenches. Understory comprising of *Clidemia hirta* was also a target due to its ability to shade out seedlings and hinder regeneration. In the future, we would like to experiment with the removal of this monotypic understory in order to provide the areas for native shrubs, ground covers, and lianas to take root. This includes plants shown in ***figure 4***. Within the northern end of the enclosure, there is already Koa (Acacia koa) regeneration in a small area, showing a promising resiliency of an endemic species. We will continue to use community help in removing invasive flora for restoration of the exclosure.

Table 1: Numbers of invasive species removed from all 5 plots (Trees, saplings, and seedlings pooled)

Species Removed:	
Species	# removed
Psidium cattleianum	500
Araucaria columnaris	80
Clidemia hirta	39
Schefflara actiniophylla	7
Aleurites moluccana	3
Schinus terebinthifolius	2

Clidemia hirta

Figure 4. Native plants found withinenclosure (left to right):
(a) Oʻahu Sedge (*Carex wahuensis subsp. wahuensis)*;
(b) Palapalai (*Microlepia strigosa var. strigosa)*;
(c) Maile (*Alyxia stellata*)

EXPERIENCE AND CHALLENGES

The installation of the transects was our biggest challenge and was the core amount of our work. We are still at the preliminary stages of invasive removal, and will continue to set up vegetation monitoring plots throughout the enclosure. Removal of invasive trees was a hard task, being that the tools we had only work on the younger canopy species. By focusing on the smaller diameter trees, we were able to allow more light to penetrate the forest floor. The beginning of removal has sparked interest in community partners and allows for a much faster timeframe for invasive removal given more helping hands and tools provided by DOFAW. As we removed plot areas, we will be ready for seedling monitoring to assess the present seed bank (If any) that exists in the soil. A challenge with this is that rats are prone to eat seedlings since they are high in nutrients, so hopefully the next generation of seedlings is native and resilient. Also, as humans traffic and dig up the dirt, it may cause weedy alien seeds to germinate as well, potentially outcompeting other dormant tree species that would be beneficial to the restoration of this fenced area.


Pre Invasive Removal in Plot 5


Post Invasive Removal in Plot 5

CONCLUSION

This project really helped us to learn how to effectively sample an area for species density, as well as coming together with community volunteers to help with forest restoration. More sampling needs to be done, as well as removal of invasive species, in order to gain a more in depth grasp of the composition of the entire enclosure. After that is complete, we will be observing the species that germinate, telling us if there is a viable native seedbank that needs little to no assistance in growing. Being able to harness community efforts really gave us a sense of Mālama ʻĀina while working to restore this area. Future goals include many more monitoring plots, surpassing double digits, with removal of invasives. We will continue working in the enclosure as a Science 295 core project at KCC, finding students who are motivated to advance the growth of native species in the Wailupe enclosure. The more people who are affiliated with this project, the more effective the conservation effort as well as a better sense of community partnership for a common goal.

ACKNOWLEDGEMENTS

We would like to thank Patrick Mizumoto, DOFAW, DLNR, The Kapiʻolani Community College STEM program especially Mrs. Keolani Noa and Kendall Kido, Mālama Maunalua, Tim Kroessig, and community members.

Ka Manu-o-Kū, White Fairy Tern, *Gygis alba*

By Alex Awo, Gabrielle Arle, Honour Booth, Charles Dote, Kristen Feato, Ka‘iulani O‘brien, Nohe Vinayaga (*Faculty Mentor*: Dr. Wendy Kuntz)

INTRODUCTION

The White Fairy Tern (*Gygis alba*) or the Manu-o-Kū is a threatened seabird indigenous to many islands throughout the Pacific (Vanderwerf 2003). While it commonly resides in less populated islands in the Pacific, within the main Hawaiian Islands the only recorded population has been observed on O’ahu since 1961 (Harrison 1990, Niethammer et.al. 1998 as cited in Vanderwerf 2003).

An adult tern stomping their feet at a potential nest site (Nest 8B). Photo by Alex Awo

As of 2007, the Manu-o-Kū is the official bird of the City and County of Honolulu, amplifying its cultural importance and making it more recognizable to the public. The species is listed as threatened by the State of Hawai’i and is protected under the Federal Migratory Bird Treaty Act.

In 2014, KCC’s plan to build a new culinary arts facility on the former Fort Ruger Officer’s Club (FROC) site was coming to fruition. Before construction began, KCC assured the Diamond Head community that no nesting terns would be disturbed by the construction. Our team was assembled to monitor terns at the site. As plans for construction are still underway, the site continues to be monitored for tern activity. Our efforts have also expanded our monitoring to the main KCC campus.

Alex Awo And Ka‘iulani O’brien marking a nest tree.

OBJECTIVES

The main objective of our project continues to be the protection of any nesting terns found on the future KCC culinary facility and various locations on KCC campus. This semester, we expanded our awareness to the campus, making an effort to establish protocol for communicating the birds’ presence with the Auxiliary Services. We achieved this by flagging trees with confirmed nests to prevent loss due to tree trimming. The high rate of tern activity on campus encouraged our group to focus on the campus birds’ nesting

A young hatchling in a *Ficus* tree.

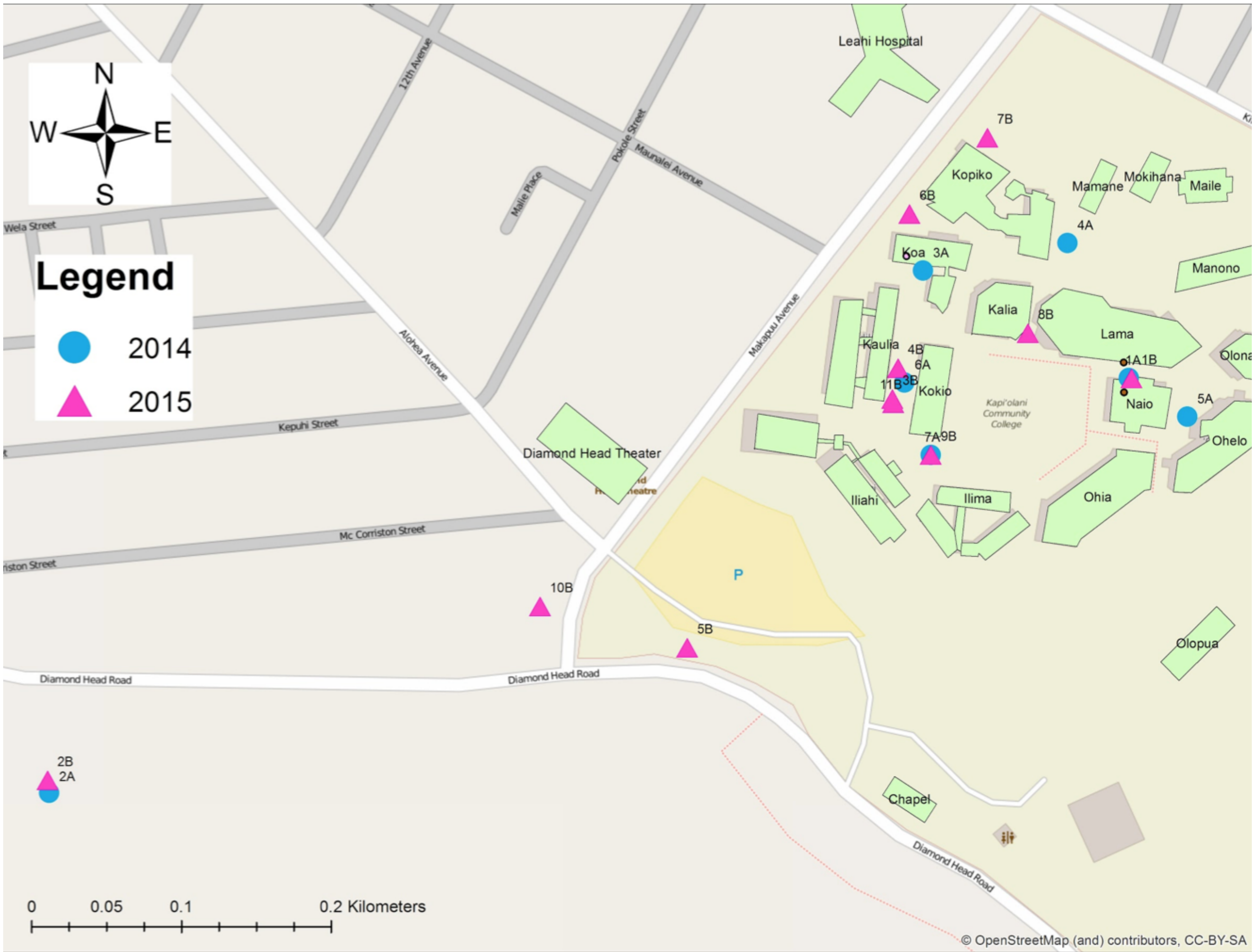


Figure 1: Nest Locations for Spring 2014 and 2015 at Kapiʻolani Community College and Surrounding Areas.

behaviors, specifically preferences of tree species and spatial distribution of nests.

MATERIALS AND METHODS

Our observations of the Manu-o-Kū were done at a minimum distance of ten meters using binoculars. Activity was recorded from Monday through Friday mornings following the sunrise on the KCC campus, along with the Cannon Club site as well. All activity was recorded, including possible nest sites, failed nests, feeding, and courtship. All nest locations were recorded with GPS and mapped in GIS. Tree heights and nest heights were calculated using a tape measure and a clinometer, standing approximately 20 to 25 meters away from the base of the tree.

RESULTS

Over the course of two years a total of eighteen nests were recorded. Eleven of these were observed during the spring 2015 semester: nine on campus, one at the FROC site, and one at the Fort Ruger Base Yard (FRBY) across the street from the KCC campus (Fig. 1). Nests 1, 3, 4 and 5 produced successful offspring as of present (Fig. 2). Nest 10 at the FRYB site was found to already inhabit a fledgling (Fig. 2). Nests 6, 7, 9 and 11 are currently incubating (Fig.2). Two nests experienced failures, nest 2 at the FROC site and nest 8 on the campus (Fig. 2). While the reason for nest 2's failure is unclear, nest 8's failure was due to high winds that occurred over the weekend before the failure was discovered.

We identified that ten of the nest trees (2A, 3A, 5A, 6A, 7A, 2B, 3B, 4B, 9B, 11B) belong to the *Ficus*

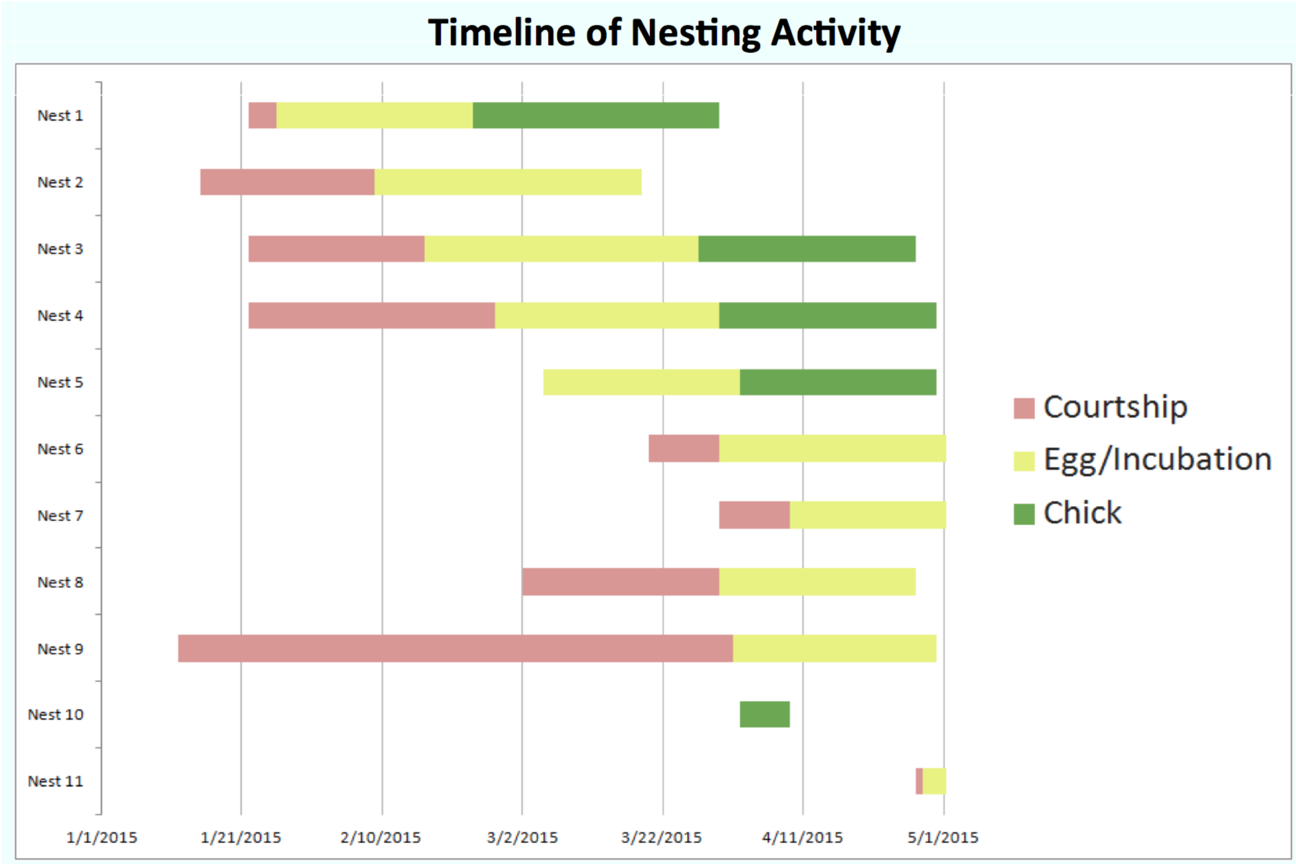


Figure 2. Nesting Behavior for Spring 2015

genus (Fig. 1). Another four (1A, 1B, 8B, 10B) are of the *Aleurites moluccanus* species, or Kukui nut tree (Fig. 1). However, the remaining four trees (4A, 5B, 6B, 7B) are of unknown species (Fig. 1). We found a nest tree height mean of 10.00m and a nest height mean of 7.20m (Figure 3). Figure 3 shows that higher nest heights occur in the tallest trees.

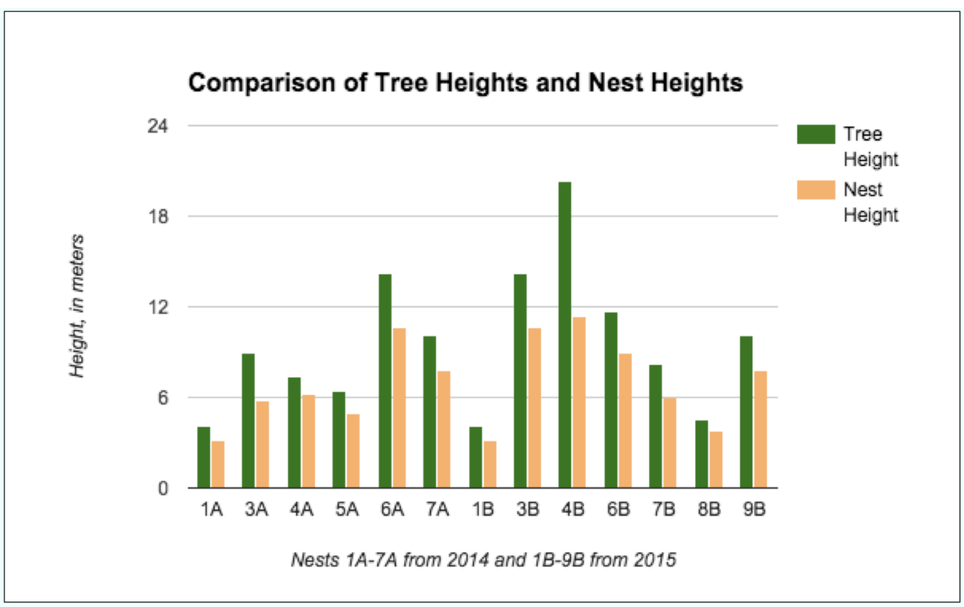


Figure 3. Tree Heights vs. Nest Heights for 2014-15

DISCUSSION AND FUTURE RESEARCH

The monitoring of the Manu-o-Kū over the past year, notably this semester (spring 2015), has opened up many avenues for research. The project began as a means to ensure conservation due to a new construction site, but has evolved into an inquiry of the behavioral biology of the species. The data we collected has not only given us better insight into tern behaviors, but also lead to further questions regarding the species nesting habits. Future research of the terns will expand to include their preference of nesting trees on the KCC campus, and whether their choice of tree is species driven or based upon availability. We also aim to investigate the historical significance of the Manu-o-Kū, utilizing the Hawaiian newspaper database and other cultural references.

Honour Booth observing a possible nest.

ACKNOWLEDGMENTS

Mahalo nui to Dr.Wendy Kuntz, Caroline Blackburn, Carol Hoshiko, Gordon Man, Eric Vanderwerf, Helene Watson, Alan Elegino, Mrs.Keolani Noa, Kendall Kido and the KCC STEM Program.

A parent feeding its hatchling at nest 1B.

Gabrielle Arle measuring nest height using a clinometer

Studying the genetic connectivity of the culturally significant sea urchin, *Colobocentrotus atratus*, in Hawaiʻi

By Maria Petelo and Lindsey Watanabe (*Faculty Mentor*: Michael Ross, MSc., *Peer Mentor*: Bradley Hughes)

BACKGROUND

Population genetics is the study of allele and genotype frequencies in a given population. The use of population genetics to monitor target species in ecologically sensitive areas is an effective management tool for understanding the structure of those populations. Understanding the genetic connectivity of separate populations will aid in the development of proper management plans for that species. In the Hawaiian Islands, management practices specific to many of our culturally important marine invertebrates, such as *Colobocentrotus atratus*, Hāʻukeʻuke in Hawaiian, are minimal or non-existent, and as a result, overharvesting can be a common and growing problem for these species. We hope our investigation into Hāʻukeʻuke population structure throughout the Hawaiian Islands will lead to better management practices for this important cultural resource.

This important cultural resource is also used in traditional medicines to treat many skin irritations, including ringworm.

Hāʻukeʻuke, or *Colobocentrotus atratus*

Hāʻukeʻuke is prized for its delicious, sweet tasting gonadal tissue.

Hāʻukeʻuke are used as bait for fishermen and are an important food source to the people of Hawai'i.

This important cultural resource is also used in traditional medicines to treat many skin irritations, including ringworm.

QUESTION

Does Hāʻukeʻuke exhibit population structure in Hawaiʻi?

HYPOTHESIS

Due to previously discovered genetic barriers between islands and a relatively short larval duration, I hypothesized that Hāʻukeʻuke would show low or no gene flow between the different island populations.

METHODOLOGY

Hāʻukeʻuke were collected from north and south shores (24 ind./shore) of Hawaiʻi, Maui, Oahu, and Kauai. Peristomal tissue was removed from each individual to extract DNA and amplify a portion of the cytochrome oxidase I (COI) gene.

RESULTS

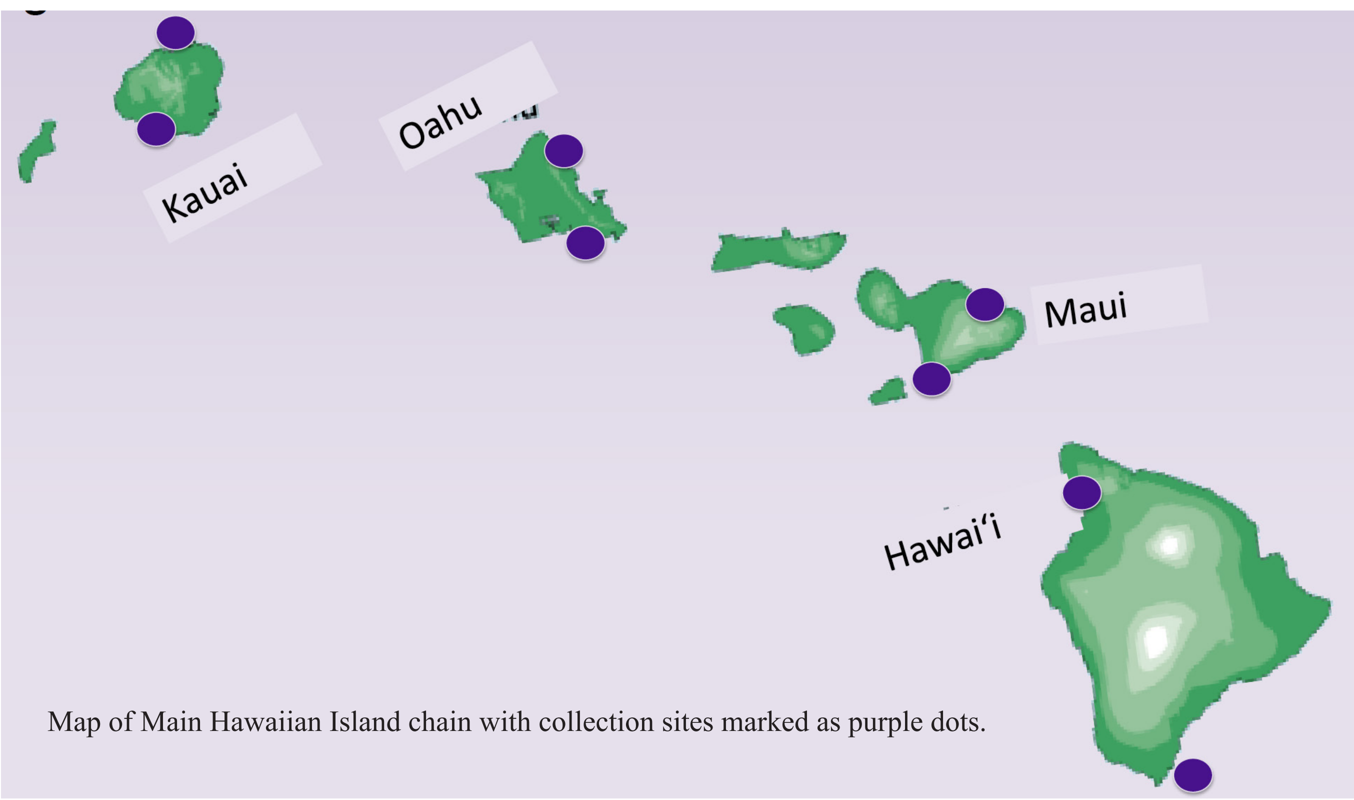
(See ***Figure 1***, page 27).

DISCUSSION

The haplotype network shown above indicates two major haplotypes can be found throughout the islands (large multicolored circles), while many individual haplotypes are unique to specific islands (small solid circles). Our AMOVA results reported significant population structure between the populations of North Maui and North Hawaiʻi, and North Maui and North O'ahu.

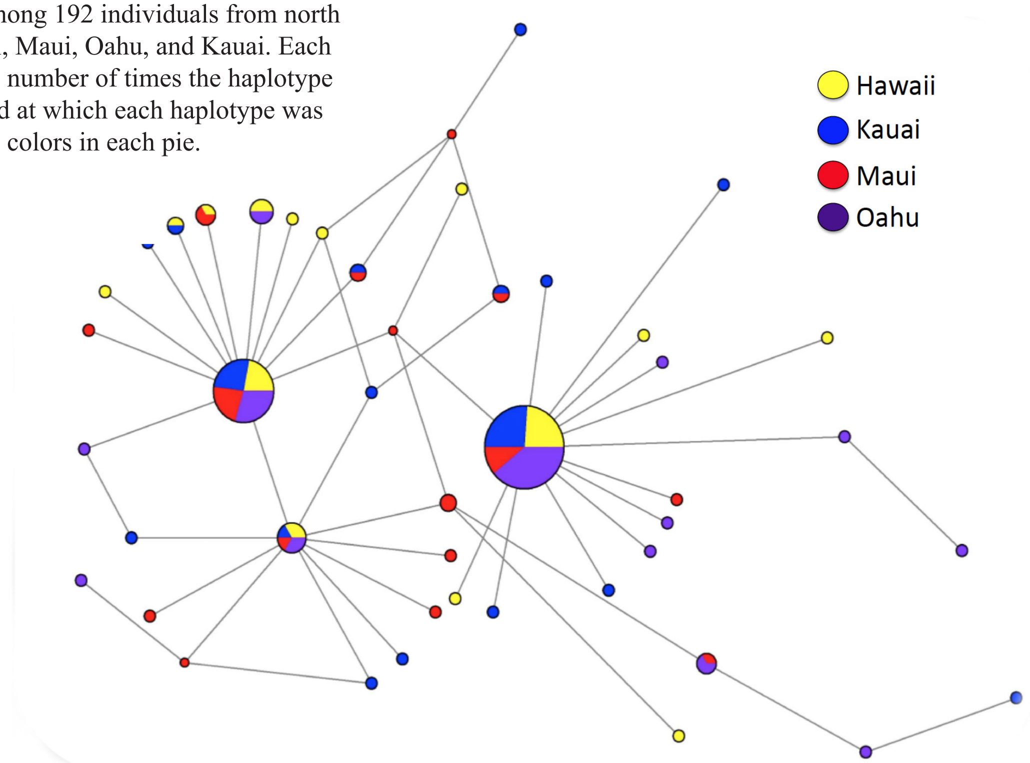
DISTRIBUTION

Colobocentrotus atratus is distributed throughout the Indo-Pacific, extending as far as east Africa. We



Map of Main Hawaiian Island chain with collection sites marked as purple dots.

Figure 1. AMOVA haplotype network created using 42 unique sequences found among 192 individuals from north and south shores of Hawaii, Maui, Oahu, and Kauai. Each circle is proportional to the number of times the haplotype was detected, and the island at which each haplotype was found is represented by the colors in each pie.



suspect that Hawai'i's population is genetically distinct from the other C. atratus populations; possibly making Hawai'i's species endemic. However, more analyses are needed. Below (fig.2) is a phylogenetic tree showing divergence of Hawai'i's *C. atratus* population from others in the Indian and East Pacific oceans.

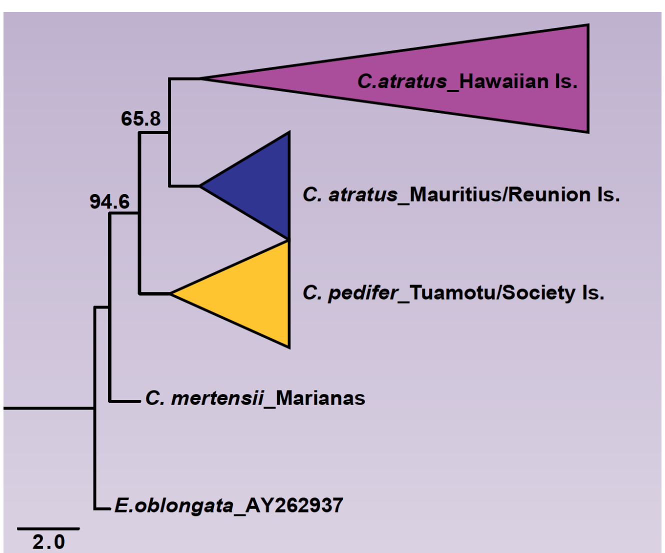


Figure 2. Phylogenetic tree based on sea urchin data matrix; species name and location of origin are labeled. The numbers at the branches are confidence values based on 500 bootstrap replications.

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Relative Iron (Fe) Concentrations in the Leaves of *Chamaesyce multiformis* (Euphorbiaceae), a Traditionally Used Endemic Hawaiian Medicinal Plant

By Maria Petelo and Lindsey Watanabe (*Faculty Mentor*: Michael Ross, MSc. *Peer Mentor*: Bradley Hughes)

INTRODUCTION

In the *Kānaka Maoli* (Hawaiian culture), C*hamaesyce multiformis* is known as ʻAkoko, which refers to blood.[1] ʻAkoko is an endemic plant to the Hawaiian Islands and the leaves are traditionally used to aid in women's health, because of it's medicinal properties.[2] ʻAkoko is a rare woody shrub that's found scattered in open, dry to wet forest regions on the islands of Oʻahu, Molokaʻi, Maui, and Leeward Hawaiʻi.[3] Furthermore, ʻAkoko is one of the few endemic Hawaiian plants that undergoes C4 photosynthesis.[4] This special plant undergoes five different phases in which the leaves change colors from blue, to green, yellow, orange and finally red, before the leaves abcise. In the Hawaiian culture, the yellow to red colored leaves of the ʻAkoko are collected on the *lāʻau* moon phase (waning gibbous phase) and made into a tea by the *Kahuna Lāʻau Lapaʻau* (medical practitioner) to treat women's menstrual pains and pregnancy-related debilities.[2] Many of these types of debilities are often caused by iron deficiencies.[5] Therefore, we originally hypothesized that the yellow and red leaves of the ʻAkoko would be higher in iron than that of any other color phase. Initially, we made teas using the yellow, green, and blue leaves because red leaves were not available for collection (Graph 1). At a later time when the red leaves were available, we did a follow up analysis using green, yellow, and red leaves (Graph 2).

Figure 1. ʻAkoko Plant

Figure 2. ʻAkoko leaves transitioning

Figure 3. ʻAkoko flowers form in solitary cyathia.

METHOD

For the first study, blue, green, and yellow ʻAkoko leaves were collected on December 20, 2013 on the Lāʻau moon (Lāʻaukūlua) at roughly 6:00 am in Honolulu, Hawaiʻi. A total of 9 leaves for each color phase were picked (n=3, subsamples) and a tea was made for each color phase. For the second study, green, yellow, and red ʻAkoko leaves were collected on February 19, 2014 on the Lāʻau moon (Lāʻau Pau) at roughly 2:00 pm at three different locations in Honolulu. A total of 30 leaves for each color phase were picked (n=10, per sample) per location. However, in this study the leaves were not made into a tea instead, the whole leaf tissue was analyzed. In both studies, all samples were analyzed for iron concentration using the ICP spectrophotometric method at the Agricultural Diagnostic Center, University of Hawaiʻi at Mānoa. We analyzed our data using a one-way ANOVA with Tukeyʻs Multiple Comparisons in XLSTAT 2014, which was also used to generate boxplots.

RESULTS

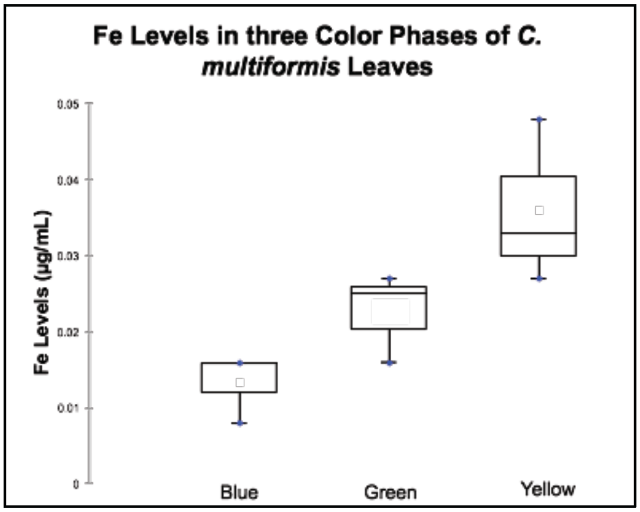
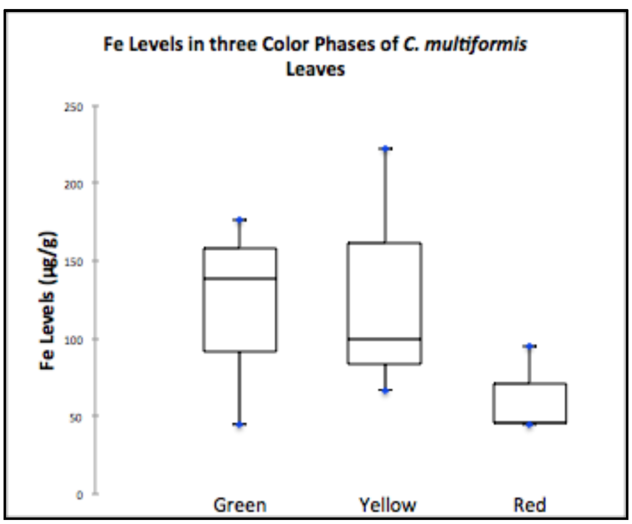


***Figure 2*. *Graph 1*.** Boxplot showing the Fe levels in teas made from the blue, green, and yellow leaves of ʻAkoko (n=3, subsamples).



***Graph 2*.** Boxplot showing the Fe levels in the tissue of green, yellow, and red leaves of ʻAkoko (n=10, per sample). There were no statistically significant differences between the three color phases (p-value>0.05).

CONCLUSION

In the first study, we confirmed our hypothesis that the yellow leaves were higher in iron (Fe) than the green and blue (Graph 1). Our data shows that there is an increasing trend in iron levels from blue to green to yellow. The higher levels of Fe in the yellow leaves may help explain why this plant is effective in traditional Hawaiian medicine. The increased levels of Fe in the yellow leaves may be due to the breakdown of Fe-rich proteins associated with photosynthesis during leaf senescence.[6] However, all of our data for the first study came from a single ʻAkoko population. In the second study, we collected leaves from three different populations of ʻAkoko. Although the results were not statistically significant, this discrepancy may be due to the time of gathering. Traditionally, the leaves were gathered in the morning hours, however, we gathered our samples in the afternoon. We believe that iron is mobilized in the late morning to afternoon and is retranslocated from the red leaves to actively growing parts of the plant.[7]

In the future, we plan to replicate this study using samples gathered in the morning. Due to the scarcity of this plant in the wild, we have chosen to perpetuate this plant by propagating cuttings and out-planting them into the wild as well as for research purposes. The cuttings were taken from two populations of ʻAkoko and rooted in hydroponics (Figure 4) then out-planted (Figure 5). We hope that our efforts will encourage others to propagate and help increase the population sizes of this rare endemic medicinal plant.

***Figure 4*.** ʻAkoko cuttings in hydroponics.

Figure 5. ‘Akoko out-planted at Leahi medicinal garden.

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We would like to thank the Kapi’olani CC STEM Center for allowing us to use its facilities and Mānele Garden for the propagation cuttings and facilities.

Special thanks goes out to Ms. Naomi Nihipali, STEM Undergraduate Research Coordinator, and Mrs. Keolani Noa for the support and help through the duration of this project. We would also like to thank Colleen Allen, KCC Biology Lab Technician, for the falcon tubes and DI water, and the Kupuna for passing on the knowledge of this plant for many generations.

Analysis of the Fe samples were funded by an Epscor NSF grant.

The Effects of Different Moon Phases on the Medicinal Properties of *Chamaesyce multiformis* (Euphorbiaceae)

By Lindsey Watanabe and Maria Petelo (*Faculty Mentor*: Michael Ross, MSc. *Peer Mentor*: Bradley Hughes)

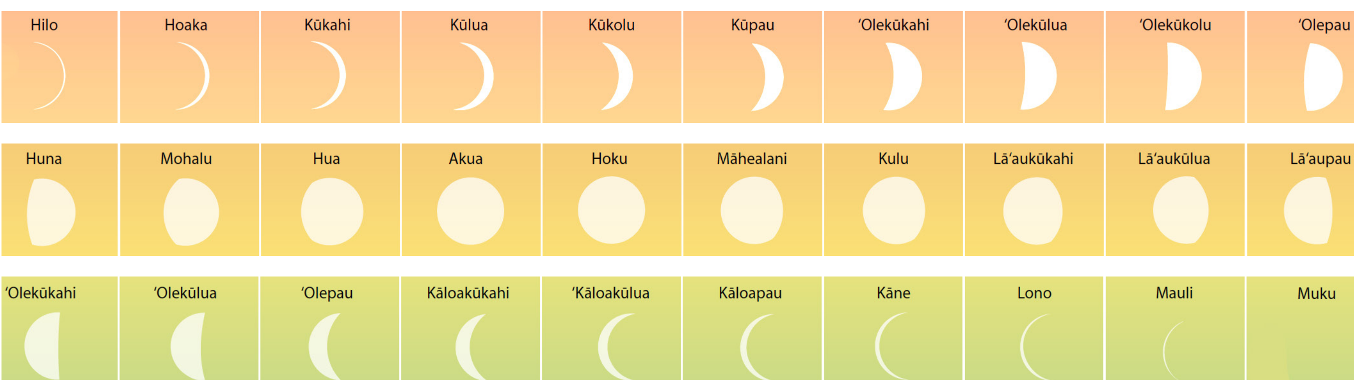
INTRODUCTION

Western knowledge of the lunar phases start with four principle stages; New Moon, first quarter, full moon then finally the last quarter, also known as the third quarter.[1] In addition it is known that the moon waxes as the cycle progresses to a full moon and wanes as the cycle continues to the third quarter. In the Hawaiian culture, the lunar phases were essential to the way of life.[2]

The *Kahuna Lāʻau Lapaʻau* (Medicinal practitioner) would often collect the plants in the morning of a Lāʻau moon believing culturally that the potency (mana) of a medicinal plant would be at its highest and therefore be the most effective in treating health related conditions. Traditionally, a tea was made from *Chamaesyce multiformis*, also known as ʻAkoko, to treat menstrual and pregnancy-related debilities. Most of these types of debilities are due to iron deficiencies.[3] The red leaves of this plant are known to be high in iron. Based on this knowledge, we

Figure 1. ʻAkoko leaf transitioning between color phases.

Figure 2. Hawaiian moon calendar, with the names of 30 moon phases, from Hilo, the first crescent, to Muku, the new moon (Graphics from *2014 Hawaiian Lunar Calendar*, Western Pacific Regional Fishery Management Council).



The moon calendar was used to determine when to harvest, prepare, and administer lāʻau (Lāʻaukūkahi, Lāʻaulūlua, and Lāʻaukūpau (*Year 2014 Ancient Hawaiian Moon Calendar Related to Fishing and Farming*. Prince Kuhio Hawaiian Civic Club).

Hoku: Excellent for planting all kinds of plants, but taro and bananas will be abundant with small fruit or corms. Seeds will become animated by the full moon.

Māhealani: Plant bananas in the evening, will grow plentiful and large. Plant taro, gourds, yams, flowers. Everything is animated by the moon.

Kulu: Plant bananas. Excellent night to plant potatoes and melon. Not a good night to build a house, put up a roof or a fence because kulu means to fall.

Lāʻaukūkahi: Plant bananas, but no sweet potatoes. Gather medicinal plants.

Lāʻaukūlua: Good for cultivating, but no planting. Gather lāʻau for medicinal use.

Lāʻaukūpau: Good day to plant anything but vine-type plants. Medicine was prepared and administered by the kahuna lāʻau lapaʻau.

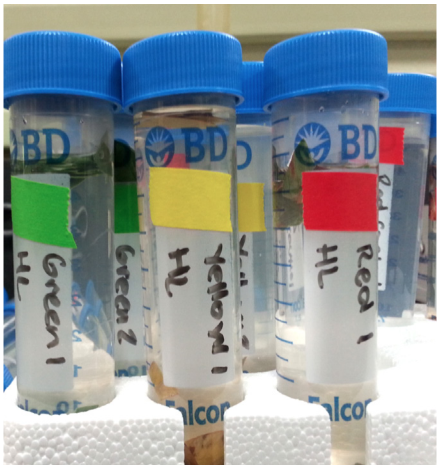


Figure 3. ‘Akoko tea samples in falcon tubes.

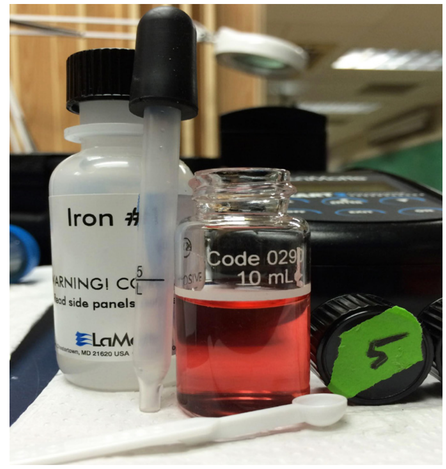
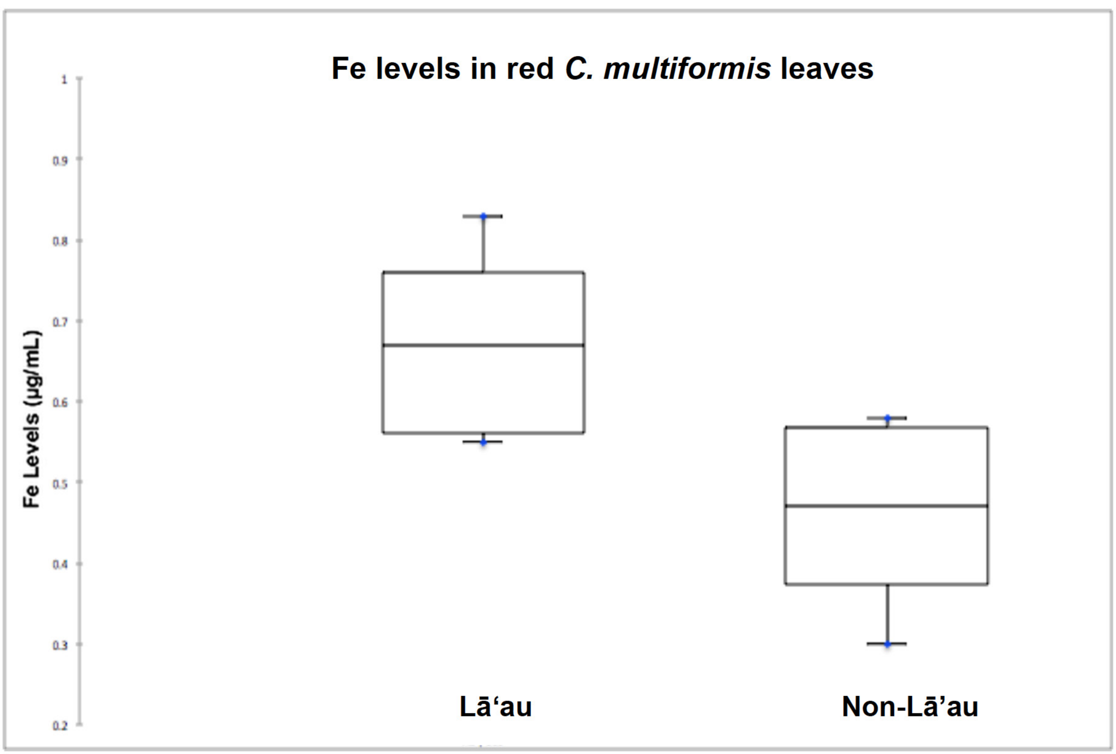


Figure 4. Iron reagent added to tea sample.

hypothesized that the red leaves of ‘Akoko collected on a lāʻau moon phase would be higher in iron than red leaves of ‘Akoko collected on a non-lāʻau moon phase. In this study, the red leaves of ‘Akoko were collected both on a lāʻau moon and a non-lāʻau moon and the levels of iron in the leaves were analyzed and compared.

METHODS

In this study, ‘Akoko leaves were collected on June 15, 2014 (Lāʻau moon) and on September 7, 2014 (non-lā ʻau moon) at roughly 6:30 am from Hawaiʻi Loa Ridge, Oʻahu. Six individual ‘Akoko plants were haphazardly chosen and 10 red leaves were collected from each plant. The leaves were placed into separate pre-labeled ziploc bags and transported to Kapiʻolani Community College. The leaves were torn and steeped in boiling water for 15 minutes. The levels of iron were analyzed using the LaMotte Smart Colorimeter. This method reduces Ferric iron to Ferrous iron and



Graph 1. Boxplot showing the Fe levels for red leaves of ‘Akoko collected and prepared on a lāʻau and a non-lāʻau moon. NOVA (p-value=0.017).

subsequently forms a colored complex with bipyridyl, which allows for the iron levels to be measured spectrophotometrically. Normality tests were conducted to confirm that the data met the assumptions of the ANOVA. The data was then analyzed using a one-way ANOVA with Tukey's Multiple Comparisons in XLSTAT 2014. Boxplots were also generated for visualization.

RESULTS

See Graph 1, p. 34.

CONCLUSION

The results from our study confirm our hypothesis that the levels of iron are higher in the red leaves of ʻAkoko collected and prepared on a lāʻau moon. The differences in iron levels were statistically significant between the two moon phases. The higher levels of Fe in the leaves collected and prepared on a lāʻau moon may help explain why this plant was selected by the *Kahuna Lāʻau Lapaʻau* during this particular moon phase. Perhaps, the change in moon phase relates to changes in the movement of water through a plant or in a particular organ.

The relationship of the moon and gravitational force exerted on the earth varies depending on the phases of the moon, for example, the drastic fluctuations between spring and neap tide cycles following full and new moons. Typically, during a full moon, the moon's gravitational force is at its greatest, causing water levels on the earth's surface to be more mobilized.[4] As the moon begins to wane, its gravitational force weakens, reducing the ability of water to mobilize. The lāʻau moon may draw more water into the leaves or away from the leaves resulting in changes in the internal chemistry of the leaf cells. This may help explain why there are such pronounced differences in the levels of iron between the two moon phases. Immediate future studies will compare leaves of ʻAkoko collected and prepared during the four principle stages of the moon: new moon, first quarter, full moon and third quarter. A more in depth longitudinal study will map the levels of iron in the ʻAkoko plant over the four standard seasons of the year.

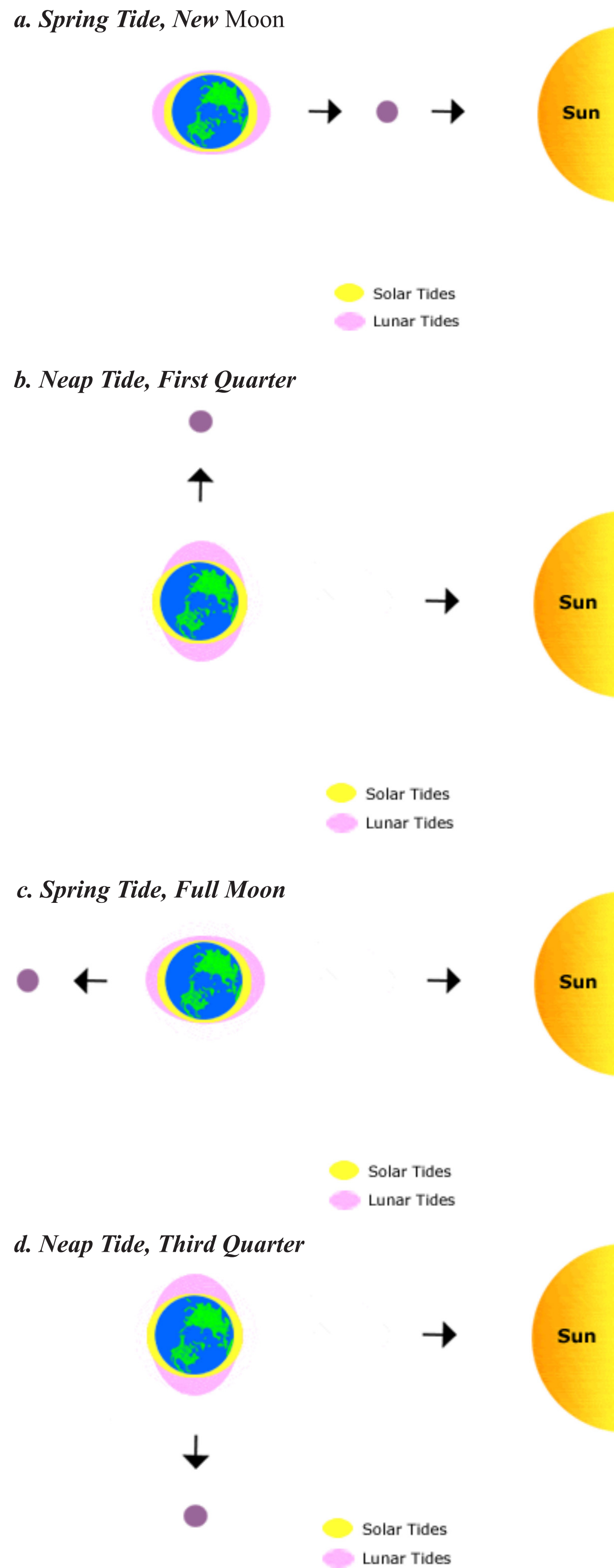


Figure 5. Relative positions of the sun, moon, and earth during the monthly spring and neap tides. (NOAA ocean education service, 2008).

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We would like to thank the Kapi'olani Community College, STEM Center for allowing us to use their facilities. Special thanks to Ms. Naomi Nihipali and Mrs. Keolani Noa for the support and help throughout the duration of this project. We would also like to thank Colleen Allen for the falcon tubes and DI water, and the LaMotte Colorimeter, Kimberly Kahaleua for assisting during our collection process and testing stages, and the Kupuna for passing on the knowledge of this plant for countless generations.

Bacterial Effects of Nīoi (*Capsicum frutescens*)

By Kimberly Kahaleua (*Faculty Mentors*: Keolani Noa, Kathleen Ogata, Nelda Quensell)

INTRODUCTION

Chili peppers are widely used around the world for food and medicine. The chili peppers, which originated from Central America, are called "Nīoi" by Native Hawaiians. Although nīoi (*Capsicum frutescens*) was introduced, they have become naturalized to the islands. This shrub is generally long lived and produces white flowers and green fruits that ripen to a bright red[1] (Fig.1). The red fruit contains capsaicin, one of the capsinoids (Fig.2), which is responsible for the popular spicy sensation. Kahuna lāʻau lapaʻau, also known as traditional Hawaiian health practitioners, had a high status of knowledge and well being. They used nīoi to treat arthritis, wounds, and other health issues (Table 1). When the fruit of this plant is pounded and applied to a sore or wound, it has analgesic properties.[2] Practitioners would use nīoi with other ingredients to make their remedies, such as pounding the seeds with salt to help with rheumatism.[3] The long term goal of this project is to bridge Hawaiian medicine with science.

Medicinal Purposes	
Internal Usage	**External Usage**
• Digestive system cleanser	• Topical for body aches and pain
• Clears up sinuses	• Arthritis
• Toothaches	• Rheumatism

Table 1. Internal and external medicinal purposes of Nīoi

Figure 1. Nīoi plant with mature fruits

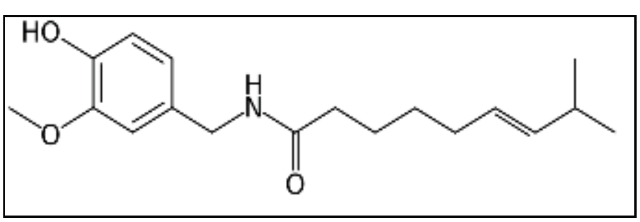


Figure 2. Capsaicin

METHODS

In this study, nīoi was grown in hydroponics and the capsinoids were partially purified (Fig. 3) with various solvents and silica gel chromatography. Thin layer chromatography (TLC) was used to identify the active compounds. The silica-gel column fraction containing the highest capsinoid content, as visualized by fluorescence (Fig. 4), was used for high-pressure liquid chromatography (HPLC) separation.
Samples were then tested on Staphylococcus aureus using a disk diffusion assay[4] to observe any bactericidal activity. To simulate a wound healing process, human embryonic kidney (HEK 293) cells and adult human epidermal keratinocytes (HEKa) cells were treated with purified capsaicin to measure and observe the effects through a proliferation and wound healing assay[5]. Data was collected using

Figure 3. Isolation scheme of Capsinoids

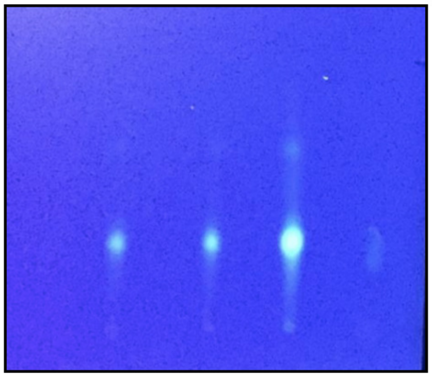


Figure 4. Thin layer chromatography of Nīoi samples. Capsinoids were visualized with UV light. The fraction containing compounds with the most intense fluorescence (third from the left) was further separated on HPLC; to the right is the faint capsaicin standard.

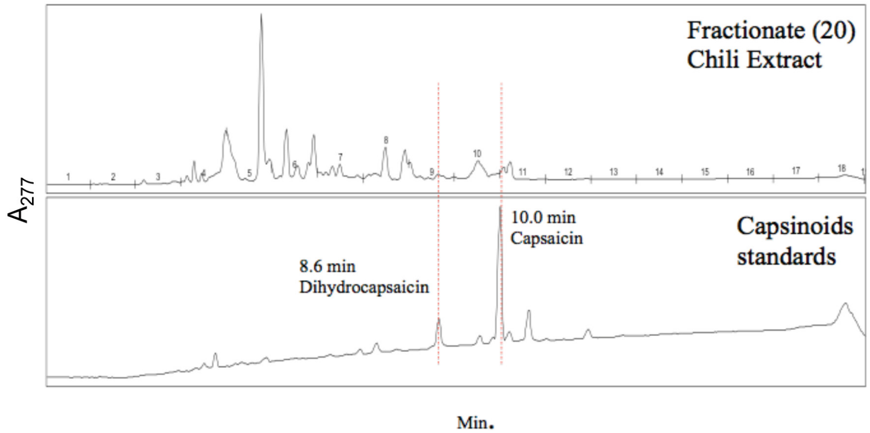


Figure 5. RP-HPLC separation System: Scanning Abs 200-600nm, Extracted Abs. 277 nm; 1% gradient over 15 min, with a 100% organic wash for 5 min before returning to original condition of Solvent A 95% (0.1% v/v Formic Acid/ Aq.) and 5% Solvent B (1:9:0.1 H2O:MeCN:TEA). Column Phenomenex Kinetex 2.6u C18 100A, 100x4.6 mm.

Infinity Analyze, a SpectraMax 340 spectrophotometer and ImageJ, and was analyzed with Graphpad Prism software.

Compounds with the same retention time as capsaicin and dihydrocapsaicin were identified by HPLC (Fig. 5). The presence of capsaicin was confirmed by the HPLC and TLC data.

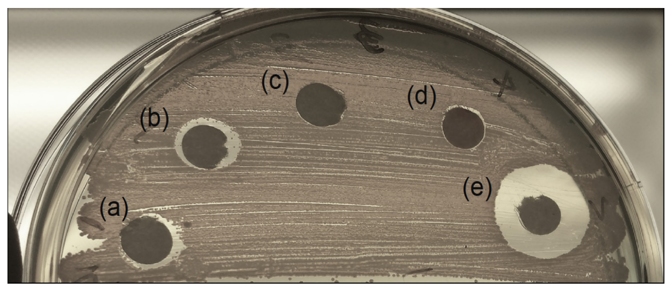


Figure 6. Bactericidal activity of (a) ethanol, (b) ethanol and pure capsaicin, (c) acetone, (d) Capsaicin sample, and (e) zephiran chloride on *Staphylococcus aureus*.

DISCUSSION

The results suggest that nīoi has less effective bactericidal activity compared to the capsaicin standard, as shown in Figure 7. Since nīoi is used for wound healing in lāʻau lapaʻau, human cells are a better test system. Cell migration and proliferation of capsaicin treated cells were observed as a measure of the wound healing process. In our experiments, HEK 293 (Fig. 8b) and HEKa (Fig. 9b) cells did not show significant difference in migration rates upon capsaicin treatment. Although there was no significant effect of capsaicin treatment on the proliferation of HEK 293 cells (Fig. 8a), HEKa keratinocytes treated with 0.1µM and 1.0 µM capsaicin showed a significant decrease in cell proliferation, compared to untreated cells (Fig. 9a). Of note, a higher concentration of capsaicin had no such effect on the cells. For future studies, I would like to replicate my experiment to get more accurate data, and also test using my partially purified samples.

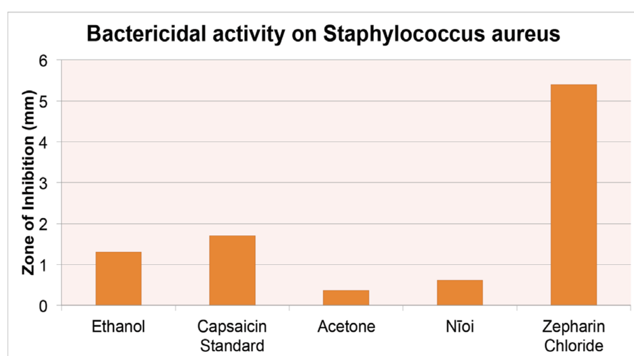


Figure 7. Bactericidal activity of ethanol, ethanol and pure capsaicin, acetone, Capsaicin sample, and zephiran chloride on *Staphylococcus aureus*.

Figure 8. The effect of capsaicin treatment on (a) proliferation and (b) migration in human embryonic kidney (HEK 293) cells. ** means p≤ 0.01.

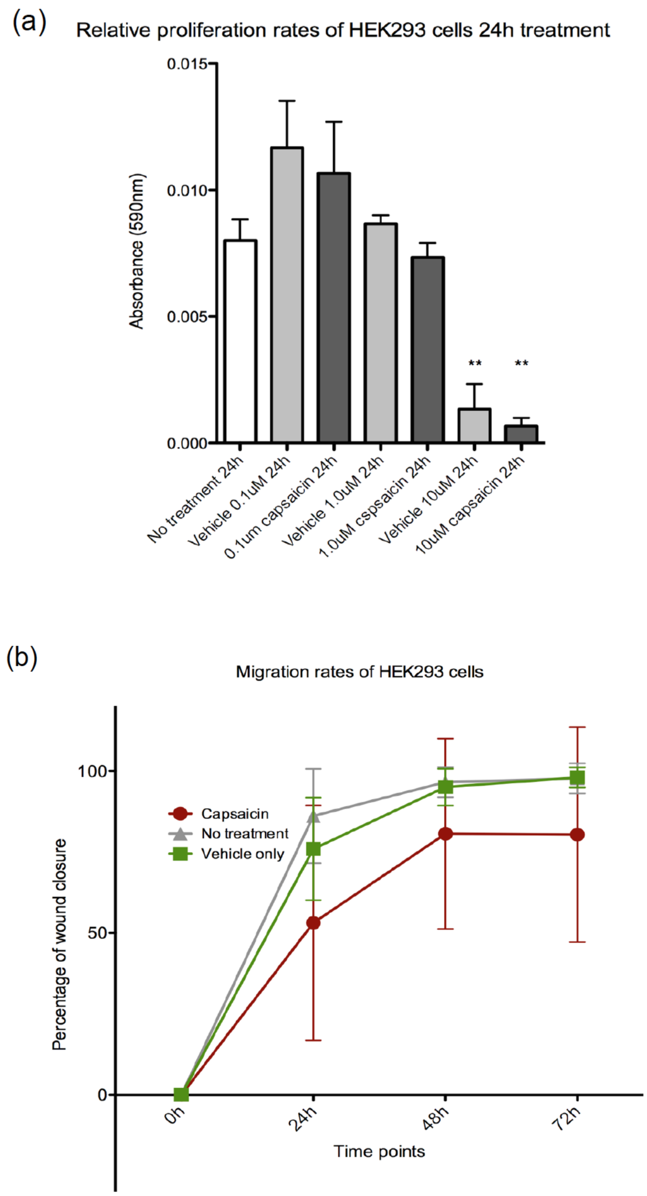
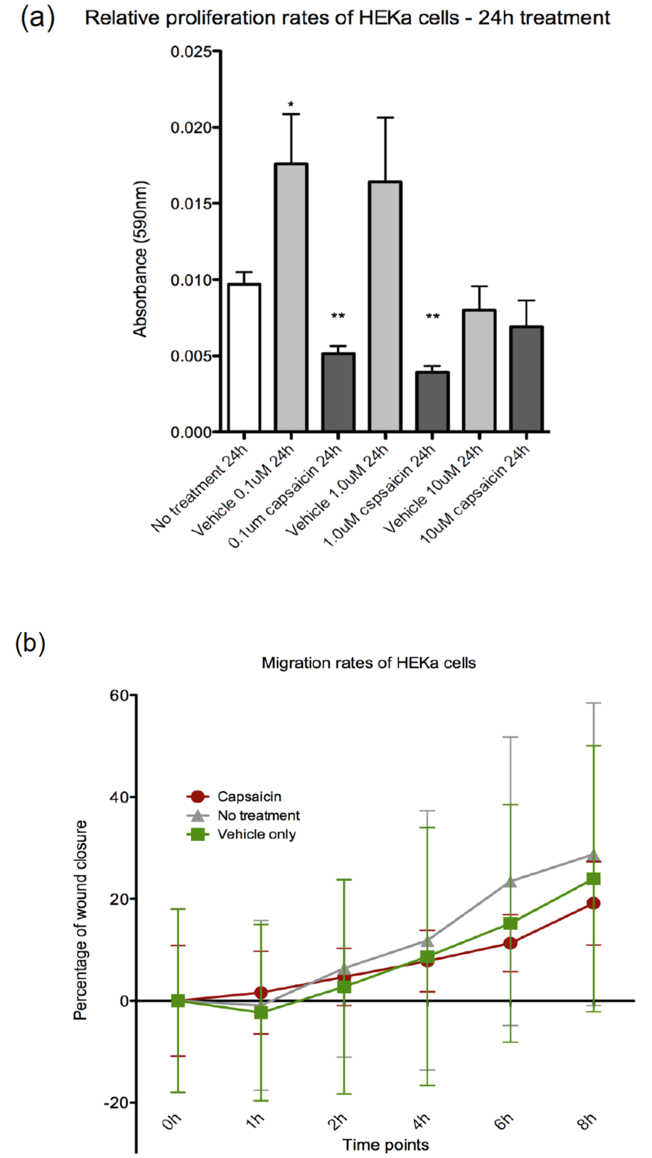


Figure 9. The effect of capsaicin treatment on (a) proliferation and (b) migration in adult epidermal keratinocyte (HEKa) cells. * means p≤ 0.05 and ** means p≤ 0.01.



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Ultrasound-mediated transformation of *Chlamydomonas sp.*

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PROBLEM

- Producing protein-based therapeutics, such as insulin, is becoming more expensive. There is a great need for cheaper alternatives of producing recombinant protein.
- Biotechnology utilizing microalgae is a fast-growing field that shows enormous potential for producing commercially important compounds, however; current methods of microalgae transformation are limiting and inefficient.

OBJECTIVES

- Prove Ultrasound-Targeted Microbubble Destruction (UTMD) is capable of transferring plasmid DNA into microalgae cells.
- Optimize UTMD parameters by manipulating three key transformation parameters; ultrasound voltage input, microalgae density, and microbubble concentration.

BACKGROUND

- Four methods of microalgae transformation are currently used; glass bead agitation, electroporation, *Agrobacterium tumefaciens*-mediated gene transfer, and microparticle bombardment. However these methods require cell-wall deficient cells, infectious bacterium, or repeated attempts [1].
- UTMD is a technique for transformation in which bioactive molecules, such as negatively charged plasmid DNA vectors encoding a gene of interest, are added to the cationic shells of lipid microbubbles. It seems that the mechanical energy generated by the microbubble destruction results in transient pore formation in the cells. As a result of this sonoporation effect, the transfection efficiency into and across the cells is enhanced [2].

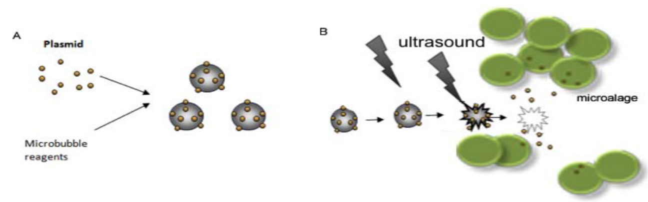


Figure 1. Ultrasound Targeted Microbubble Destruction method.

- *Chlamydomonas sp*. is a popular microalgae model that has been extensively studied and experimented. Large biofactories create transgenic *Chlamydomonas sp*. strains to commercially produce and sell an array of recombinant proteins [3].

METHODS

- *Chlamydomonas sp*. is grown to late-log phase, centrifuged to the appropriate algae density, and then suspended in 1 mL f/2 media in 24-well cell culture plates.
- Microbubbles are coated with the Green Fluorescent Protein (GFP) plasmid and then the appropriate amount of microbubbles is aliquoted and mixed with the microalgae cells.
- A 1.1 MHz 0.5” transducer is situated into the wells and switched on for 10 seconds with continuous sine energy waves.

Parameters:

- Voltage input – 150mV, 300mV, 450mV
- Microalgae density – 10^5 cells, 10^6 cells, 10^7 cells
- Microbubble concentration – 25µL, 50µL, 100µL
- Two-days post transfection, cells are harvested for microscopy, qPCR, and Western Blot analysis.

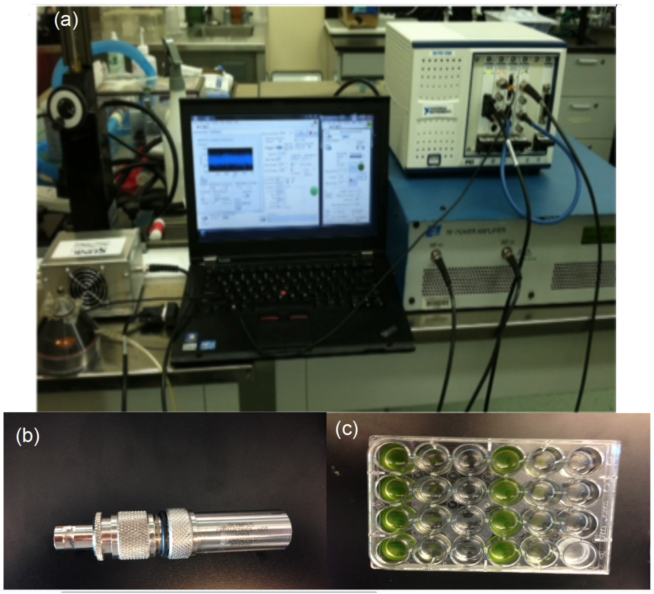


Figure 2. UTMD equipment set-up. (a) Computer connected to a custom control module with computer interfaces, oscilloscope (for calibration), and arbitrary wave function generator which signals to a power amplifier, (b) 0.5” 1.1MHz Transducer, and (c) 1mL of *Chlamydomonas sp*. is placed into 24-well cell cultures with convenient 0.5” diameter wells.

RESULTS

Figure 3. *Chlamydomonas reinhardtii* transformed with GFP plasmid. (1) Phase contrast Image. (2) GFP emission. (3) Chlorophyll autofluorescence. (4) Merge of (2) and (3) panels. Note GFP fluorescence in the cytoplasm and the chloroplast.

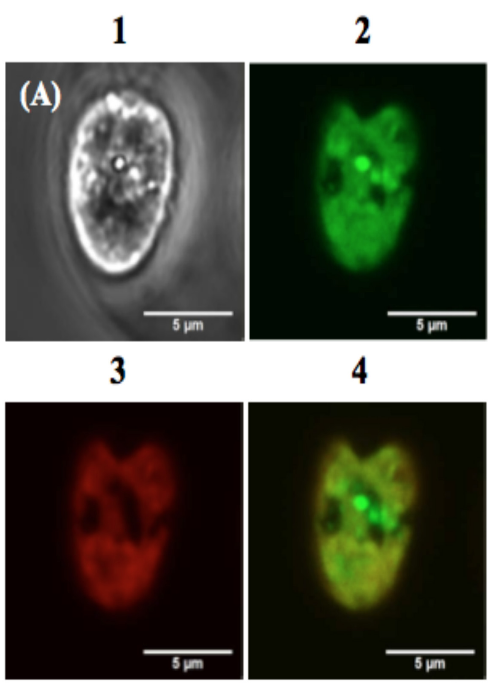


Figure 4. qPCR bar graphs of –ΔΔCt values in relation to voltage input, algal cells, and microbubble concentration. GFP transcript was compared to the housekeeping gene 18SrRNA.

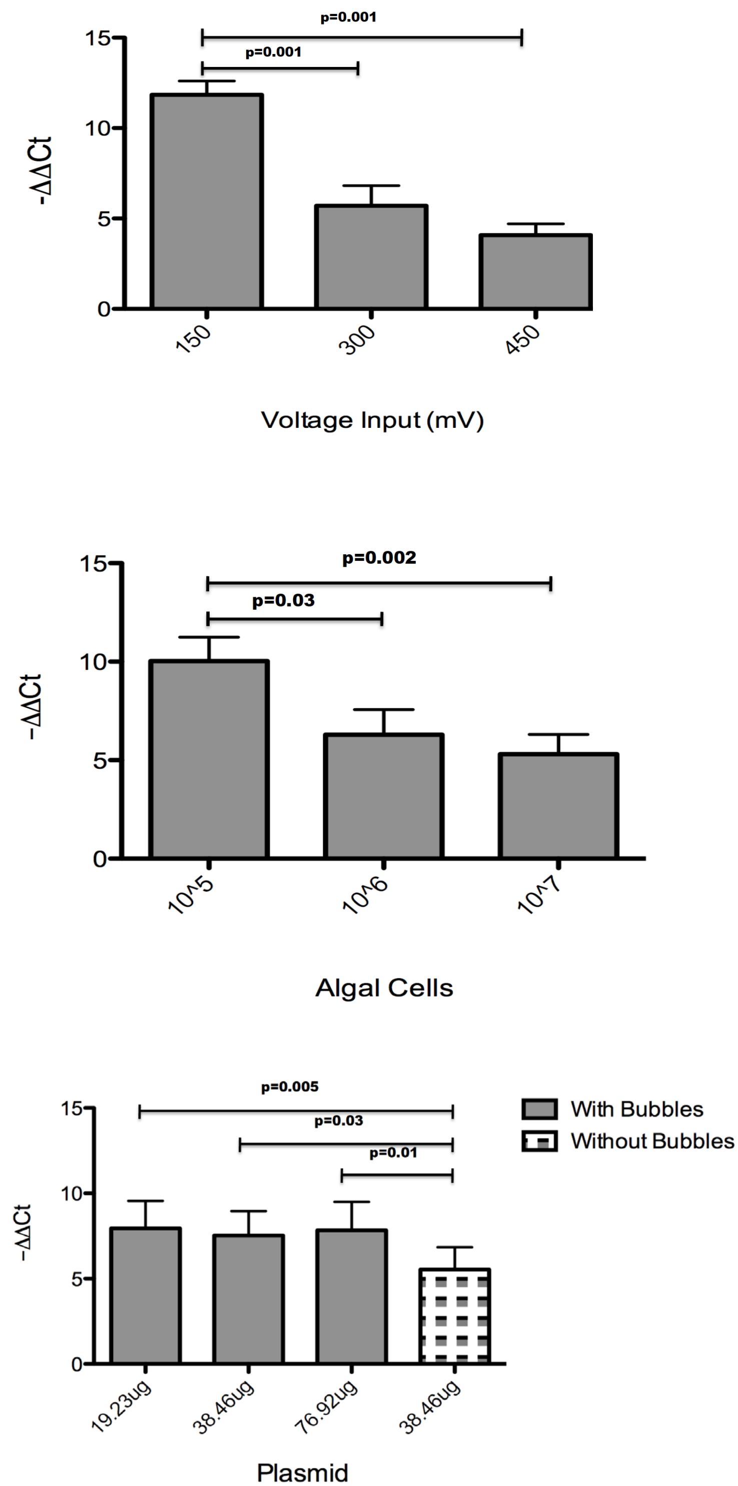
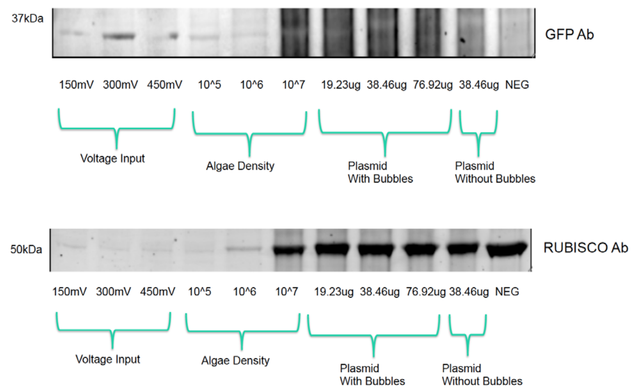


Figure 5. Western Blot GFP bands in relation to voltage input, algal cells, and microbubble concentration.



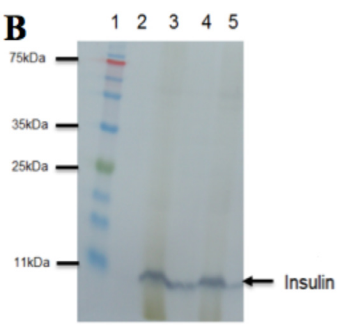


Figure 6. Western Blot analysis showing insulin expression in transgenic *C. reinhardtii*. Lane 1-Protein marker, Lane 2-Wild type *C. reinhardtii*, Lanes 3-5-Transgenic *C. reinhardtii* strains expressing insulin.

CONCLUSIONS

- UTMD successfully transforms *Chlamydomonas sp*. using the GFP reporter as determined by microscopy, qPCR, and Western Blot.
- We have determined that a lower voltage input, lower algae density, and higher microbubble concentration are optimal for this approach.
- Rapid modification of microalgae strains using this ultrasound-mediated method provides a new platform technology for the production of commercially important compounds.

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The content is solely the responsibility of the authors and does not represent the official views of the National Institutes of Health.

JOHN A. BURNS SCHOOL OF MEDICINE · UNIVERSITY OF HAWAII MANOA ·

The Center for Cardiovascular Research
University of Hawaii

NASA Simulation of an Autonomous Payload

By Bryson Racoma (*Faculty Advisor*: Hervé Collin, Ph.D. *Peer Mentors*: William Ka‘eo, and Mitch Mikami)

INTRODUCTION

The drag force acting on a payload moving through a medium acts opposite to its motion. It also depends on the shape and velocity of the payload as well as the drag coefficient. Obtaining the drag coefficient is always required to predict the terminal velocity of a payload descending through the atmosphere, which is an essential aspect of NASA's type of mission when sending scientific payloads on other planets' surface.

PURPOSE

The purpose of this project is to design and build a payload capable of obtaining the data necessary to obtain the drag coefficient during its descent.

METHOD

The method consisted on designing and building the structure of the payload and its protective container in addition to all the sensors and electronics necessary to obtain scientific data. Figure 1 and 3 show the Solidworks (CAD) design of the payload and the container. Figure 2 and 4 show their final design. The container was built using a 3D printer.
The payload contains a Microcontroller (Arduino Mini pro), two servos (for the release mechanism between the payload and container), two voltage regulators, a camera (to film the descent of the payload), a

Figure 1. (left) CAD Design of the payload

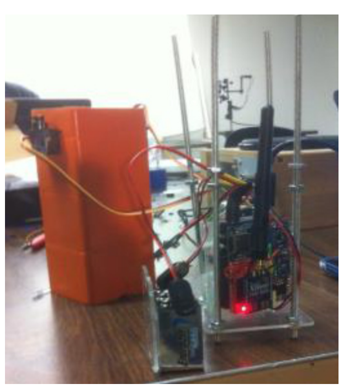

Figure 2. (right) Final Payload Design

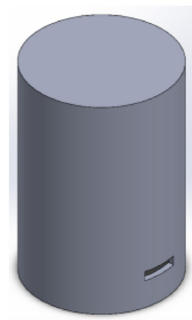

Figure 3. (left) CAD Design of the container

Figure 4. (right) Final Container Design

barometer (to measure altitude), a Xbee radio (to perform telemetry with the Ground Control Station), an accelerometer, and a power source. For redundancy, the data was also saved on an SD card. The schematics is shown on figure 5, and one of the actual boards is shown on figure 6.

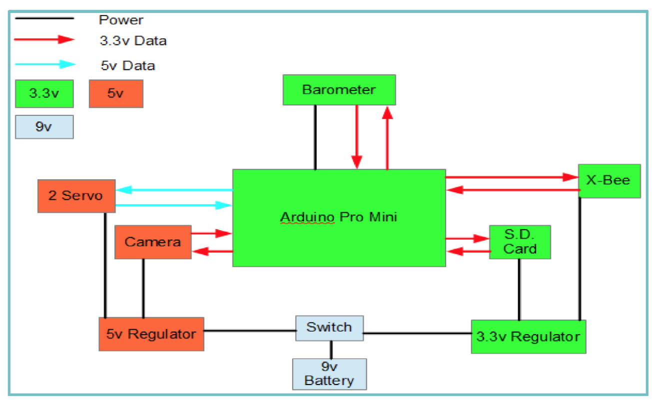

Figure 5. Payload Electrical Schematics

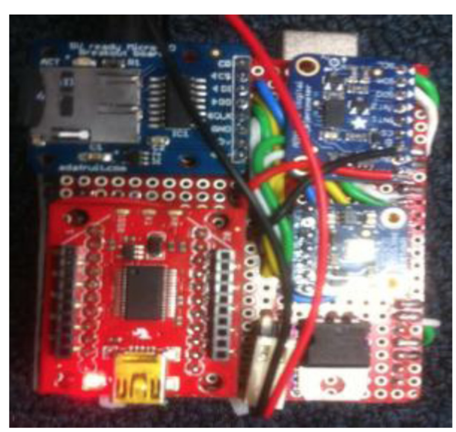

Figure 5. One of the payload's board showing the SD card breakout, barometer, accelerometer, voltage regulator and wireless shield.

The container also contains a Microcontroller (Arduino mini Pro), an additional camera (to film the deployment of the payload from the container), a voltage regulator, a power source, and an SD card (to save the video of deployment). The schematic of the container is shown in Figure 7, and the built system, from a bottom view, is provided in Figure 8.

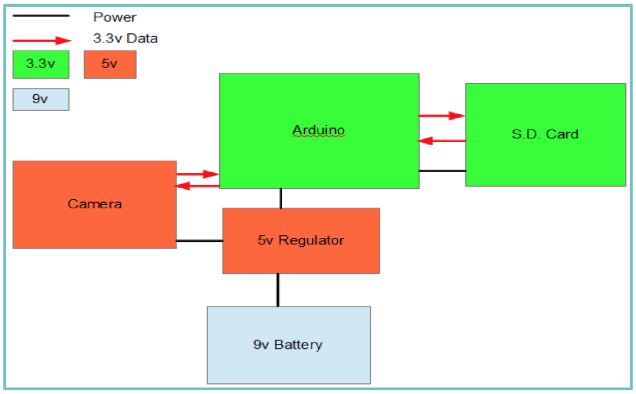

Figure 7. Container Electrical Schematics

Figure 8. Bottom view of the container showing the finished circuit

The data obtained by the barometer was converted on the fly by the Microcontroller into altitude values using the following formula:

$$h = 8353.97\ log\left(\frac{101352}{P}\right) \qquad \textit{Equation (1)}$$

In order to obtain the terminal velocity, we derived the equations of motion for velocity and position with respect to time. Both methods were used to obtained the experimental values of the drag coefficient: first a non-linear regression was applied on the position versus time function $y(t)$, then performing a linear regression on the velocity versus time function $v(t)$.

First, Newton's second law of motion was applied to the payload as it descends through the atmosphere. Two external forces are applied to the system analyzed: the weight of the payload and the drag force, which was taken to be proportional to the square of the velocity as shown in Equation (2). A free body diagram required to perform Newton's analysis on the kinematics of the payload reflects these external forces in Figure 9.

$$F_D = \frac{1}{2}\rho A C_D v^2 \qquad \textit{Equation (2)}$$

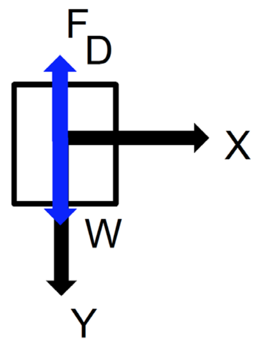

Figure 9: Free Body Diagram

In the Equation 2, ρ is the density of air, A is the cross section area of the payload, C_D is the coefficient of friction, and v is the velocity.

Applying Newton's second law $\Sigma \vec{F} = m\vec{a}$ gives:

$$mg - \frac{1}{2}\rho A C_D v^2 = ma = \frac{dv}{dt} \qquad \textit{Equation (3)}$$

Performing a separation of variables, and integrating both sides of the equation provided the functional form of the velocity as a function of time.

$$v(t) = \sqrt{\frac{2mg}{\rho A C_D}}\, tanh\left(\sqrt{\frac{g\rho A C_D}{2m}}\, t\right) \qquad \textit{Equation (4)}$$

Rewriting Equation (4) in terms of exponential, and taking its limit as time goes to infinity provided the relationship between the drag coefficient and measurable quantities.

$$\lim_{t\to\infty} v(t) = \sqrt{\frac{2mg}{\rho A C_D}}\left(\frac{e^{\sqrt{\frac{2g\rho A C_D}{m}}t} - 1}{e^{\sqrt{\frac{2g\rho A C_D}{m}}t} + 1}\right) = \sqrt{\frac{2mg}{\rho A C_D}} = v_t$$

$$C_D = \frac{2mg}{\rho A {v_t}^2} \qquad \textit{Equation (5)}$$

Substituting the relationship between velocity and time in Equation (4), we integrated one more time both sides of the equation to obtain the position as a function of time:

$$y(t) = y_0 - \frac{2m}{\rho A C_D} ln\left(cosh\sqrt{\frac{g\rho A C_D}{2m}}t\right) \qquad \textit{Equation (6)}$$

Both regressions using Equation (4) and (6) were performed using GnuPlot in order to obtain the drag coefficient C_D. The given quantities used in the above formulae are given in Table 1 below, and the values of position y were obtained by the barometric sensor during ascent of the payload in addition to after being released from the rocket at 100 meters.

Given Quantities	Variable	Values
Mass	m	0.87296 kg
Acceleration Due to Gravity	g	9.81 m/s^2
Air Density	ρ	1.1839 kg/m^3
Cross Sectional Area	A	0.304154 m^2

Table 1. Given variables used to obtain the drag coefficient

RESULTS

Using the values of the mass m, the acceleration due to gravity g, the air density ρ, and the cross section area of the parachute A shown in Table (1), we plotted the experimental values of our altitude obtained by the barometer, and fitted it with Equation (6).

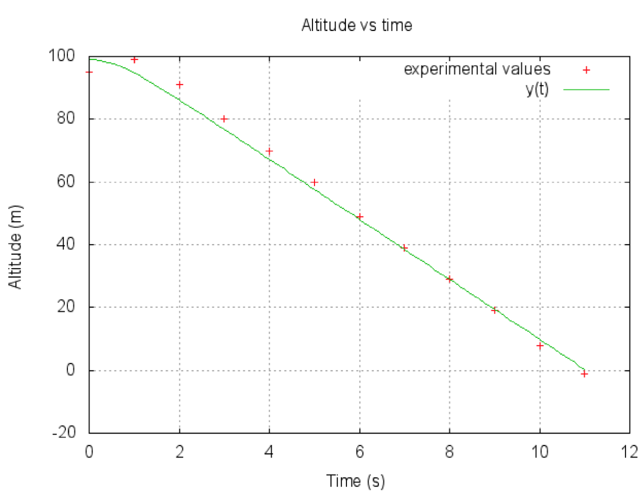

Figure 10. Non-linear regression using y(t)

Based on Figure 10 regression, GnuPlot provided the best fit with the value of $C_D = 0.552$. We performed a similar regression using Equation (4) in order to obtain the terminal velocity of the payload as shown in Figure 11.

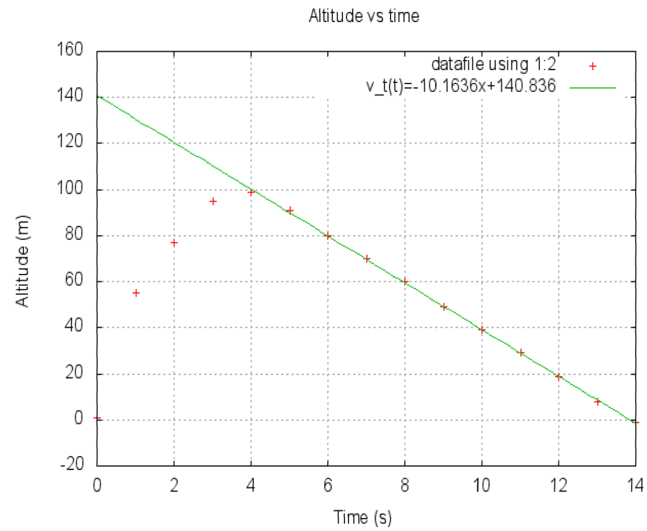

Figure 11. Linear regression using v(t)

The terminal velocity of the payload was extrapolated to be $-10.1636\ m/s$. This value was then used in Equation (5) to obtain the value of the drag coefficient. The result was 0.461.

Taking the average and the standard deviation of our two experimental values of C_D, our final prediction for the drag coefficient is:

$$C_D = 0.506 \pm 0.064$$

CONCLUSION AND FURTHER RESEARCH

Next semester, I will revisit this project, and will fix minor bugs that prevented full functionality of the payload. For this research the frequency of acquisition was 1 Hz. Increasing it to 10Hz will provide more data points, and may provide better precision for the drag coefficient value. Neither the telemetry of the data to the Ground Control Station nor the two cameras functioned properly. Even though these were secondary objectives, a critical design review based on a failure analysis will be required to improve these missing objectives. Better cameras need to be used with a higher rate of shot acquisition, which implies a microcontroller capable of handling more memory. Furthermore, a stronger mounting of radios and cameras is required to sustain the sudden acceleration during the rocket ejection, which may have been the cause of these malfunctions.

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Forward Kinematics Analysis and Design of a Hexapedal Locomotion Robot

By William Kaeo III (*Faculty Advisor*: Aaron Hanai, Ph.D.)

INTRODUCTION

A hexapod is an insect-inspired, versatile six-legged robot that is able to utilize each of its legs independently. This capability enables it to exhibit a wide range of gait motions. Indeed, a hexapod can stabilize itself on four of its six legs, allowing the two other legs to be used to accomplish other tasks.

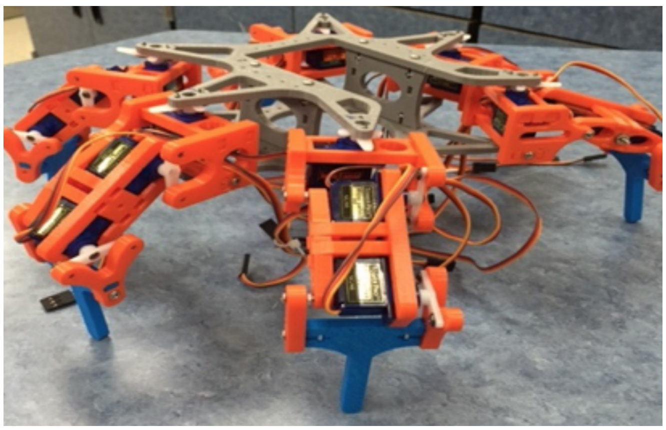

Figure 1. 3D printed Hexy platform, used as basis for new design

PURPOSE

The purpose of this research is to design the mechanical control system of a hexapedal locomotion robot to ensure the collection and deposit of regolith simulant within a simulated Martian environment. Specifically, the inverse kinematics are utilized to formulate an algorithm that enables its stabilized motion, through the calculation of the optimal angles for each joint of the hexapod legs.

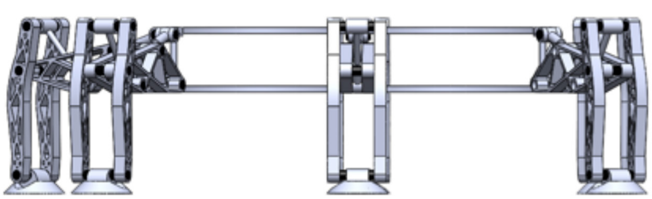

Figure 2. Side view of prototype

METHOD

The design of a working hexapod robot prototype is first accomplished using Computer Aided Design software, where each leg is designed around the specific type of motor to be used. Then, each part of the structure is 3D printed and assembled with the motors before the integration of the motor controllers and microprocessors.

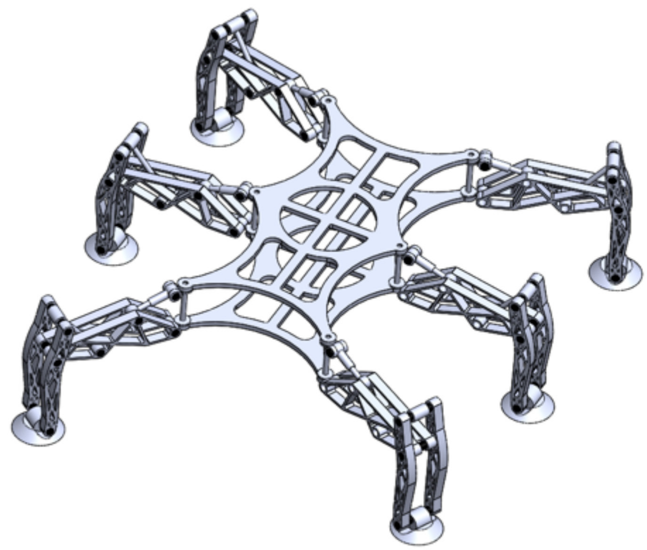

Figure 3. Current hexapod design

Each of the six legs of the robot are comprised of two mechanical segments, connected by actuators at their joints. Hence, twelve actuators must be controlled to achieve movement. For each leg, one actuator is tasked to raise the upper segment, while the other controls the rotation of the lower segment. In the preliminary prototype shown in Figure 1, all of the servo motors used could be centrally controlled by a single servo motor driver board. In the current design, each individual actuator needs its own dedicated motor controller in order for it to move.

The synchronized rotation of each segment about two perpendicular axes enables the hexapod to walk successfully. The rotational angles required for the hexapod's overall motion and gait are computed using inverse kinematic equations, which are utilized in an

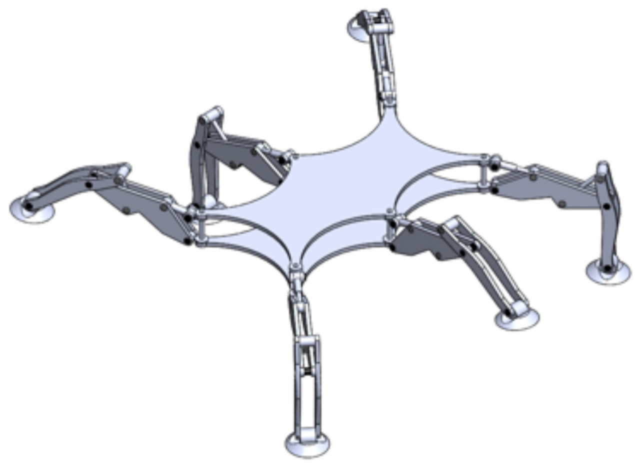

Figure 5. Arrangement of legs while walking

algorithm that controls all twelve actuators.

Given the link lengths and joint angles defined between adjacent links, the forward kinematics are utilized to determine the position and orientation of each tool point, or foot in this case. For computational purposes, the joints are assumed to be revolute actuators, as opposed to the prismatic joint actuators represented in Figure 6.

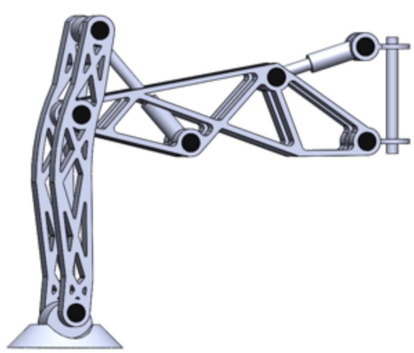

Figure 6. Decomposition of legs for kinematic equations

Because of the way the actuators are arranged, the joint motion is similar to that of a hinge, and allows relative rotation about a single axis. Through the use of geometry, it is possible to compute the orientation of the foot. To simplify the necessary math, the law of cosines can be utilized to easily compute these orientations

RESULTS & FUTURE RESEARCH

I have designed a full mechanical system for a new hexapod, utilizing linear actuators in place of

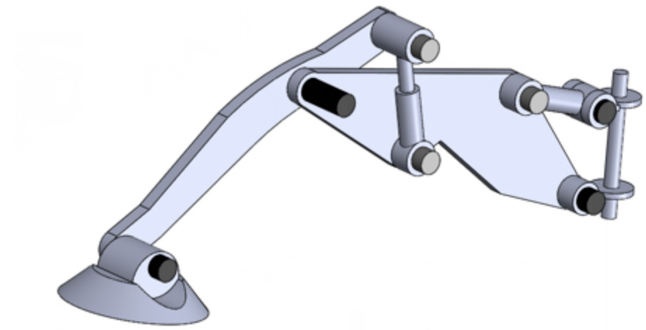

Figure 8. Decomposed leg when lifted

servo motors, for use in the NASA Robotic Mining Competition (RMC). I began working towards perfecting calculations for the implementation of walking algorithms. Based on battery storage, and the power consumption.

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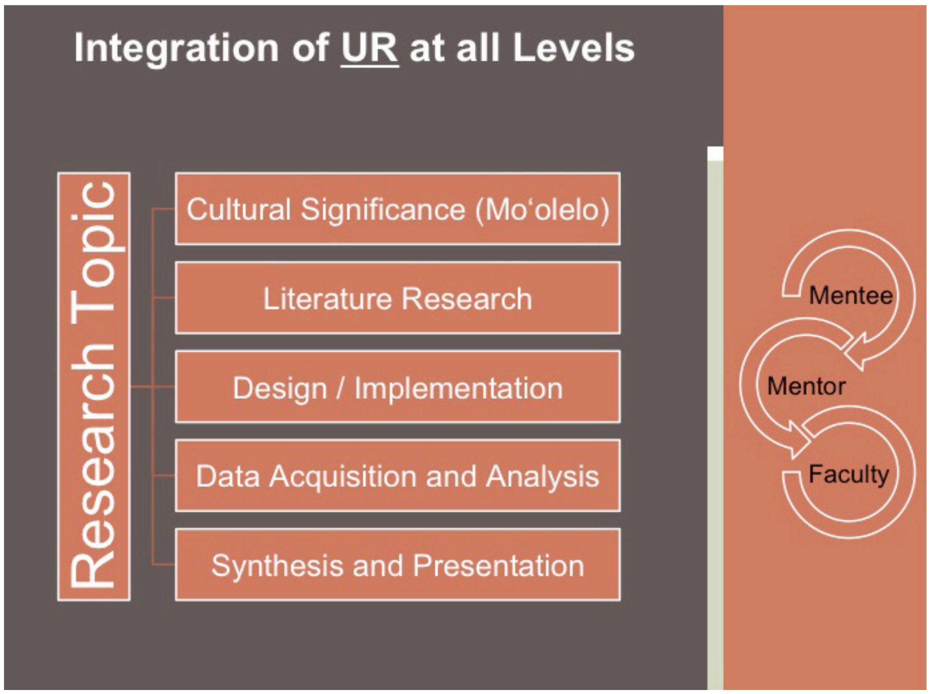
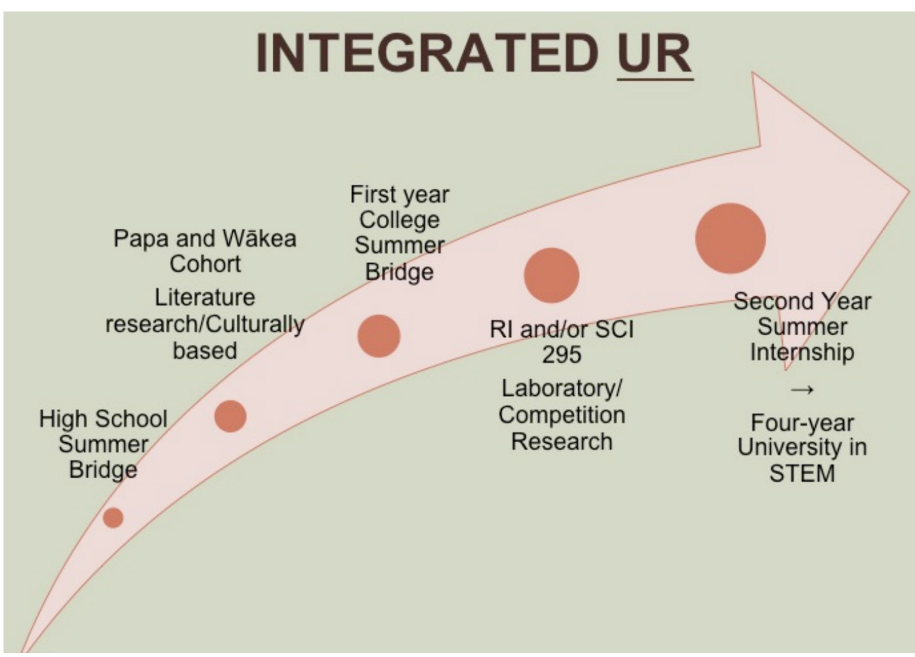
Student Reflections on the KCC STEM Experience

Undergraduate Research (UR) Model



STEM Student Timeline



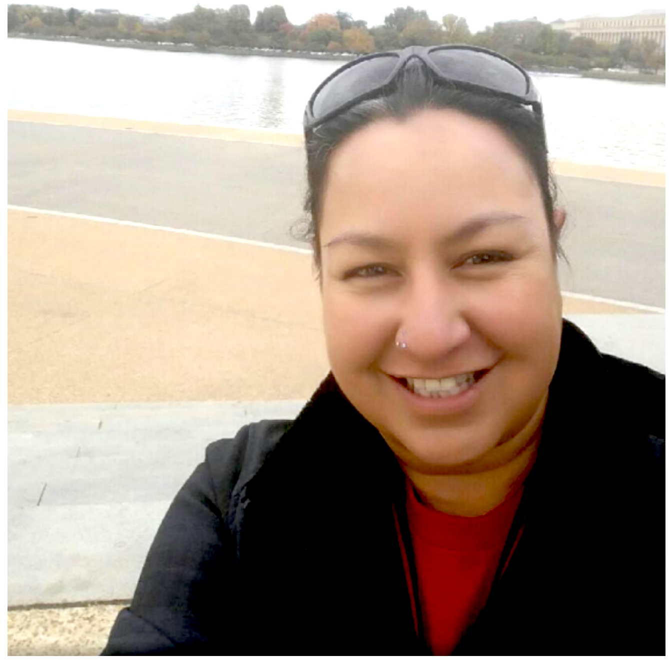
STEM Student Reflection

Patricia Malamalama Cockett

Growing up on Kauaʻi, with the influence of my family, I developed strong cultural ties to the environment. I have always felt compelled to be a steward of the land and the ocean. However, I was never encouraged to obtain a higher education because my intellect did not show through my grades in high school. Despite the unlikelihood of my success in college, I decided to take classes at various community colleges while working full time. I thought I wasn't smart enough to be a real scientist, but perhaps I could work in conservation doing more labor-intensive work. I struggled and was a typical C student. I tried applying to different internships but was always rejected because of my low GPA and lack of letters of recommendation from instructors. My situation grew in difficulty as I slowly lost the support of my family. I found myself alone and struggling to pay for classes that I could barely pass. I thought I had failed and that perhaps my family was right, I wasn't smart enough and had no place in academia.

I remember the day I gave up. I was sitting on the steps at Kapiʻolani Community College crying because my small dream of obtaining a bachelor's degree had come to an end. Something that I will never forget happened that day. A woman came walking up the steps and asked me if I was okay. With nothing to lose, I told her my sad story of failure. She requested that I accompany her to her office. The day I gave up is the day that my life as a scientist began. This woman, referred to as "Aunty" Keolani Noa, showed me simple things like filling out applications for financial aid and scholarships. She told me that I could succeed if I made the STEM Center my home and she was the support that I never received from my family. I owe her my success as a student and scientist because if she didn't come walking up those steps that day, I would never be where I am today, a PhD student studying molecular ecology.

At the STEM Center, I finally had access to computers to do my homework and I interacted with other STEM students and faculty who are still close friends till this day. The STEM Program helped me realize that I could perpetuate my culture through science. My GPA slowly increased and my dreams of



getting a bachelor's degree returned. I participated in independent research projects funded by the STEM Program with Dr. Wendy Kuntz, and I was finally able to get the internships that I applied to. I graduated from the University of Hawaii, Manoa in 2012 with a bachelor of arts degree in biology. My research background and letters of recommendation were so strong that I was accepted to two graduate programs. I am now a graduate student with dreams of returning home and becoming a professor. I currently study ʻOpihi, endemic Hawaiian limpets belonging to the genus *Cellana*. They are a culturally and economically important fishery in Hawaii, but experienced a crash in the early 1900's and have not recovered since. The populations of ʻOpihi on Oʻahu, the island with the highest population of humans, have been overharvested to near extirpation. It is for this reason that I chose to study the population genetics of ʻOpihi at Texas A&M University – Corpus Christi under the direction of Dr. Chris Bird where I earned my Master's of Science in Marine Biology in spring 2015 and am now a Ph.D. student.

My research focuses on the connectivity and genetic diversity of *C. exarata* within the Hawaiian Archipelago. We use genome-wide surveys of genetic variation (ezRAD) on *C. exarata* to investigate their genetic diversity and connectivity. My name is Patricia Malamalama Cockett and I am scientist that uses molecular ecology to study the population genetics of Hawaiian limpets in an effort to protect Hawaii's natural resources. Aloha.

STEM Student Reflection

Kelsey Kawaguchi

My journey with the KCC STEM program began when I first walked into Aunty Keolani's office in the spring of 2011. At the time, I was a semester into college and was interested in studying biology, but not confident in what I wanted. I was struggling to pay for college on my own and was seeking advice on financial and academic opportunities. I spent a good amount of time discussing the different pathways that STEM had to offer and most importantly the different scholarships that could help pay for my schooling. I felt a bit more structured after voicing out my educational goals and was guided in the right direction to become a successful individual. The STEM program provided me and many other students all the resources we could possibly take advantage and accomplish our goals to become better students. Becoming a peer mentor at the STEM Center allowed me to work for financial assistance. The Center was also a place I could visit to study in a comfortable environment. The Center gave everyone including myself a sense of place in school. I felt like I belonged among others that were going through the same struggles and had similar majors as I did, and we all motivated and pushed each other to excel.

Today, I am still very good friends with a lot of those scientists I met back then. After transferring to the University of Hawaiʻi at Mānoa, it took me 2 years to graduate with my Bachelor of Science degree in Mechanical Engineering. I have been blessed with so many opportunities since joining the KCC STEM team. Even after my journey continued at UH Mānoa, they were always there for me 100% of the way and I am beyond grateful. Through the KCC STEM program was I provided with financial assistance, research opportunities, the experience to participate in National Collegiate engineering competitions against top schools and win 1st place, the opportunity to attend conferences across the U.S., student mentoring, the chance to discover what I was most passionate about, life long friends who I consider family, and a fire to hopefully one day be as impactful on other students as Aunty Keolani has been in my life.

The lessons I've learned from her and many other mentors has had a huge impact in my life and was a constant reminder to always remember where I'm from and how I started. I am now a Structural Engineer at The Boeing Company in Seattle, Washington, and I love my career.

STEM Student Reflection

McClyde Gaborno

Five years ago, I never imagined my decision to join the STEM program would lead to the many accomplishments that transpired during my college endeavor. This program had such an impact on my life and helped shape me into the person I am today.

For many students, adversity is no stranger, whether it is the transition into the collegiate atmosphere, the financial burden associated with getting an education, or the challenging work that each course presents. It was no different for me; however, despite how daunting

these situations were, I was able to overcome them with the support of the STEM program.

The summer bridge program gave me a head start on college, allowing me to prep for calculus and adjust to the college world.

Scholarships provided me with financial stability allowing me to focus on what mattered most, my studies—something Aunty Keolani never fails to advocate as a priority. Workshops and conferences allowed me to develop professionally and gave me the opportunity to travel to places, broadening my perspective.

What really made the program special though was the sense of community and the dedicated people who have such a profound effect on students. Coordinators and faculty have a genuine interest in their students and their success. Peer mentors provided help in and out of the classroom. These people were like family. They saw the potential in me that sometimes I couldn't see myself. They encouraged me to exceed my own expectations and motivated me to push through any situation. It was this kind of drive that made me a more encouraging and confident person. It is what inspired me to become a peer mentor, to compete in an international competition, and to strive for the highest in everything I do.

I am forever grateful for everything the program provided and the many people that help get me to where I am today. I am now a Field Engineer for the Four Seasons Manele Bay Resort on the island of Lana'i and as I move forward with my career, I hope to inspire others and continue the cycle of motivation.

STEM Student Reflection

Maria Petelo

My name is Maria Petelo and I was born and raised in Ka'imukī, O'ahu. I am an aspiring medical practitioner, specifically an Obstetrician/Gynecologist. After high school I knew I wanted to go to college but I was lost and didn't know how to start. I decided to follow two of my friends who were applying for the KCC STEM Summer Bridge Program. We hand-carried our application to Mrs. Keolani Noa and she immediately gave me value for my high math and science level completed. I was a bit hesitant and shy because no one ever told me I was smart. I knew I just wanted to be with my friends but after a good talk with Mrs. Noa, "Aunty Keolani," I realize that I needed to follow my own path of opportunity to reach my goals. After joining the STEM program I've developed tremendously as a person and as a student; I had more confidence, my motivation was growing, and I was taking on more challenges than I ever thought I could handle.

In the summer of 2013, I interned at UCLA's medical school through the Summer Medical and Dental Education Program (SMDEP) for six weeks. Through this internship I was exposed to what medical school would be like; we were surrounded by medical students, participated in problem-based learning that involved different scenarios where we had to find the diagnosis, prognosis, etc., took a sample MCAT and did a mini research project. What I loved about this internship is the distribution of activities covered both aspects equally and everyone got to experience both focuses, Medical and Dental.

In the summer of 2015, I interned for the Native American and Pacific Islander Research Experience (NAPIRE) program in Costa Rica. This was an 8-week internship performing ecological/environmental research in the forest. My research was on the costs and benefits of the sexual signal of the Norops aquaticus lizard. My research done at this internship

was accepted and presented at the 2015 National SACNAS Conference as well as the 2015 National AISES conference where I received third place overall in undergraduate posters.

In the summer of 2016, I will be interning for the Māhina International Indigenous Health Research Training Program in New Zealand. Along with the other chosen scholars, we will be performing medical research from an indigenous approach, which is something I am already doing with the KCC STEM Project Olonā. I am so excited about this internship because I am passionate about indigenous knowledge and it's in my area of study/interest.

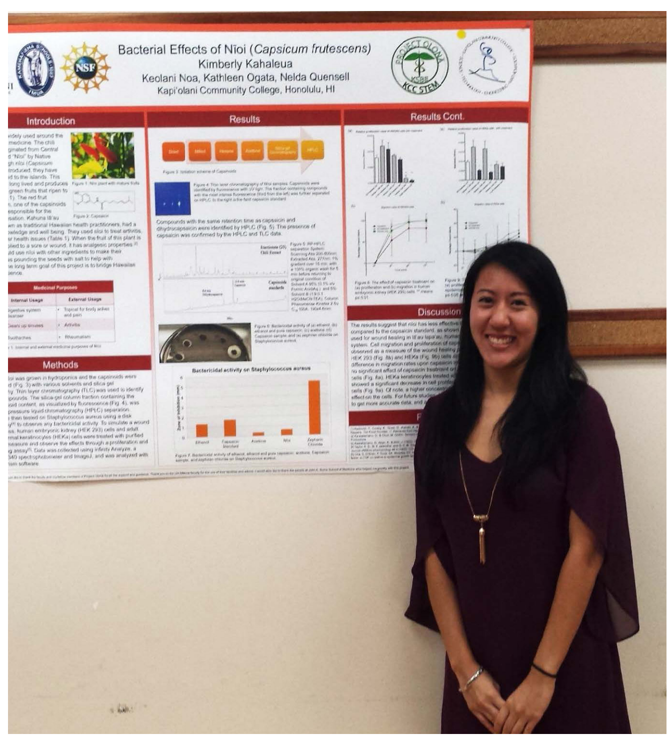
Participating in internships has been life changing and motivating. I meet new and different people every time, and each of them has influenced my academic career positively. Internships are a great way for students to explore more about themselves and see if that's what they're really interested in going into. Participating in these internships gave me a reason why I wanted to become a doctor, what I can do for my people, and how big of an impact I can make on my community. Before participating in any internship I just wanted to become a doctor because of a personal experience I went through, but these internships made me realize that if I'm going to become something, then it has to not only benefit me, but everyone as a whole—thinking with impact, which is something Aunty Keolani always emphasizes.

STEM Student Reflection

Kimberly Kahaleua

My name is Kimberly Kahaleua and I was born and raised in Waipahu, Oahu. I graduated from Pearl City High School in 2011. At first, I wasn't sure if I was good enough to go to college but I was persuaded by my friend to join the Kapiʻolani Community College Science, Technology, Engineering, and Math (STEM) Program. The program gave me a head start to college math and environmental hands-on experiences. The great thing about the KCC STEM Summer Bridge Program is Native Hawaiian students were encouraged to participate. For me this meant I had a chance to attend college and indigenous knowledge was inclusive. It was at this point that I became immersed in the STEM program as a peer mentor and Student Kakoʻo. I've received both a Liberal Arts and Associate of Science degree in Natural Science (ASNS), with a concentration in Life Science as a biology major.

Being a Native Hawaiian STEM student, I had this wonderful opportunity to participate in Project



Olonā. This is my first experience of doing research! It is a unique opportunity for me to relate my Native Hawaiian culture with science. Our goal is to work with native Hawaiian lāʻau lapaʻau (medicinal plants) and understand their traditional usages as we research the active ingredient in each plant. I felt so amazed to explore modern-day science and at the same time strive to validate the knowledge of our ancestors.

Project Olonā helped me get to where I am today because it provided me the challenge and opportunity to develop my research skills as an undergraduate. I have built a foundation for my cultural ways of thinking, and established a network of people support that Project Olonā partnerships have provided. I am grateful to have Project Olonā and the opportunity to do research because without it, I probably wouldn't get this type of experience from my regular classes. It is one thing to learn in a classroom, and another thing to do hands-on experience in the field or lab.

Being a part of this research project, I had the opportunity to present my findings at one of the biggest national conferences called the Society for Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS). Within my category, I competed with other undergraduate students from four-year universities and I was able to win! From this experience I gained more confidence in my researching and presenting skills. I've learned new things, made new connections with our various partners (UH Mānoa and JABSOM), and reconnected with my cultural side. Further researching the medicinal properties of these native plants and their usage by Kahuna lāʻau lapaʻau made me feel proud that my ancestors knew these specific things, which are very similar to what modern science knows today. To be able to support and connect what my Native Hawaiian ancestors knew with modern science was a great experience. Project Olonā is important to me because it gives Native Hawaiian students, like myself, the opportunity to do research and to expand their experiences and skills. But rather than just building academics, I believe that this project also helps students to explore their own personal capabilities and support their confidence in pursuing a STEM degree.