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Prediction of Red Tides Based on Nitrate and Phosphate Levels in the Pacific Ocean, Carlee Gravesen 68
The Effects of Mycorrhizae on the Growth Rates of the Plant *Lycopersicon esculentum*

Lauren Gold and Michael Ko  
*Department of Biological Sciences*  
*Saddleback College*  
*Mission Viejo, CA 92692*

**Abstract**

Mycorrhizal fungus has the ability to form a symbiotic relationship with plant root structures to aid in growth and absorption while helping to cope in stressful environments. In this study, *Lycopersicon esculentum* was subjected to varying volumes of water with and without mycorrhizae. According to past studies, plants with mycorrhizae grew at faster rates and were able to cope better in harsh environments, especially under low water volumes. In our study, there was a direct comparison of increased growth for plants with mycorrhizae and low water volumes. Plants administered a reduced amount of 5 ml of water with and without mycorrhizae had an average height of 6.27 cm and 2.47 cm, respectively. The growth rates for plants given higher volumes of water were not affected even if mycorrhizae were present.

**Introduction**

Mycorrhizal fungus has existed for over four hundred million years and can be found in about ninety percent of all land plants (Karanashov et al. 2003). This specific fungus forms a mutualistic relationship with plant roots. The roots provide essential nutrients and sugars for the growth of mycorrhiza, while mycorrhiza serves as a supplementary root system to increase the amount of water and nutrients that the plant may obtain from the surrounding soil. The branching network of mycorrhizal hyphae is responsible for increasing the absorptive surface area of plants. In addition to increased nutrient and water uptake, this mechanism offers afforded benefits to the host plant including tolerance to disease, and abiotic stresses, such as drought, chilling, and salinity (Dionne and Pelletier, 2004). As a result, mycorrhizal plants are often more competitive and better able to tolerate environmental stresses than are nonmycorrhizal plants. It has become increasingly recognized, however, that mycorrhizal fungi may result in no benefit or detrimental effects to host plants under certain conditions (Hartnett and Wilson, 1999). Due to inconsistencies in the results of numerous experiments, continual research is being conducted in order to establish a more definitive conclusion (Fitter, 1985).

The purpose of the experiment was to determine the effects of mycorrhizae on the growth rates of *Lycopersicon esculentum* (tomato plants) in varying water volumes. The hypothesis of the experiment was that *Lycopersicon esculentum* groups treated with mycorrhizae would increase in height at a faster rate than those without mycorrhizae. Furthermore, the groups subjected to the abiotic stress of water deficiency treated with mycorrhizae were hypothesized to increase in height at a faster rate than those without mycorrhizae.

**Materials and Methods**

Six groups of six individual *Lycopersicon esculentum* were studied in varying water volumes with and without mycorrhizae exposure. The plants were housed within a greenhouse at the Saddleback College Campus. *Lycopersicon esculentum* seeds were immersed a quarter of an inch under the soil in separate one liter containers. The first twelve plants were each given forty milliliters of tap water and six of them were administered 0.22 grams of mycorrhizae. The second and third sets of twelve plants were treated with tap water and 0.22 grams of mycorrhizae in the same fashion except they were given twenty milliliters of water and five milliliters of water, respectively. The tap water was measured in graduated cylinders and the mycorrhiza was measured on an analytical balance. The plants were watered with their respective amounts once a week for four weeks. During this time frame, measurements of stem height were recorded in centimeters each week. The height was measured from the soil surface up to the most elevated point. Initially, the average change in height for the four week period of each group of six was going to be calculated. Unfortunately, only three weeks of quantitative data was recorded due to early death of some plants. The recorded measurements were then used in a one-way factorial ANOVA test from [www.statpages.com](http://www.statpages.com). Using the information provided from the ANOVA test, the post-hoc test was used to compare the plants with and without mycorrhizae exposed to the same water volumes. In addition, plants with mycorrhizae were compared amongst each other in relationship to different water volumes. The plants without mycorrhizae were compared in the same way. The results of the post-hoc test were used to verify significance of the data.

**Results**

The experiment showed that there was no statistical difference in the growth rate between mycorrhizal plants and non-mycorrhizal plants given 20 ml and 40 ml of water. The most interesting results came from the 5 ml group.
The 5 ml group with and without mycorrhizae had an average height of 6.27 cm and 2.47 cm, respectively (Table 1). The difference of average height for the 5 ml group was 3.8 cm (Figure 1). Comparing the plants with and without mycorrhizae given 5 ml of water yielded a p-value less than 0.05.

Non-mycorrhizal plants given 40 ml of water compared to 20 ml of water were not significant. However, non-mycorrhizal plants given 40 ml of water compared to 5 ml of water were significant. Non-mycorrhizal plants given 20 ml of water compared to 5 ml of water were also significant. Average heights for the 40 ml and 20 ml were similar but the 5 ml group was considerably lower (Figure 2).

The comparison between mycorrhizal plant groups, regardless of water volume, was not significant. The results for the average heights of this group were all similar (Figure 3). This suggests that there is not a difference in growth rates with varying amounts of water when subjected to mycorrhizae.

<table>
<thead>
<tr>
<th>Volume of Water (mL)</th>
<th>Average Height</th>
<th>No. of plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 mL with mycorrhizae</td>
<td>8.67 cm</td>
<td>6</td>
</tr>
<tr>
<td>40 mL without mycorrhizae</td>
<td>8.27 cm</td>
<td>3</td>
</tr>
<tr>
<td>20 mL with mycorrhizae</td>
<td>7.27 cm</td>
<td>6</td>
</tr>
<tr>
<td>20 mL without mycorrhizae</td>
<td>7.58 cm</td>
<td>6</td>
</tr>
<tr>
<td>5 mL with mycorrhizae</td>
<td>6.27 cm</td>
<td>6</td>
</tr>
<tr>
<td>5 mL without mycorrhizae</td>
<td>2.47 cm</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 1. Average height and sample size for each group of *Lycopersicon esculentum*

![Figure 1. Comparision of average growth rate of *Lycopersicon esculentum* with or without mycorrhizae](image.png)
**Figure 2.** Weekly growth comparison of *Lycopersicon esculentum* without mycorrhizae

**Figure 3.** Weekly comparison of *Lycopersicon esculentum* with mycorrhizae
Discussion

The results of our experiment did correlate with part of our initial hypothesis that the addition of mycorrhizae would help plants with reduced amounts of water. The post-hoc tests showed there was no difference in growth rate between plants with or without mycorrhizae except for the plants given 5 ml of water. There was a considerable difference in average growth rate for the group given 5 mL of water. This suggests that mycorrhizae benefits *Lycopersicon esculentum* in water deficient environments. Our results paralleled another study done with *Artemisia tridentate* (Stahl, et al. 1998). On the other hand, *Lycopersicon esculentum* treated with mycorrhizae did not grow at a faster rate than plants without mycorrhizae given 40 ml and 20 ml of water. The average growth rate of both plant groups were similar in height and showed no correlation. Our results were contradictory to other similar studies with plants showing improvements with mycorrhizae in sufficient volumes of water (Mathur and Vyas, 2000).

Comparing the plants within the non-mycorrhizal group, there was significance between the groups given the least amount of water compared to the other groups. Giving less water to *Lycopersicon esculentum* was detrimental to the growth rate of the plant when comparing plants given more water. However, the 40 ml non-mycorrhizal group and the 20 ml group did not show a significant difference. The plants of these two groups showed that the amount of water given to them did not affect their growth rate. This may be due to 20 ml of water being a sufficient volume for *Lycopersicon esculentum* to survive. This study indicates less than 20 ml of water posed a stress upon the plants.

Comparisons of the groups of varying water volume with mycorrhizae showed no significance. The amount of water available to each group did not affect the growth rate of the plants. The 5 ml group showed no significance when compared to the 40 ml group. Stated earlier in this study, the non-mycorrhizal group showed that there was a significant difference between 40 ml and 5 ml plants. This supports the hypothesis that plants with mycorrhizae will fair better than plants without mycorrhizae especially under water stress conditions. Numerous past studies have confirmed that mycorrhizae can reduce plant stress resulting from nutrient deficiencies and drought (Ellis, et al. 1992).

During the time the experiment was performed, different factors could have altered the results. For the first three weeks, the greenhouse provided the plants with a controlled environment except for humidity. Unfortunately, within the fourth week plants given 20 ml and 5 ml of water died. One reason may be attributed to their mandatory relocation in the greenhouse. This relocation brought the plants closer to the heater, which may have more quickly evaporated the water given to the plants. Also, having the plants closer to the heater increased the temperature of their environment.

There are many ways to improve the study to better evaluate the effectiveness of mycorrhizae. Using seedlings as the subject may not have yielded the best results because their growth rate is so rapid. One possibility of improvement would be to utilize mature tomato plants. With mature plants, the growth rate is reduced and other variables can be observed. [Stahl, et al (1998)] found that as seedlings aged, the beneficial influence of mycorrhizae on soil water stress tolerance increased.

Literature Cited


Gender-Related Heart Rate Differences in Humans age 18-25

Portia Corrales
Department of Biological Sciences
Saddleback College
Mission Viejo, CA 92692

Abstract
The goal of this study was to determine whether or not there is a significant correlation of gender with resting heart rate. Fifty-three individuals between the ages of 18 and 25 years of age were randomly sampled for their pulse rates. Pulses were counted for 15 seconds and then multiplied by four to give a heart rate per minute. The study showed that males surveyed had a lower average heart rate of 72.04 beats per minute compared to the female average rate of 75.12 beats per minute. The T-test value resulted in 0.23 which is significantly larger than 0.05. This difference in heart rate is in accordance with gender-related studies done on heart rates ranging from newborns to geriatrics.

Introduction
Statistics from large random samples have shown that the average human heart rate is between 60 and 80 beats per minute (Aoyogi, 2003). The definition considers heart rate to be measured by calculating the number of pulses—the stretching of arteries caused by the pressure of blood exuded by the contraction of the ventricles of the heart—per one minute. The question that is posed is do males have a higher or lower pulse, and subsequently higher or lower heart rate, than females of the same age group?

Prior to beginning research, I had hypothesized in the past that males would have a higher heart rate. This idea came about from being around males who complain to be constantly warm. The possibility for such heat could come from a higher heart rate would circulate the blood faster to skin surface capillary beds for needed cooling, thus giving off a feeling of always being warm. Studies by Carter have found body temperature affects heart rate directly by stimulating the metabolism of cardiac cells; raising body temperature one degree Celsius has shown to increase heart rate by 10 beats/minute (2003). However, a study into actual body temperature difference between males and females was not conducted for this experiment.

According to studies by E. Nagy, baseline heart rate is gender related in adults as well as in fetuses. These studies have shown that heart rate for fetal and infant males to be an average of 128.28 beats/minute and 136.48 beats/minute for females of the same age group. In studies on the effect of age in variability of heart rate in males and females, females were found to have a higher baseline heart rate than males; as age increased in years, the difference in hear rate decreased (Stein et al, 1997). Children aging between 10 years of age to 18 years of age tested by W. Pearl showed the same correlation with female children having a higher pulse rate than their male counterparts. With a test group between the ages of 18 – 25 years of age, the difference in heart beats per minute should be significant enough to be deciphered from the data.

Materials and Methods
In this experiment data was collected and interpreted from 50 individuals between the ages of 18 and 25 years of age. Twenty-eight males and twenty-six females were asked their age and then to participate in this survey by having their pulse taken and a few questions asked of them. Participants were surveyed and had their pulses taken in calm environments such as a classroom or library setting on campus at Saddleback College at various times of day. Subjects were surveyed in environments which they had been sitting for more than 10 minutes. The pulse was taken on the radial side of the left wrist and counted for 15 seconds. The amount of beats in 15 seconds was multiplied by four to get the average beats/minute rate for one minute. Subjects were then asked if they had any cardiovascular exercise within the last 3 hours. Due to exercise having the ability to raise the heart rate five fold, data of three subjects who had exercised prior to the survey was not included. Subsequently another individual was polled in
order to reach the goal number of 25 males and 25 females. Data were collected on paper and put into Microsoft Excel where raw data was averaged as well as where t-test was performed.

**Results**

Figure.1 shows the visible difference in average of heart rate between males and females of this study. Total average heart rate of all 50 individuals can be seen here as an average of 73.58 ± 9.94 beats per minute. Males had a lower pulse rate than females; males averaged 72.04 beats/minute ± standard deviation from the average of 11.01 beats/minute. In comparison, the female heart rate was 75.12 beats/minute ± standard deviation from the average of 8.70 beats/minute. The T-test resulted in a p value of 0.23 which is significantly higher than 0.05 and shows that there is a difference in average heart rate of males in comparison to heart rate of females ages 18-25.

![Chart 1.1](chart1.png)

**Figure 1.** Heart rates of males and females in this study.

**Discussion**

In accordance with previous studies of newborns as well as children, the results of this study have revealed the same gender-related differences. With a T-test result of 0.23 being larger than .005, I fail to reject my hypothesis that males between the ages of 18 and 25 have a lower heart rate than females of the same age group.

One possibility for this difference is that cardiac output and/or stroke volume (the amount of blood pumped out of the heart in one contraction of the heart) may differ between the physiology of the male and female. If this were true, a further investigation would inquire if there is altered cardiac muscle activity and what causes it. Other possibilities for difference in pulse rates could be things such as size of heart as well as the differences in human anatomy between males and females. These differences include, but are not limited to, body size, the hormonal environments, and overall health, and/or mechanisms like respiratory sinus arrhythmia - respiratory modulation of the heart- of each individual.

If this study was conducted again caffeine intake and body temperature would have been taken into account as well as exercise and aforementioned body differences. The study would ideally by taken in a controlled environment where subjects sat at rest for a day and were randomly monitored by an EKG machine. However due to the limitations of budget in this study, simple improvements in method and surveying before pulse was taken should improve conditions for data to be collected.

**Literature Cited**

Survey for the demonstration of bark beetle infestation in early California impressionistic, *Plein Air* paintings from 1874 to 1934 in relationship to drought

Angela Draper, Jason Fitzgibbon and Andrew Morse  
*Department of Biological Sciences*  
*Saddleback College*  
*Mission Viejo, CA 92692*

**Abstract**
Bark beetle infestation displays distinguishable symptoms of golden yellow to rusty orange/brown foliage in conifers. These symptoms have been recorded in remarkable detail in plein air, impressionist paintings of the Sierra Nevada Mountain Range, CA from the late 19th and early 20th centuries. Current studies support a strong link between bark beetle infestation and drought. It is our belief that an analysis of bark beetle infestation in California plein air paintings will correspond to drought years as well, and in effect may be used to supplement the historical climatic record. Observational data in the form of the number of visible trees infected with bark beetle was collected from *Plein Air* paintings of the Sierra Nevada Mountains. Paintings of similar periods were grouped and percentage healthy trees were compared against a control group of paintings from a recent, known drought period. Analysis; using ANOVA to determine variance amongst all groups and f-test to determine variance between groups, revealed enough significant variance (p<0.05) between the groups to allow for tentative assumptions of ‘drought’ or ‘wet period’. Assumptions are as follows: 1874-1878 (drought), 1913-1919 (wet period), 1921 (drought), 1925-1927 (drought) and 1930-1934 (wet period). Results show a tentative correlation to Palmer Drought Severity Index (PDSI) values, though further research is recommended.

**Introduction**
In recent years, bark beetle infestations have reached epidemic levels in California’s forests, spurring extensive discussion as to causes, and impact on forest health. There are at least twenty-five recognized species of bark beetle in Western forests distributed over a wide range of hosts, though a predominate number target conifers. Among these, species belonging to the genera *Dendroctonus* and *Ips* are the most destructive. As with most natural disturbance agents affecting boreal regions, (others being fire, pathogens and outbreak species of insects) bark beetles have a dynamic ecology that responds to climate change as well as to other disturbance agents (Paine et al., 1997). Primary bark beetles are classified as near obligate parasites, attacking healthy living trees and killing them by means of mass colonization. Generally such a trend occurs when the beetle species are at high density. At low densities, primary beetles tend to colonize unhealthy trees (Coulson, R N, 1979). Both primary and secondary bark beetles (facultative parasites) are capable of killing trees that have been heavily stressed by disease, drought or previous beetle attack. In all cases bark beetles bore through the bark of their hosts into the phloem where they lay eggs which hatch and feed on phloem throughout their lifespan. When engaging in mass colonization, most species employ a complex sequence of pheromones to attract additional beetles; the sheer numbers of which are able to overcome a tree’s defenses. Once a tree has become infected, its foliage color changes rapidly from green to yellow, gold, to a rusty brown, often beginning halfway up a tree and spreading in both directions. Because of their well defined physical affect on the trees, distinctive from other biotic disturbances, bark beetle infestations are easily recognized and recorded. Depending on the severity of the attack, the tree may be killed within one beetle life-cycle (1 – 2 yrs), or it may eventually overcome the attack and recover. When considering the overall health of the forest, longer sustained outbreaks result in higher mortality rates while shorter outbreaks favor increased regeneration (Malmstrom, 2000).
Currently, California’s bark beetle explosion is being attributed to two major (though by no means exclusive) factors. The first is climate; specifically sustained periods of drought, because lack of water weakens a tree’s defenses and limits its ability to ward off attack (Hagen, 1995). Noteworthy, as was the case in British Columbia in the 1970’s and 80’s where a large outbreak of *Dendroctonus rufipennis* was caused by a temperature-driven reduction in lifecycle from two years to one, climate may be responsible for other variables as well (Van Sickle, 1995). Another major factor contributing to the outbreak is thought to be changes in forest age brought about by extensive fire management. Several studies have found that in “regions with moderate precipitation and fewer fire ignition events, the area affected by biotic disturbance is often greater than that affected by fire” (Malmstrom, 2000). Conversely, areas where fire damage is more widespread tend to have lower insect-induced mortality.

Relevant to this study is the relationship between drought and bark beetle infestation. While current correlations are noted, we are interested in methods of tracing such a connection in the historical record. In the late 1800’s to early 1900’s, California witnessed an expansion in the popularity of impressionist, plein air paintings. *Plein Air* is a French term meaning “open air” and refers to paintings or drawings depicted expressly from nature; based on direct observation of the visible world, and not on conceptions, conventional images or memories of it (Landauer, 1996). The roots of this style were laid by mid-19th century artists such as Edouard Manet, Claude Monet, Edouard Degas, and Auguste Renoir, impressionists who espoused the idea that the form of nature was merely a reflection of light which could be conveyed by color. It was heavily influenced as well by the French ‘Barbizon’ school which “reacted against the conventions of classical landscape and advocated a direct study of nature” (The Columbia Encyclopedia, Sixth Edition. 2001). Edgar Payne, Albert Bierstadt, William Keith, and a great many others are artists known for such impressionist depictions of California’s Sierra Nevada Mountains. A frequent number of these paintings detail conifers with the rusty, orange/brown coloring distinctive of bark beetle infestation. We will compare bark beetle infestation in these turn-of-the-century paintings to modern *Plein Air* impressionist paintings of a known drought period, hypothesizing drought via this correlation. In addition, we will chart proposed drought periods against the Palmer Drought Severity Index (PDSI) numbers for their respective regions and years.

**Materials and Methods**

Impressionist plein air paintings of California’s Sierra Nevada Mountain Range were studied on April 30, 2004 at The Redfern Gallery located at 1540 S. Coast Highway Suite# 103 Laguna Beach, California, and at Joan Irvine Museum located in Irvine, CA. In addition a few prints were studied off of The Redfern Gallery’s web site (http://www.redferngallery.com). The primary artist used was Edgar Payne. Table 1 displays a complete listing of artists and paintings. The paintings studied depicted landscape views of the Sierra Nevada Mountain Range, which contained clear and visible paintings of conifers, and ranged in date from 1874 through present. Only individually visible trees were counted. Trees that were considered “infected” by bark beetles included signs of yellow to rusty/orange/brown coloration, particularly on the upper part of the trees. Dead trees in “infested” areas were also counted as infected. The number of infected trees was compared against the total number of visible trees in each painting, and a value for % healthy trees (all visible conifers not displaying signs of bark beetle infestation) was calculated. Paintings were grouped together based on date painted, groupings being subject to the limitations of our set of observed paintings. Each historical ‘group’ was then compared against our control group of plein air impressionist paintings of the Sierra Nevada Mountains in 2001-2002, a known drought period. Data was analyzed using statistical analytical methods in Microsoft Excel; an ANOVA test was done to firstly establish significant variance amongst the entire data set, and finally single groups were then compared to our recent “control group” using F-test for variance between two groups. Using calculated p values for significance between comparisons, suggestions were then proposed regarding climate of each group’s period (drought or wet period). PDSI values were then used to support each proposition.

Drought records were obtained from the National Climactic Data Center (Cook, et al., 1994) in the form of annual PDSI values for the region. PDSI is a monthly (condensed to annual) index generated to indicate the severity of a wet or dry spell and ranges from -6 (dry) to +6 (wet). Values of 0 to -0.5 = normal, -0.5 to -1.0 = incipient drought, -1.0 to -2.0 = mild drought, -2.0 to -3.0 = moderate drought, -3.0 to -4.0 = severe drought and >-4.0 = extreme drought.

**Results**

ANOVA test of grouped data resulted in p=0.03 therefore validating our data set for analysis of paired groups using F-test for variance. Percentage of healthy trees for each painting is given in table1. Results of the comparison of each group against the 2001-2002 control (F-test for variance) are as follows: 1874-1878 (p=0.22; drought),
1913-1919 (p=0.034; wet period), 1921 (p=0.053; drought), 1925-1927 (p=0.098; drought), and 1930-1934 (p=0.039; wet period).

When the percentage of healthy trees were compared to recorded historical PDSI values (Figure 1), there seemed to be a correlation between the two, although statistical analysis is lacking. Visually, the graph supports our hypothesis that there is a direct correlation between drought records and bark beetle infestations as depicted in Plein Air paintings of the Sierra Nevadas.

**Discussion**

When set against PDSI values of historic climatology our data lends tentative support to the hypothesis that Plein Air paintings documenting bark beetle infestations can be used to comparatively back historical drought records. The collected observational data suggests; assuming that recent bark beetle infestations are related to drought, that paintings done in 1874-1878 exhibit a similar enough number of infected trees (lack of variance) to conclude that drought conditions then were similar to 2001-2002 (p=0.22). Between 1913-1919 however, comparative analysis to recent paintings provides significant variance amongst number of infected trees (p=0.034), allowing us to conclude that 1913-1919 was a “wetter” period. 1921 is concluded to be a marginal drought

<table>
<thead>
<tr>
<th>Period</th>
<th>Painting Title</th>
<th>Artist</th>
<th>Date</th>
<th>% Healthy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1874-1878</td>
<td><em>In the High Sierras</em></td>
<td>J. Wilckinson Smith</td>
<td>1874</td>
<td>85%</td>
</tr>
<tr>
<td></td>
<td><em>Mt. Lyell</em></td>
<td>W. Keith</td>
<td>1874</td>
<td>81%</td>
</tr>
<tr>
<td></td>
<td><em>Head Waters of San Joaquin</em></td>
<td>W. Keith</td>
<td>1878</td>
<td>44%</td>
</tr>
<tr>
<td>1913-1919</td>
<td><em>Near Sabrina</em></td>
<td>E. Payne</td>
<td>1913</td>
<td>72%</td>
</tr>
<tr>
<td></td>
<td><em>Packing the Sierras</em></td>
<td>E. Payne</td>
<td>1915-1917</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td><em>Palisades and Lake</em></td>
<td>E. Payne</td>
<td>1919</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td><em>Yosemite</em></td>
<td>K. Yells</td>
<td>1919</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td><em>Wooded Slope</em></td>
<td>E. Payne</td>
<td>1919</td>
<td>100%</td>
</tr>
<tr>
<td>1921</td>
<td><em>Sierra Divide</em></td>
<td>E. Payne</td>
<td>1921</td>
<td>67%</td>
</tr>
<tr>
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<td><em>Majestic Mountains</em></td>
<td>E. Payne</td>
<td>1921</td>
<td>73%</td>
</tr>
<tr>
<td></td>
<td><em>Peaks and Lakes</em></td>
<td>E. Payne</td>
<td>1921</td>
<td>80%</td>
</tr>
<tr>
<td></td>
<td><em>High Sierra (20x24&quot;)</em></td>
<td>E. Payne</td>
<td>1921</td>
<td>50%</td>
</tr>
<tr>
<td>1925-1927</td>
<td><em>High Sierra Glacier</em></td>
<td>E. Payne</td>
<td>1925-27</td>
<td>71%</td>
</tr>
<tr>
<td></td>
<td><em>High Sierra (34x34&quot;)</em></td>
<td>E. Payne</td>
<td>1925-27</td>
<td>46%</td>
</tr>
<tr>
<td></td>
<td><em>A View of Glacial Path</em></td>
<td>E. Payne</td>
<td>1925-27</td>
<td>67%</td>
</tr>
<tr>
<td>1930-1934</td>
<td><em>Edge of the Lake</em></td>
<td>E. Payne</td>
<td>1930</td>
<td>56%</td>
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<td><em>Peaks of Light</em></td>
<td>E. Payne</td>
<td>1930-32</td>
<td>71%</td>
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<tr>
<td></td>
<td><em>Sierra Morning</em></td>
<td>E. Payne</td>
<td>1930-32</td>
<td>82%</td>
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</tr>
<tr>
<td>2001-2002</td>
<td><em>Cloud Shadows</em></td>
<td>K. McPherson</td>
<td>2001</td>
<td>56%</td>
</tr>
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<td></td>
<td><em>Yosemite</em></td>
<td>K. McPherson</td>
<td>2001</td>
<td>56%</td>
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<td></td>
<td><em>South Lake</em></td>
<td>G. Hull</td>
<td>2002</td>
<td>0%</td>
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</table>

Table 1. Bark Beetle Infestations as Observed in Plein Air Paintings of the Sierra Nevadas. Artists, specific paintings used and % healthy trees per painting.
(p=0.053), with trees perhaps remaining a bit more healthy because of the previous wet period, 1925-1927 drought (p=0.098) and from 1930-1934 wet period (p=0.039). The 1930-1934 data is interesting considering those were the early years of the massive continental drought that later became known as the ‘Dust Bowl’. It would be very informative to analyze paintings just after this period of known drought. Historical drought records in and of themselves are an incredibly complex set of analyses. PDSI values are only one of several indices available and are not 100%, conclusively agreed upon. As noted by Kelly Redmond in a commentary on the depiction of drought, “the Palmer index is often the standard of comparison simply because it is familiar, widely available, and frequently quoted” (Redmond, 2002). Because of the unknown margin of error associated with the use of the Palmer Drought Index, we used PDSI values as merely a suggestion of drought with which to compare our data. More accuracy and certainty might be obtained by the analysis of several concurrent indices (ie: the Standardized Precipitation Index, etc.), along with a detailed investigation of local historical records. Such a study would require a more precise specification of location (which is recommended), and a larger set of data.

Potential sources of error are as follows; the percentage of infected trees recorded is subject to human error due to potential flaws in the artists’ accuracy as well as in the observation of the painting. While the signature discoloration of conifers due to bark beetle infestation is very clear, it is possible that some of the trees may have been infected with a range of other parasitical organisms and pathogens. In addition, the above groupings of years or periods from which our statistical analysis was obtained were compiled out of convenience, and it is noted that alternative groupings may reveal varied statistical results.

![% Healthy Trees vs. PDSI](image)

**Figure 1.** Comparison of percentage healthy trees vs. Palmer Drought Severity Index

While by no means conclusive, our data suggests a link between bark beetle infestation and drought in the historical record. This preliminary study calls for additional research on the matter, particularly in the ways of a larger data set, precise identification of location and alternative sources of climatic data for those locales.

**Literature Cited**


Daily Airborne Fungal Trends/Fluctuations within Fungal Species

Victoria L. Leigh

Department of Biological Sciences
Saddleback College
Mission Viejo, CA 92692

Abstract

A consistent fluctuation or trend in the outdoor airborne fungi was to be established. Samples taken three times a day at six-hour intervals for five non-consecutive days were identified and the data processed. The species found were Fonseca pedrosi, Alternaria, Epicocum, Sterile White Mycelium, Verticillium, Penicillium, Cephalosporum and Mucoracae. None of the species were found to have a distinguishable daily trend. All of the data was run through ANOVA and post hoc tests and did not show significant colony difference between the sampling times. The p value was set at 0.05; all of the values were significantly larger. The fungal samples as a whole, regardless of species, was run through the previously stated data analysis to reveal no daily trend (p = 0.425, p = 0.073, p = 0.498). In conclusion, there are no daily outdoor airborne fungal trends present.

Introduction

The effect of airborne fungal spores is being studied more intensely and thought to be a cause of many allergies. Of all of the airborne pollutants, fungi make up the largest portion (Horner 1995 & D’Amato 1995). In addition, a study was conducted that linked the presence of dust-borne fungi to infant’s respiratory problems if exposed in the first three months of the infant’s life (Stark 2001). Air quality is a big concern when dealing with air-conditioned office buildings with many workers (Schillinger 1999). Air conditioning systems are supposed to filter the fungal spores from the air to minimize the allergies that the workers experience.

In my previous experiment, the thesis was supported by the results, which revealed that the daily airborne fungal levels were higher outside than inside a building (Leigh 2003). This experiment is a continuation of the aforementioned research to explore the levels of airborne fungi. This procedure will determine whether there is a daily outdoor airborne fungal fluctuation or trend in concentration of spores present per species as well as in the overall spore levels.

Materials and Methods

The sites of the specimen collection were decided upon prior to the days of specimen sampling. All of the plates were placed in the same location for specimen collection. The location was in a residential area, in the back yard of...
5 Brockton, Irvine, California. Each set of three plates was exposed for one hour, for five non-consecutive days at three equally spaced sampling times of 6 hours apart. The times of day which samples were gathered were 6am – 7am, 12pm – 1pm and 6pm – 7pm. The days were not consecutive, so that the average trend could be determined.

Three plates were used at each sample period to get an average of colonies present at that specific time. The plates had a potato dextrose medium, which encourages the growth of fungal colonies. The number of colonies counted on the plates was a representation of the number of spores present.

The plates were labeled, opened and left to collect spores for one hour for each time period. Abiotic factors were recorded including temperature, percentage of sky overcast, wind, barometric pressure, sun on samples and relative humidity.

After the spores were collected, the plates were incubated at 25 degrees Celsius for approximately 1 week at the California Microbiological Reference Laboratory in Anaheim. The fungal colonies were then counted and the species identified.

**Results**

The fungi species present were *Fonseca pedrosi, Alternaria, Epicocum, Sterile White Mycelium, Verticillium, Penicillium, Cephalosporum and Mucoraceae*. The average colonies were calculated by taking an average of the colonies for all three plates taken at the time of sampling (Table 1). The number of colonies represented the number of airborne spores for that fungal species.

Firstly, the data from Table 1 was made into line graphs to see if a visual trend could be established for the individual fungal species. The only visual trend that could be identified was that of *Epicocum* (Figure 1).

![Figure 1](image-url)

*Figure 1.* The average of the *Epicocum* spores for all 5 days (generated from data for *Epicocum* in Table 1.)

Secondly, the data from Table 1 was run through an ANOVA (analysis of variance) test and immediately through a Post-Hoc test to compare the 6A and 12P hours, 12P and 6P hours as well as 6A and 6P hours of colonies present in each individual species. None the individual fungal species showed significant difference in the airborne fungal concentration, including *Epicocum*, which previously showed a visual trend. The significance interval, p, was set to be less than 0.05 – all of the fungal species had p values higher than 0.05.

Finally, the average fungal colonies were calculated for all three time intervals for the five days of sampling. Table 2 reveals the data calculated.

Table 1. **Data sorted into fungal species with average colonies per time interval per day of sampling**
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<tbody>
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<td></td>
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</table>
An ANOVA and post hoc test calculated on the average fungal data revealed no significant difference in the spore concentration. None of the comparisons for the different time intervals had a p value of less than 0.05 (Table 3).

**Discussion**

The thesis stated that each airborne fungal species had its own daily fungal fluctuations. The data, however, did not support the hypothesis.

The initial visual trends seen in the line graphs calculated were not strong enough to portray a sturdy daily fluctuation that was consistent for all five days. An example of the latter can be seen in the *Epicocum* line graph shown in Figure 1.

The data attained after the ANOVA and Post-Hoc analysis revealed the airborne fungal spores were present in somewhat equal amounts throughout the day regardless of species.

There was no single fluctuation that could be determined for all of the fungal species combined. This is confirmed in Table 3, where a Post-Hoc test was performed revealing p values greater than 0.05.

Some sources of error in this experiment could be the wind factor, which could have blown on more airborne spores, or contrarily, blown off the fungal spores from the plates. In addition, the hour that the plates were left out varied by up to 10 minutes. This might have had a slight effect on the data; however this can be seen as a negligible amount of error.

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Table 2. The Total Average Fungal Colonies Calculated (all species combined)

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Table 3. The Statistical Analysis derived from the Post-Hoc test of the Total Average of Fungal Colonies

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<th>Comparison</th>
<th>Significance (P &lt;0.05)</th>
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<tr>
<td>1: 6A v. 12P Total</td>
<td>No</td>
<td>0.425</td>
</tr>
<tr>
<td>2: 12P v 6P Total</td>
<td>No</td>
<td>0.073</td>
</tr>
<tr>
<td>3: 6A v 6P Total</td>
<td>No</td>
<td>0.498</td>
</tr>
</tbody>
</table>

This experiment was the follow-up experiment from my previous work on fungal trends. Beforehand, the previous analysis of outdoor/indoor fungal concluded the fungal levels were four times higher outside for every species compared to the levels inside buildings. Fluctuations in the species spore presence were visible, and a daily fungal fluctuation for airborne fungal spores was conducted to refute or confirm the hypothesis of this paper. Concisely, there is no daily airborne fungal fluctuation for any of the species analyzed in this study.

Further research could analyze the seasonal variance in airborne spore presence within individual species and overall fungal spores.

**Literature Cited**


In studying the effectiveness of hand washing and antibacterial sanitizer on bacteria, an experiment was performed based on the relationship between the numbers of bacterial colonies versus the method of hand washing. The purpose of the experiment was to define the relationship between the bacteria count and cleansing method. In the experiment samples of bacteria were collected from a human hand (n=6/group, 3 groups x 2 dilutions; 2 and 1.8 colonies, 11 and 8.8, and 2 and 2.5, respective to order of procedure) to determine effectiveness of different washing procedures. Bacteria were rinsed from the subject’s hand with 10mL of deionized water and collected under 3 separate conditions: unwashed, washed, and sanitized. A drop of each of the three samples was then diluted to a ratio of 1/1,000 (Dilution 1) and then to a ratio of 1/10,000 (Dilution 2). The unwashed sample had the lowest average bacteria count (1.9 colonies), the washed sample had the highest average count (9.9 colonies), while the sanitized sample had the median average (2.25 colonies). Because the bacteria had not been loosened, the unwashed sample did not show a significant result, while the washed versus washed and sanitized sample showed a significant difference. The most probable explanation for the significant difference in the numbers of bacterial colonies was that using the sanitizer subsequent to washing with soap and water was effective in reducing bacteria.

**Introduction**

It has been estimated that proper hand-washing could eliminate close to half of all cases of food borne illness (Center for Disease Control and Prevention, 2004). Bacteria exist everywhere, and while some are beneficial, others can cause serious illnesses, including, for instance, food poisoning or Pneumonia. Its spread and growth can be inhibited by factors such as pH, high temperature, desiccation, salinity, and ultraviolet light (Walter, 2003). To reduce the spread of infection between people, the CDC recommends washing your hands for 15-20 seconds and utilizing an alcohol based sanitizer (CDC, 2004).

Antibiotics, like antibacterial sanitizers, are effective in eliminating bacteria. Antibiotics work by destroying either the proteins that build a bacterium’s cell wall or the protein- producing ribosomes (Greene, 2000). Antibacterial sanitizers contain ethyl alcohol that breaks down the germs’ cell walls, causing them to die and fall off the skin surface. While the widespread use of antibiotics and sanitizers can help reduce the spread of bacterial infection, the act of killing or attempting to kill bacteria poses potential problems.

One consequence of antibiotic use is antibiotic resistance. Scientists originally disregarded the early emergence of resistant bacteria at the time when many new antibiotics were still being discovered, suggesting that effective drugs would always be available (Amabile-Cuevas, 2003). However, it is now evident that bacteria build resistance to antibiotics. There are several mechanisms that allow bacteria to develop antibiotic resistance. These include mechanisms that prevent the entrance of noxious chemicals into the cell, methods of pumping antibiotics out of the cell once they have entered, and mutations in the genetic information of a bacterial cell preventing an antibiotic from acting on it.

Another drawback to antibiotics and antibacterial sanitizers is that they also target the “good bacteria,” known as probiotics. Probiotics work to maintain a healthy intestinal tract and help fight illness and disease (Gerasimov, 2004). Because antibiotics are found in commercially raised animal and dairy products, these products that people consume are reduced in the bacteria count that they would otherwise have. This, coupled with the fact that people take precautions against ingesting bacteria in the first place, results in people not getting enough probiotics (essential to our immune system).

The purpose of the experiment was to compare the quantity of bacteria on a subject’s (human being) unwashed hands, after washing with a non-antibacterial soap and water, and after applying Purell Instant Hand Sanitizer subsequent to washing. The hypothesis was that the use of a hand sanitizer subsequent to washing will significantly reduce the number of bacterial colonies on a subject’s hands compared to simply washing with soap and water.
Materials and Methods

Bacterial count of a subject’s hand was observed under three conditions: unwashed, washed, and sanitized. Thirty six nutrient agar plates, purchased from www.sciencestuff.com, were prepared with nutrient agar and divided into two groups of eighteen, each group a different dilution. Each group of eighteen was further divided into three groups of six plates designated as “unwashed,” “washed,” and “sanitized.” For the unwashed sample, 10 mL of deionized water was poured over an unwashed hand and collected in a beaker. The same dirty hand was then washed with Softsoap Naturals non-antibacterial soap and water for 20 seconds and again rinsed with 10 mL of deionized water. Purell Hand Sanitizer was then applied, and again the hand was rinsed with 10 mL of deionized water. One milliliter of each concentrated sample (unwashed, washed, and sanitized) was then diluted in 100 mL deionized water and labeled as Dilution 1. One milliliter of each diluted sample was further diluted in 100 mL of deionized water and labeled as Dilution 2. For each of the three conditions (unwashed, washed, and sanitized) six nutrient agar plates were streaked using Dilution 1 and six plates using Dilution 2. All plates were incubated (at 30 degrees Celsius) for three days and the number of bacterial colonies was counted from the fourth quadrant.

A statistical analysis was performed to further analyze the correlation between bacterial count and the different cleansing methods. A one-way factorial ANOVA with multiple comparison (available from http://www.physics.csbsju.edu/stats/anova) was done to determine whether the hypothesis, that using a hand sanitizer after washing hands is the most effective method of reducing bacteria, was valid to the outcome of the p-value (±0.05).

Results

The bacterial count varied with respect to washing method. For the unwashed samples, the average bacterial colony count was 2 and 1.8 (For Dilution 1 and Dilution 2 respectively), while the washed samples had an average count of 11 and 8.8 respectively. For the sanitized samples, the average count was 2 and 2.5 respectively. Figure 1 illustrates that the hypothesis was valid, given that the bacterial count decreased when a hand sanitizer was used subsequent to washing with soap and water. The p-value (0.530), greater than 0.05, did not, however, support the hypothesis.

Discussion

It was found that the most effective method of reducing bacteria was using hand sanitizer after washing with soap and water. However, the “washed” samples had a higher bacteria count than the “unwashed” samples. This deviation is most likely attributed to the fact that soap loosens bacteria and makes it more readily rinsed from a surface. As a result, a conclusion cannot be made on the effectiveness of hand washing versus not washing. However, a meaningful comparison can be made between the washed and the sanitized sample. It was found that
the bacteria count in the sanitized sample was significantly lower than the bacteria count in the washed sample, an indication that the sanitizer was effective.

Another unexpected result was the presence of bacteria in the sanitized sample. One possible explanation is that according to TB & Outbreaks Week, bacteria often are resistant to at least one type of antibiotic (2003). Therefore, the remaining bacteria may have been resistant to the sanitizer. Another explanation for this remaining bacteria could be due to air-borne and/or equipment contamination.

The relatively small sample size (n=6) had an impact on the outcome of the one way factorial ANOVA, and although statistically there was no difference between the samples, the hypothesis was supported by the observation that the use of a hand sanitizer significantly reduced the number of bacterial colonies. Therefore, use of a sanitizer after washing with soap and water effectively reduced the quantity of bacteria. However, while this may be true now, in the future antibiotics and antibacterial sanitizers may become less effective, as they breed more resistant bacteria.

**Literature Cited**


ANOVA.http://www.physics.csbsju.edu/stats/anova_NGROUP_NMAX_form.html


**The Effects of Warmer Temperatures on Appetite and Metabolism in Carassius auratus.**

Josh Patton and Stephanie Kemp  
Department of Biological Sciences  
Saddleback College  
Mission Viejo, CA 92692

**Abstract**

An organism depends on the coordination of its body functions to maintain homeostasis when dealing with environmental changes. Temperature is a major factor in the environmental stresses that an aquatic organism must deal with. Two groups of ten large goldfish (*Carassius auratus*), were used to demonstrate the changes in metabolic rate versus a change in the water temperature in which it inhabits. Two, three-gallon holding tanks were used to house the fish. Two aeration rocks and an air pump were put in each tank to provide adequate oxygen in the water. Ten fish were placed into each tank with room temperature water and acclimated for 48 hours. An aquatic heater was placed into one tank to raise the water temperature to 30°C. Each group of ten *Carassius auratus* was fed 0.30g of Tetra-fin fish flakes twice daily for six days after acclimating to the temperature of the water and a two day fast. *Carassius auratus* kept at 21.0°C had a mean rate of consumption of 386 seconds while the group kept at 30.0°C had an mean consumption rate of 227 seconds. A t-test conducted from the raw data gave a t-value of 13.38, which was greater than the one tail critical t-value at 1.72, indicating a statistically significant difference between the ten *Carassius auratus* kept at 21.0°C for six days and ten *Carassius auratus* kept at 30°C, showing a difference in the metabolic rates in correlation to higher temperature.
Introduction

Metabolism can be considered the process of breaking down carbon based food particles to yield vital energy for life sustaining processes. The form and function of every organism is in part directed by metabolism in some way. Most of the energy spent in an organism’s life span is dependent upon environmental factors such as temperature and food supply. These two factors coincide directly with the metabolism of an organism and can also determine whether or not it will survive. In cold-blooded organisms, as body temperature rises, within limits, we can expect to see faster metabolism, faster movement, faster feeding [times], and faster digestion (Alexander, 1999). It is important to recognize that metabolism is directly related to temperature in many ways. An aquatic organism such as the common goldfish, *Carassius auratus*, must deal with temperature changes in its environment. These changes may be acute, for example during migration, flooding, tidal changes, etc, or maybe seasonal or long term in nature (Bennett, 1995). For this reason, *Carassius auratus* uses its metabolism to regulate its body functions. The metabolic rate of a fish depends on the temperature of the water [in which it resides] and can change by one or two orders of magnitude with a change in temperature (Schmidt-Neilson, 1984). Higher body temperatures result in higher rates of metabolism and shorter digestion [time] (Abe, 2003). It is expected that in the two groups of goldfish (*Carassius auratus*), one group kept at 21.0°C and a group kept at 30.0°C will show significant differences in metabolic rates with the group kept at 30.0°C having the highest rate of consumption.

Materials and Methods

Twenty large *Carassius auratus* (goldfish) were purchased from Wilds Animal Supplies, in Laguna Niguel, CA, along with two holding tanks that could hold approximately 11 liters of water. Six gallons of purified water was used to fill the tanks so that water treatment was not a factor. The tanks were rinsed and washed and pebbles were placed on the bottom of both tanks, and then filled with enough water up until about 11cm from the top. Two aeration rocks, tubing, and an air pump were also used to oxygenate the water. The aeration rocks were buried under the pebbles to secure them from floating around. The water was aerated all throughout the experiment. The bags of goldfish were divided into two groups of ten, and the fish were placed into their separate tanks. Both groups were acclimated for 48 hours in their tanks at a temperature of 21.0°C. The fish were not fed during this period. With a gram scale from the Biology lab at Saddleback College in Mission Viejo, CA the food (Tetra-fin fish flakes) was measured out to into a 0.30g serving for a total of twelve servings and were placed in Ziploc Bags.

After 48 hours of acclimation, the tanks were moved away from each other, and an aquatic heater was placed into one tank. The thermostat on the heater was set to 26.0°C which was sufficient in heating the water in the tank to 30.0°C as seen in Figure 1.

The fish were then left in their environments, ten in 21.0°C and the other ten in 30.0°C for another 24 hours without feeding. The group of fish in 21.0°C water, as seen in figure 2 was the control while the experimental group was the group in 30.0°C water. After 24 hours, both groups were fed a 0.30g serving of fish food twice a day for six days consecutively. With both groups, once the food hit the surface of the water, the amount of time it took for all the food to be eaten by the fish was recorded in seconds as shown in figure 3.

The results of each feeding were recorded in a table after each trial. Once all the data was collected it was entered into a spreadsheet in Microsoft Excel. A t-test for two samples assuming unequal variances was conducted at p<0.05.
Results

After the twelve feedings it was noted that the average rate of consumption for the ten Carassius auratus in 21.0°C water was 386 seconds while the 30.0°C group was 227 seconds as shown in Figure 4.

The t-test for two-samples assuming unequal variances gave a t-value of 13.38, which is greater than the hypothesized one-tail critical t-value given in the excel worksheet after calculations (1.72). This indicates a statistical significance between the group kept at 21.0°C for six days and the group kept at 30.0°C for six days.

A histogram using the raw data set from each temperature setting (21.0°C and 30.0°C) and BIN values of 190 to 430 is shown in Figure 2. The minimum time to consume all food was 190 seconds in the group of Carassius auratus kept at 30.0°C and the maximum time was 275 seconds. The minimum time to consume all food for the group kept at 21.0°C was 355 seconds and the maximum time was 445 seconds.

Discussion

The ten Carassius auratus kept at 30.0°C had a high rate of consumption that was on average 159 seconds faster than the ten Carassius auratus kept at 21.0°C. It has been previously demonstrated that at higher temperatures that fish ate more, twice as much at 30.0°C compared to the control at 21.0°C (Alexander, 1999). This means that temperature has a significant effect on an organism’s capability to use fuel for energy and ability to acclimate to environmental changes like temperature in order to survive. The metabolism of fish is affected by temperature, and the increased metabolic rate during digestion encompasses both the direct effect of digestion and that caused by an increase in body temperature [due to environmental factors]. Usually, [higher] temperature causes digestion to occur faster at the expense of increased rates of metabolism in Carassius auratus (Abe, 2003). Aside from digestion, it was observed that Carassius auratus kept at the higher temperature moved more rapidly in the holding
tank, showing an increased energy output. This is because maximum aerobic metabolic rates tend to rise with increasing temperature (Alexander, 1999).

There were a few factors, however, that were not taken into consideration for this experiment. These include the psychological state of Carassius auratus in the holding tanks as well as the level of disturbance every day that might have somehow skewed the results. Taking into account that necessary cleaning of the tanks every two days may have had an affect on the rates of consumption, causing the fish to eat more or not at all if they were traumatized in some way. However, a physiological response to feeding is an increase in metabolic rate and these post feeding responses collectively generate metabolic rates above basal rates ranging from 100-800 percent for invertebrates, fishes, amphibians, reptiles, birds, etc (Faulkner, 2002). It is unlikely that such a disturbance would have affected the need to consume a meal at any rate because of such a physiological drive. The hypothesis was supported in stating that the group of ten Carassius auratus kept at 30°C would have the highest rate of consumption (metabolic rate) in comparison to the ten Carassius auratus kept at 21.0°C. Thus, demonstrating that [environmental temperature differences] have a major impact on the profile of the post feeding metabolic response (Faulkner, 2002).

**Literature Cited**

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Faulkner, Angela C; Secor, Stephen M. 2002. Effects of meal size, meal type, body temperature, and body size on the specific dynamic action of the marine toad, Bufo marinus. Physiological and Biochemical Zoology v75 i6 p557 (15).


**California living with Mountain Lions: Are the attacks increasing over the years?**

Barbara L. Parker

**Department of Biological Sciences**

**Saddleback College**

**Mission Viejo, CA 92692**

**Abstract**

Due to the increase in California’s population, housing developments are spreading to more rural land and taking over many wildlife habitats. The purpose of this experiment is to see if mountain lions are being forced out of their former home range and into the city, by California’s increasing population and housing developments. It is believed that the increased interaction between human and lions give raise to more potential attacks. The correlation coefficient statistics for the association between mountain lion attacks and increase population growth in California holds a significant value of r equal to -0.046, p is less than or equal to 0.8692, and t equal to -0.168 with a degrees of freedom equal to 13. These findings indicate a slight negative- no correlation between increase human population in California and mountain lion attacks in California. An indirect association was found between the two variables. It is believed that other factors are involved such as a legal status change to “special protected mammal”. This has increased the mountain lion population and has had a direct increase in expansion in home range location due to lack of quality and quantity of territory. Therefore, adult mountain lions are forced into urban areas and rural farm land looking for food and place to live for survival. Ultimately, this increase’s the potential for attacks on California’s residence and visitors.

**Introduction**
Mountain lions have become a popular topic in today’s news media, especially the recent attack on local southern California residents in January 2004. These wild large cats have become one of California’s household fears. Research on human and lion encounters help inform California’s residents to not fear but become aware of the potential danger mountain lions hold in our growing society.

A majority of California residents do not realize that the bulk of California is mountain lion country. These animals have roamed this territory for thousands of years and have claimed this land as their habitat and home long before man moved west to California. Mountain lions are carnivorous animals living off deer, wild hogs, rabbits, jackrabbits, javelina, rodents and other wildlife. According to the state of California, Department of Fish and Game an adult male’s lions “home range” territory often spans over 100 square miles, and for females, generally twenty to sixty square miles. Experts state that the competition for habitat has increased significantly along the western slope of the Sierra Nevada, estimating that as many as ten adult lions may occupy the same 100 square mile”. According to a field study there are estimates of 4,000 to 6,000 mountain lions living in California today (Anonymous 3, 1998).

Fourteen years ago, the mountain lion’s legal status changed from game animal to “special protected mammal”. With this new status, mountain lions are not aloud to be trapped, injured, possessed, transported, imported, or sold (Anonymous 5, 1990).

Due to the increase in California’s population, housing developments are spreading to more rural land and taking over many wild life habitats. It is hypothesized, that mountain lions are being pushed out of their former home range and into the city by California’s increasing population and housing developments. Therefore, interaction between human and lions increase and raise the potential for attacks. This research will indicate the strength of the association and correlation between these two variables.

Materials and Methods

Data was collected on mountain lion attacks via the internet, news paper articles and news media announcements. California population data and statistics were acquired through the 1990 and 2000 California State Census reports.

Since 1990, there have been seven mountain lion attacks recorded, of those, three were fatal. The first recorded attack under the new mountain lion legal status was on March 12, 1992. A nine year old boy was attacked while hiking in the Gaviota State Park in Santa Barbara. In August of 1993, the second attack was recorded in the Manzano River area in the Los Padres National Forest in Santa Barbara. A six year old boy was attacked by a mountain lion, however, the California Department of Fish and Game did not recognize the encounter as an actual attack due to the fact injuries were not verified by a physician. The third attack was in September of the same year. A young lion attacked a ten year old girl while camping in Pasco Picacho Campground in Cuyamaca Rancho State Park with her family. Attack four was the first of the three fatal deaths since 1990. On the 23rd of April, 1994, a 40-year old woman was attacked and killed while she was training for a long distance run in the Auburn State Park in Placer County. In the same year, on 16th of August, a 48-year old woman was attacked by rabid female lion while camping with her husband in Dos Rios in Mendocino County, making it attack five. On March 20th, 1995, a 27-year old cyclist riding in the Angeles National Forest was bitten and cut by a cougar, making it attack six. From 1996 to 2003 no known attacks were recorded. Then on January 8, 2004, a 35-year old man and a 30-year old woman were attacked in Whiting Ranch Wilderness Park in southern Orange County. These two attacks were two separate events, but on the same day, with the same lion (Chester, 2004). A map of California and its counties are shown in Figure 1, and the mountain lion county locations are represented by the red area.

![Figure 1. California’s Mountain Lion Country Source: State of California, Department of Fish and Game](image)

Table 1. County and State Population from 1990 through 2004

<table>
<thead>
<tr>
<th>County</th>
<th>1990 Population</th>
<th>2000 Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Los Angeles</td>
<td>3,951,283</td>
<td>4,035,421</td>
</tr>
<tr>
<td>San Diego</td>
<td>1,261,047</td>
<td>1,309,303</td>
</tr>
<tr>
<td>Sacramento</td>
<td>357,412</td>
<td>395,223</td>
</tr>
<tr>
<td>San Francisco</td>
<td>757,951</td>
<td>805,000</td>
</tr>
<tr>
<td>Orange</td>
<td>1,102,110</td>
<td>1,164,012</td>
</tr>
<tr>
<td>Fresno</td>
<td>405,197</td>
<td>444,039</td>
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<tr>
<td>Los Angeles</td>
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<tr>
<td>Orange</td>
<td>1,102,110</td>
<td>1,164,012</td>
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<tr>
<td>Fresno</td>
<td>405,197</td>
<td>444,039</td>
</tr>
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</table>

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California year by year population estimates were calculated by projections from the 1990 and 2000 California census. There were 6 counties that experienced a mountain lion attack within the last 14 years. These counties are Los Angeles, Mendocino, Orange, Placer, San Diego, and Santa Barbara.

Table 1 illustrates the 6 counties population increase between 1990 through 2004. The purple (dark) shaded squares are the State of California’s population during the year of one of the seven attacks. The yellow (light) shaded squares are the population of the county during these corresponding attacks.

This data was collected for analyzing direct correlation between the increase in California’s population growth and the increase in mountain lion attacks. A correlation coefficient and regression line analysis was done on a year by year basis for mountain lion attacks and the State of California’s increasing population.

**Results**

Over the past fourteen years, California’s population has grown by 122.77% that equals to 2,775,037 people. Figure 2 depicts a line graph showing the growth of California’s population with a year by year estimate from 1990 at 29,758,213 people to 2004 at 36,533,250. These calculations are estimates provided by the California Department of Finance Demographic Research based on the 1990 and 2000 California Census Projections (Anonymous 1 and 2, 2003 and 2000)

<table>
<thead>
<tr>
<th>1990</th>
<th>Los Angeles</th>
<th>8,863,052</th>
<th>80,345</th>
<th>2,410,668</th>
<th>172,796</th>
<th>2,498,016</th>
<th>369,608</th>
<th>29,758,213</th>
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<td>81,200</td>
<td>2,435,400</td>
<td>179,200</td>
<td>2,529,800</td>
<td>371,900</td>
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<td>82,100</td>
<td>2,485,200</td>
<td>187,200</td>
<td>2,572,500</td>
<td>376,700</td>
<td>30,723,000</td>
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<td>2,531,100</td>
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<td>83,200</td>
<td>2,563,100</td>
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<td>2,604,400</td>
<td>379,700</td>
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<td>2,613,100</td>
<td>382,400</td>
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<td>2,625,300</td>
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<td>2,621,100</td>
<td>384,300</td>
<td>31,837,000</td>
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<tr>
<td>1997</td>
<td>9,147,100</td>
<td>84,800</td>
<td>2,672,800</td>
<td>222,300</td>
<td>2,653,400</td>
<td>387,700</td>
<td>32,207,000</td>
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<td>1998</td>
<td>9,225,800</td>
<td>85,300</td>
<td>2,724,500</td>
<td>229,700</td>
<td>2,702,800</td>
<td>391,300</td>
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<td>9,330,100</td>
<td>85,500</td>
<td>2,776,100</td>
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<td>2,751,000</td>
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<td>2,829,800</td>
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<td>86,900</td>
<td>2,846,289</td>
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<td>2,856,000</td>
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<td>2002</td>
<td>9,817,400</td>
<td>87,600</td>
<td>2,930,500</td>
<td>265,700</td>
<td>2,908,500</td>
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<td>2,961,600</td>
<td>410,300</td>
<td>35,591,000</td>
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<td>2004</td>
<td>4,989,800</td>
<td>44,100</td>
<td>1,489,400</td>
<td>137,800</td>
<td>1,480,800</td>
<td>205,150</td>
<td>17,795,500</td>
<td></td>
</tr>
</tbody>
</table>
California’s Population

Figure 2. California’s increase population growth from 1990 through 2004.

Figure 3 illustrates the pattern of mountain lion attacks in California over the past 14 years. The first attack was in 1992, another two in 1993 and 1994, and one in 1995. After an 8 year break, there were two more attacks in 2004 recorded.

Figure 3. Mountain lion attack from 1990 through 2004

The correlation coefficient statistics show a significant value of r, degrees of correlation, equal to -0.046, a p value less than to equal to 0.8692, the t value, level of significance, is equal to -0.168 with a degrees of freedom equal to 13. Figure 4 is the regression line analysis of the California’s population verses mountain lion attacks. This is based off calculations done on the mean value X, number of mountain lion attacks, equal to 0.533, and Y, State of California’s year by year increased population equal to 23,000. The correlation of X and Y was equal to -0.368. The Regression of Y on X was equal to -18.904 and the regression X on Y was equal to -0.007.

These calculations were put into an equation that produced the lines that are illustrated on the regression graph below in Figure 4. The X was calculated by the equation $y = a * x + b$ where $a = \left( \frac{\text{Sum}(x * y) - \text{Sum}(x) \times \text{Sum}(y) / N}{\text{Sum}(x^2) - \text{Sum}(x)^2 / N} \right)$ and $b = \frac{\text{Sum}(y) / N - a \times \text{Sum}(x) / N}$. 
Regression Equations:

\[ x = 0.533 + 0.007(y - 23.000) \]
\[ y = 23.000 - 18.904(x - 0.533) \]

**Figure 4.** Regression line graph depicting correlation coefficient

**Discussion**

The finding indicated a slight negative, no correlation between the increasing human population in California and mountain lion attacks in California. The correlation coefficient statistical analysis for this data is slightly negatively correlated indicating that there is a minor relationship between the two variables when one variable increases, the other variable decreases. These findings do not suggest that these two variables are unconnected, unassociated or unrelated, but rather, they are indirectly related and can not be analyzed in this matter. What this suggests is both variables are dependent upon a third variable that was not considered in this research.

There are considerable amounts of other possible dependent variables other than an increase in human population. For instance, one could compare the increase in outdoor activity (physical or passive) in national or state parks as compared to national forests. One could also consider a decrease in food source in mountain lions or even an increase in mountain lion population with lack of quality home ranges. These variables are directly affected by either the increase in California’s population with more people exploring parks, or the increase in mountain lion population due to the “special protected mammal” status and invading already claimed territory.

In exploring the idea of the increasing mountain lion population one could hypothesize that due to the change in legal status of mountain lions in 1990, their population has increased significantly to an estimated 4,000 to 6,000 today. The increase in population is thought to affect the amount and quality of home range available to adult mountain lions. According to the State of California Department of Fish and Game, humans have invaded the lion’s space in many areas but mountains lions are also starting expand their range in to new area’s and are starting to appear where they have never be sighted before. “Experts state that biological explanation [of mountain lions expanding their range] is that the good habitat is already full of lions. Since they compete for food and space, some lions are forced to move, ending up in marginal areas where they are more likely to cause trouble. The fact that damage to livestock is increasing in rural counties like Inyo, Lassen, Modoc and Mono, where human populations have not greatly increased, suggests lions are expanding their range (Anonymous 4, 1996).” This could explain why mountain lions are being sighted and recorded attacking humans in urban areas, as well as rural farm locations.

Mountain lions are expanding their range and entering into our home areas, due to the increased competition between adult mountain lions, lions are in search of food and places to live. Almost all mountain lion attacks recorded, were from young lions attacking people who are either young, small or vulnerable. I believe that the seven attacks recorded in the last fourteen years were due to the fact that young mountain lions were in search of food and a home range which is not already occupied by older, stronger lions or people in new housing developments.
Abstract

Different wavelengths of light and thermoperiod affect the rate which plants photosynthesize in the environment. Temperature influences photosynthesis, by affecting the kinetic rate of enzymatic reactions occurring in both light and dark photosynthetic reactions. In this experiment oxygen release in Spinacia oleracea L. was examined under various conditions before and after photosynthesis. The photosynthetic rate of spinach was measured in three different temperature environments: high (34°C), room (22°C), and cold (7°C). The most effective temperature was hypothesized to be high temperature where photosynthesis increases O₂ production. The results for the first 12 minutes entirely supported the hypothesis, until the photosynthetic rate of 7°C variable surpassed the photosynthetic rate of the 22°C, due to photooxidation. The most amount of photosynthesis (O₂ production) took place in high temperature.

Introduction

Photosynthesis is the process that converts light energy into chemical energy, which is stored as carbohydrates like glucose (Luis, 2002). The photosynthetic process is composed of two different types of reactions, the dark and light reactions. In dark reactions, CO₂ is converted to glucose via the Calvin Benson Cycle. Conversely, the light reactions generate ATP and NADPH, both of which are good source of energy in cellular metabolism (Luis, 2002). A by-product of photosynthesis is oxygen. Photoinhibition, the inhibition of photosynthesis, can be influenced by several factors such as light and temperature (Luis, 2002).

Temperature has an influence on photosynthesis; by affecting the kinetic rate of enzymatic reactions which occur during both light and dark photosynthetic reactions (Martindale, 1997). As temperatures increase, the rate of chemical and enzymatic reactions increases, therefore the photosynthetic rate increases to a certain point (Evans, 2000). Exposure of a plant to cool (0°C -12°C) or freezing (<0°C) temperatures effects the plant’s metabolic processes, which would lower the photosynthetic process (Luis, 2002). Photosynthesis suffers in conditions with light intensity and low temperature; if treatment is continued for a long period of time, photooxidation of the pigment results. However, when a plant is placed in cool temperatures and the dark, photosynthesis is not significantly affected. Plants become sensitive to Photoinhibition at low temperatures, because low temperatures lower the photosynthetic capacity of the plant. Similarly when the environmental temperature is above the threshold level for the plant, photosynthesis decreases (Luis, 2002). However, exposure to light intensity and high temperatures for a short time is beneficial to plants by eliminating damage to the photosynthetic system.

Literature Cited


The Effect of Temperature on the Photosynthetic Rate of Spinacia oleracea L.

Amir Sadri, Christina Friedman

Department of Biological Sciences

Saddleback College

Mission Viejo, CA 92692
The purpose of this experiment was to determine the effects of environmental temperature on the photosynthetic rates (O₂ production) for three *Spinacia oleracea L.* were compared under temperate environments: high (34°C), room (22°C), and cool (7°C). It was hypothesized that the photosynthetic rates of *Spinacia L.* would be highest in high temperate environment.

**Materials and Methods**

A preliminary experiment was conducted in an effort to demonstrate that photosynthesis would indeed take place in the spinach disks that would be used for the latter experiment. Using a “light exposed” sample of spinach and a “dark” sample, which was placed in a light proof container, differences were observed between the two photosynthetic processes. Results confirmed that in absence of light, spinach could only use its initial supply of ATP and NADPH, and could not produce these vital cofactors to any further extent, hence limiting the photosynthesis process. Consequently, w photosynthetic rate in light reactions was measured and showed to produce the cofactors, and release oxygen as a byproduct.

The young spinach plant (*Spinacia oleracea L.*) was initially attained in the form of individual leaves, which were relatively fresh and soaked in water. Samples of the spinach plant were utilized in the form of leaf disks, which were small circular pieces, about 1 mm², each cut from the spinach plant, by a cork borer. All leaf disks were of equal size to ensure that they all had the same surface area and same exposure to light (Halogen Lamps). The mesophyll layer of the leaf tissue initially contained extensive air spaces where oxygen is stored. In an effort to measure the rate at which photosynthesis occurred, the oxygen from all the leaf disks was removed by a vacuum, which allowed them to sink in the bicarbonate solution. The bicarbonate solution would also be a source of CO₂, vital to the Calvin-Cycle. Once the disks were exposed to light and the process of photosynthesis occurred, the spaces within the mesophyll layer, refilled with oxygen, and floated to the top. Moreover, by recording the number of leaf disks that floated per unit time for different temperature treatments, the relative rate at which photosynthesis had occurred could be calculated.

Using a dilute 0.2% sodium bicarbonate solution and filling Petri dishes two thirds full, the oxygen was vacuumed out of the spongy mesophyll layer, and replaced by bicarbonate solution. The vacuumed disks were then carefully transferred to petri dishes using forceps, with special attention not to prevent any damage to the tissue of the leaf disks. Twenty disks were transferred to six petri dishes, and three different temperatures were tested: a high temperature environment (34°C), a room temperature environment (22°C), and a cold temperature environment.

![Figure 1: Room Temperature Data (22.5°C)](image)

**Figure 1.** Photosynthetic rate of spinach at room temperature. Note variation after 10 minutes. See text for explanation. In an effort to minimize any procedural errors, two tests were conducted simultaneously for each individual independent variable and averages of the results were calculated. Moreover, the data was collected by assessing the number of floating disks, or rate of photosynthesis per unit time. The numbers of floating disks were recorded in 5 minute intervals, until the variable trial with all disks floating in solution was determined.
Oxygen production was calculated by the number of floating discs. Data was compiled into an Excel file and encoded into statistical data, utilizing a line graph to compare time vs. oxygenated discs in three environments low (7°C), room (22°C), and high (34°C). Averages of low (7°C), and high (34°C) were encoded into an Excel file, using a statistical tool pack, a t-test was performed of unequal variance with an alpha value of 0.05.

**Results**

The null hypothesis has been refuted and the initial hypothesis is valid due to the high temperature producing the most oxygenated discs (Figure 4). The effective temperatures showed that high and low were important in photosynthesis due to the most oxygen production, which supported the initial hypothesis.

In this study, all experimental data was collected simultaneously and there were two separate trials conducted per independent variable. Running two separate trials allowed elimination of any experimental error, and allowed us to calculate the average values for the variables that were testing. (Figure 1) represents the data collected in a room temperature environment. This temperature treatment is most closely related to a control, and can be used as a control to compare the other temperature treatments. The two trials differed only slightly, as is obvious from the line graph. Trial B took longer to start the photosynthetic process, but then the two constantly caught up to each other and then leveled off. Ultimately, at the end of the data collection, an average of 16.5 of the 20 disks successfully went through the photosynthetic process, produced oxygen, and floated to the top.

![Figure 2: Cold Temperature Data (7.0 C)](image)

*Figure 2.* Photosynthetic rate of spinach at cold temperature. Note variation after 20 minutes. See text for explanation.

Figure 2 is indicative of the low-temperature environment (approximately 7°C). In this case there seemed to be a greater difference between the two trials when compared to the room temperature results. Initially the two seemed to start on the same track, and had nearly identical photosynthetic rates until the 15 minute mark. That’s when trial B had a significant increase in photosynthetic rate and resulted in 18 photosynthesized leaf disks at the end of data collection; versus trial A, in which only 13 disks completed the photosynthetic process entirely. The overall average photosynthetic rate of the two trials in this low temperature environment, turned out to be 15.5 of 20 spinach leaf disks.

Lastly, Figure 3 had the fastest photosynthetic rate of the three temperatures. This suggests that the high temperature environment was more favorable to the photosynthetic process when compared to the temperature conditions within the other two variables.

Photosynthetic rates of the two trials are noticeable, yet like Figure 1, the photosynthetic rates eventually caught up to one another and the differences can be considered negligible. The relative average number of fully oxidized leaf disks in this environment was 18 of 20 disks within the 30 minute data collecting period. Once variance was established and accounted for, the focus was placed on determining the differences between temperature treatments.

Average values were calculated based on data recorded for each individual trial, and all three temperature
treatments were compared to determine the effects of varying temperature on photosynthetic rate (Figure 4). The high temperature environment clearly had the highest photosynthetic rates when compared to the two other environments, as predicted in the hypothesis; however the cold environment did not have a lower photosynthetic rate as hypothesized, but a higher photosynthetic rate when compared to the control.

The high temperature had the highest photosynthetic rates when compared to the two other environments, as
predicted in the hypothesis. The high temperature variable showed an immediate increase in photosynthetic rate with an average of 8.5 spinach disks oxygenated (photosynthesized) by the 5 minute mark. Interestingly, the cold and room temperature environments had very similar average values. Initially, the room temperature variable seemed to have a higher amount of oxygenated discs which was assumed based on the reasoning that helped establish the hypothesis. However, 12.5 minutes into the experiment the cold temperature variable had a surprising increase in photosynthetic rate as it surpassed the photosynthetic rate of the room temperature variable for a period of 10 minutes before data collection was completed. Ultimately, the results validated the hypothesis by showing the rate of photosynthesis of Spinacia oleracea L. generally increases with an increase in temperature. However, the results of the t-test gave a p value of 0.26 indicating there is no significant difference between the photosynthetic rate in low (7°C), and high. The results of the t-test gave a p value of 0.26 indicating there is no significant difference between the low (7°C), and high (34°C) temperatures.

Discussion

Results validate the original hypothesis which stated that photosynthetic rate would be highest in a high temperature environment. Temperature has an influence on photosynthesis, by affecting the kinetic rate of enzymatic reactions which occur during both the light and dark photosynthetic reactions. It is a general phenomenon of chemical thermodynamics, which states that the rates of chemical reactions increase as temperature increases (Evans, 2000). Assuming that this general phenomenon was entirely true when applied to spinach, one would assume that photosynthetic rate would be higher in room temperature environments when compared to cold temperature environments. Results, (Figure 4) for the first 12 minutes of observation would entirely support this assumption, until the photosynthetic rate of the 7°C variable surpassed the photosynthetic rate of the 22°C variable about half way through the experiment. Additionally, other studies related to the effects of temperature on photosynthetic rate, have found that with spinach that was grown at room temperature; then exposed to a temperature of 10°C for a period of 10 days, the capacity for leaf photosynthesis at low temperature was increased (Martindale, 1997).

This suggests that the photosynthetic rate would be higher in low temperature environments instead of high temperature environments. Once again, recall from (Figure 4) that the results indicate that the cold temperature variable surpassed the room temperature variable at the 12 minute mark and had a higher photosynthetic rate. Further research attributed this to temperature acclimation, which is a change that compensates the drop in temperature, and occurs in many physiological processes (Gray, 1994). This would explain why these results were not completely observed as the spinach was exposed to low temperatures only for a short time before data recovery. Perhaps the spinach remained in the low temperature environment for a longer period; the experiment might have also reflected temperature acclimation, and photooxidation. Furthermore, research has attributed the temperature acclimation in spinach to increased sucrose synthesis in spinach cells; also, evidence for temperature acclimation was more evident under saturating CO2 conditions (Martindale, 1997).

A couple of procedural errors could have affected the results. As mentioned in the materials and methods section, lamps were the source of light (solar) energy. When trying to account for differences between the two trials in the independent variables, it became obvious that the exact distance between the leaf disks and the lamp had not been taken into consideration. This could potentially have affected the light intensity at which the disks were absorbing rays of light. Although the distances between lamps and disks only differed by a maximum of 5 cm between trials, this error could still have been significant, and should be avoided in a repeated experiment. Another error could have been the damage, or bruising of the spinach leaf while cutting it into circular discs. The damage to the mesophyll could have also had a small effect on photosynthesis on the outside circumference of the disc.

Despite these minor errors the hypothesis was supported by an increase of photosynthetic rate at high temperature (34°C). However, a larger sample size would be needed in order to get better results.

Literature Cited


Effects of Cigarette Smoke on Cucumber plants

Josephine W. Han

Department of Biological Sciences
Saddleback College
Mission Viejo, CA, United States.

Abstract

There are numerous effects of smoking that affect each individual. They can affect not only your health but also your social and family life. It can also affect the non-smoker within the same area. Plants, like humans, take in carbon dioxide, use it and let it out oxygen gas. In this experiment, the effect of cigarette smoke on plant growth was studied. Twenty sprouted cucumber plants were obtained from a nursery and placed in two separate groups. Each group of ten plants was placed in a homemade greenhouse and received the same amount of water and sunlight each day. The purpose for the greenhouse was that once the cigarettes were lit inside, smoke will be trapped within, forcing each plant to inhale the smoke. Each day, twenty Marlboro Menthol Light cigarettes were lit inside of the experimental greenhouse. After one week of tobacco exposure, each plant was then measured. Within the controlled greenhouse, growth achieved was in between 1-2 cm. In the experimental group, very little growth was observed between 0-0.5 cm. These results support the hypothesis that cigarette smoke does affect plant respiration and growth.

Introduction

Prenatal exposure to second-hand smoke unfavorably affects the size and weight of newborns, according to a study by the Columbia Center for Children's Environmental Health, part of the Mailman School of Public Health at Columbia University. The research involved a sample of two hundred twenty-six infants of non-smoking women in New York City (Anonymous 2004). The study examined the effect of prenatal exposure to second-hand smoke, also known as Environmental Tobacco Smoke (ETS), which contains hundreds of chemicals and combustion-related pollutants known as polycyclic aromatic hydrocarbons (PAHs). PAHs enter the environment when combustion occurs, e.g., from car, truck, or bus engines, residential heating, power generation, or tobacco smoking (Anonymous 2004). When compared those infants with mothers who lived during pregnancy in households with an active smoker, their measured DNA damage from PAHs in the umbilical cord blood of the newborns, providing an individual biomarker of PAH exposure and vulnerability to PAHs. Second hand smoke has significant combined effect of ETS and PAH-DNA damage had about a 7% reduction in birth weight and about a 3% reduction in head circumference (Anonymous 2004).

Cigarette smoke is the major cause of pulmonary emphysema, suffered by one of every five hundred Americans (Camevali 2003). Scientists know smokers are significantly more likely to develop emphysema compared with nonsmokers, and the seriousness of the disease is directly correlated with the amount of cigarette smoking. Among the different toxic effects of cigarette smoke on human tissues, oxidation of structural and functional molecules and inflection of cell turnover play a major role. Because fibroblasts play a crucial role in remodeling of pulmonary tissue, researchers have exposed fibroblasts to cigarette smoke and have studied two important processes: oxidative stress and apoptosis (Camevali 2003). Oxidative stress is a disruption in the oxidant-antioxidant balance, resulting in potential cell damage. It is involved in many biological and pathological processes, such as inflammation and carcinogenesis, and in the development of many pulmonary diseases. In response to oxidative stress, lung cells release inflammatory mediators and cytokines that are able to induce neutrophil recruitment and activation of transcription factors such as activator protein-1 and nuclear factor-B (Camevali 2003). Because oxidative stress and apoptosis are implicated in numerous processes, including aging, inflammation, and carcinogenesis, it is reasonable to hypothesize a link between these two processes. The mechanisms by which oxidants can modulate the apoptotic pathways have been recently reviewed. The aim of a new study was to evaluate the ability of cigarette smoke to induce fibroblast oxidation and apoptosis.

Cigarette smoke contains around four thousand chemicals, many of which are known to be highly poisonous. The chemicals found in a cigarette include benzene, a gasoline additive found in paints, paint thinners, adhesives and plastics. Asbestos also found in cigarette smoke is only dangerous when its fibers become loose or when the material crumbles, which causes small particles to be set free and inhaled. Once inhaled, the microscopic fibers remain in the body forever. Asbestos can cause lung and bowel cancer, mesothelioma, asbestosis and other lung diseases. The risk of disease is believed to increase with smoking. Vinyl chloride is plastic resin found in many...
products, including pipes, hoses, flooring, windows and credit cards. While pesticide levels in foods are relatively harmless, pesticides used in homes or on lawn may be dangerous in large quantities. In some studies, farmers with high exposure to pesticides were found to have a higher risk of several different cancers, including leukemia (Anonymous 2000). Formaldehyde initially was found to cause nasal cancer in rats. Since then, there has been considerable controversy as to the role of formaldehyde in causing cancer in humans. Other chemicals include chloroform, trichloroethylene, tetrachlorethylene and dichlorobenzene. These may be found in solvents, cleaning products or deodorizers (www.PhilipMorris.com).

The purpose of this experiment is to determine the effects of cigarette smoke on plant heights. The greenhouse exposure to the cigarette smoke will not achieve any favorable growth.

**Materials and Methods**

From Home Depot nursery in the City of Industry, California, twenty newly sprouted cucumber plants were randomly selected from stock and purchased at the same time. Two groups of ten randomly chosen plants were separated and placed in two homemade green houses. In order to standardize these plants, both green houses received 10 mL of water per day and approx 14 hours of sunlight for two days. After two days another factor was introduced to the experimental green house, cigarette smoke. Seven packs of Marlboro Menthol Light cigarettes were purchased from Albertson Supermarket in Rowland Heights California, within each pack were twenty cigarettes. Each day, twenty cigarettes were lit separately within the experimental green house. After a week, each plant was observed and measured for growth. In the controlled green house, all plants appeared healthy, green and achieved growth from 1-2 cm. In the experimental green house, all plants appeared not as vibrantly colored and achieved very little growth. All measurements were obtained and tabulated into Microsoft Excel for statistical purposes.

**Results**

Cucumber plants in the controlled green house had similar growth patterns, and appeared very uniform in heights and color. The experimental cucumber plants appeared slumped over, yellowish in color and no visual growth could be observed. After measurement, these plants only achieved in the area of 0-0.5 cm in growth. The controlled cucumber plants were taller on average than the experimental cucumber plants throughout the whole experiment. For the first three days, not much difference could be observed in both green houses. Around the fourth to fifth day, visible wilting was observed in the experimental green house. Plants in experimental greenhouse appeared worse in coloration and growth. Very little difference was observed in the controlled environment at all, all plants appeared normal and no abnormal coloration observed. After all measurements were tabulated into Microsoft Excel, the p value obtained was 2.04577E-05 (Table 1), which is less than 5%, therefore there is statistical difference between controlled and experiment cucumber plant growth. This also supports the original hypothesis, there is a significant difference in growth from both plant groups and the data obtained aside from sampling error is valid.

<table>
<thead>
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<th>Table 1. The t-Test results combined from twenty cucumber plants’ growth</th>
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<td>Mean</td>
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**Discussion**

The growth data obtained from each group showed a significant difference in growth with the effects of cigarette smoke. Although the results were significant, there are some factors that might interfere with these results. Originally, each plant used in this experiment was going to be grown from seedling for more accuracy. At first seeds were obtained, plotted, and grew. But all twenty plants died as a result of temperature change and lack of water. Therefore, twenty newly sprouted cucumber plants were purchased from a nursery. Out of all twenty plants obtained, there are many different factors that can effect the growth of each plant. The soil each of these plants were planted in cannot be confirmed coming from the same batch of plotting soil, therefore some plants might have higher in nutrient than others. Next, before obtaining the plants, the amount of sunlight exposure cannot be confirmed, for that reason, some plants could achieve better growth due to receiving optimal sun exposure.
Another reason why the cigarette smoke stunned the growth of cucumber plants could be that all smoke was trapped inside of the green house. Although holes were pierced on the walls of the green house for ventilation, when a lit cigarette was placed within the green house, most smoke produced was trapped within it. The heat from the cigarette smoke can be the factor that contributed to wilting and stunning the growth instead of the actual chemicals in the smoke. Also the smoke trapped inside the green house lingered for a while before it was ventilated out, creating a harsher environment. Further research is required to determine if cigarette can harmfully effect plant growth. Another experiment design will be needed to eliminate the factors listed above to obtain more accurate results.

**Literature Cited**


The Effects of Miracle-Gro, Mycorrhizal Fungi, and *Aspergillus* on the Growth Rate of Corn Plants (*Zea mays*)

Deirdre Hazard and Jonathan Snyder  
*Department of Biological Sciences*  
*Saddleback College*  
*Mission Viejo, CA 92692*

**Abstract**

Plants rely on an abundance of nutrients being present in the surrounding soil in order to grow and perform chemical reactions. A deficiency of these nutrients can impede the growth rate of a plant, or possibly kill it, while an abundance of these nutrients can help the plant thrive. Other factors present in the soil can also contribute to plant success, such as mutualistic or parasitic relationships between plants and fungi. Mycorrhizal fungi are known to form mutualistic relationships with the roots of plants by feeding nutrients from the soil directly into the plant’s roots. It is logical then to assume that the presence of a mycorrhizal fungus in the soil of a growing plant would increase its growth rate compared to a plant living in soil where a mycorrhizal fungus is not present. It can also be expected that when a parasitic fungus, such as *Aspergillus*, is present during the germination process that a plant will suffer from reduced growth rates. In this experiment, the effects that mycorrhizal fungus had on the growth rates of corn plants (*Zea mays*) when introduced at varying stages of plant development were studied, along with the effects of *Aspergillus* and Miracle-Gro plant food. Corn seeds were soaked thoroughly, planted in identical environments, and monitored while they germinated and grew for 11 days. There was a control group where the seeds were given nothing but soil and water, and then four other groups that received soil and one of the following variables: mycorrhizal fungus before germination; mycorrhizal fungus after germination; *Aspergillus* before germination; and a Miracle-Gro plant solution after germination. Average group growth rates were 1.70, 0.69, 2.53, 1.36, 1.16 cm/day, respectively. The results show that adding mycorrhizal fungus to the soil after germination produces the largest growth rates while adding mycorrhizal fungus before germination causes the lowest growth rates. This shows that adding mycorrhizal fungus to the roots of already germinated plants produces the best results.

**Introduction**

Plant success is dependent on many factors, a few examples being water abundance, sunlight, and nutrient availability in soil. The latter can be manipulated quite easily with chemical plant fertilizers, such as Miracle-Gro. Miracle-Gro comes equipped with many essential nutrients that are often lacking in people’s yards. It contains nitrogen which is essential for all stages of growth (especially leaf formation), phosphorus which is essential for the formation of plant roots and flowers, and potassium which helps plants absorb all these other nutrients (Mattern, 1997). All of these elements and compounds are water soluble, so by combining them into a liquid fertilizer like Miracle-Gro, the plant will absorb all of the nutrients it needs for healthy growth and development with the water it takes in at its roots.

However, the secret to plant success is not just dependent on the amount of nutrients present in the soil but also the plant’s ability to extract those nutrients and the water it needs from the surrounding soil with its roots. Therefore, below ground, where these roots establish a network of root hairs for absorption purposes, they also establish essential symbiotic relationships with fungi. One such class of fungi is called arbuscular mycorrhizal fungi. This mycorrhizal fungi takes up residence within the roots of a vast majority of plants where it 1) enhances nutrient uptake within the plant’s roots; 2) enhances phosphorous cycling; 3) increases pathogen resistance for the plant; 4) improves growth of the roots; and 5) promotes fitness and competitive ability for the plant which it inhabits (Chasan, 1998). The fungus in turn receives beneficial sugars extracted directly from the plant’s roots (Chasan, 1998). It is logical then to assume that the addition of mycorrhizal fungi near the root system of a plant would most likely be of benefit to that plant.

However, there are also fungi that may not necessarily be detrimental to a plant’s growth, but also cannot be considered mycorrhizal. One such fungus is *Aspergillus*. *Aspergillus* can infect the kernels and ears of heat weakened corn, and if ingested by humans, the aflatoxins (a carcinogen produced by the *Aspergillus* fungus) present in the infected corn can lead to cancer of the liver as well as acute-poisoning deaths (Wood, 1989).

The purpose of the following experiment was to compare the effects that the introduction of *Aspergillus*, mycorrhizal fungi (introduced both before and after germination), and the popular plant growth enhancer Miracle-Gro had on the growth rate of *Zea mays* (corn) plants. It was expected that the addition of mycorrhizal fungi during any point of plant development would have the greatest positive effect on plant growth, while the addition of the fungus *Aspergillus* would have the greatest negative effect on the growth rate of the corn plants, perhaps preventing the seeds from germinating at all. The addition of Miracle-Gro was expected to produce the same results as the control group since a nutrient rich soil was already being used to grow all the plants during the experiment, making the addition of the nutrients from the Miracle-Gro solution superfluous and unproductive.
Methods and Materials

A bag of *Zea mays* (corn) seeds were soaked for 8 hours in tap water. Thirty seeds were then chosen randomly for planting in thirty plastic pots (10 cm diameter X 9 cm height) each filled 2 cm from the top of the pot with Premier PRO-MIX General Purpose Growing Medium. Five groups were examined – a control (C) group, a “mycorrhizae before” (MB) group, a “mycorrhizae after” (MA) group, a Miracle-Gro (MG) group, and an *Aspergillus* (ASP) group. Each group contained six seeds, each individually planted in their own pot in divots 1 cm deep in the soil. The pots were then labeled according to which group they belonged to and numbered 1-6 in order to differentiate and keep accurate records of the growth rates of each individual plant.

The C, MA, and MG groups received only soil in their pots on the day of planting. The MB group received one teaspoon of Chappy’s POWER ORGANICS Mycorrhizal Root Booster placed into the divot with the corn seed at the time of planting. Colonies of the fungus *Aspergillus* were cultured on a nutrient agar slant provided by Kathleen Moloznik of the Saddleback Biology Department. These colonies were then placed directly on the corn seeds in the ASP group using an O-ring before placing them in the divot during planting. All the divots were then covered with the soil that was previously displaced, watered generously, and left to germinate and grow for 7 days in the greenhouse at Saddleback College (with watering taking place every 2 days).

After 7 days, the first sets of data were collected. Each plant that had germinated was measured in centimeters from the base of the plant’s stem, where the plant broke the soil’s surface, to the tip of the tallest leaf (when held upright). After this data was collected, the roots of the MA group were gently exposed, and 1 teaspoon of Chappy’s POWER ORGANICS Mycorrhizal Root Booster was placed into the divot and onto the roots of the corn plants. The divots were then replaced. At this point, all the groups were watered, except for the MG group which was watered with a solution of 1 tsp Miracle-Gro Patio Plant Food (special 20-20-20 mix)/1 gallon water. The 20-20-20 formula refers to the percentage of nitrogen, phosphorous, and potassium present in the Miracle-Gro mix. After this initial data collection the plants were measured and watered every 2 days, with the exception of the MG group which received the Miracle-Gro solution instead of pure water on all of the remaining data collection/watering days. Eleven days after the initial planting of the corn seeds the final heights of the plants were measured and recorded. The data that had been collected on 3 separate occasions was compiled into a Microsoft Excel spreadsheet that was used for calculations and graphical analysis. The average growth rates of each individual plant were calculated by dividing the total growth of the plant that occurred after the introduction of the designated growth factor by the number of days the plant grew after the growth factor was added. Average group growth rates were also calculated, and an ANOVA test was performed on the data to determine if there was a significant difference between the growth rates of each group.

Results

A total of fourteen seeds failed to germinate during the course of the experiment. Two of these failed germinations occurred in the C group. Therefore, we will use the C group as an example of how many seeds can reasonably be expected to germinate under the experimental conditions – despite any introduced variables – and use this standard in order to interpret the results. Since two seeds did not germinate in the control group, we will discount two failed germinations from every group.

![Figure 1](image-url)  
**Figure 1.** Average rate of corn plant growth before and after treatment with Mycorrhizal fungus, Miracle-Gro and *Aspergillus*
The average group growth rates of the corn plants (Fig. 1) for MB, MA, ASP, MG and C groups were 0.69, 2.53, 1.36, 1.16, and 1.70 cm/day, respectively, indicating that the MA group had the highest average growth rate of all the groups while the MB group had the lowest. The overall results organized into decreasing order with respect to average group growth rate are as follows: MA, C, ASP, MG, and MB.

Figure 2 shows the average growth rates of each individual plant organized by growth factor used. For each group, the individual growth rates (in cm/day) were as followed (with the two failed germinations already removed from each group): 2.17, 0.35, 0.23 and 0.00 for the MB group; 2.28, 2.60, 2.60, and 2.65 for the MA group; 2.14, 1.74, 1.57 and 0.00 for the ASP group; 0.00, 2.25, 2.38 and 0.00 for the MG group; and 1.64, 2.00, 1.23, and 1.94 for the C group.

Both figures indicate that the MA group produced the highest average growth rates overall while the MB group produced the lowest. The calculated p-value for the ANOVA test was 0.38, which is greater than 0.05 statistical difference assumed, indicating that there is not a significant difference between the average growth rates between the five groups.

Discussion

Due to the fact that fourteen seeds failed to germinate during the experiment, the results are hard to evaluate, and this presented a source of error. Some of the failed germinations may have been the direct result of the variable introduced into the soil during the experiment, such as the Aspergillus which is a fungus known to act as a parasite to the kernels of heat weakened corn (Wood, 1989). However, some failed germinations may have been due to other controllable factors such as bad seeds or inadequate soaking of the seeds before planting. By using the control as an example of how many seeds should have been expected to germinate under the experimental conditions we are able to compare the effects of the experimental variables by disregarding two randomly-selected failed germinations from each group.

The data clearly shows that adding mycorrhizal fungus to the soil after seed germination produces much greater growth rates as opposed to adding mycorrhizal fungus before seed germination. In fact, according to our data, adding mycorrhizae to the soil around a seed before it has germinated inhibits the plant’s initial growth rate. The MB group had the worst growth rates in the entire experiment with 2 of the corn plants only averaging 0.35 and 0.23 cm/day by the end of the experiment. A possible reason for this could be the fact that mycorrhizal fungi form symbiotic relationships with plants through their roots only (Chasan, 1998). Since there were initially no plant roots to interact with, the fungus may have used a great deal of nutrients in the soil for itself. This would have withheld vital nutrients the corn seeds needed in order to start the germination process.

Another surprising result was the fact that the addition of Aspergillus to the corn seeds at the time of planting did not seem to affect the growth rates of the corn plants negatively. A possible explanation for this is the
fact that *Aspergillus* needs hot and dry conditions in order to infect the ears and kernels of corn plants (Wood, 1989), and these conditions were not idealized during the experiment.

The calculated p-value indicated that there was not a significant difference between the growth rates of the five groups. This suggests that the factors introduced to the corn seeds/plants will not greatly affect their growth rates one way or another. However, for the best and most consistent results, the addition of mycorrhizal fungus to the soil around the roots of a growing corn plant after germination is the best choice according to the results of this experiment.

### Literature Cited


http://www.physics.csbsju.edu/stats/anova_NGROUP_NMAX_form.html

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### Measuring Methyl Mercury in *Glyptocephalus zachirus* and *Onorhynchus tshawytscha*

Karen Lee and Michelle Voli  
*Department of Biological Sciences*  
*Saddleback College*  
*Mission Viejo, CA 92692*

### Abstract

There is an increasing concern in consumption of fish due to its content of methyl mercury. Mercury poisoning has been linked with the ingestion of fish tissue, and can result in consequences such as central nervous system decay and heart disease. Methyl mercury is bioaccumulated and biomagnified as it rises up on the food chain level. The purpose of this experiment was to measure the mercury levels relative in two fish whose main difference was size and diet. The rex sole (*Glyptocephalus zachirus*) and king salmon (*Onorhynchus tshawytscha*) were the two fish that were tested. Because king salmon is higher up on the food chain compared to the smaller rex sole that lives at the bottom of the floor, it was predicted that the king salmon would contain more mercury as compared to the rex sole. Methyl mercury completely desorbs in 1 M HCl, so this particular acid was used to ingest the tissue under heat. The chemical reaction for our experiment was: $\text{CH}_3\text{Hg}^+ + \text{HCl} \rightarrow \text{HgCl} (\text{aq}) + \text{other side reactions}$. Because the chemical context of our side reactions remained unknown, water was added to help dissolve any polar impurities, and to keep these side reactions in solution. Using a distillation apparatus, this liquid mixture was distilled to 200ºC, and the final product was weighed. King salmon had an average $\text{HgCl}$ weight of 89.449 mg/g of fish. The rex sole had an average of 68.690 mg/g fish. This supported the hypothesis that larger, predatory fish contain more mercury than smaller fish. However, when a t-test was conducted to analyze the data, the p value was found to be 0.135, holding the results insignificant.

### Introduction

Studies have shown that a diet consistent in omega-3 fatty acids, a fatty acid easily found in fish, can prevent certain diseases such as heart disease (Sexton, 2003). However, FDA findings have also discovered that trace amounts of mercury are also found in fish, resulting in unhealthy consequences. According to FDA toxicologist Mike Bolger, Ph.D., “approximately 2,700 to 6,000 tons of mercury is released annually into the atmosphere naturally by degassing from the Earth's crust and oceans. Another 2,000 to 3,000 tons is released annually into the atmosphere by human activities, primarily from burning household and industrial wastes, and especially from fossil fuels such as coal.” (Foulke, 1994).

Bioaccumulation is the accumulation of a substance, in our case, a toxic chemical, in various tissues of living organisms. Biomagnification is the process by which the concentration of a substance increases at higher levels of the food chain (Williams, Martinez, 2004). Trace amounts of mercury are soluble in bodies of water, where bacteria chemically transform inorganic mercury to organic methyl mercury. Methyl mercury first enters the food chain by being absorbed by algae, zooplankton, and other small plants and animals. It should also be noted that methyl mercury in water can also be absorbed through the gills of a fish. As methyl mercury accumulates up the food chain,
the biggest game fish whose primary diet consists only of other fish contain the highest level of mercury. It’s not only humans that are affected by eating methyl mercury. Eagles, turtles, otters, and other fish eating creatures are also at risk. Mercury in their diet causes early death, thinning of egg shells for birds, weight loss, as well as problems with their ability to reproduce (Williams and Martinez, 2004). Unfortunately, wildlife animals cannot read advisories to change their diet to avoid this contamination.

Typical symptoms of low-level mercury poisoning are fatigue, headaches, hair loss, upset stomach, and difficulty concentrating. It has been known to be a factor in cardiovascular disease and central nervous system decay. Some doctors even speculate on a link between mercury toxicity and autism, and studies are looking at a possible connection (Cropper, 2004). The FDA's consumer advisory addresses only the high-risk groups of pregnant women, those of child-bearing age, and their children. Mercury crosses the placenta and can damage the developing fetal brain. Therefore the U.S. Food and Drug Administration (FDA) have advised that these high-risk groups avoid eating bigger game fish such as swordfish, shark, and king mackerel (NewsRx, 2003). According to the FDA, the recommended limit for mercury consumption is 5 mg/kg of blood. Cooking has no effect on methyl mercury, so it doesn’t matter if you grill your fish or eat it as sushi. "You eat mercury; it goes into your blood. You stop, and the mercury levels go down." (Cropper, 2004) A blood test can be used to confirm mercury poisoning in your body.

Not everyone agrees, however, about what advice to provide to consumers. This is particularly evident in sport fish advisories provided by states around the country. Because states use different criteria for their fish advisories, states may provide different advice about fish from the same bodies of water. Some states have adopted a zero risk approach and have advised consumers not to eat certain species, while others have put a limit on intake that is more consistent with the FDA approach (Horowitz, 2002).

Materials and Methods

Ten samples of each fish tissue, each from a different sample of fish, were store bought at Bristol Farms market. This market obtains their fish supply from American Fish Company. The ten samples were weighed roughly into 5,000 g. Each fish tissue was then desorbed with 10-mL HCl (1 M) on a hot plate for 20 minutes. The liquid containing the HgCl was then filtered from the fish tissue solid using vacuum filtration by a Büchner funnel. 5-mL of water was added to the liquid mixture to ensure that the side reactions would remain in solution and remain separated from the HgCl. Distillation is a process that separates two or more liquids in a mixture. It heats the liquid mixture until it hits the boiling point of the liquid with the lowest boiling point, removing the vapors through a cooling and condensing apparatus, and finally collecting the condensed liquid in another receiver (Donis, Gerbaut, Joulia, 2002). A simple distillation apparatus was set up using a 25-mL round-bottom flask, distillation head, thermometer adapter, water condenser, vacuum adapter, heating mantle, controller set at 120 V, and the 50-mL Erlenmeyer flask that was pre-weighed before use. The boiling point of mercurous chloride is 384°C, but a thermometer that went up to 350°C was not available, so the liquid solution was distilled to 200°C. After distillation was complete, the crude product weight was noted for each sample. The transportation of the fish tissue was done by ice box and was always kept refrigerated over the period of four days it took to complete this experiment.

Results

After extracting the HgCl from both species, king salmon was found to have an average HgCl content of 89.449 mg/gram of fish (mg/g), while rex sole had an average of 68.690 mg/g fish (Figure 1).
Figure 1. Average HgCl found in rex sole and king salmon.

When compared against the mass of the sample, king salmon had a higher percentage of HgCl than rex sole. King salmon had 0.089%, whereas rex sole had 0.069% HgCl to body mass (Figure 2).

A statistical t-test was conducted to determine the significance of the data, and the p value at one-tail was found to be 0.135, which is greater than 0.050, making the results insignificant. However, this data supports the hypothesis that the king salmon has higher HgCl content as compared to the rex sole.

Discussion

This experiment shows that king salmon had higher mercury content than the rex sole, although the values were not significant, and rightfully so. The rex sole’s diet differs from the king salmon. The rex sole is a type of sand dab and hunts for worms and small mollusks on the bottom of the sea floor. The maximum size a rex sole has ever
reached is 59 cm with a weight of 1,500 g. The king salmon on the other hand preys on other fish, such as the fin fish. It also eats insects and worms like the rex sole. The maximum size a king salmon has reached is 150 cm with a weight of 61,400 g (Casal, 1995). In general, methyl mercury levels for most fish range from 0.01 ppm to 0.5 ppm. The larger, predatory fish can have levels higher than 1 ppm (Foulke, 1994). Parts per million is equivalent to 1 mg/L or 1 mg/kg.

There are several things that could have occurred that contributed to the high levels of mercury that we found in our fish tissue. When the fish tissue was bought at the store, it was kindly asked that they get each piece from different fish so that we could have ten different samples of each. The problem in doing this was that the tissue matter collected from the fish most likely did not come from the same part of the body. It is possible that different tissue parts of the fish carry varying amounts of methyl mercury in their system. This problem could have been solved by obtaining our own fish from the ocean instead of buying fish from a market. Then we could have caught ten samples of each fish (with the assumption that a certain fish is plentiful in one area), and gotten the same piece of tissue from each fish, thereby ensuring the credibility of our experiment. It should also be noted that some of the actual values from the weight at the end were very similar in amount between the rex sole and king salmon. Another problem with measuring mercury in our fish is that the hydrochloric acid that was used to desorb the tissue could have reacted with other compounds besides methyl mercury. 1 M hydrochloric acid is a strong acid and likely underwent side reactions in our experiment. The addition of water most likely helped during the distillation, but it is likely that not all of the side reactions distilled, adding to the weight of HgCl. If we could have verified the exact nature of these reactions, extraction may have proved more accurate if we knew how to remove the impurities. Our availability of technology and sources were limited, and is the reason why we were narrowed down to chemical reactions. Due to these factors that may have faulted our data set, if a similar type of experiment was done with more funding available, some of these factors could have been factored out, and there may be a significant difference between the two fish. An interesting continuation of this experiment could test methyl mercury in different bodies of water, or measuring methyl mercury from a variety of fish (more than two species) as you go higher up in the food chain.

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The Effects of Nutrients on Wheat Germination Grown in Hydroponic Culture

Marjaneh Mottaghi
Department of Bioengineering
Saddleback College
Mission Viejo, C.A. USA

Abstract
The purpose of the study is to determine the major nutrient uptake on wheat growth without soil within a 14-day period. Wheat was grown in a modified hydroponic culture to ascertain the effects of nutrients on germination and shoot tip length. A completely randomized design in rectangular plots (310.0 x 500.0 mm) was used to evaluate the effect of nutrients on wheat germination in hydroponic growth settings. Treatments consisted of the control, group a (DI water), group b (Potassium Nitrate + DI water), group c (Ammonium Nitrate + DI water), group d (Magnesium Sulfate Heptahydrate + DI water), group e (Monopotassium Phosphate + DI water) and group f (Potassium Nitrate + Ammonium Nitrate + Magnesium Sulfate Heptahydrate + Monopotassium Phosphate + water) in the nutrient media. Treatments were given to a population of 300 wheat seeds per section, and six sections were created. Wheat seeds were placed within a semi-sterile environment in one layer. Group c (31.4±21.3 mm) had the greatest growth, followed by group b (31.1±23.5 mm), group f (29.4±20.8 mm), group e (23.4±14.3 mm), group d (23.1±14.6 mm) and group a (10.9±0.85 mm). The shoot tips and average growth rate were calculated to show that the plant nutrients in the aqueous ammonium nitrate setting yielded the best results because plants need reduced nitrogen. For that reason, the ammonium is a more effective source of nitrogen for chlorophyll’s porphyrin ring. Group b, which offered another source of nitrogen, in conjunction with potassium for the wheat, produced the second best growth rate. Nevertheless, the ion content provided by all the solutions was not an accurate quantity for the wheat seeds under study; therefore, no statistical significant difference in germination rate between wheat grown in DI water compared to wheat grown in five solutions containing different nutrients along with DI water was seen, and the hypothesis was rejected.

Introduction
Wheat is the most widely grown cereal crop in the world (Zhou et al., 2001), constituting an important irrigated crop, and it is moderately tolerant for different salt and sugar concentrations (Steppuhn et al., 2001). The culture medium used by plant tissue culturists in horticultural crops is the Murashige and Skoog basal salt mixture (MS), containing basic salt formulations (macronutrients and micronutrients), carbohydrates, vitamins and plant growth regulators (Murashige and Skoog, 1962). This culture medium provided an outline of adequate nutrients to use. Unpelted wheat seeds were maintained in a modified Murashige and Skoog liquid medium (Dutta Gupta and Conger, 1999).

Macronutrients, which are elements required by plants in large amounts, include NPK (nitrogen, phosphorus, potassium), magnesium, and sulfur (Campbell and Reece, 2002). The amount of organic salts present in the MS medium validate that the concentrations of nitrate, potassium, and ammonium need to be higher for rapid growth (Smith, 2002). In hydroponic plant production, a considerable amount of systems control is possible (Silberbush and Lieth, 2004); therefore, hydroponics culture was used to identify essential nutrients by omitting and adding particular nutrients from the culture medium (Campbell and Reece, 2002). Seedling emergence is the result of an important growth phase, and the seedbed environment influences emergence, with moisture, pathogens, temperature and nutritious food resources being the most important components (Hamman et al., 2002).

The purpose of this experiment was to determine the major nutrient uptake by wheat not grown in soil within a 14-day period. Wheat was grown in a modified hydroponic culture to ascertain the effects of nutrients on germination and shoot tip length. It was hypothesized that there would be a change in the average growth rate of seedlings submerged in the solution containing one or four of the basal salt nutrients (groups b, c, d, e and f) compared to the control (group a).

Methods and Materials
To begin with, a modified MS macronutrient was presented into experimental groups b, c, d, e, and f, supplying the five major elements needed to increase plant growth: potassium, phosphorus, nitrogen, magnesium and sulfur (the last two being secondary plant foods and NPK as the primary plant foods). Fertilizers are made of combinations of these elements in order to grow healthier and stronger plants. For that reason, group f had a combination of all nutrients.

The specific reasoning behind using nutrients which provided the primary and secondary plant foods was based upon previous plant cell research done by Murashige, Skoog, and fertilizer examination. Plants need nitrogen because it is a part of all proteins, enzymes and chlorophyll. Nitrogen is commonly absorbed through the nitrate (NO3-) and ammonium (NH4+) ions formed by the disassociation of ammonium nitrate which was provided by solutions c and b. Phosphorus, being a component of nucleic acids (essential for the backbone of DNA and RNA), phospholipids, adenosine triphosphate (ATP), is also needed for sugar movement and functioning in several coenzymes. The phosphorus was provided by solution e (H2PO4-). The physiological functions of potassium (K+)
provided by solutions b and e, included eight functions: enzyme activation (a coenzyme), osmoregulation, operation of the stomata, a major solute functioning in water balance, formation of carbohydrates, photosynthesis, nucleic acids, and proteins (a cofactor that functions in protein synthesis). Solution d ($\text{Mg}^{2+}$) is a source of magnesium which plays a role in activation of many enzymes and is a component of chlorophyll (chlorophyll contains a porphyrin ring system with a magnesium atom at the centre of the system, joining hands with four neighboring nitrogens). Sulfur as a component of amino acids, proteins, vitamins and coenzymes was provided by solution ($\text{SO}_4^{2-}$).

Wheat seeds were then bathed in solutions of various nutrients. Known concentrations and four particular nutrients were omitted from the culture to test whether it was essential for wheat growth. The dependence of wheat growth on the major nutrient response was studied within a 14-day period. All the seeds were soaked in water for a 24-hour period to allow water to seep into the dicot dormant seeds, increasing imbibition. The seeds were germinated within a moistened cloth soaked in its group’s respective solutions for a 48-hour period. The dormant and problematical seeds were then eliminated, and it was ensured that the seeds used within the experimental trays had the potential to survive due to all having initially begun to germinate before experimented upon.

From a previous experiment (Figure 1) with the same conditions but differing nutrients for a different species (radish seeds), the growth of Rhizopus resulted in decomposition. Thus, seeds needed to be protected against spores in the air as much as possible. For this reason, a semipermeable membrane was used until all the seeds had germinated. The containers were covered with pierced wrap after each watering interval until all the seeds had germinated 3 mm, causing a green house effect. Overall environmental conditions were taken into account. The total germination length included the time for steeping and the time for sprouting. The grains were soaked with solutions for 15 min at 12 h intervals and turned (aerated) by shaking once every 24 h in order to prevent rootlets matting.

Rectangular shaped plots (310.0 x 500.0 mm), each consisting of 300 seeds, were wrapped with clear plastic wrap (figure 3). The wrap was punctured with 50 holes at the top to create a semipermeable membrane to keep the grains at constant moisture without drying them and keep them free of contaminating outer particles. Seeds were supplied with nutrients in each watering interval. A solution of 50 ml for each watering occasion was used, which was applied by a solution-specific 10 ml volumetric pipet with an accuracy of ±0.02 ml.

Six groups, each with 300 seeds, were studied. Groups were treated with nutrient media consisting of control, group a (DI water), group b (Potassium Nitrate + DI water), group c (Ammonium Nitrate + DI water), group d (Magnesium Sulfate Heptahydrate + DI water), group e (Monopotassium Phosphate + DI water) and group f (Potassium Nitrate + Ammonium Nitrate + Magnesium Sulfate Heptahydrate + Monopotassium Phosphate + water). Environmental conditions such as acidity, temperature and light time were taken into account. The hydrogen concentrations of the six solutions were measured with pH strips and showed readings of group a (pH=7), b (pH=6), c (pH=7), d (pH=6), e (pH=7) and f (pH=6). The average amount of light time for each experimental group was eight hours, and the average outdoor temperature was 76°C. Equation used (1):
The total germination length in two-day intervals was measured using a ruler with an accuracy of ±0.5 cm. Rate of growth was determined by the equation (2);

2) Growth Rate=\( \frac{\Delta L}{\Delta t} \)

Data was analyzed in ANOVA statistical test with a multiple comparison (available from www.statpages.net).

Results

Group c (31.4±21.3 mm) had the greatest growth, followed by group b (31.1±23.5 mm), group f (29.4±20.8 mm), group e (23.4±14.3 mm), group d (23.1±14.6 mm) and group a (10.9±0.85 mm), but no statistical difference between any of the groups (b, c, d, e, f) and the control group a was seen. Figure 4 shows how germination rate increases with time. The difference seen in growth rate was not large due to small sample size (n=1800); however, on average the wheat seeds (n=300) in group c were observed to have a greater germination rate than the ones in the five other groups. Average growth rates for the groups were group a (0.7786 mm/day), b (2.2214 mm/day), c (2.2429 mm/day), d (1.6500 mm/day), e (1.6714 mm/day) and f (2.1000 mm/day). However, there was no statistically significant difference between the six conditions (p>0.05).

Discussion

When a cereal plant like wheat is grown under controlled conditions, as allowed by the modern greenhouse technology, external signals such as irradiance, temperature, day length, etc., may play a secondary role. In the case of wheat, the rhythm is associated with man-induced grain production cycles (Silberbush and Lieth, 2004). Light
seems to be the main cue that tells the seedling it has broken ground. By tricking the seedling, exaggerated hypocotyls are extended, and after food reserves have been exhausted, the seedling stops growing and dies (Campbell and Reece, 2002). Light intensity and leaf nitrogen content affect leaf photosynthesis (Milroy and Bange, 2003); furthermore, several conditions, when not met, cause the plants to be in a compromised condition. Nitrogen deficiency is a major limiting factor for wheat production and decreases wheat grain numbers. Insufficient magnesium stresses some plants, yellowing the leaves (a condition called chlorosis) and reducing crop yields (Konstant 1991). Potassium deficiency causes a reduction in growth rate leading to chlorosis, followed by a decrease in turgor, causing a poor resistance to drought, and restricted formation of the xylem and phloem tissue (Amor and Marcelis 2003). Phosphorus shortage is a major factor limiting primary productivity. Sulfur insufficiency limits protein synthesis and increases rates of protein degradation within chloroplast (Sexton et al., 1997). Therefore macronutrients play an important role in plant functioning.

The results show that there was no statistical significant difference in germination rate between wheat grown in DI water compared to wheat grown in an ammonium nitrate solution alone, potassium nitrate solution alone, magnesium sulfate heptahydrate solution alone, monopotassium phosphate solution alone or a mixture of these nutrients along with DI water. These results were insignificant due to the small sample size (n=1800). Therefore, the hypothesis that there would be a significant difference on wheat germination in hydroponic growth settings due to the effects of different nutrients is rejected. This conclusion agrees with certain studies done on wheat germination, which show that the difference in contents and general appearance of wheat sprouts after 8 days of germination are attributed to steeping time-related variation, causing a difference in antioxidant contents; vigor and wholesomeness that are either due to water sensitivity or lack of adequate oxygen (Yang et al., 2001); or wheat’s susceptibility to inadequate field conditions (Zhou et al., 2001).

Group b, which was a source for reduced nitrogen that is used in biosynthesis to incorporate nitrogen into the amino acids, gave the impression of greener and healthier looking shoot tips. A greater increase in group f should also have occurred because it received the greatest amount of nutrients. However, the subjects weren’t supplied with the appropriate magnitude of nutrients for water absorption via root hairs. Thus, germination rate seems to increase with time attributable to the consumption of nutrients and sugars during the growth of the embryo into a seedling until the seed has exhausted its own resources and fully seeks its nourishment from its surroundings. Then, if the environment supplies the sufficient plant foods, which these seeds did not receive, the seeds will keep on growing.

A reason why the experiment may have not been consistent with other experiments could be the low concentrations of basal salts used in groups b,c,d,e and f, which caused a nutrient-deficient root system and possibly NPK starvation. The cation exchange and mineral ion uptake in root hairs give plants a means of controlling nutrient uptake (Campbell and Reece, 2002), which might have been imbalanced within this experiment. The consumption of endosperm nutrients during dicot seed growth seemed to have been the only legitimate reasons for growth seen. Consequently, germination efforts for wheat seed growth rate improvement should not focus solely on nutrient concentration (Nam et al., 1997).

A more conclusive method would have been to test with variable concentrations of solutions with larger test groups under completely sterile laboratory settings. With a larger population within an environmentally-controlled greenhouse (Steppuhn et al., 2001), less error and more accurate growth rates for a general population could be studied without any unwanted variables entering into the experiment. It is possible that certain germination conditions (light, temperature, soaking time, etc.) could be modified to increase the germination of wheat grains (Yang et al., 2001).

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The Effects of a Stimulus on Heart Rate

Reza Al and Pegah Rad

Department of Biological Sciences
Saddleback College
Mission Viejo, CA 92692

Abstract

The heart rate of a person can be influenced by several different factors. For instance, exercise, panic, or nervousness can increase a person’s heart rate. Conversely, activities such as sleeping, watching television, or other relaxing activities can result in a decreased heart rate. In this experiment, people’s heart rates were measured before and after riding a roller coaster, to see how much their beats per minute (bpm) fluctuated. Testing was conducted upon three factors: sex, age and weight. The radial pulses of fifty people were measured for one minute before they stepped into the ride, and again after they got off. The results showed that out of the twenty-five males and twenty-five females, the average change in heart rate for males was higher than the average change in heart rate for females. However, with the calculated p-value of 0.373, these results proved to be insignificant. Of the twenty-six people surveyed who were twenty-one years old and younger, the average change in heart rate was lower than the average of the twenty-four people who were twenty-two years old and older. Again, however, with the calculated p-value of 0.404, these results proved to be insignificant. Lastly, the results pertaining to weight showed the twenty-eight people that weighed sixty-eight kilograms or less to have a lower average change in heart rate than the twenty-two people that weighed over sixty-eight kilograms. Once more though, with the calculated p-value of 0.485, these results proved to be insignificant. The results showed that the stimulus had no apparent effect on the different categories tested. One reason for this may be that the stimulus has no direct relation to a person’s gender, age, or weight.
Introduction

Heart rate is the number of times a heart contracts per minute and resting heart rate is the number of contractions the heart undergoes in one minute when the body is at complete rest. The better physical condition a body is in, the less effort and fewer beats per minute it takes the heart to pump blood to the body at rest. Exercising or performing any kind of activity, especially riding on a roller coaster, will cause an increase in heart rate. A heart rate of one-hundred beats per minute or greater is known as Tachycardia. This allows the heart to pump blood throughout the body at a faster rate, providing more oxygen to the tissues. When a person experiences fear, anxiety or stress their heart rate will increase. Similar emotions are expressed when a person experiences a roller coaster ride, which should result in an increased rate. Variations in heart rate period arise through the different balances of sympathetic and parasympathetic nervous modulation of heart rate. Through differences in the physiological response of the myocardium to the neurotransmitters acetylcholine and noradrenaline, a greater variation in heart rate period arises when the parasympathetic nervous system predominates than with predominant sympathetic modulation (Winsley et al, 2003). In the normal heart, norepinephrine concentration in the atria is about 3 times that in the ventricle. Sympathetic and parasympathetic stimulation can reduce the atrial refractory period in atrial tissue, which decreases wavelength (Kern, 2004).

As is the case when one is on a roller coaster ride, there is a lot of sudden movements and as Radtke explains, rapid reorientation of the head induces an acceleration of heart rate that normally occurs within one heartbeat but is delayed if vestibular function is absent. The head drop restores normal head-neck alignment from a slightly flexed posture and could stimulate several sensory and neurovascular structures (Radtke et al, 2000).

The purpose of this experiment was to test the hypothesis that there is a difference in the average change in heart rate within sex, age, and weight groups. Specifically, that females, older people, and heavier people will have a greater difference in average bpm after a stimulus than males, younger people, and lighter people will have.

Materials and Methods

The heart rates of fifty subjects were tested before and after they rode a roller coaster at Knott’s Berry Farm. Before each person stepped into the ride, their radial pulse was recorded for one minute using a stopwatch; their age and approximate weight were also recorded. The person then rode the roller coaster and their radial pulse was again recorded for one minute immediately after they exited. This procedure was repeated with fifty subjects, twenty-five males and twenty-five females of various age groups and weights.

Once the data was compiled, it was entered into a computer and analyzed using Microsoft Excel. Three different charts were made sorting the data by sex, age and weight. In the first chart, the data was split into the two groups of male and female. The second chart sorted by age divided the results into the two groups of twenty-one years old and younger, and twenty-two years old and older. The final chart sorted the data into the two groups of sixty-eight kilograms and lighter and those heavier than sixty-eight kilograms. The average of the initial heart rates of one group was taken and subtracted from the average final heart rates of the same group to give an average for the entire sex/age group/weight class. This average was then compared to the average of the opposing sex/age group/weight class to see which had a higher average change. To test the significance of the data, a T-test was run which yielded the standard deviation and p-value that was then compared with an alpha value of .05, to give a 95% level of significance.

Results

The results pertaining to the first hypothesis that females would have a higher average change in heart rate was proven to be incorrect; as the results showed an average change of a female’s heart rate to be 7.60 bpm, while a male’s average change showed to be 9.12 bpm (Table 1). As seen graphically in Figure 1, females have about a 1.52 bpm lower difference in heart rate after a stimulus than males. With a p-value of 0.373, this data can be regarded as insignificant.

The hypothesis regarding the factor of age was supported by the data, showing the younger group, ages twenty-one and younger, had a lower average change in heart rate then the older group, ages twenty-two and older. Although the younger group’s average change was 7.69 bpm, while the older group had an average change of 9.08 bpm (Table 1); with a p-value of 0.404, this data can be regarded as insignificant. The chart in Figure 2 shows how the change in beats per minute spread across the span of different ages and how there is no consistent trend or pattern when age is a factor.
Table 1. Average change in heart rate (beats per minute) for the different age, sex and weight classes.

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Standard Deviation</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>9.12 bps</td>
<td>4.35 bps</td>
<td>25</td>
</tr>
<tr>
<td>Female</td>
<td>7.60 bps</td>
<td>7.34 bps</td>
<td>25</td>
</tr>
<tr>
<td>p-Value</td>
<td>0.373</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21 yrs and younger</td>
<td>7.69 bps</td>
<td>7.56 bps</td>
<td>26</td>
</tr>
<tr>
<td>22 yrs and older</td>
<td>9.08 bps</td>
<td>3.72 bps</td>
<td>24</td>
</tr>
<tr>
<td>p-Value</td>
<td>0.404</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>68 kg and under</td>
<td>7.86 bps</td>
<td>7.11 bps</td>
<td>28</td>
</tr>
<tr>
<td>Over 68 kg</td>
<td>9.00 bps</td>
<td>4.35 bps</td>
<td>22</td>
</tr>
<tr>
<td>p-Value</td>
<td>0.485</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 1. Average change in BPM of the two different sexes.

The final hypothesis regarding weight classes was also proven to be correct. Even though the data showed the sixty-eight kilograms and lighter group to have an average change of 7.86 bpm, while the heavier group of higher than sixty-eight kilograms, had an average change of 9.00 bpm (Table 1), with a p-value of 0.485, this data can be regarded as insignificant. As shown in Figure 3, the increase in the change of heart rate is not a consistent, linear increase or decrease across the weight span; however, as an average of the two weight classes, the lighter group still had a lower average change.
Discussion

The results showed that the average change in heart rate in males was higher than the average change in heart rate in females. Secondly, the average change in heart rate in people that were twenty-one years old and younger was lower than the average change in heart rate of people that are older than twenty-one. Lastly, the final set of results showed that the average change in heart rate in people that weighed sixty-eight kilograms or less was lower than the average change in heart rate of people that weighed more than sixty-eight kilograms. However, all data sets proved to be inconclusive due to their high p-values of 0.373, 0.404, and 0.485 respectively.

According to our results, none of the factors tested could be said to have an influence on the average change in heart rate because of the high p-values yielded. Although in each of the groups tested there was one class that had a higher average than the other, the standard deviations were all fairly high, skewing the data, making it insignificant. Every person had a different response from their sympathetic nervous system meaning that regardless of gender, age or weight, one person could have a higher average change than another, whether there are male or female, young or old, light or heavy. Even within the three groups, two people of the same class, such as two females can have two completely different responses; exemplified by the highest change in female bpm of 20, compared to the lowest of 3.
This example of outliers shows how within a single class, variation was so strong that it skewed the data great enough to eventually make it invalid.

There are several errors that could have occurred during the course of this experiment. One type of error could have been that the heart rate of the person being measured may have already elevated due to running, previous rides, or anxiety. Not being at a normal, resting heart rate can skew the results by lowering the heart rate reserve. Another error that could have happened is inaccurate measuring of the heart rate due to not counting every pulse correctly, or people not giving accurate information about their weight and age.

In the future, steps can be taken to prove the stated hypothesis by surveying a larger sample size, using more accurate instruments of measurement, and making sure that the person is completely at rest before the addition of the stimulus, so that their true resting heart rate can be measured without the influences of elevating factors.

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The Effects of Potassium Deficiency on Capsicum frutescens
Michael Bui and Adam Naujock
Department of Biological Sciences
Saddleback College
Mission Viejo, CA 92692

Abstract
Macro nutrients are essential ingredients in organic life. Plants rely on potassium for a number of functions. When potassium enters guard cells, it opens the stomata of plant leaves, allowing gas exchange. In this experiment we tested the effects of a lack of K⁺ nutrient in Capsicum frutescens, tabasco hot pepper plants. Our hypothesis is that the absence of K⁺ nutrient will stunt the growth of pepper plants. Ten plants served as the experimental group grown in an artificial mixture of soil that was created with the lack of K⁺. Another mixture of soil as created with K⁺ included to serve as the control group which included another ten plants. Average plant growth in the control group was 0.45cm, whereas the experimental group shrunk 0.075cm on average. The experimental group shrunk 2.211%, whereas the control group grew 9.123%. A t-test p-value of 0.000389 proves a significant growth difference between these two groups. A superior test that used hydroponics and a strictly controlled environment may have maintained the height of the experimental group.

Introduction
Potassium is a major nutrient required in a variety of biological processes in plants. The major role it plays includes regulation of turgor pressure, protein synthesis, and the movement of leaves (Maathuis, F.J.M.; Sanders D. 1994). The function of focus in this paper is the ability of K⁺ to affect the opening of stomata.

Potassium is found mostly in the cytosol and vacuoles of plant cells (Walker, D.; Leigh, R.; Miller, A. 1996) where it acts in a purely biophysical function. It causes guard cells to bend, consequently opening stomata pores to allow gas exchange. There are two modes of K⁺ transport; across the plasma membrane and tonoplast. K⁺ entry into the cell involves inwardly rectifying K⁺ channels that activate on membrane hyperpolarization. K⁺ release involves outwardly rectifying K⁺ channels that activate on membrane depolarization, a point where Nernst membrane potential is greater than the K⁺ equilibrium potential (Hosy, E. et al. 2003). It has also been shown that the K⁺ channel KAT1 exhibits a regulation by voltage at even 10µM concentrations of K⁺ to mediate K⁺ uptake. This means H⁺ ions can influence pH changes and alter the voltage difference between two cells, therefore altering the flow of K⁺. Put simply, KAT1 is more of a voltage sensor rather than a K⁺ concentration sensor (Brüggemann, L. et al. 1999).

As K⁺ supply declines to become deficient, cytosolic K⁺ concentrations within the plant decline only as the vacuolar K⁺ concentrations fall below minimal value, causing a decrease rate in growth (Walker, D.; Leigh, R.;
Miller, A. 1996). It has been shown that most plants are able to maintain growth at even 10µM to 10 mM concentrations of K⁺ (Maathuis, F.J.M.; Sanders D. 1994). The purpose of this project is to determine if a lack in K⁺ will affect growth. We propose that the absence of potassium nutrient would cease growth in Capsicum frutescens.

Materials and Methods

This experiment was conducted using twenty small potted pepper plants bought at Green Thumb Nursery, El Toro, California; ten plants used as the control group and ten used as the experimental group. All plants were carefully washed at the roots using ordinary water to remove all excess soil nutrients. Once numbered for easy identification, all plants were measured in centimeters from the low end portion of the stem, excluding the roots, to the tip of the stem, excluding the leaves.

An artificial soil was created that included all macronutrients except K⁺. Various materials were used: granular 15% iron plus chelate for iron and zinc, bone meal for phosphate and calcium, blood meal for nitrogen, epsom salt for sulfur and manganese, washed sand as a filler, and pumice. Each individual container had a specific percentage of nutrients by weight volume as shown in Table 1.

<table>
<thead>
<tr>
<th>Material</th>
<th>Calcium</th>
<th>Iron</th>
<th>Sulfur</th>
<th>Nitrogen</th>
<th>Phosphate</th>
<th>Manganese</th>
<th>Zinc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Granular iron</td>
<td>1.4</td>
<td>15</td>
<td>10.5</td>
<td>0</td>
<td>0</td>
<td>0.75</td>
<td>1.5</td>
</tr>
<tr>
<td>Bone Meal</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Blood Meal</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>13</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Epsom Salt</td>
<td>0</td>
<td>0</td>
<td>13</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>10</td>
</tr>
</tbody>
</table>

To mix the appropriate soil mixture, fifty cups of the washed sand was mixed with half a cup of each container of nutrients, with the exception of using only 1/8 cup for the granular ion plus chelate. After the soil was mixed thoroughly, pumice, a volcanic ash material, was added to allow water and oxygen to circulate through the roots for nutrient absorption. A separate soil mixture was prepared exactly as the experimental group with a half cup of potash, 22% K₂O, to provide a source of K⁺ to serve as potting for the ten control plants.

Potting each plant in their respective soil, both experimental and control groups were placed in a semi shaded area with adequate sunlight exposure. Each plant was watered daily. Pictures of the plants and heights were recorded periodically. Finally, plant height was recorded after a 20 day period.

Data were interpreted using Microsoft Excel. A t-test was utilized to observe significance in our results by use of the two tailed p-value. Results were expressed as change in plant height following the twenty day period.

Results

Growing pepper plants without the presence of potassium proved to limit their growth (Table 2). Plants without potassium shrunk on average 0.075cm while the plants in the control group grew an average of 0.45cm. A t-test p value of 0.000389, which is smaller than 0.05, proves a significant difference in growth between these two groups. Average percent growth in the control group was 9.123% versus -2.211% in the experimental group.

| Table 2. Plant growth was greater in control group than experimental group. |
|-----------------------------|-----------------------------|
|                             | Experimental Group | Control Group |
| Observations                | 8                          | 10             |
| Average growth change (cm)  | -0.075                     | 0.45           |
| Growth percent change       | -2.211                     | 9.123          |
| p value ( two-tailed test of t) | 0.000389                  |

Discussion

Our hypothesis that Capsicum frutescens would not grow without potassium was proved by our experiment. On average, plants placed in soil without potassium shrunk a small amount. This goes against previous knowledge because they should have seen no growth, yet maintained their size. Still, the average amount of shrinkage in the experimental group of pepper plants was 0.075 cm, a miniscule amount.

Improving on this lab would involve a more careful oversight of our plants to ensure proper moisture and pH levels in the soil throughout the length of the experiment. It has been found that K⁺ channels may be activated by pH levels, as mentioned earlier (Brüggemann, L. et al. 1999). Day and night temperatures would also have to be strictly controlled since stomata open in the morning is chiefly due to potassium accumulation in the vacuole and cytosol pool. K⁺ concentration in the open turgid stomata in the midday drops to one third their maximal value achieved in
Effects of Temperature and pH on Enzyme Activity

Farzin Farshidi and Ali Amrollahie
Department of Biological Sciences
Saddleback College
Mission Viejo, CA 92692

Abstract
Enzymes are catalysts in living organisms’ reactions. Enzymes will attach to the substrate and speed up the reaction without changing itself. Most enzymes have an ideal condition in which they perform better. For example high temperature or low pH can break down the enzyme structure and make the enzyme nonfunctional. Peroxidase is an enzyme common to most living cells which breaks down hydrogen peroxide into oxygen and water. In this experiment the peroxidase enzymes from potato plants were studied under different temperatures and pHs. Three fermentation test tubes containing potato and acidic solution and three fermentation test tubes containing potato and neutral solution were prepared. To each test tube 5 ml of hydrogen peroxide was added and the volume of oxygen produced in each test tube was measured. The same procedure was done for another six test tubes but all the test tubes contained neutral solution and three of them were put in 25°C water bath and other three were put in 80°C. Our results show that the oxygen production was different at the pH solution of 3.13 and 7.96 (p=0.000983) and at different temperatures (p=2.56E-05). The mean value of oxygen production at a pH of 3.13 was 1.4ml, 2.3ml at a pH of 7.96, 2.2ml in 25°C and 1.1ml in 80°C. The results indicate that enzyme activity will decrease by decreasing the pH and by increasing the temperature. In high temperature and low pH, peroxidase will unfold and it can not attach to its substrate.

Introduction
In living organisms, there are many different types of reactions, which depend on biological catalysts known as enzymes. Without enzymes, biological reactions would require either high temperatures or long reaction times to occur. Enzymes carry out and help regulate most of the chemical and physical changes that occur within cells and therefore within all organisms. The substance with which the enzyme reacts is called its substrate. The substance produced at the end of an enzyme catalyzed reaction is called the product of the reaction. Enzymes will only

the morning hours. Here, K⁺ is replaced by sucrose to balance the decrease in osmotic pressure within the leaf (Pottosin, I.; Martinez-Estevez, M. 2003).

Light cycles and light intensity should also be controlled. To further refine our technique would involve a more sophisticated apparatus to create different conditions to grow our plants in. A hydroponic system using a modified Murashige and Skoog medium (Maathuis, F.J.M.; Sanders D. 1994) maintained throughout the length of the experiment would be ideal. Also, using Arabidopsis thaliana, also known as thale-cress or mouse-ear cress, would have been better since it is one of the more widely studied and well known plant species.

Our experiment fits into existing bodies of knowledge by proving that less than 10 µM to 10 mM concentrations of K⁺ is insufficient to maintain growth in Capsicum frutescens.

Literature Cited


catalyze specific reactions of certain substrates. Some enzymes will catalyze more substrates than others, but in general enzymes are so specific that they are only able to catalyze a single reaction. The reason that enzymes are so specific is that the three-dimensional structure of an enzyme gives it a very unique active site, which allows only certain substrates to join. The forces which maintain the shape of the enzyme include salt bridges, hydrogen bonds, disulfide bonds, and hydrophobic interactions. Any chemicals or temperature changes can alter these forces within the enzyme, and limit the ability of the enzyme to attach to the substrate. Most enzymes shut down beyond certain temperatures. This can happen if temperature gets too low or too high. In high temperature most of enzymes lose their specific structure and substrates cannot attach to it (Kuk et al., 2003). The effects of ion concentration and pH on the activity of an enzyme depend on the particular enzyme, but most enzymes have an optimal pH range of 6-8; there are some exception like pepsin which has an optimal pH of 2 (Sabat and Gonzalez, 2003).

Potato and other living tissue contain a peroxidase enzyme which breaks down hydrogen peroxide which is a harmful by-product of cellular respiration into water and oxygen (Ikehata et al., 2004). The rate of this reaction can be measured by measuring the volume of oxygen gas released. In this experiment the enzyme activity was studied at different pH’s and temperatures. The hypothesis is that enzyme activity will decrease by increasing the temperature and decreasing the pH.

**Materials and Methods**

**Part A-The Effects of pH on the Catalyst**

Two different solutions were made to accommodate the two pH’s needed. The first solution was prepared by placing 1 ml of HCl inside 1 L flask and filling up the rest with deionized water to 1 L mark. The second solution was made the same way as the first solution, however no acid was added. Using a pH meter, the pH’s obtained were 3.13 and 7.96. 0.5 g of potato was measured and was cut into very small pieces. The small pieces of potato were placed into fermentation test tubes. 10 ml of acidic solution was added to three of the test tubes and 10 ml of neutral solution was added to other three test tubes. After shaking each test tube for at least one minute, 5 ml of 3% hydrogen peroxide was added to each test tube. The test tubes were then stoppered. The volume of oxygen produced in each test tube was recorded every 5 minutes for total of 15 minutes.

**Part B-The Effects of Temperature on the Catalyst**

Two water baths were prepared with two different temperatures, the first at 80°C and the second at 25°C. 0.5 g of small pieces of potatoes were put into six test tubes and the test tubes were filled with 10 ml of deionized water. Three test tubes were put inside the 25°C and the other three were put inside the 80°C water bath. After 10 minutes 5 ml of 3% hydrogen peroxide was added to each test tube and the volume of oxygen produced in each test tube was recorded every 5 minutes for 15 minutes.

**Results**

Oxygen production is shown in Table 1 and Table 2. Increasing pH resulted in increased oxygen production, while increased temperature resulted in a decrease in oxygen production.

At both pH 3.13 and pH 7.96, the oxygen production increased over 15 minutes time duration. The 3.13 pH solution had an O2 production of 0.4 ml after 5 minutes, 0.9 ml after 10 minutes and 1.4 ml after 15 minutes, whereas the 7.96 pH solution had an O2 production of 0.7 ml after 5 minutes, 1.6 ml after 10 minutes and 2.3 ml after 15 minutes (Table 1).

**Table 1. Oxygen production at two different pH values**

<table>
<thead>
<tr>
<th>pH</th>
<th>O2 production after 5 min (ml)</th>
<th>O2 production after 10 min (ml)</th>
<th>O2 production after 15 min (ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.13</td>
<td>0.4</td>
<td>0.9</td>
<td>1.4</td>
</tr>
<tr>
<td>7.96</td>
<td>0.7</td>
<td>1.6</td>
<td>2.3</td>
</tr>
</tbody>
</table>

For different temperatures, the temperature 25°C solution had O2 production of 0.6 ml after 5 minutes, 1.5 ml after 10 minutes and 2.2 ml after 15 minutes whereas the solution of 80°C had an O2 production of 0.3 ml after 5 minutes, 0.7 ml after 10 minutes, and 1.1 ml after 15 minutes (Table 2). Two t-test were done one for pH of 3.13 and 7.96 and one for temperatures of 25°C and 80°C and p1=0.000983 (for pHs) and p2=2.56E-05(for temperatures) were obtained.
Table 2. Oxygen production at different temperatures

<table>
<thead>
<tr>
<th>Temperature</th>
<th>O2 production after 5 min (ml)</th>
<th>O2 production after 10 min (ml)</th>
<th>O2 production after 15 min (ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>0.6</td>
<td>1.5</td>
<td>2.2</td>
</tr>
<tr>
<td>80</td>
<td>0.3</td>
<td>0.7</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Discussion

Our results show that by increasing the pH, the oxygen production increases as well and by increasing the temperature, the oxygen production decreases, and this support our hypothesis. In this experiment oxygen production represents the enzyme activity in potato, increasing the oxygen production means more enzyme activity and decreasing oxygen production means less enzyme activity. At high temperature like 80°C most of the enzymes including this peroxidase enzyme begin to unfold (Tang et al. 2003). An enzyme’s function depends on its specific conformation. Enzymes are usually presents in their tertiary or quaternary structure. Different bonds like salt bridges, hydrogen bonds, disulfide bonds, and hydrophobic interactions help to make the complex structure of an enzyme. These bonds are relatively weak and they can be broken in high temperature or low pH, as these bonds are broken enzyme will go back to its primary structure which is not functional (Soares et al., 2003). This can clearly be seen in our result which shows less activity in high temperature and low pH.

During our experiment there could be some source of errors which has affected our results. One source of error could be that some of the oxygen released in air and it was not included in total volume of oxygen produced. Another source of error may be that in high temperatures, gas has higher volume, so the volume of oxygen production at 80°C is actually more than what it would be in 25°C.

This experiment can be improved by converting the gas volumes to mole. In order to do that, pressure of the gas need to be recorded, and by using the gas law, volume can be converted to mole.

Literature Cited


A Survey of Halophilic Bacteria in the Salt Pools of Badwater, Death Valley and in the Water Inclusion of a Halite Crystal

Danielle Bennett, Mia Luna and Yue Ting Xu

Department of Biological Sciences
Saddleback College
Mission Viejo, CA 92692

Abstract

Halophilic bacteria are typically found in salt lakes or near deep-sea hydrothermal vents, and can also survive in a dormant state in halite crystals. In this experiment, two water sources with the potential for halophilic activity were studied. Attempt to cultivate halophilic bacteria from a water inclusion in a halite crystal and a Death Valley Badwater sample, were performed. Agar plates were prepared with a standard halophile medium. The NaCl concentration of the agar was divided into three groups: 10% NaCl, 15% NaCl and 30% NaCl. Attempts were made to culture the Badwater sample on all three concentrations, while the water inclusion sample was only incubated on a 30% NaCl medium. All samples were grouped and incubated under standard (25 °C) and elevated (36 °C) temperatures. The plates were examined for bacterial growth after 72 hours incubation period. The results indicate that there were no extreme halophiles present in either sample, but that a moderate halophilic bacteria was present in the Badwater sample.

Introduction

Organisms called extremophiles are “lovers” of extreme environments within the domain, Archaea. They are divided into two kingdoms; Crenarchaeota and Euryarchaeota. The taxa Crenarchaeota consists mostly of thermophiles, which thrive in hot environments such as deep sea hydrothermal vents. Euryarchaeota contains anaerobic methanogens, which produce methane as a waste product, and salt-loving halophiles (Campbell and Reece, 2002). Halophilic (salt loving) archaea are normally found in salt lakes or near deep-sea hydrothermal vents, and they can survive in a dormant state in salt crystals. Halophiles are able to grow in saturated concentrations of NaCl (NaCl), and their growth is normally affected by the concentration of NaCl. Although bacteria and archaea represent two different domains, there is still confusion as to the proper taxonomic organization of certain organisms. Therefore, the kingdom euryarchaeota consists of a broad group of organisms including halobacteria, or halophilic bacteria.

Extreme halophilic bacteria are salt-loving bacteria that can be found in environments with elevated NaCl concentrations. Typically, halophiles have been found in bodies of water with unusually high NaCl concentrations such as lakes and salt pools. The ocean, only consisting of about 3.5% NaCl (Huntley, personal communication), is not considered high in NaCl. Organisms are considered halophiles if they grow in a concentration of at least 0.2 M (Takai et al. 2001). Most halophiles optimum growing medium is one that is nearly saturated with NaCl, approximately 35% salt (Danson, 2004).

Moreover, a recent success in the culturing of halophilic bacteria from halite water inclusions has caused a resurgence of interest in halophiles and their potential habitats (Powers et al. 2000). Halites (salt crystals), are evaporites, and thus form when a body of water that is high in NaCl evaporates. Frequently during the formation of the halite, a small droplet of saturated NaCl water becomes trapped in the halite, and is called a water inclusion. If halophilic bacteria is present in the water, this bacteria may also be trapped inside the water inclusion. The halophilic bacteria can remain dormant or in a suppressed state for an indeterminate period of time. Recently, halophilic bacteria was successfully cultured from a 250 million year old halite rock (Powers et al. 2000).

In the present experiment, extreme halophilic bacteria is sought to be cultured from a water sample originating in a salty pool, called Badwater, located in Death Valley National Park, CA. Badwater exists as a saturated solution of NaCl that ranges from a very shallow pool to a near-dry salt evaporite. Most bacteria cannot live in these extreme conditions because they cannot survive in such high salinity. The objective of this experiment is to find and culture halophilic bacteria from the two samples, and then to experiment with different concentrations of NaCl to determine the optimum concentration for growth.

Materials and Methods

Attempts were made to culture halophilic bacteria from two separate samples. The first sample obtained was from a water inclusion in a halite crystal, and the second, a salt pool sample from Badwater, Death Valley. Agar plating was performed with a standard halophile medium: 0.6 g Tryptone, 0.3 g Yeast Extract, 0.12 g Glucose, 2.4 g Agar Nutrient and 120 ml de-ionized water. The NaCl concentration in the agar was separated into three groups: 10%: 12 g NaCl, 15%: 18 g NaCl, and 30%: 36 g NaCl. The samples were held at two different temperatures, standard and elevated, (25 and 36 degrees Celsius respectively).
The Badwater sample was plated on each of the three NaCl concentrations, and incubated at both standard and elevated temperatures. The water inclusion sample was retrieved with a thin syringe and then plated on the 30% agar medium. The water inclusion sample was also incubated at both standard and elevated temperatures. Nutrient agar control plates were incubated at both 25 °C and 36 °C as well. After an incubation period of 72 hours, the plates were examined for growth. This experiment was performed at Saddleback College in April of 2004.

**Results**

The results showed that there was some type of moderate halophilic bacteria in the Badwater solution, and no extreme halophilic bacteria in the salt inclusion. When the Badwater sample was incubated at 25 °C, the nutrient agar, 15% NaCl agar, and 30% NaCl agar showed no bacterial growth. However, colonies were found in all of the 10% NaCl agars.

When incubated at 36 °C, the 15% NaCl and 30% NaCl Badwater samples had no bacterial growth. The 10% NaCl agar had growth of what appeared to be the same organism (see Table 1). Although all three of the nutrient agar plates at 36 °C showed growth of bacteria, their colonies were smaller and not completely on the streak marks. The agar plates for the water inclusion from the halite had no bacterial growth, and the agar had dehydrated.

**Table 1.** The ratio of plates with growth out of the total number of plates at each concentration and temperature for the two samples.

<table>
<thead>
<tr>
<th>Sample Source</th>
<th>Medium</th>
<th>Ratio of Plates with Growth at each Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>25°C</td>
</tr>
<tr>
<td><strong>Badwater</strong></td>
<td>Nutrient Agar</td>
<td>0/3</td>
</tr>
<tr>
<td></td>
<td>10% NaCl</td>
<td>4/4</td>
</tr>
<tr>
<td></td>
<td>5% NaCl</td>
<td>0/4</td>
</tr>
<tr>
<td></td>
<td>30% NaCl</td>
<td>0/1</td>
</tr>
<tr>
<td><strong>Water Inclusion</strong></td>
<td>30% NaCl</td>
<td>0/3</td>
</tr>
</tbody>
</table>

**Discussion**

The results indicate that no extreme halophiles were present in either sample, but that a NaCl tolerant organism (a moderate halophile) was present in the 10% NaCl-concentrated Badwater sample. The optimum growing medium for extreme halophiles is approximately 35% NaCl (Danson, 2004). Neither water sample at 30% NaCl agar exhibited growth, demonstrating that no extreme halophilic bacteria were present. Moderate halophiles appear to be present in the Badwater sample, as evidenced by their growth at 10% NaCl.

Several reasons may have affected the growth of halophiles on the 30% NaCl agar medium. Most importantly, the high salinity of the agar caused it to dehydrate and crystallize, which may have adversely affected the halophilic growth. Also, many halophiles are moderate, meaning their optimum growing medium is 5-15% NaCl. Often, moderate halophiles will not grow at concentrations greater than 15%. Therefore, the absence of growth on the 30% NaCl medium, but growth on 10% NaCl is consistent with moderate halophile growth.

Similarly, the absence of growth in the 15% NaCl medium could be explained by the inability of moderate halophilic bacteria to withstand such high concentrations of NaCl. Because some bacteria appeared to grow on the nutrient agar plates that appeared to be the same organism found on the 10% NaCl plates, it can be deduced that the optimal threshold for the growth of this particular bacteria is somewhere between 0-10% NaCl. Further, because there were more colonies and larger sized colonies on the 10% NaCl medium than the nutrient agar, the organism appears to benefit from NaCl.

Bacterial growth from the Badwater sample at both temperatures was present in the 10% NaCl medium, yet absent in the nutrient agar at 25 °C. This inconsistent growth may be due to unevenly distributed bacteria in the water sample. The sample on the streak plate did not represent the entire population of bacteria in Badwater. Therefore, it is possible that a non-representative sample was used to streak the nutrient agar plate. Moreover, some colonies on the nutrient agar at 36 °C did not grow on the streaking lines. This is an atypical growth pattern, which may indicate that contaminants were present.

Further studies may include using different techniques for culturing bacteria. For example, a spread plate would allow for more bacteria to be represented from the Badwater sample. Also, halophiles are normally very colorful, and the water inclusion in the halite crystal in this experiment was not brightly colored. Extractions of water inclusions should be performed on a halite crystal that is slightly colored, which is indicative of halophilic presence.
In addition, further identification of the organisms on the agar and 10% NaCl medium could be performed with gram staining.

**Literature Cited**


**Listerine®: The Antiseptic Effects on Oral Bacteria Concentration**

Michelle Thomsen and Denise D. Tirrell

*Department of Biological Sciences*
*Saddleback College*
*Mission Viejo, California 92692*

**Abstract**

The human mouth is teeming with a diverse population of bacteria. Several products have been developed to diminish the presence of these bacterial inhabitants. The oldest of these bacterial combatants is Listerine®, first introduced over the counter in 1914. This study challenges the claim put forth by Listerine® that it “Kills germs that cause bad breath, plaque, and the gum disease gingivitis.” Observing the products alcohol content of 21.6%, it is hypothesized that their claim is valid and will significantly reduce bacteria. Using serial dilutions, a concentrated saliva sample, a 1/100 dilution, and a 1/10,000 dilution of the same concentrated saliva sample were plated on blood agar and incubated at 37°C for 24 hours. The bacterial colonies were then counted, the dilution considered. The combined average of the bacterial flora in the subjects’ mouth before using Listerine® was 17.35 million colonies. After using Listerine® to cleanse the oral cavity, the bacterial count was reduced to 0.9 million colonies, a reduction of 94.81%. A p-value of 0.206 resulted, far exceeding the alpha value of 0.05, concluding that there was not a significant reduction. Based on the statistical data, Listerine® has antibacterial properties, however further experimentation utilizing a larger sample size needs to be conducted to test for a more accurate conclusion of significance.

**Introduction**

Unseen to the naked eye, a tiny microscopic world co-exists with the macroscopic world. The observed effects of this intersection can be both beneficial and detrimental. Bacteria, the citizens of this microscopic world interact with each other, often forging affiliations with larger eukaryotic organisms. Some of these affiliations are mutually symbiotic relationships benefiting both bacteria and host; however there are examples of pathogenic relationships as well. The human mouth is a microbial niche to more than 500 bacterial strains which interact amongst themselves and their host (Kroes et al, 1999). While most of these bacterial strains are asymptomatic in humans, some strains such as *Mutans streptococci* have an adverse effect on the health of the host (White et al, 2004). Translocation of oral bacteria to other body regions may have deleterious effects like nosocomial pneumonia (Houston et al, 2002).
Coaggregation occurs between genetically distinct strains of oral bacteria forming a biofilm that coats the oral cavity surface (Foster et al, 2003). Principle surfaces of concern are the teeth, mucosal epithelial cells, and the nascent surface (surfaces coated with bacteria) (Kolenbrander et al, 1996). Dental plaque, commonly referred to as “plaque”, is a nascent biofilm that is formed by bacteria adhering to the pre-existing bacterial coating on the tooth surface (Kolenbrander et al, 1996). Plaque is known to play a role in tooth decay and periodontal disease, (Slavkin, 1997) and is also recognized as a root cause of oral malodor (bad breath) (Loesche, 2003). About a quarter of the American population is estimated to have chronic bad breath (American Dental Association, 2003).

Mechanical means such as brushing the teeth, flossing, tongue brushing and mouthwashes are the most commonly prescribed methods to combat tooth decay and bad breath (White et al, 2004). While mouthwashes are used primarily for cosmetic purposes, studies have shown that they have some therapeutic properties as well (Fischman, 1998). In 1914 Listerine® became the first over-the-counter mouthwash, promising relief to bad breath sufferers everywhere. Pfizer, the manufacturer of Listerine® claims that their product kills oral bacteria that cause gingivitis and bad breath (Pfizer, 2004). Two types of mouthwashes dominate the market: essential oil mouthwashes and chlorhexidine mouthwashes (Santos, 2003). Each type boasts a product that has received the American Dental Association Seal of Acceptance: Listerine® (essential oils) and Peridex® (chlorhexidine) (Mandel 1994). Essential oil mouthwashes are preferred over chlorhexidine mouthwashes because chlorhexidine mouthwashes can cause staining on the teeth and tongue (Santos, 2003). Listerine® destroys bacterial cell walls, inhibiting bacterial enzymes and extracting endotoxins from gram-negative bacteria (Mandel, 1994). Another benefit to essential oil mouthwashes is that bacteria do not develop a resistance to the essential oil mechanisms (Fischman, 1998).

The focus of this study is to assess the validity of the claim put forth by Pfizer in its marketing campaign for Listerine® mouthwash. Listerine® claims to “Kill germs that cause bad breath, plaque and the gum infection Gingivitis” (Pfizer, 2004). Alcohol comprises 21.6% of the Listerine® solution, so based upon this information alone it is hypothesized that bacterial concentration will be significantly reduced in the oral cavity.

**Methods and Materials**

This study was conducted on the campus of Saddleback College and took place in the months of February and March 2004. Saliva samples were obtained from Denise Tirrell (hereafter referred to as subject 1) and Michelle Thomsen (hereafter referred to as subject 2) for the purpose of comparing bacteria concentration before and after rinsing their mouths with the essential oil mouthwash, Listerine®. To obtain the bacterial count present before rinsing with Listerine®, subjects rinsed their mouths with 10 mL of 0.85% sterile saline solution (Figure 1). The saline was then vigorously swished for thirty seconds and then discharged into a sterile cup. One milliliter (1 mL) of the oral discharge was then pipetted into 100 mL of sterile 0.85% Saline solution creating a 0.01 mL dilution. From this first dilution, 1 mL was pipetted into a second 100 mL bottle of 0.85% sterile saline resulting in a 0.0001 mL dilution. A 0.1 mL fraction of the original saliva sample and the two dilutes were then plated on petri dishes containing Tryptic-Soy Agarose with 5% sheep blood (Figure 2). A total of twenty (20) such plates were purchased from MacNan Biological Supply Company headquartered in Birmingham, Alabama (Figure 2). Each plate was then allowed to incubate for 24 hours at 37°C. The bacteria were then counted on the plate that resulted in less then 300 bacterial colonies, the dilution being held into account. To get the post-Listerine® bacterial count, the same procedure was employed however the procedure was preceded by the following steps: Both subjects first rinsed with 20 mL of Freshburst Listerine® (Figure 3) for thirty seconds, adhering to the directions on the bottle of the antiseptic product, and subsequently discarding the solution. The specific bottle of Freshburst Listerine® used in this study was purchased at Savon Drugstore located at 25272 Marguerite Pkwy., Mission Viejo, CA  92692. Sixty seconds after spitting out the Listerine®, 10 mL of 0.85% sterile saline was once again gurgled with for 30 seconds and the same steps again taken to dilute, plate, and count the bacteria. A total of four plates were analyzed (n=2 for subject 1 and n=2 for subject 2) for a total replication value of n=4. Microsoft Excel was used to conduct a one-tailed t-test to determine whether the difference was significant, indicated by a p-value less than the alpha value of 0.05.
Results

Subject 1 had a pre-Listerine® bacterial count of 29.8 million bacteria. Analysis of bacterial counts after Listerine® yielded 1.2 million colonies. This calculates to a 95.98% reduction in bacterial colonies. Subject 2 had a bacterial count of 4.9 million colonies before rinsing with Listerine®. After an oral flush with Listerine®, subject 2 had a bacterial count of 0.6 million colonies (Figure 4). This equates to an 87.76% diminution of oral bacterial colonies. The combined average of subject 1 and subject 2 yielded a 17.35 million colony count before rinsing with Listerine®, and 0.9 million colony count after. This provides evidence of a 94.81% average reduction produced by the Listerine® mouth wash. A one tailed t-test was utilized to check for a significant difference however, a p-value of 0.206 was produced. This is far higher then the alpha value of 0.05 indicating that the difference produced by Listerine® is not statistically significant. However, the t-test is a statistical tool based upon probabilities. With such a small sample size (n=4), it is virtually impossible to use the t-test tool accurately. When working with probabilities, sample size is of paramount importance. For example, to determine the precise frequency of flipping “heads” and “tails” on a coin, the coin must be flipped many times. The small sample size used in this study is analogous of not flipping the coin enough. A much larger sample size is required to sufficiently apply the t-test statistical tool to determine significance. Bacterial colony counts were counted as precisely as possible, but human error must be considered when considering the accuracy of these counts.

Discussion

The efficacies of antiseptic mouthwashes are an important topic in research and development departments in both the medical and health/beauty care industries. The reduction of bacterial colonies in the oral cavity, as confirmed in this study, is beneficial in terms of both health and social etiquette. The normal oral flora can play a role in carcinogenesis and is believed to harbor parasitic pathogens. For these two reasons alone, an effective weapon against oral bacteria has remained a focus of many clinical trials (Kroes et al, 1999). Mouthwashes like Listerine® are one such suggested weapon offered by the pharmaceutical industry. The observed 94.81% average reduction of bacterial concentration after rinsing with the essential oil mouthwash, Listerine® confirms the antibacterial power of this particular mouthwash. While essential oil mouthwashes like Listerine® are not as effective as chlorhexidine products, studies have proven them to be more beneficial than not using a mouthwash at all (Brecx et al, 1992). The extremely small sample size used for this study inhibits accurate statistical analysis as observed by the rather high p-value of 0.206 indicating an insignificant reduction. For this reason it is helpful to look at the results of external studies incorporating higher sample sizes to infer consequences. Other studies have
shown that Listerine® can reduce plaque accumulation and the severity of Gingivitis by up to 34% (Fischman, 1998).

The recent correlation drawn between oral bacteria and cardiovascular disease has prompted researchers to seriously consider the systemic effects of oral bacteria. These studies also probe the clinical relevancy of available mouthrinses efficacy and how they may be used to reduce the risk of cardiovascular disease (Whitaker et al, 2000).

Some researchers have taken the angle of using mouthwashes as a preventive measure against disease. Patients undergoing heart surgery are prone to pneumonia contracted through the hospital environment (nosocomial pneumonia). A major cause of nosocomial pneumonia is the aspiration of oral bacteria. Studies have shown that patients treated with antibacterial mouthrinses such as Listerine® are less likely to develop nosocomial pneumonia (Whitaker et al, 2002). In the dental industry, mouthrinses are replacing distilled water as a sanitizer of closed-circuit waterlines. These waterlines are susceptible to developing microbial biofilms on their interior surface, threatening contamination. Studies have shown a reduction of these biofilms, when waterlines are rinsed with antimicrobial agents such as Listerine® (Kettering et al, 2002). The future of mouthwash research holds further promising advances in preventive medicine. As bacteria become more and more resistant to antibiotic treatments, researchers are turning to genetic recombination technology to counter this resistance. It is not far-fetched to imagine a futuristic mouthwash that uses recombinant technology to target periodontal disease-causing bacteria (Larkin, 2001).

The dramatic reduction of oral bacteria observed in this study and others has clearly illustrated that rinsing with an oral rinse is a beneficial addition to any existing oral hygiene regimen. Benefits include the pacification of halitosis symptoms, plaque reduction, prevention of periodontal disease and a reduced risk of cardiovascular disease. Although Freshburst Listerine® mouthwash is an over-the-counter mouthwash, care must be exercised. Due to the relatively high alcohol content of 21.6%, Listerine® can inhibit or enhance the affects of other medications (Weathermon et al, 1999). It is always advised to strictly follow the written instructions on the product’s label when administering.

Acknowledgements
The authors wish to thank Kathleen Cannon and Dr. Ruth Wrightsman, of the Saddleback College Biology Department, for their guidance and assistance throughout the course of this study.

Literature Cited


**The Effect of Red Bull and Gatorade on Blood Pressure**

Sahar Iranipour and Sanam Salour  
*Department of Biological Sciences*  
*Saddleback College*  
*Mission Viejo, CA 92692*

**Abstract**

Blood pressure is essential in regulating the heart and maintaining the overall health of the body. Countless factors can work to fluctuate blood pressure such as physical well-being and outside forces. In this experiment the effect of Red Bull and Gatorade on blood pressure was measured. It was hypothesized that both energy drinks will increase blood pressure, yet Red Bull will have a greater effect. Fifty *Homo sapiens* individual’s blood pressure was taken before drinking Gatorade and then taken ten minutes after they consumed six fluid ounces of the liquid. The same procedure was repeated the following day for the Red Bull. The data was obtained and the blood pressure was expressed in terms of mean arterial pressure. The mean arterial pressure before drinking Gatorade was 89.20 mm Hg and after drinking was 89.67 mm Hg. Whereas the mean arterial pressure before drinking Red Bull was 87.86 mm Hg and after drinking was 89.82 mm Hg. After completing a one-tail t-test for both drinks, Gatorade had a value of 0.3099, while Red Bull had a value of 0.03156. The results show that Gatorade has no substantial effect on blood pressure, while Red Bull increases blood pressure. The reason for this may be because Red Bull contains caffeine, which increases blood pressure, while Gatorade lacks the substance.

**Introduction**

Blood pressure is a pressure of blood in the arteries, which are blood vessel that carry blood from the heart to the rest of the body. During its rhythmic cycle, the heart relaxes, which refer to as diastolic. In the relaxation phase the atria and ventricles are both in diastole having blood flow into atria and ventricles. The blood would then contract and force the remaining blood from the atria into ventricles and this contraction is referring to as atrial systole. The next step of heart contraction is when ventricular systole pumps blood into the larger arteries of the body. Blood pressure is expressed as systolic pressure over diastolic pressure and is measured in millimeter of mercury (mm Hg).
The normal blood pressure range of systolic is 100 mm Hg-140 mm Hg and for diastolic is 60 mm Hg-90 mm Hg (Harrigan, 2004).

It is important to maintain a normal blood pressure, because the consequences of either higher or lower blood pressure can be very severe. High blood pressure also called hypertension, is defined as blood pressure greater than or equal to 140 mm Hg systolic pressure and greater than or equal to 90 mm Hg diastolic pressure (Anonymous, 2004). There are two types of high blood pressure; one is secondary hypertension which means there is an underlying cause of their high blood pressure such as problems with kidney or adrenal gland. The other type is essential hypertension meaning there is no definite cause for hypertension. Vasoconstriction occurs, which is when small blood vessels in the body narrow and causes blood pressure to build up (Anonymous, 2004). Low blood pressure is defined as blood pressure less than or equal to 100 mm Hg systolic pressure and less than or equal to 60 mm Hg diastolic pressure. Low blood pressure is caused by numerous factors, such as heart condition like arrhythmias or congenital heart failure, asthma, pneumonia, hypoxia and dehydration (Brochert, 2003).

Energy drinks such as Red Bull are used to boost alertness, stamina and are known to have an impact on blood pressure (Kendall, 2001). Red Bull contains 80 mg of caffeine, which is an equivalent of cup of coffee (Anonymous, 2003). Some studies have found that people who consume caffeine regularly throughout the day have a higher average blood pressure than those consume none (Warner, 2002). Researchers believe that the cause of this is due to caffeine’s ability to increase the stiffness of the arteries. Caffeine works to narrow blood vessel by blocking the effect of adenosine, a hormone that helps keep them widen. Other influential contents of Red Bull include ephedrine and amphetamine-like substances which causes high blood pressure, increasing heart rate, and insomnia. It also contains, salt, which rises blood pressure, and taurin, an amino acid that works to boost physical and mental performance (Kendall, 2001).

Sport drinks such as Gatorade is known to replace the fluid and the electrolytes that were lost during vigorous exercise. Gatorade contains carbohydrates and sodium for endurance exercise (Kendall, 2001). Gatorade uses high amounts of sodium in order to stimulate thirst so athletes will drink more and stay better hydrated (Clark, 1999). Yet Gatorade is like any other sugar-based drink and is loaded with sodium that can raise the blood pressure.

An experiment was conducted to see how energy drinks such as Gatorade and Red Bull effect blood pressure. It was hypothesized that both Gatorade and Red Bull will have an increased effect on blood pressure, yet Red Bull will have a greater increase than Gatorade.

**Materials and Methods**

Fifty human subjects first completed a questionnaire that asked the following: whether they are a smoker or non-smoker, what they ate an hour before the experiment and current stress level. Their blood pressure was then taken using a sphygmomanometer. Each individual drank six fluid ounces of Gatorade. After ten minutes their blood pressure was once again measured and recorded. The following day the same procedure was performed on the same individuals yet with six fluid ounces of Red Bull instead of Gatorade. Using the mean arterial pressure equation: MAP = D.P. + 1/3 (S.P. – D.P.) the blood pressure data was calculated. Once the data were compiled a paired t-test was used for statistical comparison, p ≤ 0.05 was considered the statistical difference.

**Results**

Fifty different individual’s blood pressure was measured before and after drinking both Red Bull and Gatorade and the mean arterial pressure for each individual was calculated. Based on the data collected before and after drinking Gatorade there was no significant difference in the blood pressure. Before drinking Gatorade the mean value was 89.20 mm Hg while after drinking the mean value was 89.67 mm Hg (Table 1). The one-tail t-test value which is 0.3099 is greater than p ≤ 0.05 indicating that there is no significant change in blood pressure (Table 1).

<table>
<thead>
<tr>
<th>Gatorade</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (mm Hg)</td>
<td>89.20</td>
<td>89.67</td>
</tr>
<tr>
<td>Observation</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>p value (one-tailed test of t)</td>
<td>0.31</td>
<td></td>
</tr>
</tbody>
</table>

However the data collected before and after drinking Red Bull showed that there was a significant increase in the blood pressure. Before drinking Red Bull the mean value was 87.86 mm Hg and after drinking was 89.82 mm Hg (Table 2). The one-tail t-test value, which is 0.03156, is less than p ≤ 0.05 indicating a significant difference in the blood pressure (Table 2). Based on the graph Red Bull exhibits a greater increase in the level of blood pressure (Figure 1).
Table 2. Mean arterial pressure of individual drinking Red Bull.

<table>
<thead>
<tr>
<th></th>
<th>Red Bull</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (mm Hg)</td>
<td>87.86</td>
<td>89.82</td>
<td></td>
</tr>
<tr>
<td>Observation</td>
<td>50</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>p value(one-tailed test of t)</td>
<td>0.03</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Discussion

Based on the results Gatorade does not affect blood pressure whereas Red Bull had an increased effect on blood pressure. One factor that could be responsible for Gatorade’s inability to increase blood pressure is salt. In general salt has a direct effect on blood pressure (Clark, 1999). However the amount of salt contained in Gatorade is only a fraction of what the body needs to consume per day. Gatorade contains 83 mg of sodium per 6 fluid ounces, yet the ideal daily intake of salt is 10 to 12 grams (Kendall, 2001). Another key difference between Gatorade and Red Bull is the presence of caffeine in Red Bull. Caffeine is a major factor that influences the rise in blood pressure (Anonymous, 2004). The absence of caffeine in Gatorade suggests why there was no significant difference in blood pressure.

There were several sources of error that were introduced in the experiment that may have swayed the outcome. The amount of fluid taken by each individual could have been insufficient in order to obtain proper results. Another important factor that influenced the results was the fact that the questionnaire was not extensive enough. It lacked questions involving whether the individual is currently on any medication or if they have a history of hypertension in their family. The results that were obtained could have been caused by these factors or other influences included in the questionnaire not solely by the drink itself. Although Red Bull showed an increase in blood pressure many of the individuals tested had medium to high stress levels that could have manipulated the results. Also many of the participants were smokers which could have played a role in the outcome. Another variable that kept the experiment from being controlled was that many of the individuals tested had already consumed high amounts of sodium and caffeine in their food or drink prior to the testing. If there had been an increase in the blood pressure it could have been due to what they had previously ate or drank rather than the energy drinks that were provided.

Literature Cited


Protein Supplements and Skeletal Muscle Gain in *Mus musculus*

Matthew J. Griffin and Nam-Kim G. Tu  
Department of Biological Sciences  
Saddleback College  
Mission Viejo, CA 92692

Abstract

Many companies produce protein supplements in the forms of ready-mix shake powders, snack bars, gels, and capsules. The proposed effects of these protein supplements include increasing muscle bulk, endurance, and body mass. Through the process of strenuous exercise (“working out”), skeletal muscle is torn and subsequently rebuilt into a stronger and larger form. Protein plays a vital role in the production and function of skeletal muscle. Ingested protein undergoes protein degradation into free amino acids via the proteosome degradation pathway. Therefore, if an ample supply of amino acids is available for protein synthesis then the production of new muscle tissue will be more efficient. This experiment set out to prove or disprove the claims made by the protein manufacturers by studying the effects of protein supplements on *Mus musculus*.

To verify this hypothesis, two groups of seven mice were used, one being given pure water and the other a mixed liquid with a whey protein supplement for a period of seven days. A weight difference was obtained for each mouse to determine the individual weight gained during the experiment. The t-test results suggest no significant difference with significant difference set at 95%. The experimental group gained an average of 3.62g and the control group gained an average of 2.84g. Lack of strenuous exercise, the weight loss effects of a high protein diet and relatively short experimental period are possible explanations for a rejection of the hypothesis. Further experiments on a larger scale and longer time period should be conducted to gain another perspective on this experiment.

Introduction

In today’s public consciousness about fitness and health, protein supplements available at neighborhood nutrition stores promise enhanced strength and muscle gain when accompanied by exercise and proper diet (McCaffree, 2002). The common supplements are in powder form and mixed accordingly with water and taken orally prior to an anticipated workout (Greenwood et al., 2003). Increased intake of protein and increased muscle mass seem to go hand in hand in the views of the public, so much so that 81% of polled athletes believed this to be true (Kahanov et. al., 2002). With so much hype surrounding these products, a scientific micro study was performed to verify or cast doubt on these claims.

The science behind high protein intake lies in that the body utilizes the amino acids obtained from digested proteins to remanufacture them into new and different proteins for vital functions within the body. This entails the proteasome degradation of ubiquin-tagged proteins and reabsorption of free amino acids into the lumen of the intestine and subsequent distribution into the blood stream for various tissues to absorb. In a way, the entire human body, and any living thing for that matter, is just a massive network of proteins providing chemical catalysts, structural support and chemical signaling. In fact proteins play a major role in the regulation of energy balance and overall health (Anderson and Moore, 2004). Out of the twenty amino acids that are combined to make the larger protein chains, eleven amino acids are strictly obtained from digested proteins and are unsynthesizable by the body from other molecules.

The link between muscle production and protein stems from the basic point of “working out” such as lifting weights and resistance training. When muscles are strenuously worked they partially degrade (tear or rip) during strenuous contraction and retraction (Zachwieja and Yarasheski, 1999). The torn muscle will rebuild itself into a larger tissue capable of more strength, and muscle gain is obtained. The rebuilding process involves the production of more skeletal muscle tissue and thus, more cells. These new cells require an optimal amount of protein, synthesized from amino acids, to function and form properly. High protein diets insure decreased muscle protein loss as well as increased thermogenesis (Baum and Layman, 2004). In essence, the addition of protein prior to work...
out should theoretically maximize the results obtained from working out due to an optimal amount of amino acids available to properly form new muscle cells and ultimately, new muscle mass and increased body weight. To quantitatively verify this hypothesis, common laboratory white mice, *Mus musculus*, were provided with a steady amount of top of the line whey protein supplement, boasting 97% protein content. A profound increase in weight of the experimental group over the control group would verify the increase in muscle/body mass. It is critical to point out an area of some confusion. The study was performed with protein and exercise in an attempt to boost the animal’s muscle content and weight of the animal. However, high protein/low carbohydrate diets are very popular today as a means of loosing body weight by decreasing intake of fat, simple carbohydrates, and sugar with a counter balance of increasing protein. The goal here is to maximize the efficiency of the body and only take in enough energy that will be directly utilized. However, both high fat and high protein diets pose serious health risks (Anderson and Moore, 2004).

**Materials and Methods**

The experiment was conducted over a time period of seven days. Fourteen *Mus musculus* were used, seven in the experimental group and seven in the control group. An initial mass was obtained for each mouse and a nontoxic marker was used to identify each mouse by marking the tails. The two groups were separated into two separate housing containers and given both given the same hard diet of assorted nuts and grains. The experimental group was given a mixed liquid of two scoops of whey protein supplement (approximately 35 grams) to 300 ml of water. The control was given normal tap water. Both the hard food and either protein liquid (experimental group) or water (control) was replenished upon exhaustion throughout the seven day experimental period. Both groups were housed in a temperature controlled climate of 25 °C. Wastes were properly disposed of by frequently changing the shredded paper. In addition, observations on behavior and eating habits were taken continuously throughout the experiment. These observations were used as supplemental information to further analyze and support the results. On the seventh day, both groups were reweighed and their final masses recorded according to the specific mouse.

The difference between the initial mass and the final mass was determined to be the mass gained during the experiment. A t-test assuming unequal variances for the weight loss/gain amount for the experimental group and the control group were run on Microsoft’s Excel program. The experimentally significant difference was set at 0.95.

**Results**

Both the control mice and experimental mice had an overall weight gain. However, the mice fed high-protein supplements experienced a greater mean weight gain than the control mice. The control group’s initial average weight was 20.612g and the post-experiment average weight was 23.459g. The experimental group’s initial average weight was 18.846g and the post-experiment average weight was 22.470g (Figure 1). Although the mice with a high-protein diet began and ended with lower average weights compared to the control group, the average weight gain was greater for the experimental mice. The average weight increase for the mice on a high-protein diet was 3.625g, while the average weight increase for the control mice was 2.847g.

![Figure 1](image-url)  
**Figure 1.** Average weight of the experimental group and control group initial to the experiment and post-experiment.
Although the experimental group showed a greater increase in weight gain over the control group, statistical analysis showed no significant difference between the two. Table 1 shows that the calculated one-tailed p-value of 0.0957 is greater than the 0.05 level of significance.

Table 1. The average weight gain for the two groups of *Mus musculus* and the calculated p-value.

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Protein-Rich Diet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>2.85 g</td>
<td>3.62 g</td>
</tr>
<tr>
<td>Sample size</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>P(T&lt;=t) one-tail</td>
<td>0.096</td>
<td></td>
</tr>
</tbody>
</table>

Supplementary results also show that overall the experimental group ate more food than the control group. On day one and two of the experimental period, the control group consumed approximately 100g of food and 300 ml of water each day, while the experimental group consumed approximately 100 g and 150 ml of protein supplement each day. However, on days three through seven, the control mice decreased their intake to approximately 50g of food and 300 ml of water each day, while the experimental mice increased to approximately 200g of food and approximately 600 ml of protein supplement each day.

The calculated p-value showed no difference between mice who had high-protein diets and those who did not. Although the seven individual mice had a mean weight increase greater than those seven individual mice that had a normal diet, the overall results provide evidence of no significance between the two.

**Discussion**

The experiment aimed to test the effects of increased amino acid abundance and muscle gain. By supplying a protein source in the water from a whey protein supplement, the *Mus musculus* was expected to increase its muscle mass due to a variety of new amino acids from the freshly degraded protein. The increased muscle mass, and consequently increased body weight, would be the result of the ability of the mouse’s skeletal muscle to rapidly rebuild muscle cells damaged from exercise with proteins synthesized from the free amino acids derived from the supplement (Scott, 2003).

Although the results indicate that there is no significant difference in the weight gain between the experimental group and the control group, the relatively low p-value of 0.095 indicates that there is somewhat of a large difference in the two data sets. This p-value would make the experiment significant on a 90% significant difference scale. Interestingly enough, both groups gained weight, possibly due to the underfed status from the pet store or the growing bodies of the adolescent mice. The average mass increase over the seven days for the seven control mice was 2.85g and the average mass increase of the seven experimental group mice was 3.62g with an increase of 0.77g on average over the control. The experimental group had a 3% increase in body mass of the experimental group.

Perhaps the experiment was ended prematurely or not enough physical exercise was done by the mice to cause the full effects of the protein supplement. Clearly, although statistically insignificant, there is some correlation between the protein supplement and increased weight gain over the control. There may also be a correlation between high-protein diets and appetite. Observations showed an increase in food intake with the experimental group. In the absence of strenuous exercise, the source of this weight gain can be somewhat shrouded. Since any macromolecule (protein, carbohydrate, lipid) can be inter-converted to other forms, it is at least possible that the excess amino acids could have been converted to either a glycogen or lipid form for more compact energy storage by various pathways (Cunningham and Marcason, 2001). This would also result in weight gain as well.

The experiment is not completely conclusive in one-way or the other. It suggests a possible link between whey protein supplement and increased muscle mass. For a more conclusive and definite answer, a larger scale experiment should be conducted using an experimental and control group population of at least twenty-five mice. In addition, the experimental time should be increased to a few months for a larger difference in body mass to be obtained. Also, the input of food and output of waste products should be more closely monitored, especially before initial and final weight recordings of the mice. Lastly, mice at full maturity should be used to eliminate adolescent growth spurts from skewing the data. Further experimentation must be done in order to fully analyze the effects of high-protein supplements on weight gain and appetite in mice.
Transpiration Rate in Monocots and Dicots

Melody Asgari, Shabnam Majidian Azar, and Gisele Fassino  
Department of Biological Sciences  
Saddleback College  
Mission Viejo, CA 92692

Abstract

Land plants must absorb a certain amount of water and be able to obtain that water in order to survive. Different types of plants may absorb water at different rates in order to adapt to their environment. Transpiration is the water that is lost in these plants. During photosynthesis, plants transport water in xylem elements from the roots to the leaves of the plant. This is possible due to open stomates that allow for the exchange of oxygen and carbon dioxide. However, open stomates also allow for water loss. Water is pulled from the roots to the leaves due to the adhesion-cohesion transpiration that occurs in the xylem. In this experiment, plant transpiration was measured in both monocot and dicot plants using Asiatic lilies and chrysanthemums in diluted blue dye for one hour. This was conducted in order to measure the distance traveled of the dye and either support or disprove the hypothesis that monocot angiosperms have a higher transpiration rate than dicot angiosperms. The transpiration in lilies was compared to the transpiration in chrysanthemums using the t-test for unequal variances. The results supported the hypothesis that monocots transported water more quickly (p = 0.0080).

Introduction

Vascular plants possess tissues that are specifically assigned for efficient water and solute transport. Examples of vascular plants include ferns, gymnosperms, such as conifers, and angiosperms. Angiosperms, flowering plants, are the most common plants on land (Arens et al, 2003). This group is divided into monocots, such as grasses and corn, and dicots, such as oak, roses, and beans. In vascular plants the upward movement of water from the roots to stems and leaves occurs through xylem tissue.

The cohesion theory, or transpiration theory, postulated in the early 1800’s supported the theory that water is pulled up by the xylem from the roots and surrounding soil due to transpiration (anonymous, 1999). There is a large loss of water from plants by evaporation due to the opening of stomata on the surface leaves during the day to provide Co2 for photosynthesis. Upon the opening of stomata, there is an evaporating loss of water from the plant through the stomata opening. This evaporative loss of water, called transpiration, generates an osmotic potential,
which sucks the water out of the surrounding xylem tissue to replace the water lost by evaporation. The water molecules moving out of the xylem must pull the adjacent water molecules. This pulling effect will extend from the top of the tree to the roots. The theory is that there is a cohesive molecular force between water molecules that allows the molecules to be pulled upward from the roots. This cohesive force is due to the hydrogen bonding between the individual water molecules (Anonymous, 1999).

Essential for survival, land plants living in various environments have developed structural and/or physiological adaptations to cope with balancing water uptake and loss.

Once water is made available, it is absorbed by the roots of a plant and transported upward from the roots to the shoot as xylem sap. Transpiration (primarily through stomata) creates a force within the leaves that pulls the xylem sap upward (Koch et al, 2004). Plants lose an astonishing amount of water by transpiration, and unless the water loss is replaced by water transported in the xylem, leaves wilt and eventually die.

The driving force that allows for the xylem sap to move upward to the leaves and against gravity is the result of the transpiration-cohesion-tension mechanism. In addition to transpiration providing the pulling force, the cohesion of water due to hydrogen bonding transmits the upward pull along the entire length of the xylem (Koch et al, 2004). In a closer look at the xylem themselves, they are one of two types of vascular tissue, the other being phloem, that are found continuous throughout a plant. The water conducting elements of xylem are the tracheids and vessel elements. Tracheids are spindle-shaped cells with pits through which water flows from cell to cell, and vessel elements are linked together end to end, forming long tubes, or xylem vessels (McArthur and Rice, 2004).

As crucial members in the active transport of water throughout a plant, the xylem tissue can be located, and its particular arrangements in the plant body itself identified. Although common to all angiosperms, the xylem tissue in a monocot and dicot is arranged uniquely in each (Arens et al, 2003). Xylem tissue (part of the vascular tissue) is complexly arranged in no particular order in monocots, and in dicots is arranged in a ring towards the outside edges of the shoot (Balschweid et al, 2002). The question we now seek to answer is that although providing the same function, can this different arrangement of vascular bundles alter the distance of water uptake and ultimately the transpiration rate of a plant?

The purpose of the present experiment was to compare the distance of water traveled when allowed to transpire for a controlled amount of time between a monocot and dicot angiosperm, using *Asiatic lilies* (monocot) and *Chrysanthemums* (dicot), and to determine whether their arrangements of vascular bundles has an impact on this distance. With the knowledge of the above information regarding monocot and dicot angiosperms, it is assumed that monocot angiosperms have a higher transpiration rate than dicot angiosperms until disproved.

**Materials and Methods**

In this study, plant transpiration was measured in both monocot and dicot plants. Ten lily flowers and ten daisy flowers were obtained from a florist shop in Laguna Niguel, CA. The bottom 3 cm of each stalk was cut underwater with scissors and then discarded. As each stalk was cut, it was quickly transferred into an individual plastic cup containing 0.5% methylene blue dye diluted in water obtained from Saddleback College, CA. All twenty flowers were then placed in a light but shaded spot (Figure 1 and 2) for 60 minutes under constant conditions.

![Figure 1. Daisy (Chrysanthemums)](image1)

![Figure 2. Lily (Asiatic lilies)](image2)
These measurements were made on April 24, 2004 between the hours of 1300 and 1600. The experiment was conducted in Mission Viejo, CA. No knowledge of how old the plants were was obtained. After 60 minutes, each stalk was cut at 1 cm intervals using a knife and ruler to determine how far the dye had traveled.

The data were encoded into an Excel file and the statistical analysis were found by using the Microsoft Excel program. In this analysis, the monocot angiosperms had a greater transpiration rate than dicot angiosperms. The monocot transported water more quickly to its leaves and the location of xylem vessels in each plant was determined. The transpiration in lilies was compared to the transpiration in daises using the t-test for unequal variances ($p < 0.05$).

### Results

The mean rate for the dicot was 5.3 cm/h, and for the monocot 8.8 cm/h (Table 1).

<table>
<thead>
<tr>
<th></th>
<th>Dicot (Daisy)</th>
<th>Monocot (Lilly)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (cm)</td>
<td>5.30</td>
<td>8.80</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>1.06</td>
<td>4.02</td>
</tr>
<tr>
<td>Standard Error</td>
<td>0.33</td>
<td>1.27</td>
</tr>
</tbody>
</table>

The calculated p-value of one-tail t-test is 0.0080; this supports the hypothesis that monocot angiosperms (i.e. Lilies) have a greater transpiration rate than dicot (i.e. Daisies) angiosperms.

The comparison graph shows the same results that there is a significant difference between the transpiration rate of dicot and monocot (Figure 3).

![Comparison of Transpiration Rate in Dicot and Monocot](image)

**Figure 3.** Comparison of transpiration rate in dicot and monocot

### Discussion

The results show that when measuring the distance of water traveled in *Asiatic lilies* (monocot) and *Chrysanthemums* (dicot), it supports the hypothesis that monocots have higher transpiration rate than dicots. Transpiration in Lilies was higher than Daisies (8.80 cm/hour vs. 5.30 cm/hour). Transpiration, the loss of water from leaves, creates a force within the leaves that pulls the xylem sap upward (Koch et al, 2004). Looking at the stem, xylem tissue (part of the vascular tissue) is complexly arranged in no particular order in monocots, and in dicots is arranged in a ring towards the outside edges of the shoot (Balschweid et al, 2002). Xylem in both types provide the same function in all vascular plants’ stems, but theses arrangement of vascular bundles can alter the distance of water uptake, and as we found, our monocot flower proved to have the greatest water in take and therefore greatest transpiration rate. In some studies the rate of water loss can be explained by xylem diameter and
shape of vascular bundles (McArthur and Rice, 2004). Since vascular bundles are the transpiration structure in xylem the quantity and shape of them can affect the transpiration rate. As mentioned, vascular bundles are complexly arranged in higher quantity in monocots than dicots and that may be a reason for the increases in transpiration rate in the monocots versus the dicots. Increasing the time period of experiment may also increase the efficiency of the results, allowing for the plants to transpire longer.

There are also other factors that effect transpiration rate in angiosperms such as an increase of temperature which increases the rate of transpiration. In addition, an increase in humidity decreases the rate and an increase in air currents increases the transpiration rate. Even though these factors were kept constant during the experiment there is a possibility that they led to error. Although these results supported the hypothesis, other monocot and dicot angiosperms may lead to different results. In order to more fully observe the transpiration rates of these different angiosperms, a wider range and variety of plants must be used.

**Literature Cited**


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**Prediction of Red Tides Based on Nitrate and Phosphate Levels in the Pacific Ocean**

Carlee Gravesen  
*Department of Biological Sciences*  
*Saddleback College*  
*Mission Viejo, CA 92692*

**Abstract**

Red tides can be found in any ocean and can occur at any time. They cause the water to turn a reddish orange color. Red tides have been known to kill over 100 tons of fish per day, birds, marine mammals, and sometimes even humans. A bloom of microscopic dinoflagellates in the ocean water is the definition of a red tide. The cause of this sudden and temporary bloom of animals in unknown, and because there are so many variables that can play a role in causing a red tide, they are very difficult to predict. These variables can include nitrate and phosphate levels, time of year, and temperature of the water. Nitrates and phosphates are what the animal feeds on; therefore if there were to be a sudden sharp increase in nitrate and phosphate levels, this might cause the occurrence of a red tide. Because red tides are seemingly unpredictable, a study was done to determine whether or not a red tide could be predicted based on levels of nitrates and phosphates in the water. Water and plankton samples were collected approximately one mile off the coast of Dana Point, California. These samples were tested for nitrates and phosphates and viewed under a microscope for plankton identification. Inconclusive data showed that this was not an accurate way of predicting red tides because it failed to show any correlation between rising levels of nitrates and phosphates, and the occurrence of red tides.

**Introduction**

Red tides are found throughout the earths oceans, and can drastically affect different cultures and people especially those whose lives revolve around the ocean. They have been known to cause death in whales, dolphins, fish, and birds, amongst many other marine species. These animals die from exposure to neurotoxins that are produced by these dinoflagellates. Humans are also at risk of being indirectly poisoned by a red tide. Shellfish that live in the ocean filter ocean water regularly. When there is a red tide, they are filtering water with neurotoxins in it. This causes them to keep the neurotoxins inside of them, transferring them along to whoever consumes them. This can lead to diseases such as Paralytic Shellfish Poisoning (PSP), and Neurotoxic Shellfish Poisoning (NSP)
Red tides are the result of a bloom of phytoplankton dinoflagellates in the ocean water. Intriguingly, all red tides are not the same. Red tides in Asia are caused by a different organism (*Gyrodinium aureolum*) than a red tide in California (*Gonyaulax polyhedra*). In the waters directly off the southern Californian coast, red tides occur sporadically, with seemingly no pattern (Houtman, N. 1999). In southern California, red tides are usually cause by the dinoflagellate protozoan animal *Gonyaulax polyhedra* (Reish, 1994). This animal is microscopic, and its color cannot be seen when looked at as a single entity, but when millions of these organisms are present in the water, the water tints a reddish orange color.

*Gonyaulax polyhedra* has many characteristics that a plant may have. It uses photosynthesis to manufacture its own food and also has the advantage of controlled movement. This gives it a big advantage, allowing it to spread and move in around in the water it inhabits. Unfortunately, there is no proven cause to this bloom of dinoflagellates that causes red tides, but it is speculated that the dinoflagellates feed off of nitrates and phosphates in the water. Aside from naturally occurring nitrate and phosphate levels, city run off can also boost levels of nitrates and phosphates. When it rains, the rainwater collects everything off the city streets as it flows towards the ocean. It can collect things such as soaps and pet wastes, which contain nitrates and phosphates, and then dumps this water straight into the ocean. This could be a cause of rising nitrate and phosphate levels. Since *Gonyaulax polyhedra* feeds off of nitrates and phosphates, it should flourish when there is an increased number of nitrates and phosphates in the water (Smalley, 2002).

**Figure 1.** Plankton net

### Materials and Methods

Water samples were collected from ocean waters directly off Dana Point, California twice a week during the weeks of March 2-April 15, 2004. Using the research vessel the R/V Sea Explorer, water samples could be collected roughly one mile south of the harbor. A plankton net, like the one in Figure 1, was dragged approximately 2 feet underwater for five minutes from the stern of the boat. The plankton net filtered out the plankton from the water and automatically deposited them into a 50 ml, cylindrical glass jar. Another sample was taken, as a control, from the side of the vessel that had not been filtered for plankton. This sample was taken by casting a clean, plastic, gallon sized bucket over the side of the vessel. A 50 ml sample was taken from the bucket and placed in a sterile glass jar. It was then tested for nitrates and phosphates, placed in a 3-inch petri dish, then viewed under the microscope on board the boat. Both samples were taken within 5 minutes of each other.

For the first week, the filtered sample was collected then immediately tested for nitrates and phosphates using specialized test papers much like pH paper. It was then places in a 3-inch, shallow petri dish and viewed under a microscope to identify species of plankton. The nitrate and phosphate paper that was used for the first week was expired and was giving negative results; therefore, a more accurate water testing kit was used for the remainder of the study. Using this testing kit, a 2-5ml samples were placed in test tubes one was tested for nitrates, the other for phosphates by adding specialized drop to the sample and shaking them. For the remainder of the experiment, the more accurate test was used to test both the filtered sample and the control sample. All testing kits and testing paper were obtained from the R/V Sea Explorer.

### Results

In this study, the data did not support the hypothesis that red tides could be predicted from rising nitrate and phosphate levels. As the data were recorded and analyzed, it became apparent that the levels of nitrates and phosphates never deviated from a normal level (less than 0.5 ppI), as you can see in Figures 2 and 3.
Also, after viewing 14 samples of plankton filtered, and 14 samples of unfiltered water, the species *Goyaulax polyhedra* could never once be identified. The levels of nitrates averaged out to be 0.0214 ppl, which is a normal level. There was no difference in the plankton filtered water and the control (not filtered) water, both ending up with an average of 0.0214 ppl. A one-tailed t-test was run, using Microsoft Excel. The p-value (p=0.5) shows that rising levels of nitrates and phosphates in this study could not predict red tides.

**Discussion**

The data collected did not indicate an accurate way of predicting an upcoming red tide, but that does not mean that red tides cannot still possibly be predicted. The data for the control and the experiment group ended up with the same data set and same average (0.0214 ppl) level of nitrates and phosphates. The initial nitrate and phosphate test papers were not very detailed, and neither were the other testing kits. They did not seem to give perfectly accurate results. Because the tested water, and testing strips turned colors, they had to be matched to a chart showing the shade that correlated to the level of nitrates or phosphates. This allows for some human error in reading the color or shade of the water.
When a sample of plankton was viewed under the microscope, there were countless organisms that needed to be viewed and identified. Obviously, they could not have been individually viewed and identified because there were hundreds of thousands of them in each petri dish. This could have easily lead to an overlooking of the dinoflagellate *Goyaulax polyhedra*, the plankton that was important to this study.

It would probably have been a good idea to test pH and water temperature along with nitrates and phosphates. The pH and water temperature may play a key role in the cause of red tides (Jeong, H. 2003). Though this study did not demonstrate that red tides could be predicted, it is not to say that they will never be able to be.

**Literature Cited**


