ERGO

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Contents

Featured Articles

Goddard School of Business and Economy

Jerry & Vicky Moyes College of Education

Research Abstracts

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Acknowledgments

Each article published in Ergo was peer reviewed by a committee of students and faculty from Weber State University, and all of the research abstracts were presented at state, regional, or national conferences by the students who developed them.

The staff and faculty advisors of Ergo would like to thank the students and faculty members who volunteered their time and expertise to make Ergo a better journal as well as many others who were willing to contribute. The success of this journal in future years will depend on the continued involvement and interest of every college and department at Weber State.

The Office of Undergraduate Research would also like to sincerely thank the following who have contributed to the undergraduate research efforts at Weber State University:

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Ms. Lisa Eccles

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Mr. Ronald S. Mitchell

Mr. Robert Hunter

Dr. Kathleen M. Lukken

Letter from the Editor

"If we knew what it was we were doing, it would not be called research, would it?"

Albert Einstein

I am very excited to introduce this year's publication of Ergo. I hope that students, faculty, and community members from all academic disciplines are able to pick up a copy and engage with the innovative ideas and discoveries being made at Weber State University. I believe that WSU offers students a unique opportunity to participate in undergraduate-level research, frequently working one-on-one with faculty mentors. I can attest to the benefits of this vital work through first-hand experience, having worked for over three years studying the functional morphology of syringeal muscle fibers. I believe it is important for students and faculty members to take advantage of these opportunities at WSU and open new doors yet to be discovered.

In this issue, we were able to include several fields of interests, ranging from the mysterious physics of hot chocolate to the complexities of microeconomics. We have also been fortunate to have Dr. Jodi L. Smith, M.D., Ph.D., a Weber State University graduate and current pediatric neurosurgeon, introduce this year's edition with her experiences in research at undergraduate and graduate levels. Dr. Smith is an accomplished individual who has remained very active in research within her field.

This year's Ergo Staff has been exceptionally helpful and productive. The production of the Spring 2009 edition has demanded much effort from all who value undergraduate research. I would like to give special thanks to Jessica Barraza, Ximen McMillan, Amy Douangdara, and Elizabeth Dohrer for their unrelenting patience and hard work. I would especially like to

express my gratitude to Dr. John F. Cavitt, who continues to oversee the Office of Undergraduate Research so that this journal can be produced.

Finally, I wish to thank the Administration of Weber State University, its faculty, and its exceptional students for continuing to believe and engage in undergraduate research. Our combined efforts are helping WSU to develop a tradition of outstanding scholars.

Amiko Uchida
Editor-in-Chief

Introduction

Weber State, Weber State! Great, Great, Great! I am very pleased to write this Introduction for Ergo - the Undergraduate Research Journal. I attended Weber State College (1979-1983) on a softball scholarship, graduating Summa Cum Laude, with a B.S. in Zoology (Chemistry minor.) My educational experience at Weber was second to none.

Although premed-bound when I began, I had the opportunity of doing a senior research project on pituitary gland development with Dr. Gloria Z. Wurst (Department of Zoology), an incredible mentor, role model, and friend. That research experience, combined with Dr. Wurst's outstanding Cell Physiology course my junior year, helped to develop my critical thinking and writing skills and fostered an intense interest in developmental biology research.

This newly-discovered love for research pointed me toward graduate school, for which my experiences at Weber prepared me very well. A Department of Anatomy research fellowship at the University of Utah School of Medicine supported my graduate studies (1983-88); I received my Ph.D. in December 1988 for research on the regulation and role of neuroepithelial cell wedging in formation of the neural tube, the central nervous system rudiment. The project was designed to elucidate mechanisms underlying normal development in order to understand and prevent neural tube defects such as spina bifida.

Despite immersion in research, I retained my desire to pursue a medical career, and, in fact, graduate studies in a medical school environment helped to shape and solidify that desire. Therefore, after receiving my Ph.D., I applied to medical school with one goal – to pursue a career in academic pediatric neurosurgery. I completed my M.D. and Neurological Surgery residency training at the University of Utah School of Medicine. Following residency, I completed a Shillito Fellowship in pediatric neurosurgery at Children's Hospital/Harvard Medical School in Boston, Massachusetts, deepening my fascination with the whole of pediatric neurosurgery.

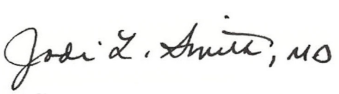
In 2000, I joined the Department of Neurological Surgery at Indiana University School of Medicine (Indianapolis) and became Director of Pediatric Neurosurgery at Riley Hospital for Children

in 2006. My career is dedicated to advancing all aspects of Pediatric Neurosurgery, including patient care, education, and research, and I treat all neurosurgical problems in children. I delight in caring for my patients and their families, as well as in teaching medical students, residents, fellows, nurses, and other physicians (e.g., primary care physicians, pediatric neurologists, and pediatric general surgeons.) I pursue basic science research on pediatric epilepsy and collaborate on clinical research projects, aimed at increased understanding of disease processes and, ultimately, improved neurosurgical care of children throughout the world.

I am indebted to the teachers/mentors who have guided me along my educational path. A high school Physiology teacher recommended that I change my career goals from PE teacher/coach to a career that I had never considered – medicine. My fascination with research at Weber led me to graduate school and another incredible educational experience. In graduate school, I worked with a Primary Children's Hospital fellow who pointed me to a career in pediatric neurosurgery, thus combining medicine with my research interests in neural development.

In September, I was honored as one of two 2008 Weber State University Distinguished Alumnae. I thoroughly enjoyed returning to campus, talking with students, and visiting devoted teaching faculty who are also providing research opportunities for students, thus enhancing their ability to think critically and solve problems as well as improving their ability to compete for employment and/or gain admission to top-ranked post-baccalaureate programs.

I will be forever grateful to Weber State for launching me on a career path that fulfills me completely and allows me to contribute significantly to enhancing the quality of other people's lives.



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Featured Articles

Dimensions of Brand "Flair" and Quality in WTP for Coca-Cola

Collin Bell & Cliff Nowell

Abstract

This paper examines the value placed on the brand "flair" by using a real auction to unveil the role brand names play in buyer's choice and valuation of Coca-Cola. Together image (perceived quality) and actual quality greatly influence consumer purchase behavior. Yet which is the dominant variable? This experimental economics paper compares two experiments designed to reveal brand preference.

Introduction

Consumers often pay higher prices for allegedly superior products. What motivates consumers in their purchases – image (brand association) or actual quality? Are consumers paying for the fancy packaging or actual higher quality? Using a real auction and willingness-to-pay (WTP), we seek to understand whether consumers place an added value in a brand name beyond the normal consumption of a quality good. Are consumers willing to pay more for Coca-Cola (Coke) because of brand name or its physical characteristics?

Survey of the Literature

In its simplest form, consumers are motivated by price and perceived quality and can be characterized by the trade-offs they make between these two critical variables when purchasing packaged consumer goods (Corstjens & Lal, 2000, p. 283). While this answer is fundamentally true, it is incomplete. Looking more closely at the words of Corstjens and Lal, we discover the term "perceived quality," which gives us greater insight to consumer behavior in a world that has become so raveled with image association. As price is fundamentally straightforward, let us examine perceived quality in greater depth. According to Roach, "30% of retailers are indicating a growing enthusiasm for premium, high quality store brands intended to compete directly with leading manufacturer brands on quality and image, not just price" (1995, p. 65). Beyond quality, Roach also identifies a second critical consideration of image.

To shed light on the roots of this issue let us return to the incipient cola times. Coca-Cola is created in 1886. Fourteen years later, in 1899, Pepsi-Cola is created. Pepsi offers a bargain drink at half the price of Coca-Cola's. This strategy, however, does not serve Pepsi well as it catered to the "price shoppers" (*Consumer Reports*, 1991, p. 523). As Pepsi can no longer afford the bargain price it offered and prices are driven upward, Pepsi drinkers abandon the once bargain cola soft drink. Pepsi is then left to change its formula and engage in the arduous task of eliminating its inferior cola image. Contrastingly, Coca-Cola had developed such a strong following and culture that almost one-hundred years later when Coke attempted to change its formula Coca-cola's consumers' contempt can be summarized by the following statement, "Changing Coke is like God making the grass purple or putting toes on our ears or teeth on our knees" (*Consumer Reports*, 1991, p. 523).

Theoretical Background

At the root of this issue lies consumer satisfaction. Consumers create the demand for a good in a market. Consumer demand is a function of a variety of variables that make up their set of preferences. No two set of preferences for consumers are exactly alike. Yet, fundamentally the first common factors generally accepted to find place in a demand function include the price of the good, the price of a substitutable good, the income of the consumer, etc. Where does image or perceived quality fit in demand? Image today has become so prevalent that it largely influences consumer behavior. Due to the degree of influence image now has on purchasing behavior, it has become worthy of a closer look. Do consumers receive additional satisfaction from image association?

Methods

The Experiment I

Our experiment was designed to observe whether people place a monetary value in brand "flair," a value beyond normal consumption of a consumer good (Anderson et al, 2000, p. 154). Using two separate groups of participants, two experiments were implemented to measure the WTP for Coke based on 1) brand name and 2) taste (quality).

First Experiment – Brand Presence

In the first experiment, participants sampled two cola soft drinks individually labeled as 1) Coke and 2) Unknown. After sampling each soft drink, participants bid in two silent auctions on a two-liter bottle of each soft drink already sampled. To provide a control in the experiment, Coke was used across the board for both samples although participants understood each cola soft drink sample to be different.

Second Experiment – Brand Absence

In the second experiment participants sampled two cola soft drinks individually labeled as 1) Sample A and 2) Sample B. After sampling each soft drink, participants bid in two auctions on a two-liter bottle of each soft drink already sampled. Sample A and Sample B respectively corresponded to Bottle A and Bottle B. In this experiment, the control was brand name, both being unknown to participants. Unlike the first experiment the actual sample drinks varied; Coke was used for Sample A and Big K Cola manufactured by Kroger was used for Sample B.

Using the bids made by participants, the design of the two experiments allowed statistical analysis to separate preferences of brand association or brand "flair" from a drink's taste (quality) by providing important controls in each experiment (see Table 1 below.)

Table 1

	Experiment 1 – **Brand Presence** (Group 1)		Experiment 2 – **Brand Absence** (Group 2)	
(Actual Sample)	(Coke)	(Coke)	(Coke)	(Big K Cola)
Sample Labeled	Coke	Unknown	Sample A	Sample B
Item Auctioned	Coke	Unknown	Bottle A	Bottle B
Bid Analysis Reference	WTP-C	WTP-U	WTP-A	WTP-B

The Experiment II: Experimental Design

A total of 48 students from Weber State University agreed to participate in this experiment. Coke, manufactured by Coca-Cola, was selected as the focus brand considering Coca-Cola's intense history of brand cultivation. Since we desired to quietly observe brand preference in the first experiment relative to taste preference assuming equal quality between different cola soft drinks, the mere presence of the brand name Coke on the bid statements and a red Coca-Cola 2-liter bottle at the head of the auction next to an unlabeled 2-liter bottle of cola soft drink sufficed for brand treatment. As for the second experiment, we desired to observe taste preference, so all brand labels and cues were removed altogether.

We tested three hypotheses. The first focuses on the difference in bids where brand presence was isolated. The second focuses on the difference in bids where taste preference was isolated. Whereas the third hypothesis focuses on the difference in bids between the valuations of

Coke in each experiment; that is first Coke, labeled as Coke, in the first experiment tested against Coke, not labeled as Coke, in the second experiment. How did Coke perform against itself and against a competitor? The hypotheses are stated below.

1. H_0: μWTP-C ≤ μWTP-U
   H_A: μWTP-C > μWTP-U

2. H_0: μWTP-A ≤ μWTP-B
   H_A: μWTP-A > μWTP-B

3. H_0: μWTP-C ≤ μWTP-A
   H_A: μWTP-C > μWTP-A

Method

The chosen auction method used to elicit valuations in the experiments was the single-unit Vickrey auction. The Vickrey auction method is desirable in eliciting true valuations due to its incentive compatibility property (Anderson et al., 2000, p.157). As Vickrey states, "It is easily shown that the required procedure is to ask for bids on the understanding that the award will be made to the highest bidder, but on the basis of the price set by the second highest bidder" (Vickrey, 1961, p. 20). This is advantageous considering the built-in incentive for participants to bid a true valuation considering the highest bidder will only pay the second highest price. By using the Vickrey second-price auction format, the mean WTP can be determined for all auctioned goods and enable direct comparison of means.

After reviewing a formal set of instructions pertaining to the auction all participants received $5 as an incentive to participate and possibly use in the auction. Participants were asked to read the statement bid, which then directed them to sample the drinks placed before them. After sampling the drinks, participants wrote in bid values for each cola soft drink. Bids were submitted and reviewed to determine the winners and the price each winner would pay. The descriptive statistics of the bids are shown in Table 2.

Table 2

Conditions	Mean ($)	S.D.	N	
Experiment 1	(a) WTP – C	1.382	1.233	25
	(b) WTP – U	1.082	.773	25
Experiment 2	(c) WTP – A (Coke)	.879	.774	23
	(d) WTP – B (Big K Cola)	.90	.830	23

Results

The experimental results are summarized in Table 2. Let us first examine Experiment 1 with brand presence. Although quality has improved for private label brands, image (a major partner to quality in creating perceived quality) has not entirely receded into the background (Perloff, 2004, p. 650; Corstjens & Lal, 2000, p. 282). Assuming brand preferences have not yet been entirely surmounted by private labels we formed the following hypotheses:

$$H_0: \mu WTP\text{-}C \leq \mu WTP\text{-}U$$
$$H_A: \mu WTP\text{-}C > \mu WTP\text{-}U$$

With a mean WTP-C of $1.38 and mean WTP-U of $1.082 a paired *t* test of means yields a *t* value of 1.86 and a *p* value of 0.037. Accordingly, we reject the null hypothesis that μWTP-C ≤ μWTP-U. Under the assumption of equal quality between cola soft drinks, the brand name Coke still elicited a higher WTP than its disguised self.

Let us now examine Experiment 2 with brand absence. By eliminating brand name from the equation, we can make an inference about taste. Assuming that Coke's dominant popularity results from its superior taste, we should be able to observe this supposed phenomenon in the data. Thus, we formed the following hypotheses:

$$H_0: \mu WTP\text{-}A \leq \mu WTP\text{-}B$$
$$H_A: \mu WTP\text{-}A > \mu WTP\text{-}B$$

With a mean WTP-A (Coke) of $.879 and mean WTP-B (Big K Cola) of $.90, a paired *t* test of means yields a *t* value of -.014 and a *p* value of 0.554; we fail to reject the null hypothesis. Failing to reject the null hypothesis furthers the quality argument that if brand loyalists would set aside their Coke, they might just be as happy as with an alternative cola soft drink (*Consumer Reports*, 1991, p. 519).

We will now compare the means of WTP for the soft drink Coke in each experiment; both with and without brand presence. According to Table 2 we see that the mean for WTP-C is $1.382 and the mean for WTP-A is $.879. At first glance the difference of means is intriguing. Again according to the literature we still feel that despite substantial improvements in private label quality, these improvements have not overcome the dominant effect of brand "flair." We formed the following hypotheses:

$$H_0: \mu WTP\text{-}C \leq \mu WTP\text{-}A$$
$$H_A: \mu WTP\text{-}C > \mu WTP\text{-}A$$

To test this hypothesis we use a two-sample *t* test. We see that the test yields a *t* value of 1.71 and a *p* value of .048. Accordingly, we reject the null hypothesis that the mean WTP for Coke with it's brand "flair" in the first experiment of brand presence is equal to or less than the mean WTP for Coke without brand presence.

Conclusion

Actual quality without the brand "flair" is becoming increasingly important and the opaque veil of perceived quality is becoming increasingly transparent as products are seen for what they are and less for the "flair" they offer. Through this experiment we can see that there is legitimate value to this phenomenon that incorporates consumers' willingness to pay for the "flair" that any brand might offer. Manufacturers and businesses would be wise to develop a strong culture within the brand and its consumers, while reinforcing this culture through the quality of its products. Further research might address the variables of usage-experience and increasing marginal utility from brand commitment (Moorthy, 2000, p. 222-223). In addition, the behavior of consumers when presented with an alternative private label soft drink to a national brand soft drink in vending machines may also be investigated. Another possibility to observe this phenomenon might be achieved using clothing, which is identical in quality and design and doesn't bear any outward indication or marking of the producer but only in knowledge to the consumer whether it is produced by a popular brand or a generic private-label.

Acknowledgments

We thank Dr. Cliff Nowell for his ample insight and discussion readily offered on this research topic and aide in the funding of the experiments. We also thank Dr. Doris Geide-Stevenson for her guidance and contribution in uncovering critical relevant literature, and to the students who were willing to participate in the experiments.

References

Anderson, J., Vadnjal, D., & Uhlin, H. (2000). Moral dimensions of the WTA – WTP disparity: an experimental examination. *Ecological Economics*. 32, 153-162.

Consumer Reports. (1991, August) The Cola Wars: Who's Got the Right One? *Consumer Reports*. August, 518-525.

Corstjens, M., & Lal, R. (2000). Building Store Loyalty Through Store Brands. *Journal of Marketing Research*, August. 37, 281-291.

Moorthy, S. & Zhao, H. (2000). Advertising Spending and Perceived Quality. *Marketing Letters,* 11. 3, 221-233.

Perloff, J.M. (2004). *Microeconomics* (3rd Edition). Pearson Addison Wesley. University of California, Berkley.

Roach, L. (1995). Mapping the Future of Private Labels. *Discount Merchandiser,* 35. 11, 65.

Vickrey, W. (Mar., 1961). Counterspeculation, Auctions, and Com petitive Sealed Tenders. *The Journal of Finance*, 16. 1, 8-37. Accessed: Nov. 18, 2008. http://www.jstor.org/stable/2977633.

Microcredit in the US: A Case Study of the Utah Microenterprise Loan Fund

Michael S. Kofoed & Nazneen Ahmad

Abstract

Beginning with the Grameen bank model in Bangladesh, microcredit has become an innovative method of fighting poverty throughout developing countries. Microcredit institutions strive to make credit available to those who cannot or are not served by the mainstream banking industry. The poor use these loans to start their own businesses and pull themselves out of poverty. Despite the success of these institutions, replicating microcredit in the United States has in most cases proved unsuccessful due to cultural differences. These differences have prompted American microcredit groups to adapt the original Grameen Bank model to fit their own circumstances.This case study examines the Utah Microcredit Loan Fund (UMLF), based in Salt Lake City, Utah. It examines the changes that the UMLF has made to the original Grammen Bank model and how these changes have helped it overcome challenges faced by their counterparts in the United States; such as recruitment, sustainability, and the joint liability model. This study also examines how successful UMLF has been executing its mission.

Introduction

The first microcredit institution was the Grameen Bank founded by Professor Mohammad Yunus in 1976. Later many developing countries introduced the system of microcredit to fight poverty. Inspired by the success of microcredit institutions in the developing countries, microcredit programs were initiated in the United States in the mid-1980s. Microcredit institutions in developing countries provide loans of small amounts to the poor who lack access to mainstream financial institutions, and use microcredit to develop their own enterprise or initiate some type of income generating self-employment activities. While the microcredit system is generally considered to have positive impact on

developing economies, its impact in the United States appears to be insignificant (Scheiner and Murdock, 2002).

The original Grameen Bank model has been adapted many times in developing countries and by American institutions. That may lead many to wonder, what adaptations would have to be conducted to make microcredit viable in Utah? This study examines Utah Microcredit Loan Fund (UMLF) Salt Lake-based microcredit institutions, and the changes they have made to the original Grameen Bank model. The Grameen Bank model will be used for comparison because it is the original microcredit model, while other American institutions are simply derivations of the Grameen model. The study also examined how successful these changes have been, and how well UMLF fulfills its mission to alleviate poverty in Utah.

Review of Literature

Studies on microcredit programs in the U.S. primarily focus on the challenges these institutions experience. Scheriner and Murdock (2002) point out reasons why microcredit institutions in the U.S. are not successful. They concluded that the small size of microenterprise sector increases the costs of operation and makes it hard for the institutions to achieve financial self-sufficiency. Safety nets available to the low income and unemployed discourage self-employment and hurt recruitment. Competition from commercial lenders, limits to joint liability groups, and strict regulations make it harder to start up small businesses in the U.S compared to developing countries. These issues are all challenges American microcredit institutions currently face.

Bhatt, Painter, and Tang (2002) conducted an empirical study on microcredit programs in California to analyze the prospect of microcredit in the U.S. They found that micro credit programs in California have achieved limited outreach and sustainability. They asserted that one of the challenges experienced by the U.S. microcredit programs was to identify poor borrowers who can make profitable use of small loans. Woolcock (1999, p. 17-42) argued that the group lending system of original microcredit system goes against many social norms of developed countries and suggests that for microcredit to succeed, it must be tailored to individual economies and situations.

Vinelli (2002) asserted that achieving financial self-sufficiency is especially challenging for the U.S. microfinance organizations. Many institutions could not survive without government loans and grants. Those who do not receive such assistance do so at the expense of higher interest rates to their borrowers.

Methods

Grameen Bank, and UMLF: A Comparative Analysis

Microcredit institutions in the U.S. attempt to follow the mission of Grameen bank by targeting a population that is inadequately served by mainstream financial institutions. Similar to Grameen bank, UMLF also distributes loans for "investment" or nonconsumption productive purposes. However, UMLF deviates from the Grameen bank model in many aspects.

Objectives:

The main mission of the Grameen Bank is to serve the financial needs of those who could not otherwise gain access to the financial sector. Thus Grameen Bank not only extends loans to the poor, but offers other banking services such as savings accounts and student loans. Grameen Bank's main objective is to develop the economy on a macro-scale by distributing credit and financial assets to the lower income population.

In Utah, however, there exists a well-developed credit market that allows those with acceptable credit to fully participate in the financial sector. The goal of UMLF is not to serve as a substitute to the financial sector as a whole, but help those with little or no credit gain the necessary credit experience to participate in the mainstream banking industry. Hence they do not provide savings accounts, and many of their microentrepreneurs do not return to UMLF when they have gained access to the financial sector.

Borrower Characteristics:

Grameen Bank and UMLF are similar in that they strive to offer loans to the poor, women, and ethnic minorities. In addition to these groups, UMLF may extend loans to people who have special circumstances that inhibit them from receiving a loan elsewhere. Like Grameen bank, UMLF distributes small loans to people who would be denied loans from mainstream banking institutions. However, not all UMLF borrowers are poor. Currently, 68% of the UMLF's borrowers are considered low/moderate household income. Low income means a family that earns less than $46,150 per year, or a single person who earn less than $32,300. All others are considered middle or high household income. These borrowers may come to UMLF when they have credit troubles or are somehow disabled and cannot work.

Loan Size and Interest Rate:
The average Grameen loan is Tk 23,553, which is equivalent to $344. Loans given by the UMLF and other American microcredit institutions are significantly larger than Grameen loans because of the higher fixed costs that a new entrepreneur must incur in the United States. The maximum loan amount distributed by UMLF is $25,000, and is given in monthly installments.

In Grameen credit system, interest is not charged after the interest amount equals the principal, and interest on Grameen loan is simple interest. For normal income generating loans, Grameen Bank charges a 20% interest rate on a declining balance method. UMLF's borrowers have up to five years to repay loan with a simple interest rate of the current prime rate plus 5-7%. This additional interest rate is to compensate UMLF for the higher risk due to the low or no credit of the borrowers.

The Joint-liability Model:
To obtain Grameen credit one must join a group of borrowers; credit standing of a borrower depends on credit standing of other members in the group. In this joint-liability model, group members police each other, while social pressure and fear of losing face in the community serve as motivation to make payments on time.

While joint-liability model has been very successful in Grameen credit system, especially in terms of risk sharing and reducing monitoring cost of the borrowers, this system has been found to discourage potential borrowers in the U.S. As such, one of the major adjustments made in the U.S. microcredit system, including UMLF, is the removal of the joint-liability system. Borrowers are solely responsible for the own repayment.

Funding:
Unlike the Grameen Bank, which was originally funded by the Central Bank of Bangladesh in 1983 and currently is funded by deposits, UMLF is funded by private banks as part of the Community Reinvestment Act (CRA).

The CRA was passed by the Congress in 1977 and requires banks to prove that they are meeting the needs of the entire community in which they are located. Essentially it requires banks to set aside funds for either home loans to the underprivileged or assistance to small businesses. To come into compliance with the federal mandate, many institutions in Utah give funding to the UMLF. The banks serve on UMLF's board of directors and assist in the loan approval process. Once a loan is ap-

proved, small amounts of the loan are made available from each of the banking institutions. If the loan defaults, the amount the bank must write off is small because the loss is shared among the banks. Along with being sustained with private investment, the other benefits of this model are that risk is equally shared among the banks and credit unions that fund UMLF. This is in contrast to the many American institutions that are funded by local, state, or Federal governments (Bhatt, N., G. Painter, and S. Tang, 2002). In most cases, government subsidies result in lower interest rates, while being independent may cause the institution to have higher interest rates. UMLF is neither subsidized by the Federal Government nor the Utah State Legislature.

Results and Discussion

There has been much debate on the criteria of a "successful" microcredit institution (Bhatt, N., G. Painter, and S. Tang, 2002; Schreiner, M. and J. Murdock, 2002). Some claim that success is sustainability and financial self sufficiency, while others adhere to the idea that a successful institution is based on the percentage of its fund that is loaned out. In this section we considered UMLF successful if it executed its mission (lend to the poor and specifically to women and minorities) and is financially stable (low loan loss rate, low percentage of at risk loans).

Demographics:

Like many American microcredit institutions, UMLF makes credit available to low income potential entrepreneurs, specifically focusing on women and minorities. One of the missions of UMLF is to "help women have the flexibility they need to balance their home and work responsibilities" (Utah Microcredit Loan Fund, 2008). UMLF also aims to assist immigrants, refugees, and ethinc minories to start their own businesses. Figure 1 (panels A & B) represents demographic information for UMLF, which assesses whether the institution is successful in satisfying its mission in terms of serving minorites and women.

Panel A shows, that between 1999 to 2008, the precentage of ethinic minorites, particually hispanic borrowers, increased. Panel B implies that the precentage of female borrowers has varied considerably over the time. Currently, male and female borrowers are almost equal. This may be explained in part due to the rise in businesses that are owned by a partnership of both men and women.

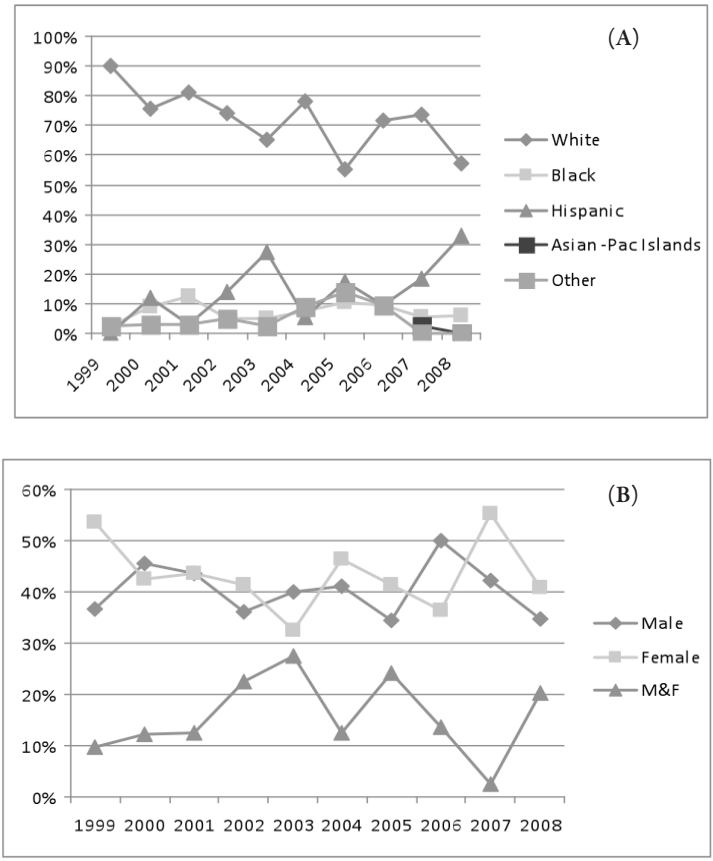

Figure 1. Panel A shows the proportion of the different ethnic groups UMLF has loaned to, and Panel B shows how many male, female, and male-female partnerships. Both male and female means a joint business venture with both male and female partners (i.e. a husband and wife starting a business).

Loan Size:

Figure 2 represents the total loan fund, and the amount of loan dispensed by UMLF since 1993. As the graph shows there is a substantial difference between the total amount of funds available for lending and the total amount dispensed. UMLF, on average, loans out just below 50% of its loan fund. It also appears that the difference is increasing over time. This discrepancy can be attributed to the challenge of recruiting borrowers.

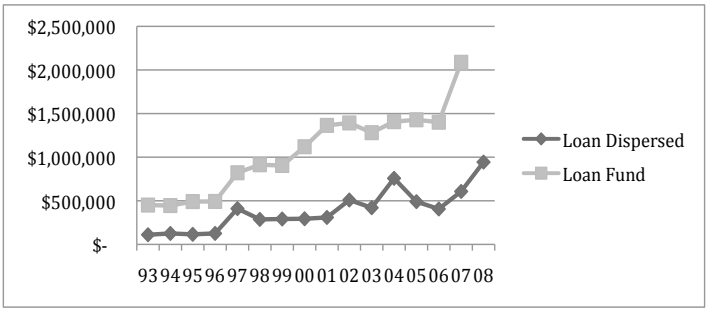

Figure 2 shows the total loan fund and how much has been dispersed over time.

Loan at risk and loss rate:

We found that the trend of percentages of UMLF loans at risk was generally downward. Figure 3 shows that there were a few years where the amount of risky loans spiked, notably 1998, 2000, and 2002, but one can see that UMLF is doing a better job over time by either decreasing the amount of high-risk loans, or preventing the loans that are currently outstanding from reaching the point of being in danger of default.

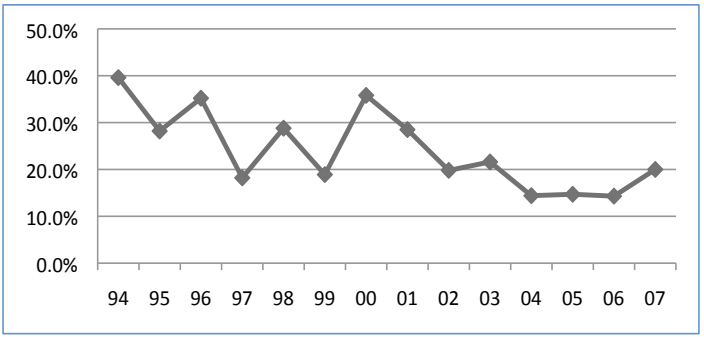

Figure 3. Percent of loans are considered at risk each year with percentage on the y-axis and year on the x-axis.

The annual loss rate that describes the percentage of loans that defaulted gives us a good insight on the suitability of UMLF. It appears from Figure 4 that annual loss rate is significantly high. During 1995-2004, the loss rate steadily increased and climaxed at an alarming rate of 19% in 2004. After sharply declining in 2005 to 5.4%, the loss rate increased in the following year.

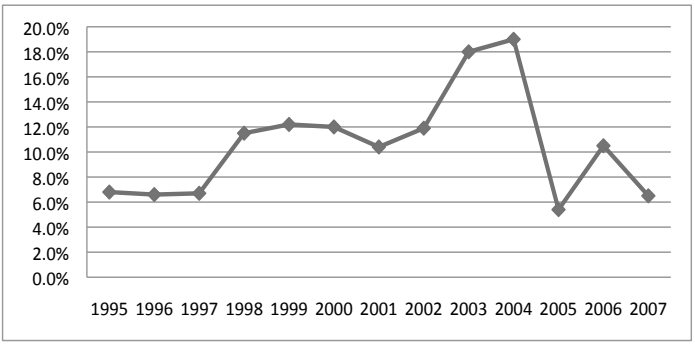

Figure 4. Annual loan loss rate over time.

Conclusions

Microcredit in developing countries has proved itself to a viable force in fighting poverty. Regrettably, this success has not carried over in the same magnitude in the United States. This paper showed how UMLF adapted the Grameen Bank model and how successful these adjustments have been towards fulfilling UMLF's mission. We discovered that UMLF has been successful in fulfilling its mission in many respects. For example, UMLF has been successful to reach out to minorities and women. Independent from extensive government subsidy, UMLF has also been able to keep interest rates reasonably low. However, the largest challenge facing UMLF is recruitment. We found out that the institution on average loans out below 50% of its loan fund. Reaching out to minority advocate groups, universities, and business schools in the area may help UMLF to contact people who are already contemplating entrepreneurship, and only need the capital to begin. We found that UMLF's average loss rate since 1995 is 9.9%. While it is imperative that the institution follows its mission of loaning to those who do not have access to mainstream credit, in order to be sustainable, UMLF needs to control their loss rate.

Acknowledgements

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References

Bhatt, N., G. Painter, and S. Tang. (2002) The Challenges of Outreach and Sustainability for U.S. Microcredit Programs. *Replicating Microfinance in the Untied States*. Baltimore, Maryland: The John Hopkins University Press.

Schreiner, M. and J. Murdock. (2002). Opportunities and Challenges for Microfinance in the United States. *Replicating Microfinance in the Untied States*. Baltimore, Maryland: The John Hopkins University Press.

Utah Microcredit Loan Fund (2008). *UMLF –Our Lending History*. Retrieved Aug 17, 2008, from http://umlf.com/umlf/history.html.

Vinelli, A. (2002). Financial Sustainability in U.S. Microfinance Organizations: Lessons from the developing world. *Replicating Microfinance in the Untied States*. Baltimore, Maryland: The John Hopkins University Press.

Woolcock, J.V. Learning from Failures in Microfinance: What Unsuccessful Cases Tell Us About Group-Based Programs Work. *Journal of Economics and Sociology*. 58(1), 17-42.

Valuing Clean Air in Weber County, Utah

Nick Beckstead, David Breen, Adam Gardiner, Jan Hamer, Patricia Harris, Erik Lehmann, Amiko Uchida & Therese Grijalva

Abstract

In this study we explore how much residents of Weber County, Utah, would be willing to pay to improve local air quality by reducing the number of "red air" days (poor air quality) in the County. We conducted a contingent valuation study using a system of dichotomous choice questions. Participants were asked if they would be willing to pay $X (ranging from $.50 to $10) for one day of improved air quality, indicated by changing a "red air" day to a "green air" day (good air quality). Essentially, respondents were asked to buy a green air day. Respondents were questioned as to health concerns, household income, duration of residence in the county, and attitudes toward environmental concerns. The surveys were conducted in person, with the Environmental Economics class (ECON 1100) attempting a random sample of county residents and the Econometrics (ECON 4550) class surveying Weber State University students. Overall, the results show that as the price increases, fewer respondents were willing to pay this amount. This finding is consistent with the law of demand; as price increases, quantity demanded decreases. The econometric class analysis showed that more than 50% of the respondents would be willing to pay $25 for one day of improved air quality. These results suggest that Weber County residents value good air quality more than the survey designers anticipated when setting bid amounts.

Introduction

Air quality along the Wasatch Front is impacted by temperature inversions. What are temperature inversions? On most days, the temperature of air in the atmosphere is cooler at higher altitudes. Most of the sun's energy is converted to sensible heat at the ground, which in turn warms the air at the surface. The warm air rises in the atmosphere, where it expands and cools. Sometimes, however, the temperature of air actually

increases with altitude. This is referred to as a temperature inversion, because the temperature profile of the atmosphere is "inverted" from its usual state. There are two types of temperature inversions: surface inversions that occur near the Earth's surface, and aloft inversions that occur above the ground.[1] Inversions are common and can persist for days when an area experiences long nights (i.e., winter) and high pressure, which essentially results in still air and the accumulation of pollutants. In addition, local topographical features can enhance the formation of inversions, especially in valley locations like the Wasatch Front (National, 2008).

During the winter, warm air above cooler air acts like a lid, suppressing vertical mixing and trapping the cooler air at the surface. As pollutants from vehicles, fireplaces, and industry are emitted into the air, the inversion traps them near the ground, leading to poor air quality. Air quality is related to the strength and duration of an inversion.

A large contributor to poor air quality during the winter is residential wood burning. Wood smoke contains much higher amounts of particulate pollution than smoke from oil or gas-fired furnaces. In some areas of the country, local governments issue burn bans to curtail the use of wood stoves and fireplaces under certain weather and pollution conditions (National, 2008). In Northern Utah, the air quality is designated as red, yellow or green days, where burning is banned on red days. Motor vehicles are another important source of pollutants with diesel engines estimated to be the source of at least 70% of the total toxic risk posed by air pollution in the United States (Moeller, 2004, p. 112). Along the Wasatch Front, driving on yellow or red days is discouraged.

The EPA established the National-Scale Air Toxics Assessment (NATA). NATA found that the risk of developing any kind of cancer over a lifetime due to exposure to certain air toxins exceeded 10 in 1 million for the contiguous 48 states, Puerto Rico, and the U.S. Virgin Islands, substantially higher than the EPA's goal of 1 in 1 million. More than 20 million people live in counties with much higher risk, exceeding 100 in 1 million, and localized "hot spots" pose an even higher risk within some counties (Weinhold, 2002). The Wasatch Front is troubled by some of the poorest ratings (highest numbers) in the country.[2] Under

[1] A complete discussion of surface and aloft inversions is available upon request from the faculty mentor.

[2] A state and national interactive mapping of air quality is available online at the Office of Air Quality Planning and Standards, U.S. EPA. National Scale Air Toxics Assessment (hhtp://www.epa.gov/ttn/atw/nata/maprisk.html, accessed February 5, 2009.

the Clean Air Act and Amendments, states retain the authority to control existing sources (Harrop, 2002, p. 226). As such, the State of Utah has the authority to control air quality problems along the Wasatch Front.

From a policy standpoint, determining the value that residents place on clean air can be seen as an informational input in setting air quality standards and regulations in the State of Utah. The purpose of this study is to evaluate the value that residents in Weber Country place on clean air using the Contingent Valuation Method (CVM). CVM is a survey technique that is frequently used in determining the value individuals place on environmental goods and services. Details about CVM are explained in Section 3.

CVM Air Quality Literature

While there a literally hundreds of recent CVM studies, there are only a few studies that estimate the value of clean air and visibility in the U.S. In an early study, Rowe, D'Arge and Brookshire (1980, p. 1-19) examine the value in maintaining the air quality in the 4-Corners region of the Southwest, designated by the USEPA as a 'Prevention of Significant Deterioration (PSD) air quality' area. PSDs are areas where air quality is better than what is established by national regulations. Using a variant of CVM, Rowe, D'Arge and Brookshire found that residents of the region are willing to pay up to $82 per year to prevent visibility from deteriorating from 75 miles to 25 miles.

Schulze et al. (1983, p. 149-173) survey over 600 households in Denver, Albuquerque, Los Angeles, and Chicago to determine the economic value of maintaining visibility in national parklands in the Southwest. Using CVM, the authors find that average monthly willingness-to-pay (WTP) amounts ranged from $6.61 in Chicago to $9.64 in Los Angeles.

Randall and Kriesel (1990, p. 153-176) used CVM in a referendum format to determine the amount U.S. households would be willing to pay per year for a national policy to reduce air and water pollution loads by 25%. Randall and Kriesel found that U.S. households would be willing to pay $694.42 (1984 dollars) annually.

Methods

The Contingent Valuation Method

The Contingent Valuation Method (CVM) is a survey method that

can be used to elicit the value people have for environmental goods and services. CVM involves directly asking people, in a survey, how much they would be willing to pay for specific environmental services. In some cases, people are asked for the amount of compensation they would be

willing to accept to give up specific environmental services. It is called "contingent" valuation, because people are asked to state their willingness to pay, *contingent* on a specific hypothetical scenario and description of the environmental service (King & Mazzotta, 2000). CVM is used to assign dollar values to environmental goods and services that are not valued in the market.

Richard T. Carson, one the top experts in the field, contends that CVM is the best method for deciding governmental actions and policies because it constructs different scenarios for future actions. Participants are asked to state their preferences in surveys designed to simulate actual markets, and economic value is derived from their answers. "CV has been in use for over 35 years, and there are now over 2000 papers and studies dealing with the topic" (Carson, 2000, p. 12). CVM has been used to study the following: "increasing air and water quality; reduc[ing] risk from drinking water and groundwater contaminants; outdoor recreation; protecting wetlands, wilderness areas, endangered species, and cultural heritage sites; ...and provision of basic environmental services such as drinking water and garbage pickup in developing countries" (Carson, 2000, p. 13).

CVM is a controversial method because of one simple problem: Ask a hypothetical question, get a hypothetical answer. (For a complete synopsis of the debate on CVM see *Journal of Economic Perspectives* 8(4), 1984.) This invites the question of whether CVM can be considered a scientific and/or economic analysis. While it may not be a perfect method, economists who favor CVM continue to improve on it by making the surveys as detailed and realistic as possible; they attempt to address the problems of bias and hypothetical answers
In addressing the concerns and criticisms of CVM, a panel of Nobel Prize laureates in a National Oceanic and Atmospheric Administration (NOAA) report provided recommendations on the appropriate design of contingent valuation surveys (see Arrow et al., 1993, p. 4601). The most important recommendations of the NOAA panel were:

1. Personal interviews should be used to conduct the survey.
2. Surveys should be designed in a yes or no referendum format.
3. Respondents should be given detailed information on the

resource in question.

In applying CVM, the first step is defining the valuation problem, which includes defining the good or service and determining the relevant population to be surveyed. In our study, the "good" was clean air and the relevant population was Weber County residents. We decided to use in-person surveys, which are considered the most effective method when complex questions are involved. We used visual aids (photographs and tables) to help the respondents understand the scenario.[3]

Data was collected by two economics classes from Weber State University in October and November of 2008. The Econometrics class at Weber State University designed our survey, with the Economics 1100 class serving as the focus group to help determine bid amounts and what background information to elicit. The final survey had seven bid amounts: $0.50, $1, $2, $3, $4, $5, and $10. Each interviewer received 14 surveys, two sets of photographs showing "red air" and "green air" days, where one version evaluated an extremely bad red air day (Version A) and the other evaluated a 'not as bad' red air day (Version B), a map of Weber County, and a table showing red and yellow air days for the last two winters. Each respondent was asked a dichotomous choice question (yes or no) about his or her WTP a specified bid amount for one day of clean air (changing a red air day to green). The specific WTP question read:

> Suppose it is a **Red Air Day**, as shown in **Picture One**. For this one day, would you be willing to pay **$X (amounts varied between $0.50 and $10)** to improve the air quality to that of a **Green Air Day**, as shown in **Picture Two?**

Surveys were administered during late October and early November 2008, prior to any red air quality alerts during the 2008 fall season. The Econ 1100 surveyed county residents at malls, libraries, parks and other public locations. The Econometrics class surveyed Weber State students. After two week of collecting surveys, the Econ 1100 class submitted their findings to the Econometrics class for analysis and evaluation.

Results and Discussion

Participants in the survey provided individual characteristics as well as information about their environmental viewpoints and political

[3] A copy of this survey is available upon request from the faculty mentor.

ideology. The data consist of 160 observations. Table 1 represents our sample population as compared to the 2006 Weber County Census data. Our sample shows only slight differences from the census data, where the major difference is in median household income. The fact that our sample income is lower than the census is likely due to oversampling Weber State University students. Other than this difference, we have a relatively representative sample of the Weber County population. Of the 160 surveys, 125 respondents indicated that they were willing to pay some amount to clean the air. Table 2 shows the number of surveys distributed for each bid amount (i.e., $0.50, $1, $2, $3, $4, $5, and $10) and the number of "Yes" responses to the WTP question. As is expected, the higher the bid amount, the less likely someone answered "Yes." This analysis demonstrates the law of demand; as price increases, quantity demanded decreases.

Next we explored whether certain types of people were more or less willing to pay for clean air. Table 3 highlights the percentage of certain types of people who answered "Yes." It is not surprising that individuals with a respiratory illness were more likely to say "Yes" to the WTP question than those without a respiratory illness. Somewhat surprisingly, males were more likely than females to answer "Yes" to the WTP question, and those whose political affiliation was either Independent or Other tended be more likely than Republicans or Democrats to respond "Yes." While there are some differences, there seemed to be no strong indicators of what type of person was more likely to say yes; the majority of all types of respondents indicated that they were willing-to-pay some positive amount to clean the air.[4] Last, we found no striking difference between versions A and B. In general, we conclude that a majority of the population values clean air and may be willing to pay a significant amount to have clean air.

Our findings are corroborated by the statistical analysis performed by the Econometrics class. Their analysis showed that more than 50% of the respondents would be willing to pay $25 for one day of improved air quality. These results suggest that Weber County residents value good air quality more than the survey designers anticipated when setting bid amounts.

[4] This statement is corroborated by the statistical analysis conducted by the Econometrics class that showed that males were more likely than females to answer the WTP question affirmatively.

Conclusion

A contingent valuation study was conducted of Weber County, Utah, residents to determine WTP for clean air. Participants were asked to answer whether they would be willing to pay a specified bid amount to clean the air from a red air quality day to a green day. They were also surveyed on a number of factors that might influence their choices. From the data analysis, it appears that males and those who identify their political affiliation as independent or other are slightly more inclined to answer "Yes" to the various bid amounts. Further, having a family member with a respiratory disease seemed to have a slight impact on respondent's WTP. The econometric class analysis showed that more than 50% of the respondents would be willing to pay $25 for one day of improved air quality.

While the current study demonstrates that a majority of individuals are willing to pay some positive amount for clean air, there are a couple of suggestions for future research. First, the bid amounts used in the survey may need to be increased. Increasing the bid amounts will allow researchers to determine the point at which the price is too high, essentially, where nobody would be willing to pay a specified amount. Second, it would be interesting to explore the importance of providing background information on air quality to respondents. For example, are WTP amounts similar if a sample of the population is not given pictures or data on past red and yellow days? Last, it would be interesting to determine if the time of year or air quality on the day a person participates in the survey influences respondents' preferences for clean air. For example, would a respondent be willing-to-pay a higher amount if he or she were surveyed on a red air day versus a green air day?

Tables

Table 1. Data

Variable	Mean	Census (2006)
Male	54%	50.5%
Female	46%	49.5%
White	87%	95%
Median household income	$30,000-$39,999	$47,480 (year 2004)
Bachelors Degree	19% (63% had some college)	25%

Table 2. Responses to WTP question

Bid Amount	Number of Responses	Positive Responses	Percentage Yes	Cumulative[a]
$0.50	24	23	95.8%	125
1.00	23	22	95.7	102
2.00	25	18	72.0	80
3.00	23	18	78.2	62
4.00	22	17	77.3	44
5.00	20	14	70.0	27
10.00	22	13	59.1	13

[a]The cumulative amounts show the number of respondents who would be willing to pay the specified bid amount. For example, if someone said "Yes" to $1 then this person would also say "Yes" to $0.50.

Table 3. Demographic variations in WTP question

Variable	Percent of category answering "Yes" to the WTP question
Male	83%
Female	72%
White	78%
Household income: $0 – $29,999	79%
Household income: $30,000 – $59,999	78%
Household income: greater than $60,000	79%
Bachelors Degree	66%
Republican	76%
Democrat	73%
Independents/Others	82%
Respitory Illness	81%a
No Respitory Illness	74%

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References

Arrow, K., Solow, R., Portney,P., Leamer, E., Radner, R., and Schuman, H. (1993). The Report of the NOAA Panel on Contingent Valuation. *Federal Register* 58: 4601.

Carson, R. T. (2000). Contingent Valuation: A User's Guide. *UCSD Department of Economics*. Retrieved November 22, 2008, from http://weber.ucsd.edu/rcarson/

Harrop, Owen. (2002). *Air Quality Assessment and Management: A Practical Guide.* Taylor & Francis: United Kingdom.

King, D. M., Mazzotta, M. J. (2000). "CVM." *Ecosystem Valuation*. Retrieved November 22, 2008, from http://ecosystemvaluation.org/default.htm

Loehman, E., Park, S., & Boldt, D. (1994). Willingness to Pay for Gains and Losses in Visibility and Health. *Land Economics*, 70(4), 478-498. Retrieved February 4, 2009, from EconLit database.

Moeller, Dade W. (2004). *Environmental Health*. Harvard University Press: New York.

"National Weather Service." National Weather Service Forecast Office SLC, UT. EPA. 9 Nov. 2008 <http://www.wrh.noaa.gov/slc/climate/temperatureinversions.php>.

Nelson, S. A. "Control of air pollution." Tulane University. 9 Nov. 2008 <http://earthsci.org/processes/weather/airpolute/airplou.html>.

Randall, A. and Kriesel, W. (1990). Evaluating National Policy Proposals by Contingent Valuation. In *The Economic Valuation of Natural Resources; Issues, Theory and Application*. Eds. Rebbeca L. Johnson and Gary V. Johnson. Westview Press: Boulder, CO.

Rowe, R. D., D'Arge, R. C., Brookshire, D. B. (1980). An Experiment on the Economic Value of Visibiltity. *Journal of Environmental Economics and Management 7*, 1-19.

Schulze, W. D., Brookshire, D. B., Walther, E. G., MacFarland, K. K., Thayer, M. A., Whitworth, R. L., Ben-David, S., Malm, W., Molenar, J. (1983). The Economic Benefits of Preserving Visibility in the National Parklands of the Southwest. *Natural Resources Journal Volume 23*, 149-173.

Weinhold, B. U.S. Air Only Fair. (2002) *Environmental Health Perspectives*, 452-55.

The Effects of Indiscriminable Contingencies on the Independent Work Completion and Accuracy of Students with Emotional and Behavioral Disorders

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Abstract

This research describes the use of indiscriminable contingencies (IC) in a classroom of elementary students with behavioral disorders. The dependent variable was the accuracy and completion of an independent seat work assignment, also known as self-start. The independent variable was an IC, determined by the number rolled on a pair of dice. This study attempted to answer the question: What are the effects of IC on the independent work completion and accuracy for students with behavioral disorders? The study implemented a single-subject reversal design using a visual analysis of the data to interpret the results and potential success of the IC as a successful classroom intervention.

Introduction

Students with emotional and behavioral disorders (EBD) present educators and parents with a great challenge. Students with EBD experience academic failure and social rejection. The majority of students with EBD function a year or more below grade level in most academic areas (Kauffman, 2009, p. 210). Despite the increased attention given to this population, the educational, behavioral and social outcomes for this population are the worst of any of the identified disability groups (Bradley, Henderson & Monfore, 2004).

One strategy that has been used effectively to motivate students to complete academic work is the use of an indiscriminable contingency. Indiscriminable contingencies (IC) are contingencies in which the subject cannot discriminate whether his/her next response will grant a rein-

forcer (Cooper, Heron & Heward, 2007, p. 636). Because it is difficult or impossible for the students to predict which behavior will produce the reinforcer, the students are more apt to engage in all target behaviors that are eligible for the reinforcer. A benefit of the IC strategy is that the targeted behavior is more likely to occur more often after the IC has been faded (Guevremont, Osnes, & Stokes, 1986, p. 102). Popkin & Skinner found that the use of randomly selected criteria for academic work showed a significant increase in student performance across three subject areas with students with EBD (2003, p. 292). Another study using IC reported that students' mean work completion went from 22% during baseline to 91% during intervention (Ferreri, et al., 2004). A study by McLaughlin and Malaby (1972, p. 268) indicated that by using an IC, which varied the token exchange days, assignment completion rose 60%. This current study was designed to provide further information and support on the influence of IC on academic behaviors with students with EBD.

Methods

Participants and Setting

Three students placed in a self-contained classroom for students with EBD participated in this study. All students in the study were Caucasian. David was a 4th grader and had been placed in special education as a preschooler. He had initially been served as developmentally delayed, but in 1st grade was re-identified as EBD. Isaac was a Kindergartner and had been identified in the fall of his Kindergarten year for placement in the EBD classroom. Elaine was a first grader and had recently been placed in the EBD classroom. Both Isaac and Elaine's initial placement in special education was the self-contained classroom, due to clinically significant behaviors.

All participants attended a suburban public elementary school in a western state, which enrolled approximately 692 students from kindergarten through sixth grade. The ethnic composition of the school was 53% Caucasian, 2% Asian, 35% Hispanic, 7% Pacific Islander, 3% African-American. Sixty-four percent of the school population qualified for free or reduced school lunch.

Independent & Dependent Variables

The independent variable was an IC, determined by the number rolled on a pair of dice. The dependent variable was the percent complete and accurate of student work on a self-start assignment.

Materials

The materials for this study included the daily self-start assignment, a pair of a dice and reinforcers. Self-start assignments consisted of simple arithmetic problems, math word problems, and spelling and grammar exercises the students were to complete independently upon arriving to school. The teacher displayed the self-start on the overhead projector for students to complete independently at their desks. Each self-start had between 10 and 12 items. It had a corresponding answer key used by both the researcher and the classroom teacher to verify the accuracy of the student responses. The researcher conducted a student survey to generate reinforcers according to students' desires. The reinforcers consisted of edibles, stickers, small trinkets (e.g. erasers, key chains), art projects, free homework passes, and free time passes for computer time, resting, or playing with classroom toys.

Design

To examine the relationship between the completion and accuracy of independent work and the IC, a single subject reversal design was conducted. The format of the reversal design was ABA, baseline (A), intervention (B) and a return to baseline (A). This design was selected because it is the most powerful within-subject design for demonstrating a functional relationship between the independent and dependent variables. It allows for increased experimental evidence that the independent variable is the reason for the changes in the dependent variable (Cooper, Heron & Heward, 2007, p. 177).

During the baseline condition (A) the researcher examined the independent work of the three participants and measured levels of completion and accuracy. Intervention (B) consisted of the introduction of the IC following the self-start assignment.

Procedures

The participants engaged in the self-start assignment for 25 minutes. In the event that a student requested assistance from the classroom teacher the item on the self-start was recorded as complete, but incorrect. This decision was made based on the fact that the self-start assignment is designed to be independent work. The assumption was that if the student needed assistance in order to complete the task then it would have been incorrect had they done so independently.

After the 25 minutes, the researcher called the participants to the back of the room, one at a time, to roll a pair of dice. Whatever number rolled on the dice was the number of the item on the self-start assign-

ment that was checked for completion and accuracy. If the participant had completed the item, he/she received a reinforcer. If the item was also correct, the participant then received a bonus reinforcer.

Results

This study investigated the effects of an IC on the completion and accuracy of a self-start assignment for students with EBD. David attended 44 of 47 sessions throughout the study. During Baseline I David's mean score for completion was 82% (range 0-100%). His average accuracy score during Baseline I was 83% (0-100%). During Intervention his mean completion score was 90% (36-100%), his mean accuracy scores were also 90% (72-100%). During Baseline II average completion was 61% (0-100%) and average accuracy was 73% (0-100%). Figure 1 displays David's data across all study conditions.

Figure 1. Percent complete and accurate for David on self-start assignments. See www.weber.edu/OUR/Ergo2009

Isaac attended 30 of 47 sessions throughout the study. During Baseline I, Isaac's mean completion score was 59% (0-100%), his mean accuracy score was 52% (0-100%). During Intervention, his average completion score was 75% (45-100%), his average accuracy score was 38% (20-55%). During Baseline II, Isaac's average completion score was 81% (72-90%), his average accuracy score was 25% (11-45%). Figure 2 displays Isaac's data across all study conditions.

Figure 2. Percent complete and accurate for Isaac on self-start assignments. See www.weber.edu/OUR/Ergo 2009

Elaine attended 44 of 47 sessions throughout the study. During baseline I, Elaine's mean completion score was 56% (20-100%), her mean accuracy score was 89% (50-100%). During intervention, her average completion score was 91% (60-100%), her average accuracy score was 75% (20-100%). During baseline II, Elaine's average completion score was 97% (90-100%), her average accuracy score was 49% (27-64%). Figure 3 displays Elaine's data across all study conditions.

Figure 3 Percent complete and accurate for Elaine on self-start assignments. See www.weber.edu/OUR/Ergo2009

Discussion

Results from this study support previous research by Ferreri and colleagues (2004) and Popkin & Skinner (2003) for one of the participants in this study. The addition of an IC increased levels of completion and accuracy of academic work. Although this is not evident across all subjects in this particular study, the IC impacted the performance of David in both completion and accuracy. His completion increased by approximately 8% and accuracy by 6%. During Baseline II David's completion and accuracy decreased below his average of Baseline I. This indicated that the presence of the IC was impacting his performance.

Studies have shown that if a subject cannot meet the criterion required for reinforcement, the contingency has little effect on the behavior (Popkin & Skinner, 2003, p. 292). Isaac and Elaine were not functioning at grade level; thus, parts of the self-start assignments were too difficult for them to accomplish without assistance. During Intervention, the accuracy of student work diminished due to the seeming impossibility of the task. Although completion increased to levels of 100%, their percent accurate, due to the difficulty of the problem, was greatly affected.

Over the course of the study Isaac increased his completion score by 22%, and accuracy decreased by 27%. This indicated that he was completing more work, but the items he was completing were more difficult, therefore impacting the accuracy of his performance. Due to the continued increase of percent complete during the return to baseline phase, it is difficult to make statements regarding the impact of the IC on Isaac's performance. Additionally Isaac's excessive absences impacted his total data days available for analyzing. In fact, Isaac was only present for 64% of the sessions.

Elaine's completion increased by 42% over the course of the study across all conditions. However, her accuracy increased from 33% in Baseline I to 75% in Intervention decreased to 49% in Baseline II. Although completion does not reflect the impact of the reversal, the percent accurate seems to have been impacted by the removal of the IC. One explanation for this is that one reward was enough reinforcement; she was not concerned about the bonus reward for accuracy. Another possible explanation could be that she simply enjoyed being one-on-one with the researcher and this was sufficient, making accuracy inconsequential.

One of the limitations when conducting research in an applied setting is the interference of the school calendar. Spring break, field trips, and end-of-school-year activities placed limitations on the number of sessions that were conducted, and therefore the data to analyze. This impacted the length of Baseline II and a potential return to intervention. Another limitation with conducting research in an applied setting, in particular with students with behavioral disorders is the variability in their performance. Students with this type of disability are often impulsive and highly distracted, which greatly impacts their performance, both socially and academically (Kaufman, 2009).

The socioeconomic status of the population attending this school is fairly diverse, due to the geographic boundaries of this school. Results of this experiment may not generalize to populations of a different age, racial makeup, socioeconomic status, or a different geographic region. This study was conducted in a special education classroom with very few students, therefore results of this study may not generalize to classes of larger sizes.

Future research in this area should include an additional dependent variable of on-task engagement. This would allow the researcher to evaluate the percent complete to on-task behavior and any potential connection. For example, if completion was below 50%, the issue of student engagement, on-time arrival to school, removed from the class for one reason or another should be considered.

Future research should ensure that the tasks given to the students matched their academic level. This diminishes the need for teacher assistance and increases the validity of student accuracy scores. This study attempted to make some academic modifications, but more modifications to grammar and story problems would have been beneficial.

Although this study did not thoroughly answer the research question this is an area that should continue to be pursued. The intervention is one that educators can implement efficiently and effortlessly that will benefit their students in an applied, and often challenging, setting.

References

Bradley, R., Henderson, K., & Monfore D. A. (2004). A national perspective on children with behavioral disorders. *Behavioral Disorders*, 29, 211-223.

Cooper, J.O., Heron, T.E., & Heward, W.L. (2007). *Applied behavior analysis (2nd edition)*. Columbus, OH: Merrill.

Ferreri, S. J., Allen, N. J., Anderson, M.A., Wood, C. L., Musti-Roa, S., Hessler, T. L., Heward, W. L. (2004, May). The effects of structured seat work on the completion and accuracy of independent work. Paper presented at The Association for Behavior Analysis Conference, Boston, MA.

Guevremont, D. C., Osnes, P. G., & Stokes, T. F. (1986). Preparation for effective self-regulation: the development of generalized verbal control. *Journal of Applied Behavior Analysis*, 19, 99-104.

Kauffman, J. M. (2009). *Characteristics of emotional and behavioral disorders of children and youth (9th edition)*. Merrill Prentice Hall: Upper Saddle, NJ.

McLaughlin, T. F., & Malaby, J. (1972). Intrinsic reinforcers in a classroom token economy. *Journal of Applied Behavior Analysis*, 5, 263-270.

Popkin, J., & Skinner, C.H. (2003). Enhancing academic performance in a classroom serving students with serious emotional disturbance: Interdependent group contingencies with randomly selected components. *School Psychology Review*, 32, 271-284.

Macrolide Resistance Rates in *Streptococcus pyogenes* Along the Wasatch Front

Todd Keskey, Lauren Jackson, Bruce Jolly & Travis Price

Abstract

There are over 10 million cases of strep throat every year in the United States (Centers for Disease Control, 2005). Penicillin is the drug of choice to treat strep throat, however, up to 10% of the U.S. population claim to be allergic to it (Earl, Gruchalla, & Solensky, 2002, p. 822-826). In these cases, macrolide drugs such as azithromycin, erythromycin, and clarithromycin are prescribed instead of penicillin. Current research shows an increase in resistance to these drugs by the bacteria that cause strep throat. The intent of this study was to determine if there is similar resistance to these antimicrobials in Northern Utah (Wasatch Front). To accomplish this, we acquired 634 throat swabs that previously tested positive for strep, and tested the bacteria's antimicrobial susceptibility to penicillin, azithromycin, erythromycin, and clarithromycin. We confirmed the identity of the strep species after the bacteria were previously identified by rapid strep kits. Resistance rates were then determined on Kirby-Bauer plates supplemented with 5% sheeps blood using four different antimicrobial disks. Our results show 6.2% resistance to clarithromycin, 5.5% to azithromycin, and 5.4% to erythromycin. No isolates were resistant to penicillin. The intermediate resistance rate for clarithromycin was 19.1%, 18.2% to erythromycin, 15.5% to azithromycin, and only 1.9% to penicillin. This study validates the continued use of penicillin as the best option to treat strep throat infections. It also shows that macrolide drugs are still effective at treating patients sensitive to penicillin.

Introduction

Streptococcus pyogenes is the most common cause of bacterial pharyngitis. Children between the ages of five and fifteen years most commonly get strep throat, while most cases of pharyngitis in adults are of viral origin. The diagnosis of streptococcal pharyngitis relies on a throat culture or direct antigen detection, such as a rapid strep test kit. Most antigen detection tests look for the M protein specific to *S. pyogenes*. It is important to correctly diagnose *S. pyogenes* due to serious sequela complications that can follow infections if they are not treated properly. These complications include acute glomerulonephritis and acute rheumatic fever, which can lead to chronic rheumatic heart disease (Lehman, Mahon, & Manuselis, 2007, p. 395-398). Acute glomerulonephritis is a condition in which the part of the kidney responsible for filtering the blood is damaged.

Antimicrobial resistance is a growing problem in health care and is attributed to misdiagnosis, misuse, or overuse of antimicrobials by doctors and patients. People may self medicate or buy antimicrobials through other resources, when they should get a prescription after seeing a physician. An increase in the use of macrolide drugs correlates with an increase in resistance to these drugs by bacteria, such as *S. pyogenes*. As antimicrobial resistance rates increase, the drugs are no longer as effective, leading doctors to prescribe antimicrobials that may have more detrimental side effects. Gastrointestinal problems are the leading complaint of patients who take these antimicrobials. The antimicrobials destroy a significant portion of the bacteria present in the gastronintestinal tract, many of which are necessary for normal digestion. Without this bacteria-driven metabolism, patients may experience diarrhea and cramping. Due to their roles in chemical metabolism and excretion, the liver and kidneys can also be severely affected by high doses of antimicrobials. In addition to the health risks, these second line antimicrobials are considerably more expensive, often require a hospital stay to administer the drug, and may require a longer course of treatment.

The objective of this research was to determine the resistance rate of *S. pyogenes* to the drugs penicillin, azithromycin, erythromycin, and clarithromycin along the Wasatch Front. Studies performed in the U.S. show up to 10% of Americans claim to be allergic to penicillin; however, only 20% of these individuals actually are (Earl, Gruchalla, & Solensky, 2002, p. 822). The antibiotic of choice in treating strep throat infections is penicillin, but when a potential allergy would prevent the use of penicillin, physicians prescribe macrolide drugs such as azithro-

mycin, erythromycin, and clarithromycin to treat the infection (Brooks et al., 1999, p. 1727-1731). The most comprehensive and recent research compiled from 1,885 samples taken across the U.S., shows a 6.9% resistance to azithromycin, followed closely by a 6.8% resistance to erythromycin, and a 6.6% resistance to clarithromycin (Beekman et al., 2005 p. 599-608). Percentage rates of resistance change every year and vary by region because of the many different strains of *S. pyogenes*. For example, in one study done in the San Francisco Bay area, erythromycin resistance was as high as 27% in one county and as low as 4% in a neighboring county (Brooks et al., 1999, p. 1727-1731). A similar study performed in the Boston area showed resistance rates as high as 48% to erythromycin (Cole et al., 2004, p. 1559-1563). The large variation in resistance patterns supports the need for a study along the Wasatch Front. The major aim of this study was to answer the question: What are the resistance patterns of *S. pyogenes* to macrolide drugs in the northern Utah area?

Methods

From November of 2007 through February of 2008, we collected 634 positive strep throat swabs from Intermountain Healthcare and University of Utah hospitals and clinics ranging from Taylorsville to North Ogden, Utah. When strep throat is suspected, most hospitals and clinics collect two swabs from the patient. The first swab is used for the rapid strep test kit, while the second swab is usually discarded if the rapid test from the first swab indicates a positive result. We approached the clinics and hospital labs and solicited these swabs that would have been thrown away. These swabs were then used to isolate the streptococcus bacteria on sheep blood agar (SBA) plates. After isolation, we confirmed the identity of *S. pyogenes* using the criteria of strong beta hemolysis, positive streptolysin O, and bacitracin susceptibility using a 0.04 unit bacitracin ID disk (Remel, Lenexa, KS) (Lehman, Mahon, Manuselis, 2007, p. 395-398). A Columbia broth solution (Becton Dickinson, Santa Maria, CA) was made to a concentration of 0.5 to 1.0 McFarland standard units. Concentrations were measured using a Crystal Spec nephlometer (Becton Dickinson, Santa Maria, CA) to ensure continuity throughout the project. Kirby-Bauer plates, supplemented with 5% sheep's blood, (Hardy Diagnostics, Sparks, MD) were then inoculated with the broth solution using a cotton swab. After inoculation, one antimicrobial disk of 10 micrograms (µg) penicillin, 15 µg azithromycin, 15 µg erythromycin and 15 µg clarithromycin (Remel, Lenexa, KS), were placed on the plate which was then incubated at 35° C in an air incubator. After 24 hours, the plates were examined and zones of

resistance were measured using a digital caliper. The zone of inhibition is established when antimicrobials from the disks diffuse into the agar and inhibit bacterial growth. Because diffusion is radial, these zones are often distinct circles void of bacterial colonies. The diameter of each of these zones was measured in two directions to establish an average zone of inhibition. The measured zones were interpreted using the zone diameter interpretive chart supplied by Remel, the manufacturer of the antimicrobial disks. When a resistant strain was identified, we tested it further to confirm the identity of *S. pyogenes* with a negative catalase and positive pyroglutamate aminopeptidase (PYR) (Remel, Lenexa, KS). These further steps were taken to rule out the possibility of contamination during the several steps of susceptibility testing.

Results

The zone diameters used to determine the Minimal Inhibitory Concentration (MIC) of the different antimicrobial disks are listed in Table 1.

Table 1. Showing criteria for zones from CLSI/NCCLS Approved Standard, M2-A8 and Informational Supplement, M100-S15

Organism	Antimicrobial	Resistant (mm)	Intermediate (mm)	Susceptible (mm)
Streptococcus pyogenes	Penicillin	< 11	12 - 21	> 22
	Azithromycin	< 13	14-17	> 18
	Clarithromycin	< 16	17 – 20	> 21
	Erythromycin	< 15	16 – 20	> 21

We interpreted 634 separate results. From these results, 39 isolates, or 6.2%, showed resistance to clarithromycin, followed by 35, or 5.5%, resistant to azithromycin, and 34, or 5.4%, resistant to erythromycin. There were no isolates that were resistant to penicillin. These resistance rates were comparable to the national average (Beekman et al., 2005, p. 599-608). Those isolates with intermediate reactions were more striking. For clarithromycin, 19.1% of the isolates had intermediate zones, followed by 18.2% to erythromycin, 15.5% to azithromycin, and a mere 1.90% to penicillin (Figure 1).

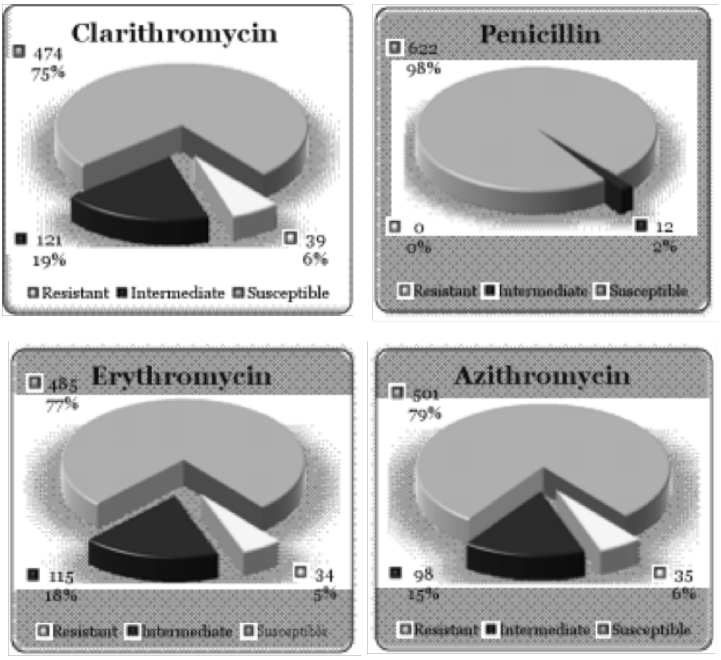

Figure 1

Discussion

Our research validates the continued use of penicillin as the drug of choice to treat *S. pyogenes* infections (Beekman et al., 2005, p.599-608). The resistance rates we tested were slightly lower than the national average established by Beekmann et al., who determined the national resistance to azithromycin to be 6.9%, erythromycin 6.8% and clarithromycin 6.6% (2005). The significance of organisms with complete resistance to antimicrobials is obvious, but there may be significance in organisms showing intermediate levels of resistance. Bacteria that show intermediate levels of resistance may not be completely killed by the antimicrobial and the bacterial infection may continue. This often leads doctors to change the patient's course of treatment to an antimicrobial that has tested to be more effective. Previous studies show results as resistant or susceptible, but do not include information on those isolates that tested intermediate. This lack of information makes it difficult to assess if there exists an increasing trend in intermediate resistance.

These results show the current strains of *S.pyogenes* along the Wasatch front have a slightly lower resistance rate to macrolide antimicrobials

than the national average. However, the relatively high intermediate results may indicate the macrolide drugs are becoming less effective at treating *S. pyogenes* infections. These findings support the need for future studies to evaluate if there is an increasing trend in resistance. These studies will determine if the intermediate bacteria are becoming completely resistant, or if they continue to show only intermediate resistance.

We dispersed our findings to local physicians so they can better treat their patients. To avoid any potential increase in resistance to macrolide drugs, it would be beneficial for physicians to investigate if their patients are truly allergic to penicillin.

References

Beekmann, S., Doern, C., Doern, G., Heilmann, K., Miller, A., Miller, N., Reid, S., Rice, C., S., Richter. 2005. Macrolide-resistant *Streptococcus pyogenes* in the United States 2002-2003. *Clinical Infectious Disease*, 41. 5, 599-608.

Brooks, G., Gibbs, L., Perdreau-Remington, F., M. York. (1999). Characterization of Antimicrobial Resistance in *Streptococcus pyogenes* Isolates from the San Francisco Bay Area in Northern California. *Journal of Clinical Microbiology*, 37. 6, 1727-1731.

[CDC] Centers for Disease Control. (2005 Oct. 11). CDC home page. Retrieved September 17, 2007, from http://www.cdc.gov/ncidod/dbmd/diseaseinfo/groupastreptococcal_t.htm.

Cole, S., Hasenbein, M., Lambert, K., McAdam, A., Onderdonk, A., J., Warner. (2004). Detection of Multiple Macrolide- and Lincosamide- Resistant Strains of *Streptococcus pyogenes* from Patients in the Boston Area. *Journal of Clinical Microbiology,* 42. 4, 1559-1563.

Earl, H., Gruchalla, R., R., Solensky. (2002). Lack of Penicillin Resensitization in Patients with a History of Penicillin Allergy after Receiving Repeated Penicillin Courses. *Archives of Internal Medicine*. 162, 822-826.

Lehman, D., Mahon, C., G., Manuselis. (2007). *Textbook of Diagnostic Microbiology. 3rd ed.* Philadelphia: Saunders. P. 395-398.

The Migration of Plants and Culture: The Presence of Traditional Mexican and Central American Medicinal Plants in the Latin Markets of Ogden, Utah

Cheyenne Church-Herland & Susan Young

Abstract

Plants sustain every ecosystem and culture. Plants, people, and information are all migratory and knowledge of indigenous plant use resides within the minds of individuals; as individuals move, so too do their culturally important plants. An increasing Latin population in Ogden, Utah prompted an investigation of the connection between traditional plant uses and immigration. Eighteen local markets were surveyed for the presence of seven sample plants. Demographic research verified a growing Latin population. Interviews with Mexican immigrants, including two traditional healers, illustrated a changing Latin world view. As culture undergoes rapid change, the plants necessary for strong cultural maintenance are represented most consistently in the continuance of traditional cuisine. Plants not used in foods and medicines or other daily customs fall out of use.

Introduction

Areas of great biodiversity and ancestral cultures possessing a wealth of knowledge about local medicinal plants exist concurrently. As illustrated by the Badianus manuscript of 1552, the oldest known documentation of indigenous plant use, the cultures of Mexico and Central America clearly possess this historical understanding (Shultes, 1995, p. 109). Ethnobotanical expeditions have revealed that as much as one-third of the Yucatan's plants are medicinally significant (Given & Harris, 1994).

Plants, people, and information are all migratory. When individuals move, they bring culturally important plants with them. Ethnobotanical

study must therefore include culture groups that have migrated to new homes. The rapidly changing demographics of Ogden, Utah indicate a dramatic increase in the number of Hispanic residents (Ogden City School District, 2007; C. Church, personal communication, 2008). Assimilation after migration requires a change in world view. Departure from traditional lifeways, exacerbated by the need to conform, leads to loss of information as loyalty to the maintenance of tradition is exchanged for the desire for acceptance. The accumulation of like cultures, such as those sharing a language and analogous struggles, represents a continuum of ideology. In Ogden's community, Latin American culture represents both a vast geographical area and collective experience.

In sum, "the cultural background...often extends to a knowledge of the medicinal plants valued in their own culture; over the years this drug-plant lore derived from diverse sources has gradually diffused through the larger...society" (Schultes, 1995, p. 349). Likewise, as Latin American communities assimilate into the Ogden community, so too does their ideological continuum. This ideology is frequently represented in the most assimilated aspect of culture: cuisine. Plants used by traditional healers are frequently found in medicinal preparations as well as the culinary traditions of cultures.

Methods

To maintain a reasonably-sized project my mentor suggested the selection of seven plants. Texts and articles from Latin America revealed a common set of plants that cross-cut the categories of medicine and cuisine: *Cascara sagrada, Chenopodium ambrosiodes (epazote), Coriander sativum* (cilantro), *Manzanilla comun* (chamomile), *Piper sp. (cordoncillo), Tilia Americana,* and *Zea mays* (corn silk). Background research was conducted on this sample to determine their regional and traditional uses. Journal articles provided empirical data, including nutritional and chemical content.

I used three anthropological informants: my neighbor Jackie Delgado, and local healers Juanita and Carlos Gonzáles, all of whom immigrated to Ogden from Mexico. Their reported folk uses of the plant sample were compared to clinical and textual findings. Field reconnaissance resulted in a map identifying eighteen markets and grocers, twelve Latin and six mainstream, within the bound study areas of 2nd and 42nd streets, and between Harrison Blvd and Wall Ave. (Fig. 1). A survey, polling each of these markets twice over a six-month period, determined the level of demand in Ogden for the sample plants.

Figure 1. Map of study area in Ogden, UT.
See www.weber.edu/OUR/Ergo2009

Results

The 2000 US Federal Census data indicated approximately 13% of Weber County is comprised of Latinos, 23.6% in Ogden (U.S. Census Bureau, 2008). Ogden City School District (OCSD) records show enrollment of Hispanic students to be just over 46% district-wide (Fig. 2). Latinos make up 60% of the patient population of Midtown Community Health Clinic, a sliding-scale medical clinic serving low-income families in Ogden (Midtown Community Health Clinic, 2006). George Mesa of *El Estandar,* the Spanish-speaking edition of the local paper, *The Standard Examiner*, revealed that his paper began production in October, 2004. The creation of this paper by the mainstream local news source acknowledges the growing Latin population. Additionally, Mr. Mesa shared his personal and professional experience that the Hispanic population of Ogden is generally underestimated (C. Church, personal communication, 2008).

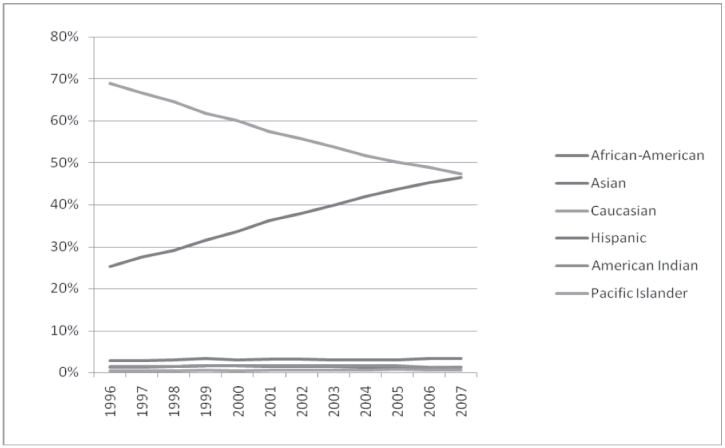

Figure 2. Ogden City School District Enrollment by Ethnicity, 1996-2007.

During our conversation, Mr. and Mrs. Gonzáles produced bags of dried plants from local markets. As they shared plant names and uses, Mrs. Gonzáles repeated the phrase, "This plant is good for *too many things*!" because one plant can affect many different body systems. They indicated the majority of their clients are healing from childbirth, injury, or serious illness. Many are suffering from preventable sicknesses brought on by poor nutrition or self care. Mrs. Gonzáles postulated

that in trying to keep up with the American lifestyle, Latin lifestyles are being dismissed and forgotten. Because of this, fewer people are seeking their help as traditional healers and their clientele has dwindled in recent years (C. Church, personal communication, 2006).

Clinical research confirmed the sample plants as important medicinal herbs. These findings are compared in Table 1 to information on folk uses gathered from interviews and literature.

Coriander sativum, Manzanilla comun, Chenopodium ambrosiodes, and *Tilia americana* were available 90.0% of the time in Latin markets. *Cascara sagrada* was available 54.5% of the time, and *Zea mays* 45.5%. *Piper sp.* was conspicuously absent from the shelves of every Latin market in Ogden.

In mainstream markets, *C. sativum* and *M. comun* were available 85.7% of the time, while *T. americana* could be found in 42.9% of stores. *Z. mays* was found 28.6%; *C. ambrosiodes* and *C. sagrada*, 14.3%. *Piper* was also absent in mainstream grocery stores.

As could be expected because their use has assimilated into mainstream American culture, *C. sativum* and *M. comun* were the most available in the combined markets of Ogden, with 88.9% of all grocery stores carrying these plants for sale in multiple forms.

Discussion

There are important connections between cultural practices and scientific research. In recent decades, traditional folk uses of medicinal plants have been largely validated by modern research techniques (Ortiz de Montellano, 1975; Shultes, 1995). Clinical research indicates that the continued use of the plants of this study may have a positive effect on health (Table 1). The cultural practice of incorporating medicinal plants into cuisine is therefore more than simply a matter of taste or habit. The maintenance of this practice has the potential to improve the health of the Hispanic community, which may have greater difficulty accessing quality healthcare for reasons relating to income, immigration status, and language.

As culture undergoes rapid change, the plants that are involved in traditional cooking are preserved, along with plants that serve as an important element in daily customs. People continue reaching for herbs

Table 1. Folk uses and clinical findings for sample plants.
www.weber.edu/OUR/Ergo2009

that are easily prepared, available, effective, and inexpensive. *Piper sp.* is an important medicine that has fallen out of use as it is not incorporated into cooking practices or life rituals (Leonti, Marco, Ramirez, Fernanado R., Stiher, Otto, & Heinrich, Michael, 2003). I suspect that this is the reason it was unavailable in the markets I surveyed.

These observations may explain the Gonzáles' decreased clientele. The efficiency of a prescription, the ease and convenience of simply popping a pill causes the work involved in contacting a healer, doing personal research, shopping for ingredients, and the preparation of home remedies to lose its allure.

Ms. Delgado also validated my observation that people are turning to plants as medicine less often. She shared that her family and friends no longer have time to make plant medicines due to a busier, more modern lifestyle in America. But because they must cook anyway and enjoy their foods prepared in the traditional way, they continue the use of herbs in their foods (C. Church, personal communication, 2006).

This study suggests that a connection between food and culture is a tangible measure of the preservation of traditional, botanical use and knowledge. Therefore, further research to continue tracking the presence of herbs available in Ogden's markets would map trends and availability, creating a clearer picture of whether this knowledge is being preserved or lost. Local anthropologists working in cultural advocacy could use this information to educate people about the need for deliberate decisions regarding the maintenance of plant customs that connect people to culture, and potentially to improvements in health.

References

Aguirre-Hernández, E., Martinez, A.L., Gonzalez-Trujano, M.E., Moreno, J., Vibrans, H., & Soto-Hernandez, M. (2007). Pharmacological evaluation of the anxiolytic and sedative effects of *Tilia americana L. var. mexicana* in mice [Electronic version]. *Journal of Ethnopharmacology*, 109 (1), 140-145.

Ali, S.S., Kasoju, N., Luthra, A., Singh, A., Sharanabasava, H., Sahu, A., & Bora, U. (2007) Indian medicinal herbs as sources of antioxidants [Electronic version]. *Food Research International*, 41(1), 1-15.

Arvigo, R., & Epstein, N. (2001) *Rainforest home remedies: The Maya way to heal your body and replenish your soul.* New York: HarperCollins.

Arvigo, R., & Epstein, N. (1994) *Sastun: My apprenticeship with a Maya healer.* New York: HarperCollins.

Bajpal, M., Mishra, A., & Prakash, D. (2005) Antioxidant and free radical scavenging activities of some leafy vegetables [Electronic version]. *International Journal of Food Sciences and Nutrition*, 56(7), 473-481.

Baumann, Leslie. (2007) Less-known Botanical Cosmeceuticals. *Dermatologic Therapy*, 20, 330-342.

Blumenthal, Mark. (2003) *The ABC clinical guide to herbs.* Austin: American Botanical Council.

Cruz, G., Pereira, P.V.S., Patricio, F.J., Costa, G.C., Sousa, S.M., Frazao, J.B., Aragao-Filho, W.C., Maciel, M.C.G., Silva, L.A., Amaral, F.M., Barroquiero, E.S.B., Guerra, R.N., & Nascimento, F.R. (2007) Increase of cellular recruitment, phagocytosis ability and nitric oxide production induced by hydroalcoholic extract from *Chenopodium ambrosioides* leaves. *Journal of Ethnopharmacology*, 111(1), 148-154.

Given, D.R. & Harris, W. (1994) *Techniques and methods of Ethnobotany*. London: The Commonwealth Secretariat.

Herrera, Cecilia Isabel Cleaves. (1999) *La Medicina Que Esta En Las Plantas*. Mexico City: Centro de Estudios, Informacion y Bases para la Accion Social (CEIBAS).

Leonti, M., Ramirez, F.R., Stiher, O., & Heinrich, M. (2003) Medicinal flora of the populuca, Mexico: A botanical systematical perspective. *Economic Botany*, 57(2), 218-230.

Midtown Community Health Center. (2006) *Site Summary Report: Demographic and Clinical Data; Fiscal Information.* Ogden, UT.

Ogden City School District. (2007) *District Totals; District Enrollment by Ethnicity; District Enrollment by Ethnicity*. Ogden, UT.

Ortiz de Montellano, Bernard. (1975) Empirical Aztec medicine. *Science*, 188, 215-220.

Pérez-Ortega, G., Guevara-Fefer, P., Chavez, M., Herrera, J., Martinez, A., Martinez, A.L., & Gonzalez-Trujano, M.E. (2008) Sedative and anxiolytic effects of *Tilia americana* var. *mexicana* inflorescences used traditionally by communities of State of Michoacan, Mexico. *Journal of Ethnopharmacology*, 116(3), 461-468.

Rivera, J.O., Gonzáles-Stuart, A., Ortíz, M., Rodríguez, J.C., Anaya, J.P., & Meza, A. (2006) Guide for herbal product use by Mexican Americans in the largest Texas-Mexico border community. *Journal of the National Medical Association*, 97(12): 1686-1693.

Shultes, R.E. & Von Reis, S. (1995) *Ethnobotany: Evolution of a discipline*. Portland: Dioscroides Press.

U.S. Census Bureau. (2000) State and county quickfacts: Ogden, Utah. Retrieved Sept. 9, 2008. http://quickfacts.census.gov/qfd/states/49/4955980.html

Zamora, Julio Rodas. (Date of publication not recorded) *Diccionario de plantas medicinales*. Belize: Perito Agronomo y Tecnico Forestal.

Bacterial Predation by Bacteriophage Isolated from the Great Salt Lake

Natalie E. Savage, Zachary Sexton, Cristy Waters, Matthew J. Domek & Craig J. Oberg

Abstract

The Great Salt Lake (GSL) is a hypersaline environment ideal for moderate to extremely halophilic microorganisms. Bacteria predation by bacteriophages has a significant impact on controlling bacterial populations in aquatic environments. Yet there are very few reports of bacteriophage predation in the GSL. Bacterial strains previously isolated from the South Arm of the GSL on 8% NaCl halophilic medium were used as potential prey. Water samples obtained from the south arm were centrifuged then filtered to remove bacteria and tested for bacteriophage activity by using a plaque assay in soft agar. A common moderate halophile in the GSL, *Salinivibrio costicola*, identified based on morphology, Gram stain, and 16S rRNA was found to be a susceptible host to bacteriophage in the south arm water sample. Amplification of this bacteriophage isolate (NS01) in broth culture resulted in a titer of 1 x 10^8 pfu/mL. NS01 bacteriophage activity was destroyed by boiling but not by freezing. Molecular analysis of NS01 bacteriophage suggests it is a DNA bacteriophage. Studies are currently underway to determine the potential impact of this bacteriophage on the *Salinivibrio costicola* population densities in the GSL ecosystem.

Introduction

The Great Salt Lake (GSL) is a hypersaline environment that is ideal for moderate to extremely halophilic microorganisms (Baxter 2005). A high concentration of nutrients, constant sunlight exposure, and wind-generated aeration allows the GSL to support a high concentration of halophilic organisms (Ventosa 2006). Bacteria predation by bacteriophages is reported to have a significant impact on controlling bacterial populations but its affect in hypersalin environments is unknown

(Dyall-Smith 2005). There are very few reports of bacterial predation by bacteriophage in the GSL. One study in the Dead Sea found 1 X 10^7 virus particle per mL of water (Oren 1997). A follow up study suggested that the titer of virus particles in the Dead Sea changed seasonally, falling to as low as 1 X 10^4 per mL during winter (Ventosa 1998).

The south arm of the GSL has lower salinity due to greater influx of fresh water. This results in a very diverse population of bacteria in this fluctuating halophilic environment that could support a diverse population of bacteriophage. There are only a few reports of bacteriophage for *Salinivibrio costicola* (previously classified as *Vibrio costicola*) and these isolates were from a Spanish saltern (Goel 1996). In this study, we investigated the role of bacteriophage predation on host bacteria isolated from the south arm of the GSL. We isolated moderately halophilic bacteria from the GSL and tested the same GSL waters for predatory bacteriophages.

Methods

Isolation of Halophilic Bacteria

Water samples were obtained from Bridger Bay, which is on the northern end of Antelope Island in the GSL. Water samples were collected between May and November of 2007. The salinity varies from approximately 8 - 12 % in this portion of the GSL. Spread plates were made from dilutions of the water samples onto Halobacteria Medium (HM) Agar supplemented with 8% NaCl (Atlas 1993). Multiple isolates were re-streaked to obtain pure cultures.

Identification of Bacterial Isolates

Thirty isolates were screened for susceptibility to predation by bacteriophage. Nine of the isolates were identified using 16S rRNA sequence analysis (DeSantis 2006) as *Salinivibrio costicola*. Two of the isolates (Table 1) were found to be susceptible to predation by bacteriophage.

Sampling for Bacteriophages

Water samples obtained from the GSL were centrifuged at 6000 x g for 20 minutes to remove debris. The supernatant was filtered through 0.2 μm filter to remove bacteria but retain any potential bacteriophages. The filtered water samples were used in the plaques assay with each of the 30 bacterial isolates. The plaque assay was also used to quantitatively determine the titer of bacteriophages. The filtrates were tested for predatory bacteriophages by plaque assay. A HM broth culture of bacterial isolates was used as the inoculum. Three drops of the bacterial inoculum and 0.1

Table 1. Phage host survey with *Salinivibrio costicola* strains from the GSL.

Strain	NS01	CW01	CW02	CW03	ZS01	ZS02	ZS03	ZS04	ZS05	ZS06
SV2	–	–	–	–	–	–	–	–	–	–
SV14	+	–	–	+	+	+	+	+	+	+
S5s-mall	–	–	+	–	–	–	–	–	–	–
S24	–	–	–	–	–	–	–	–	–	–
S9	–	–	–	–	–	–	–	–	–	–
S17	–	–	–	–	–	–	–	–	–	–
S20	–	–	–	–	–	–	–	–	–	–
S22	–	–	–	–	–	–	–	–	–	–
TT	–	–	–	–	–	–	–	–	–	–

mL of filtrate containing potential bacteriophage were added to 3 mL of soft agar. After two days of incubation at room temperature the plates were checked for predation by bacteriophage. A clearing or plaque in the bacterial growth in the soft agar represents predation by the bacteriophage. Each plaque or plaque forming unit (PFU) is equivalent to one bacteriophage.

Bacteriophage Temperature Sensitivity

One of the bacteriophages (NS01) was tested for reduction in titer at 4°C and -20°C temperatures. A filtrate containing NS01 was also subjected to heating at 50°C and boiling for 10 minutes.

Molecular Characterization

NS01 DNA was extracted using a Qiagen lambda mini kit (Qiagen, Valencia, CA). Extracted DNA was run on an 0.8% agarose gel.

Imaging of Bacteriophage

NS01 enrichment filtrate was dispensed on a formvar copper grid and treated with 3% uranyl acetate. Scanning Electron Microscopy (SEM) was performed Dr. David M. Belnap.

One Step Growth Curve

A culture of SV 14 was allowed to grow for 24 hours and then used as the host in a one step growth curve. Approximately 100 ml of the SV 14 inoculated broth was placed on a shaker at 25° C for the duration of the experiment. NS01 was mixed with SV14 host. After five minutes of incubation, unattached bacteriophages were separated from host SV14

that were infected by NS01. Only the bacteriophage infecting SV14 were retained. Samples were taken every 20 minutes. At each given time interval, 200 µl of the SV 14 broth, along with 3 drops of undiluted SV 14 were added to 3 ml of 0.5% of soft agar and poured onto 1.5% agar plates. The titer of the inoculated broth was measured by plaque assay.

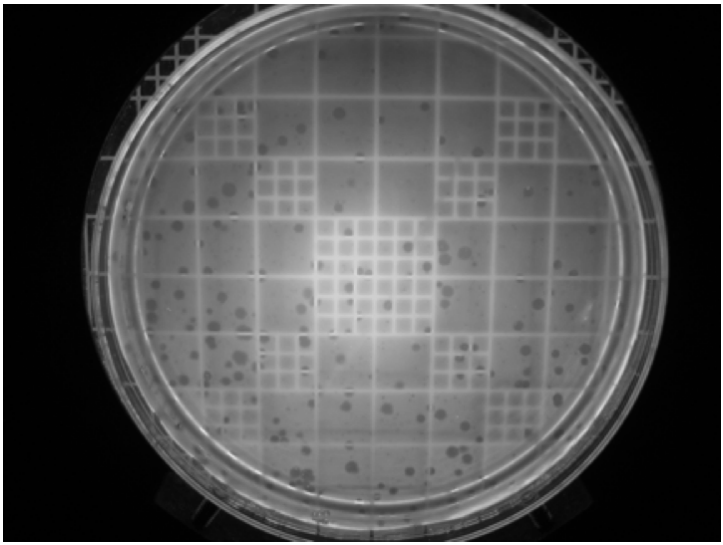

Figure 1. The filtrates were tested for predatory bacteriophages by plaque assay. A HM broth culture of bacterial isolates was used as the inoculum. Three drops of the bacterial inoculum and 0.1 mL of filtrate containing potential bacteriophage were added to 3 mL of soft agar. After two days of incubation at room temperature the plates were checked for predation by bacteriophage. A clearing or plaque in the bacterial growth in the soft agar represents predation by the bacteriophage. This plate shows predation of the SV14 bacterial host by the bacteriophage NS01.

Results

Bacterial Host Isolates

Sequencing of the 16S rRNA gene revealed that nine of the thirty isolates were 100% homologous with *Salinivibrio costicola*. Two of the *S. costicola* isolates were found to be hosts of the bacteriophages. Table 1 shows the bacteriophages and the bacterial isolates that serve as their host. Bacteriophages NS01 and ZS01-ZS06 infected *S. costicola* SV14 while CW02 infected *S. costicola* S5small. Bacteriophage NS01 was isolated in 2007 while the other bacteriophages were isolated in 2008.

Bacteriophage Predation

A measurement of the bacteriophage titer in a GSL water sample was made in June of 2008. SV14 was used and a titer of 2.3 X 10^3 pfu was determined by plaque assay. The replication cycle of the NS01 was measured in the laboratory by using a one step growth curve. A one step growth (Figure 2) of NS01 shows greater than a 2 log increase in pfu. This suggests approximately 100 bacteriophages were produced from each predated bacterial host. The replication cycle appears to take approximately 30-40 minutes (Figure 2).

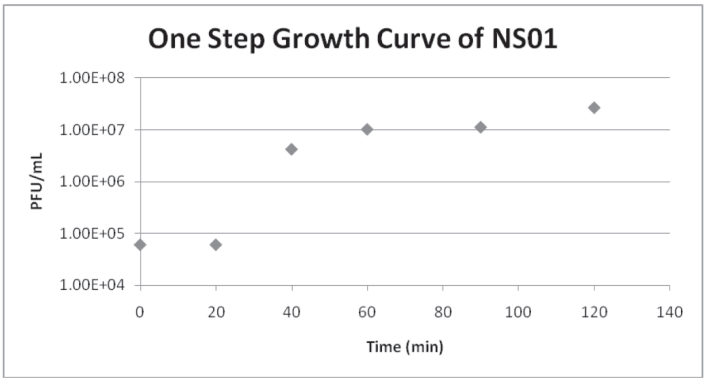

Figure 2. NS01 was mixed with SV14 host. After five minutes of incubation, unattached bacteriophages were separated from host SV14 that were infected by NS01. Only the bacteriophage infected SV14 were retained. The PFU's were measured every 20 minutes. PFU's began to increase at 30 minutes. The increase is due to the bacterial cells bursting and releasing bacteriophages (PFU's).

Bacteriophage Temperature Sensitivity

NS01 filtrate was stable at 4°C and -20°C for many months without reduction in titer. NS01 was tolerant of 50°C, however, was completely inactivated by boiling.

Molecular Characterization

Nucleic acid extracted from NS01 suggests a DNA viral genome (gel not shown).

Imaging

SEM shows two dominant shapes in the NS01 filtrate (Figure 3) an icosahedral shape and a possible short tail structure (arrow).

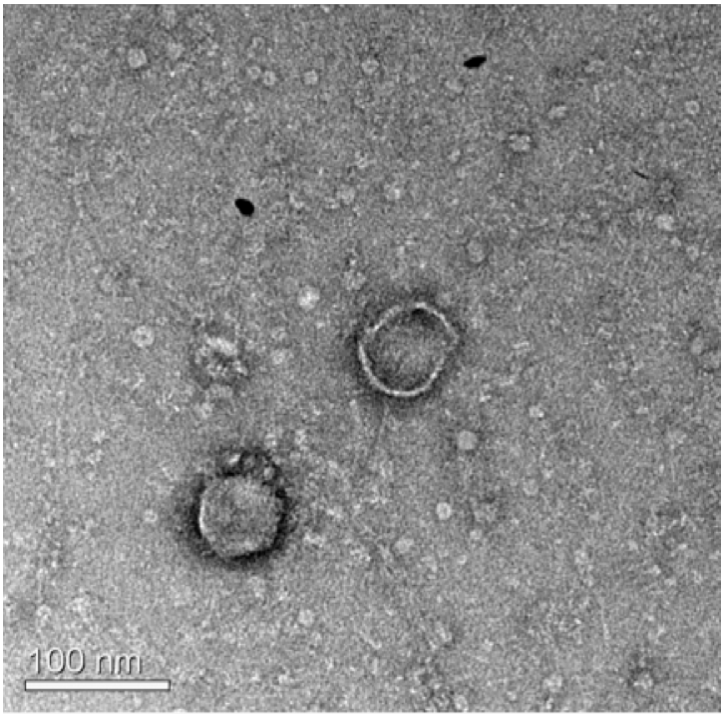

Figure 3. SEM of a icosahedral-shaped bacteriophage-like particle with a possible short tail structure (arrow).

Discussion

This study showed that a bacteriophage (NS01) can be isolated from the GSL. NS01 was tested against 30 isolates but infected only one isolate of *Salinivibrio costicola*. Additional isolates will be tested to determine its host range and its impact on predation in the GSL. NS01's tolerance to hot and cold temperatures suggests it can easily survive in the GSL through the range of winter (<0°C) and summer (>40°C) temperatures.

The molecular characterization of NS01 is ongoing. Sequence analysis should reveal its relatedness to other bacteriophages. The data was not conclusive with regards to DNA being a single or double stranded structure.

The virus-like particle in Figure 3 suggests a possible short tail structure on a icosahedral body. This shape is common among bacteriophages. This type of structure was reported Goel et al. (1996) for a bacteriophage (VTAK) that infected *S. costicola* but varies from electron

micrographs of other bacteriophages reported for *S. costicola* (Kauri 1991). Their micrographs show a much longer tail and tentatively tail fibers. Figure 3 is possibly an assemblage of incomplete virus particles. Additional electron microscopy will reveal more details regarding morphology.

Acknowledgements

SEM provided by Dr. David M. Belnap and Peter S. Shen, Department of Biochemistry, Brigham Young University, Provo, Utah. Also we acknowledge microbiology student, Benjamin Floyd, for his help with the one step growth curve. Grants from the Office of Undergraduate Research and the Research Scholarship Professional Growth Committee at Weber State University provided funding for this research.

References

Atlas, R. M. (1993) *Handbook of Microbiological Media*. Parks, L. C. (ed.) CRC Press, Boca Raton, FL.

Baxter, B. K., Litchfield, C. D., Sowers, K., Griffith, J. D., Dassarma, P. A., and Dassarma, S. (2005) Microbial diversity of Great Salt Lake. *In Adaptation to life at high salt concentrations in Archaea, bacteria, and eukarya*. Gunde-Cimerman, N., Oren, A., and Plemenitas, A. (ed.) Springer, Netherlands.

Dyall-Smith, M. L., D. G. Burns, H. M. Camakaris, P. H. Janssen, B. E. Russ, and K. Porter. (2005). Haloviruses and their hosts. *In Adaptation to life at high salt concentrations in archaea, bacteria, and eukarya*. Gunde-Cimermann, N., A. Oren, and A. Plemenitas (ed.) Springer Publishing.

DeSantis, T. Z., P. Hugenholtz, N. Larsen, M. Rojas, E. L. Brodie, K. Keller, T. Huber, D. Dalevi, P. Hu, and G. L. Andersen. 2006. Greengenes, a Chimera-Checked 16S rRNA Gene Database and Workbench Compatible with ARB. *Applied and Environmental Microbiology* 72:5069-72.

Goel, U., T. Kauri, H-W. Ackermann, and D. J. Kushner. (1996). A moderately halophilic *Vibrio* from a Spanish saltern and its lytic bacteriophage. *Can. J. Microbiol*. 42, 1015-1023.

Kauri, T., H-W. Ackermann, U. Goel, and D. J. Kushner. (1991). A bacteriophage of a moderately halophilic bacterium. *Archives of Microbiol*. 156, 435-438.

Oren, A., G. Bratbak, and M. Heldal. (1997). Occurrence of virus-like particles in the Dead Sea. *Extremophiles* 1, 143-149.

Post, F. J. (1977) The microbial ecology of the Great Salt Lake. *Microbial Ecology*. 3:143-165.

Ventosa, A. (2006). Unusual micro-organisms from unusual habitats: hypersaline environments. *In Prokaryotic Diversity: Mechanisms and Significance.* Logan, N. A., H. M. Lappin-Scott, and P. C. F. Oyston (ed.) Cambridge University Press.

Ventosa, A., J. J. Nieto, and A. Oren. (1998). Biology of moderately halophilic aerobic bacteria. *Microbiol. Mol. Biol. Rev. 62*, 504-544.

Development of an Assay to Characterize Chitinase Utilization in Euryhaline Halophiles

Travis Canova, Craig Oberg & Michele Zwolinski

Abstract

Chitin is composed of repeating units of the monomer *N*-acetyl-D-glucosamine (GlcNAc). It serves as a significant carbon and nitrogen source in the Great Salt Lake (GSL) due to the large biomass of brine fly cases and brine shrimp exoskeletons. Degradation of chitin by euryhaline halophilic bacteria is important in recycling carbon and nitrogen in the GSL, but the diversity of chitinolytic organisms remains unknown. This assay, adapted from a filter paper technique, can screen up to 96 samples simultaneously for chitinolytic activity. Assay substrates are the monomer, dimer, and trimer forms of 4-methyllumbelliferyl-*N*-acetyl-B-D-glucosaminide (4-MUF.GlcNAc). When these compounds are enzymatically cleaved, 4-methyllumbelliferyl (4-MUF) is released and fluoresces. This assay was used to screen halophilic microorganisms isolated from the GSL. The cleavage pattern for the three substrates helps characterize the chitinolytic enzymes each isolate may possess. Results indicate some halophile isolates metabolize all three forms of the GlcNAc derivatives while others prefer just the dimer and trimer forms. This assay could also provide data on the metabolic rates of carbon and nitrogen biogeochemical cycling in the GSL ecosystem. In addition, it can be used as an initial screen for organisms that may have interesting metabolic traits associated with chitinase production for use in biotechnology applications.

Introduction

Chitin, the second most abundant biopolymer in nature, is comprised of repeating units of the monomer *N*-acetyl-D-glucosamine (GlcNAc) joined by either α or β linkages (Gooday, 1990, p.177; Patil et al., 2000, p.473). Due to the large biomass of brine fly cases and brine shrimp

exoskeletons, chitin serves as a significant carbon and nitrogen source in the Great Salt Lake (GSL) ecosystem. A rough estimate utilizing brine shrimp egg harvest data for the past five years indicates a minimum of 16.7 million kilograms of chitin-composed exoskeletons produced annually.

Euryhaline halophiles are microorganisms, primarily bacteria, that can grow in environments with widely various salinities from 3% to 15% NaCl (Okamoto et al., 2004, p.323). Euryhaline halophiles are the primary isolates from the South Arm of the Great Salt Lake. Included in this group of microorganisms are *Halomonas*, *Salinivibrio*, and *Idiomarina* (Ventosa, 2006, p.223). Studies of other hypersaline lakes indicate 90% of isolates are euryhaline halophiles while only 10% are strict halophiles (Brisou, Courtois, and Denis, 1974, p.819).

Degradation of chitin by euryhaline halophilic bacteria appears essential for recycling carbon and nitrogen in the GSL, but the diversity and concentrations of chitinolytic organisms remains unknown (Baxter et al., 2005, p.11; Sanchez-Porro et al., 2003, p.295). Microorganisms that utilize chitin as a carbon and nitrogen source must perform a variety of enzymatic functions. These include finding chitin, adhering to chitinaceous substrata, degrading chitin to oligosaccharides, transporting oligosaccharides to cytoplasm, and then catabolizing these oligosaccharides to fructose-6-phosphate, acetate, and NH_3 (Keyhani and Roseman, 1999. p.108).

Chitinases are enzymes that hydrolyze the β-1-4 glycosidic bonds linking *N*-acetyl-D-glucosamine molecules that compose chitin (Metcalfe et al., 2002, p.5042). This hydrolysis typically yields oligomeric or dimeric residues capable of being transported across the cellular membrane where they are further metabolized. Chitinases are often associated with the outer membrane of the cell or can be secreted as extracellular enzymes (LeCleir et al., 2004, p.6977). Endochitinases cleave chitin randomly at internal sites yielding low molecular weight multimers (chitobiose, chitotriose, and chitotetraose). Exo-chitinases are divided into two general groups based on their substrates and reaction products. Chitobiosidases release chitobiose while B-*N*-acetyl-hexosaminidase (previously called 1-4-B-*N*-acetylglucosaminidase) produces GlcNAc monomers (Patil et al., 2000, p.473).

A variety of chitinase assays have been utilized to screen for chitin metabolism in microorganisms and to measure chitin degradation levels in the environment (Hood, 1991, p.151). Assays range from incor-

poration of chitin as the carbon/nitrogen source in agar petri plates to the use of radioactive chitin in sensitive metabolic assays (Molano, Duran, and Cabib, 1977, p.648). Generally, two methods have been favored in chitinase screening: attachment of dyes such as Remazol Brilliant Blue R (Gomez Ramirez et al., 2004, p.213) or other visualizing agents like calcofluor white M2R (Vaidya et al., 2003, p.129) to chitin in agar plate assays (Wang et al., 2001, p.492), and attachment of 4-methyllumbelliferyl-*N*-acetyl-B-D-glucosaminide to different chitin derivatives (O'Brien and Colwell, 1987, p.1718). Once 4-methyllumbelliferyl is released during the enzymatic cleavage of these labeled chitin derivatives it fluoresces under ultraviolet illumination, indicating that a reaction has occurred. The purpose of this research project was to develop an assay that could be used to screen a large number of isolates quickly and economically, and to characterize the types of chitinolytic enzymes each isolate might possess.

Methods

Culture Isolation

Samples were collected along the north shore of Bridger Bay on Antelope Island located in the South Arm of the Great Salt Lake. Sediment and water samples were collected 10 to 15 feet from the shoreline, and samples of suspended exoskeletons were collected within five feet of the shoreline.

Culture Media and Preparation

Halophile agar was prepared using the following formulation: NaCl, 120 g; agar, 10 g; $MgSO_4 \cdot 7H_2O$, 10 g; casein hydrolysate, 5 g; KCl, 5 g; trisodium citrate, 3 g; KNO_3, 1 g; yeast extract, 1 g; $CaCl_2 \cdot 6H_2O$, 0.2 g per liter of distilled water, with trisodium citrate substituted for disodium citrate (Atlas, 1993, p.421). Halophile broth was prepared using the same formulation without agar addition. Halophile broth tubes were inoculated with a 48-hour culture and incubated for 24 hours in a 30°C water bath.

Preparation of Assay Reagents

A five mM stock solution of each substrate was prepared by dissolving 3.80 mg of 4-methylumbelliferyl(MUF)-*N*-acetyl-B-D-glucosaminide (GlcNAc monomer) (Sigma-Aldrich Corp., St. Louis, MO) in 2.0 ml of dimethylformamide; 5.83 mg of 4-MUF-B-D-*N,N'*-diacetylchitobioside hydrate (GlcNAc dimer) (Sigma-Aldrich Corp., St. Louis, MO) in 2.0 ml of dimethylformamide; and 7.86 mg of 4-MUF-B-D-*N, N',N"*- triacetylchitotrioside (GlcNAc trimer) (Sigma-Aldrich Corp., St. Louis,

MO) in 2.0 ml of dimethylformamide. Stock solutions were used immediately or stored at -20°C. The 1.75 mM working stocks for each 4-MUF chitin derivative were made by adding 1.0 ml of each 5 mM stock solution to 4.7 ml of sterile phosphate buffer (0.1 M, pH 7.4). The control working stock solution was made by adding 1.0 ml of 2.0 mM dimethylformamide to 4.7 ml of phosphate buffer (0.1M, pH 7.4).

Chitinase Assay

Euryhaline halophile cultures were incubated for 24 h (final OD_{595}=0.35-0.55) centrifuged for ten minutes at 3000 rpm and resuspended in one ml of sterile 8% NaCl. One hundred microliters of each resuspended culture was added to four contiguous wells of a column in a 96-well plate. Next, 50 µl of the monomer, dimer, and trimer 4-MUF working stocks was added to each culture in rows 1, 2, and 3, respectively. The control solution was added to all cultures in row 4. The 96-well plate was incubated at 30°C for 24 h. The plate was viewed by placing it on a UV transilluminator, which causes the enzymatically-released methyllumbelliferone to fluoresce blue. Plates were examined at 1, 12, and 24 hours.

Three methods of culture preparation were examined in an attempt to optimize the assay reaction and to provide the most reproducible results. Initially, cultures were grown in halophile broth and used directly in the 96-well plate assay. Cultures were also grown in a modified halophile broth with chitin substituted as the sole carbon source. Prior to inoculation into the 96-well plates the chitin was allowed to settle and then culture was used in assay. Cultures were also grown in halophile broth and then centrifuged. Halophile broth supernatant was decanted, the cells resuspended in one mL of sterile 8% NaCl, and then the resuspended culture was used in the assay.

Results

This assay was adapted from a filter paper technique using agar-isolated colonies as the inoculum (O'Brien and Colwell, 1987, p.1718). Changes in the assay methodology from the original procedure are detailed in Table 1. After running the 4-MUF chitinase assay several times, incorporating the three methods of culture preparation, it was determined that washing the cells in 8% NaCl provided the most accurate and clear results. This procedure was subsequently incorporated into the assay permanently. Use of the chitin-based halophile broth did not seem to induce any additional chitinolytic activity in the cultures with these results the same as for cultures grown in the halophile broth. This

supports the observation of Bennett and Hood (Bennett and Hood, 1980, p.357) who found that chitinase is produced in chitinase-positive bacteria even when they are grown in a rich media since only chitin or its derivatives has been shown to induce chitin hydrolysis. Since this assay uses 4-MUF chitin-based derivatives (GlcNAc oligomers) the test reagents will induce production of chitinolytic enzymes if they are present in the test cultures.

Table 1. Comparison of the original method and the modified 4-MUF chitin derivative utilization assay method.

Original Chitinase Assay	Modified Chitinase Assay
Inoculum – Colony from agar plate	Inoculum - Broth culture (titer can be adjusted by centrifugation and re-suspension)
Assay matrix – filter paper (culture rubbed on surface of filter paper)	Assay matrix – 96 well plate
Substrate - 4-MUF.GlcNAc monomer	Substrates - 4-MUF.GlcNAc monomer, dimer, and trimer
Substrate concentration – 40 µl of 9.43 mM	Substrate concentration – 50 µl of 1.75 mM
Cell smear removed from agar plate for assay	Cells are washed in 8% NaCl buffer prior to assay
Incubation temperature – 37oC	Incubation temperature – 30oC
Incubation time – 15 min	Incubation time – 24 h
Addition of 100 µl sodium bicarbonate to each spot for fluorescence enhancement	No addition of 100 µl sodium bicarbonate required to enhance fluorescence

Use of broth cultures reduces preparation time since many halophiles grow quite slowly on solid agar media. The incorporation of 96-well plates greatly expands the ease with which large number of isolates can be screened and facilitates the use of multiple test reagents. Utilizing a variety of 4-MUF.GlcNAc derivatives, specifically chitobiose, chitotriose, and chitotetraose, allows initial characterization of chitinolytic enzyme activities for each isolate. Lower incubation temperature and longer incubation time better simulate growth conditions in the native GSL environment for isolates, particularly since many are rather slow growers under conventional laboratory conditions. Addition of sodium bicarbonate enhances the intensity of the fluorescence, however it also ends the reaction process (results not shown) and for some of the cul-

tures that were tested longer incubation times were required to obtain accurate results.

This assay was used to rapidly screen a large number of euryhaline microorganisms isolated from the GSL (Table 2). The cleavage pattern for the three substrates can help determine the types of chitinolytic enzymes each isolate may possess. Results indicate that while some halophile isolates can metabolize all three 4-MUF.GlcNAc derivatives, other halophile isolates prefer only the dimer (chitobiose) and trimer (chitotriose) forms of GlcNAc. Three patterns emerged from the assay trials, which were repeatable for a particular culture. A number of the cultures tested could not use any of the three substrates and no fluorescence was observed. Some isolates could cleave all three of the substrates, while a number of isolates only cleaved the 4-MUF.GlcNAc dimer and trimer forms (Table 3).

Table 2. Classification of chitinases found in bacteria.

Type of Chitinase	Substrates Utilized	Reaction Products
Endochitinase	Cleaves chitin randomly	GlcNAc multimers (chitobiase, chitotriose, and chitotetraose)
Chitobiosidase (exo-chitinase)	Progressive release of GlcNAc dimers	Chitobiose
B-*N*-acetyl-hexosaminidase* (exo-chitinase)	Cleaves chitobiase, chitotriose, and chitotetraose	GlcNAc monomer

* previously classified as 1-4-B-*N*-acetylglucosaminidase

Conclusions

This assay can be utilized to screen a large number of isolates simultaneously for chitinolytic activity. The substrates for the assay were expanded to include the monomer, dimer, and trimer forms of 4-methyllumbelliferyl-*N*-acetyl-B-D-glucosaminide (4-MUF.GlcNAc). When these compounds were enzymatically cleaved, 4-methyllumbelliferyl (4-MUF) was released and fluoresced to indicate chitinolytic activity against that substrate.

The cleavage pattern of the three 4-MUF chitin derivatives can help determine the types of chitinolytic enzymes each isolate may possess. Based of the screening results some euryhaline isolates lacked the ability to utilize chitin, while those isolates which cleaved only the 4-MUF. GlcNAc dimmer (chitobiose) and the 4-MUF.GlcNAc trimer (chitotri

Table 3. Chitinase activity of Great Salt Lake euryhaline halophile isolates.

GSL Bacterial Isolate	Reaction with 4-MUF.GlcNAc substrates		
	4-MUF.GlcNAc monomer	4-MUF.Gl-cNAc dimer	4-MUF.Gl-cNAc trimer
Idiomarina sp. S3	-	-	-
Salinovibrio sp. S4	-	+	+
Idiomarina sp. S6	-	-	-
Salinovibrio costicola S9	+	+	+
Salinovibrio sp. S10	-	+	+
Idiomarina loihiensis S11	-	-	-
Halomonas sp. S15	-	-	-
Salinovibrio costicola S17	+	+	+
Salinovibrio costicola S19	+	+	+
Idiomarina sp. S21	-	+	+
Salinovibrio costicola S24	w	w	w
Halomonas ventosae S25	+	+	+
Halomonas sp. LCKS0 S26	w	+	+
Halomonas sp. LCKS0 S27	w	+	+
Salinococcus sp. D23.3 S29	-	-	-
Halomonas sp. AJ275 S31	-	-	-
Salinovibrio sp. SV2 S38	-	+	+
Salinovibrio sp. SV14 S39	-	+	+

\+ Positive reaction
w Weak reaction
\- No reaction

ose) likely possess endochitinase activity but not exo-chitinase activity (Table 2). Euryhaline isolates that could utilize all three 4-MUF chitin derivatives possess exo-chitinase activity, probably a combination of chitobiosidase and B-*N*-acetyl-hexosaminidase. This is the first report of a chitinolytic activity survey for euryhaline halophiles and provides the first data indicating how microorganisms in the South Arm of the GSL metabolize chitin.

This assay can also be adapted to provide data on the metabolic rates of carbon and nitrogen biogeochemical cycling in the GSL ecosystem by monitoring reaction on a real-time plate reading spectrophotometer. In addition, it can be used as an initial screen for organisms that may have interesting metabolic traits associated with chitinase production that could be important in biotechnology applications.

References

Atlas, R. M. (1993) *Handbook of Microbiological Media*. Parks, L. C. (ed.) CRC Press, Boca Raton, FL., 421.

Baxter, B. K., Litchfield, C. D., Sowers, K., Griffith, J. D., Dassarma, P. A., and Dassarma, S. (2005) Microbial diversity of Great Salt Lake. In *Adaptation to life at high salt concentrations in Archaea, bacteria, and eukarya*. Gunde-Cimerman, N., Oren, A., and Plemenitas, A. (ed.) Springer, Netherlands, 11-24.

Bennett, C. B. and M. A. Hood. 1980. Effects of cultural conditions on the production of chitinase by *Bacillus megaterium*. Dev. Ind. Microbiol. 21, 357-363.

Brisou, J., D. Courtois, and F. Denis. (1974). Microbiological study of a hypersaline lake in French Somaliland. *Appl. Microbiol*. 27, 819-822.

Gomez Ramirez, M., L. I. Rojas Avelizapa, N. G. Rojas Avelizapa, and R. Cruz Camarillo. (2004). Colloidal chitin stained with Remazol Brilliant Blue R, a useful substrate to select chitinolytic microorganisms and evaluate chitinases. *J. Microbiol. Methods*. 56, 213-219.

Gooday, G W. (1990). Physiology of microbial degradation of chitin and chitosan. *Biodegradation*. 1, 177-190.

Hood, M. A. (1991). Comparison of four methods for measuring chitinase activity and the application of the 4-MUF assay in aquatic environments. *J. Microbiol. Methods*. 13, 151-160.

Keyhani, N. O., and S. Roseman. (1999). Physiological aspects of chitin catabolism in marine bacteria. *Biochimica et Biophysica Acta.* 1473, 108-122.

LeCleir, G. R., Buchan, A., and Hollibaugh, J. T. (2004) Chitinase gene sequences retrieved from diverse aquatic habitats reveal environment-specific distributions. *Applied and Environmental Microbiology* 70, 6977-6983.

Metcalfe, A. C., Krset, M., Gooday, G. W., Prosser, J. I., and Wellington, E. M. H. (2002) Molecular analsysis of a bacterial chitinolytic community in an upland pasture. *Applied and Environmental Microbiology* 68, 5042-5050.

Molano, J., A. Duran, and E. Cabib. (1977). A rapid and sensitive assay for chitinase using tritiated chitin. *Anal. Biochem*. 83, 648-656.

O'Brien, M., and R. R. Colwell. (1987). A rapid test for chitinase activity that uses 4-methylumbelliferyl-N-acetyl-B-D-glucosaminide. *Appl. Environ. Microbiol.* 53, 1718-1720.

Okamoto, T., A. Maruyama, S. Imura, H. Takeyama, and T. Naganuma. (2004). Comparative phylogenetic analyses of *Halomonas variabilis* and related organisms based on 16S rRNA, gyrB and ectBC gene sequences. *System. Appl. Microbiol.* 27, 323-333.

Patil, R. S., V. Ghormade, and M. V. Deshpande. (2000). Chitinolytic enzymes: an exploration. *Enz. Microbial Technol.* 26, 473-483.

Sanchez-Porro, C., Martin, S., Mellado, E., and Ventosa, A. (2003) Diversity of moderately halophilic bacteria producing extra cellular hydrolytic enzymes. *J. Applied Microbiology* 94, 295-300.

Vaidya, R. J., S. L. A. Macmil, P. R. Vyas, and H. S. Chhatpar. (2003). The novel method for isolating chitinolytic bacteria and its application in screening for hyperchitinase producing mutant of *Alcaligenes xylosoxydans. Letters Appl. Microbiol.* 36, 129-134.

Ventosa, A. (2006). Unusual micro-organisms from unusual habitats: hypersaline environments. In *Prokaryotic Diversity: Mechanisms and Significance*. Logan, N. A., H. M. Lappin-Scott, and P. C. F. Oyston (ed.) Cambridge University Press, 223-247.

Wang, S-Y, A-L Moyne, G. Thottappilly, S-J Wu, R. D. Locy, and N K. Singh. (2001). Purification and characterization of a *Bacillus cereus* exochitinase. *Enzyme Microbial Technol.* 28, 492-498.

Investigations into the Hot Chocolate Effect

Ryan Nixon & Adam Johnston

Abstract

Tapping a mug of hot chocolate with a spoon will produce a pitch that changes over time, a phenomenon traditionally known as the "hot chocolate effect." The most well-documented explanation claims that the effect is reliant on bubbles slowing the speed of sound in the liquid. The results of experiments conducted with a sonicator test and provide further support for this explanation.

Introduction

Science is not always conducted by a lone scientist in a cold, candlelit room poring over diagrams and equations. Sometimes science involves mugs, spoons and hot chocolate. This is a message science educators often try to convey to their students. A common method for teaching this involves a phenomenon dubbed "the hot chocolate effect" (Crawford, 1982, p. 398).

The hot chocolate effect occurs when one takes a mug of hot water, adds hot chocolate powder, stirs and then taps the mug repeatedly. The pitch of the resulting sound changes every few seconds for the next couple of minutes. When the liquid is stirred the effect will repeat, however, after a while the effect stops and the pitch remains constant. This effect occurs in many varied situations in addition to hot chocolate (Crawford, 1990; Farrell, McKenzie, Parker, 1969; Kilty, 1998). For this reason, the most accurate name is tapping pitch change (TPC.)

Any tenable explanation must account for:

1. why TPC repeats when the liquid is stirred
2. why the effect stops after a time
3. a change in frequency, which is heard as pitch, and
4. a pitch change from low to high.

Crawford presented one theory that adequately accounts for each of these criteria in what has become the authoritative explanation for TPC (1982). Crawford claimed that this pitch change is due to gas coming out of solution, rising to the top as bubbles and popping at the surface.

Bubbles, he argues, slow the speed of sound through the liquid. As the amount of bubbles in the liquid changes over time the amount of slowing changes. According to the relationship between the speed of sound in a medium, the wavelength, and the frequency (i.e. $v = \lambda f$) as the speed of sound through the liquid changes the frequency or wavelength must change (Knight, 2004, p. 622).

This explanation meets the above criteria. Crawford states that TPC repeats when the liquid is stirred because there is a low-pressure formed in the center of the mug. This allows gases in solution to form as bubbles. However, when there is no longer gas in the solution TPC will not repeat, as observed.

This theory also parallels the observation that the tone begins at a low pitch and progresses to a high pitch. Directly after stirring the liquid there is the maximum amount of bubbles—none of them have risen to the top and burst. At this point the pitch is the lowest. As bubbles rise to the top and burst, the amount of bubbles in the liquid decreases and the speed of sound increases with the pitch. This explanation is consistent with observations of the phenomenon. However, no experiments have been conducted to verify that the speed of sound changes nor have any experiments correlated bubbles in the liquid with the occurrence of the effect.

Methods

In order to test the correlation between bubbles in the liquid and the occurrence of TPC, a number of experiments were conducted using a sonicator. It has been shown that placing a container of liquid in a sonicator removes gas from the solution (Baur & Baur, 2006, p. 579). A sonicator is a device that utilizes ultrasonic sound waves to clean laboratory equipment (see Figure 1). This device was used to remove gas from the liquid (see Figure 2).

The first two experiments used a 600 mL glass beaker, 400 mL of water that had been heated to approximately 90° C in an electric water heater, and three 1/8 cup scoops of hot chocolate powder.

The first experiment involved mixing the water and the hot chocolate powder together, then sonicating the solution for a given amount of time. Once the solution had been sonicated, it was tested for TPC. The amount of time that the first three beakers remained in the sonicator was arbitrary. The last three beakers were removed from the sonicator

when no more bubble formation or movement was seen on the surface. In the second experiment, hot water was sonicated prior to adding the powder. After the water was sonicated, the beaker was removed from the sonicator, powder was mixed in the solution, and the beaker was tested for TPC.

In the third experiment hot water and hot chocolate powder were mixed together in two plastic cups and weighed on a four-tiered balance. One cup was placed on the table and was weighed after ten minutes. The other cup was sonicated one minute then weighed for a total of ten minutes.

Two proof-of-concept trials were conducted. One of these trials verified that TPC did occur without sonicating in experimental apparatus. The other verified that TPC occurred at 60° C, a temperature similar to that of the water when powder was added in the second experiment.

Figure 1. A sonicator

Figure 2. A beaker of hot chocolate in an activated sonicator.

Results

In the first experiment, the three beakers, in which sonicated time was arbitrary, exhibited TPC. None of the last three beakers, which were sonicated until bubble formation/movement stopped, exhibited TPC (Figure 3).

Time (min)	TPC	Observations
2.5	Yes	TPC repeated with stirring.
5	Yes	Total pitch change was minimal and would not repeat.
7	Yes	Total pitch change was minimal and would not repeat.
13	No	No pitch change observed.
8.5	No	No pitch change observed.
6	No	No pitch change observed.

Figure 3. The amount of time in the sonicator and whether or not TPC occurred.

All but two of the beakers in the second experiment exhibited TPC after being sonicated (Figure 4). However, those that did exhibit TPC had a minimized pitch change—all of them started at a higher pitch than is typical.

Time (min)	TPC	Observations
2.5	No	No pitch change observed.
5	No	No pitch change observed.
1	Yes	No pitch change observed.
2	Yes	Pitch change was minimal and would not repeat.
2.5	Yes	Pitch change occurred.
4	Yes	Total pitch change was much less than is typical for an unsonicated beaker. Effect repeated.
4.5	Yes	Total pitch change was minute compared to what is typical for an unsonicated beaker. Effect repeated.
4.5	Yes	Total pitch change minimal. The effect did not repeat.
4.5	Yes	Total pitch change minimal.
5	Yes	Total pitch change was very much less than is typical for an unsonicated beaker. Effect repeated.

Figure 4. The amount of time in the sonicator and whether or not TPC occurred.

In the third experiment, the mass of the stationary cup changed 0.6% while the mass of the sonicated cup changed of 1.1% (Figure 5).

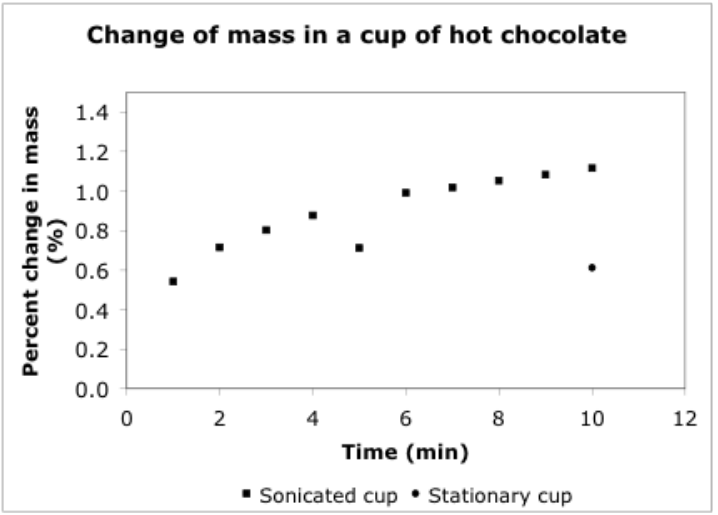

Figure 5. Percent change in the mass of a cup of hot chocolate.

Discussion

The results of the third experiment indicate that sonicating a cup of hot chocolate removes more gas from solution than if the cup were stationary.

The results of the first experiment suggest that there is a connection between the cessation of bubble formation/movement and the stoppage of TPC. Though these results favor Crawford's theory, it could not be conclusively declared that this was because the gas had been removed from the solution by sonication. This first experiment does not account for the possibility that the hot chocolate powder causes the effect and is affected by sonication. However, it seems significant that as soon as the bubble formation/movement ceased, the effect stopped.

The second experiment controlled for this possibility. These results indicate that sonicating the liquid by itself diminishes TPC. The amount of gas dissolved in the liquid, and the temperature, change as the liquid is sonicated. It was found that a beaker that had cooled to a similar temperature, but had not been sonicated, still exhibited the full effect. It is concluded, therefore, that the minimized effect is the result of gas being removed from the solution.

However, it is curious that the effect does not disappear entirely. One possibility is that gas is added to the liquid with the powder—this causes a small pitch change (Farrell, McKenzie & Parker, 1969, p. 365).

An observation confirms the prediction that gas is removed from solution as it is sonicated. The last three beakers used in the first experiment were sonicated until bubble formation/movement was no longer observed (Figure 3). Because the water poured into these beakers came from the same container which was brought to boiling prior to pouring each beaker, the water in the first beaker was only boiled once whereas the water in the third beaker was boiled three times. The data show that the time required to stop bubble formation/movement decreased successively with each beaker. This is because each time the water was boiled, gas was removed from solution and less time in the sonicator was required to remove what gas remained.

These experiments confirm the validity of Crawford's air bubble theory. It has been shown that sonicating removes gas from solution and that when the gas is removed the phenomenon disappears or diminishes.

Future Considerations

Crawford's theory rests on the claim that the speed of sound through the system changes over time. To clearly finalize this, a direct measurement of the speed of sound needs to be made. A straightforward method for measuring this would involve placing a transmitter and a receiver in hot chocolate. The transmitter and receiver would be monitored with an oscilloscope. The time delay in the signals could then be measured and, using the distance the signal was sent, the speed of sound could be ascertained. Measurements could be taken at various times and compared to see if the speed changed over time. The numerous attempts by the author to make this simple measurement were unsuccessful for unknown reasons.

Additionally, direct verification of Crawford's explanation for the restirring phenomenon should be pursued. He does not address this issue in any depth, though it is one of the most curious aspects of the phenomenon.

Further research could also examine which solutions exhibit this effect. Various sources disagree about which solutions are suitable for TPC (Crawford, 1990; Farrell, McKenzie, Parker, 1969; Kilty, 1998). Further exploration into this could reveal more about the cause of the effect.

It would also be interesting to more quantitatively examine the pitch change:

1. Does the pitch start at a uniform pitch?
2. Is there one pitch that the pitch always moves toward?
3. Does the pitch change in uniform increments?

We generally think that to do science we have to collide atoms or do advanced mathematics. However, it is clear that even with such a simple phenomenon there are many unanswered questions and that by pursuing these questions one can realize the beautiful complexity of in the universe.

References

Baur, J. E., & Baur, M. B. (2006). The ultrasonic soda fountain: a dramatic demonstration of gas solubility in aqueous solutions. *Journal of Chemical Education*, 83(4), 577-580.

Crawford, F. S. (1982). The hot chocolate effect. *American Journal of Physics, 50*(5), 398-404.

Crawford, F. S. (1990). Hot water, fresh beer, and salt. *American Journal of Physics, 58*(11), 1033-1036.

Farrell, W. E., McKenzie, D. P., & Parker, R. L. (1969). On the note emitted from a mug while mixing instant coffee. *Proceedings of the Cambridge Philosophical Society, 65*, 365-367.

Kilty, K. T. (1998). *The cheap instant coffee effect.* http://www.kilty.com/coffee.htm

Knight, R. D. (2004). *Physics for scientists and engineers: A strategic approach with modern physics* (Vol. 3). San Francisco: Pearson Addison-Wesley.

Effects of Herbicide and Pesticide on the Common Earthworm, *Lumbricus sp.*

Jared Green, Krystle Minear & Nicole Okazaki

Abstract

Earthworms represent an important component of the soil biomass, and because of their activity, can contribute extensively to soil formation and structure. The effects of an herbicide and pesticide on the health and survival of the earthworm, *Lumbricus sp.* were observed. Changes in general protein profile and Hsp70 were studied. Four different treatments were applied: a control, herbicide, pesticide, and herbicide with pesticide. Manufacturer recommended amounts of chemicals were applied to the soil during the first week, while double these amounts were added for the second week. Week one showed no apparent effect, while dramatic effects were seen at the end of the second week. The highest mortality occurred for the combined herbicide and pesticide treatment, followed by the pesticide alone, then herbicide alone. The control group remained healthy. Statistical analysis using G-tests showed a very significant difference between treatments ($G=64$, $df=6$, $p<0.001$). No change in protein profile was noted. A western blot revealed an Hsp70-like band that appeared faintly at 15 kDa with the herbicide treatment, and more strongly with the combined treatment. These results highlight the toxicity of these compounds and point to the importance of following dosage recommendations in one's own garden.

Introduction

Many human populations are practicing intensive farming in order to produce enough food crops. The spraying of pesticides and herbicides has spread widely, including among home gardeners. However, bountiful harvests still depend upon healthy soil. Under natural circumstances, the soil quality is maintained by many bacterial, fungal, insect, and annelid species, among them the earthworm, *Lumbricus sp.* These

worms burrow in moist soil and play an important role in aeration, drainage, and proper nutrient replenishment of the soil. They represent a major component of the soil biomass, and because of their activity, can contribute extensively to soil formation and structure (Mäder et al., 2002, p. 1696). The use of pesticides and herbicides in gardens and fields has been poorly documented with respect to the effects on earthworms, soil quality, and crop harvest.

Since gardeners can use these chemicals quite liberally, we wanted to test their effects on earthworms, as they are an integral part of soil health. More specifically, we wanted to observe the effects of commonly used doses on earthworm survival and activity. Exposure to toxic stress induces reactions in animals at various levels, including behaviors, organs, and cells. We chose to measure the worm's reaction to touch and two biochemical parameters. For a proper reaction to touch, the worm must have an intact nervous system as well as healthy muscles. This parameter, sometimes measured as escape behavior, is often used in various toxicology tests (Drewes, 1997, p. 347; Anderson et al., 2004, p. 1235).

We also measured two biochemical parameters potentially showing changes at the cell level. Stress, in particular toxic stress, triggers many changes within the cell aimed at eliminating or repairing cell damage. In order to do so, some proteins are downregulated while others are upregulated. Where there are abundant proteins, these changes could be detected by comparing the general protein profiles expressed under the various conditions. Some proteins, such as Hsp70, are specialized to repair damaged proteins. Earthworms may be upregulating this protein in order to cope with damages triggered by exposure to herbicides or pesticides (Rodriguez-Castellanos & Sanchez-Hernandez, 2007, p.362; Mukhopadhyay et al., 2003, p. 250). A correlation between physical symptoms and the appearance of a stress protein could give us the means to predict deleterious effects and suspend the use of these chemicals.

Methods

Groups of four worms, purchased from a local sporting goods store, were placed into potting soil where either water, for the control group (C), herbicide (H), pesticide (P), or both herbicide and pesticide (HP) was added. The H treatment consisted of 2.5 ounces of Round-up® (active ingredient: glyphosate) per gallon of water, the P treatment consisted of 1.5 ounces of the pesticide Max® (active ingredient: bifentrin) per gallon of water. For treatment HP, a volume of the pesticide and

herbicide were added, thus the amount of liquid added to the soil was twice that of the plain pesticide and herbicide.

At the beginning of the experiment, 150 ml of each liquid treatment was added to 1750 ml of soil. This mixture was then separated into five equal parts, which were then placed into the containers. At the beginning of the second week, the worms were removed from the first soil mixture, and exposed to twice the previous amount of H, P, and HP. Three hundred ml of liquid treatment was added to 1750 ml of fresh soil, and the same worms were again placed in respective containers. The containers were housed at ten degrees Celsius for the duration of the experiment. Each treatment was replicated five times (for a total of 20 worms per treatment).

At the end of the second week, the worms were classified as healthy, lethargic, or dead. Healthy worms remained active and fleshy looking. They reacted to touch immediately and strongly. Lethargic worms moved slowly and weakly, despite touch. Dead worms were limp and did not react to stimulation. Behavioral data, while not as rigorous as quantitative measurements, are commonly used in toxicology to evaluate worm health

General protein profiles were visualized using polyacrylamide gel electrophoresis, or PAGE (Clegg et al., 2000, p. 434), followed by silver staining (Eschenbruch and Bürk, 1982, p. 96). In addition, the presence of Hsp70 was tested with a Western blot followed by immunostaining with Hsp70 antibody (Blake et al., 1984, p. 176).

Since the data are not normally distributed but are presented as proportions, G tests were used to compare the effect of the various treatments (Sokal and Rohlf, 1995, p.699).

Results

A large difference in physical appearance between the control and all of the experimental groups was evident after the second week of treatment. At the conclusion of the first week, the worms in all treatments were almost unaffected. The only difference in activity level was in the mixed herbicide and pesticide group; slight lethargy was seen when handling the worms. In the second week, after the doubling of the H, P, and HP doses, much more dramatic results were observed (Fig. 1). All worms in the control group remained healthy and unaffected, 50%, 80%, and 45% of the worms in the herbicide, pesticide, and combined treatments,

respectively, were lethargic. While mortality rates were low in the herbicide and pesticide treatments (5% and 10% in H and P, respectively), 55% were dead in the herbicide/pesticide treatment. The effect of these treatments was very significant (G=64, df=6, p<0.001).

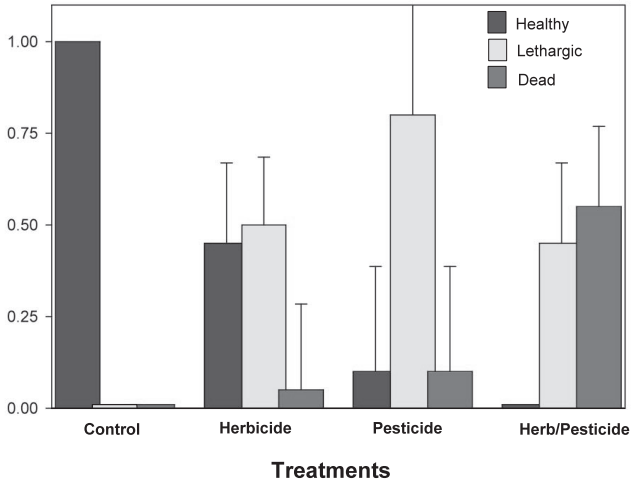

Figure 1. Effects of herbicide, pesticide and herbicide/pesticide on earthworms after two week exposure. In the control group, water replaced the herbicide and pesticide. Healthy worms responded quickly and strongly to touch. Lethargic worms moved slowly and weakly. Dead worms were unresponsive to stimulation. The data were normalized using a square root arc sine transformation. The error bars represent the upper limit of the treatment's standard deviations.

The general protein profile (Fig. 2) did not show any obvious up or downregulated proteins. Further analysis with Biorad Quantity One gel analyzer also confirmed this observation. The Hsp70 western blot stained faintly in the worms receiving the herbicide treatment and more strongly in the worms receiving both the pesticide and herbicide treatment (Fig. 3). However, the band was located at the lower 15 kDa level.

Discussion

The strong effect of the combined pesticide and herbicide on the worms suggests that liberal doses of these compounds during gardening might have a harmful effect on the soil. Thus, gardeners should not use doses of pesticide or herbicide any greater than the dose listed on the container. Recommended doses might also be harmful to earthworms since the worms exposed to the herbicide/pesticide treatment showed weakness

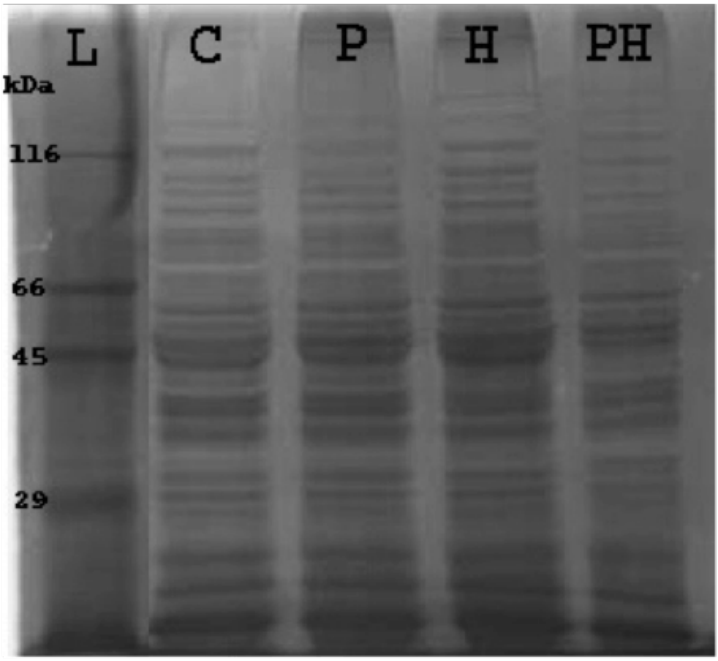

Figure 2. PAGE profile, after silver staining, of worm muscle proteins. The worms had been exposed to pesticide and/or herbicide for two weeks. L; protein molecular weight markers (kDa= kiloDalton), C= control treatment (clean environment), P= pesticide exposure, H= herbicide exposure, PH= pesticide and herbicide exposure (see materials and Methods for the amounts).

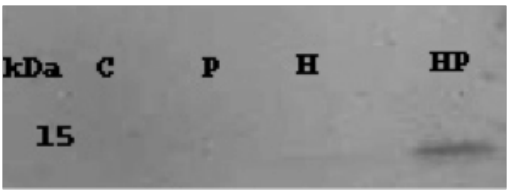

Figure 3. hsp70 Western blot. The worms had been exposed to pesticide and/or herbicide for two weeks. kDa= kiloDalton, C= control treatment (clean environment), P= pesticide exposure, H= herbicide exposure, PH= pesticide + herbicide exposure. A faint band appeared at 15kDa in the H treatment while a stronger one is evident in the combined treatment.

after one week. However, the amount of water present in the pesticide/herbicide treatment was double that of the other treatments, including the control, and this difference in water amount might have affected the outcome. Further studies measuring worm weights before and after treatment may add more information.

Lydy and Linck (2003, p.347) tested the effect of three common herbicides and one common pesticide on the earthworm, *Eisenia fetida.* They found that atrazine and cyanazine, two herbicides, caused mortality at concentrations lower than chlorpyrifos, a common pesticide. Even more interesting, atrazine and cyanazine also increased the toxicity of chlorpyrifos 7.9- and 2.2-fold, respectively. Mohamed et al. (1995, p.346) found that the highest toxic effects on the earthworm *A. caliginosa* were with pesticides, followed by herbicides and fungicides. This supports our finding that herbicide and pesticide added together produces a toxic synergistic effect. Pesticide was also slightly more toxic than the herbicide.

Conflicting opinions about the effect of glyphosate are present. This chemical is classified as having low toxicity to many species, including earthworms (World Health Organization 1996; Monsanto 2002). However, earthworms avoid soil contaminated with this compound (Verrel, and Van Buskirk, 2004, p.222). Springett and Gray (1992, p.1742) found that repeated applications of low doses slows worm growth. Our study dispels the notion that glyphosate is not toxic to the worm.

The PAGE gel profile does not show any obvious variation. However, minute amounts of some proteins are most likely up and downregulated. A recent study investigated the toxicity of six different pesticides on the earthworm *Aporrectodea caliginosa* (Mosleh et al., 2003, p.342). The authors found a reduction in growth rate with all pesticide treated worms, which was accompanied by a decrease in soluble proteins and an increase in transaminases and phosphatases. The faint band in the H treatment and strong band in the HP treatment show that an Hsp70-like protein is upregulated when the worms are placed in the toxic environment. This protein has some structural similarity with Hsp70, but at 15 kDa, is much too small. A purpose of this study was to find a protein that would appear early and flag the toxic conditions to which worms are submitted. Since these worms already show sign of severe illness, this 15 kDa Hsp70-like protein cannot be used as a warning molecule, flagging toxic conditions.

The recommended amounts of herbicide and pesticide were used during the first week without apparent negative side effects, while doubling the recommended amounts for a second week did produce severe negative side effects. These results point to the importance of following recommended doses and to the danger of using extra amounts, a common habit for the weekend gardener.

References

Anderson, G.L., R.D. Cole, and P.L. Williams. 2004. Assessing behavioral toxicity with *Caenorhabditis elegans. Environmental Toxicology and Chemistry*. 23(5): 1235–1240.

Blake, M.S, K.H. Johnston, G.J. Russell-Jones and E.C. Gotschlich. 1984. A rapid, sensitive method for detection of alkaline phosphatase-conjugated anti-antibody on Western blots. *Analytical Biochemistry*. 136: 175-179.

Clegg, J.S., S.A. Jackson, and V.I. Popov. 2000 Long-term anoxia in encysted embryos of the crustacean, *Artemia franciscana*: viability, ultrastructure, and stress proteins. *Cell Tissue Research*. 301:433-446.

Drewes, C. 1997. Sublethal Effects of Environmental Toxicants on Oligochaete Escape Reflexes1. *American Zoologist*. 37(4):346-353.

Eschenbruch, M. and R.R. Bürk. 1982. Experimentally improved reliability of ultrasensitive silver staining of protein in polyacrylamide gels. *Analytical Chemistry*. 125: 96-99.

Lydy, M.J. and S.L. Linck. 2003. Assessing the Impact of Triazine Herbicides on Organophosphate Insecticide Toxicity to the Earthworm *Eisenia fetida. Archives of Environmental Contamination and Toxicology*. 45: 343-349.

Mäder, P. A. FlieBb, D. Dubois, L. Gunst, P. Fried, U. Niggli. 2002. Soil Fertility and Biodiversity in Organic Farming. 296: 1694-1697.

Mohamed, A., G.A. Nair, H.H. Kassem and M. Nuruzzaman. 1995. Impact of Pesticides on the Survival and Body Mass of the Earthworm *Aporrectodea caliginosa (Annelida: Oligochaeta). Acta Zoologica Fennica*. 196: 344-347.

Monsanto. 2002. Backgrounder. Glyphosate and Wildlife. Retrieved February, 2009 from www.monsanto.com/monsanto/content/products/productivity/roundup/gly_wildlife_bkg.pdf.

Mosleh, Y.Y., S.M. Ismail, M.T. Ahmed and Y.M. Ahmed. 2003. Comparative Toxicity and Biochemical Responses of Certain Pesticides to the Mature Earthworm *Aporrectodea caliginosa* under laboratory conditions. *Environmental Toxicology*. 18: 338-346.

Mukhopadhyay, I., A. Nazir, D. K. Saxena, and D. K. Chowdhuri. 2003. Heat Shock Response: *hsp*70in Environmental Monitoring. *J. Biochemistry and Molecular Toxicology*. 17(5):249-254.

Rodriguez-Castellanos, L., and J. Sanchez-Hernandez. 2007. Earthworm biomarkers of pesticide contamination: Current status and perspectives. *J. Pestic. Sci.,* 32(4): 360–371.

Sokal, R.R. and F.J. Rohlf. 1995. *Biometry – The Principles and Practice of Statistics in Biological Research, 3rd ed*. New York: W. H. Freeman and Co. p:699-724.

Springett, J.A. and R.A.J. Gray. 1992. Effect of repeated low doses of biocides on the earthworm *Aporrectodea caliginosa* in laboratory culture. *Soil Biol. Biochem.* 24(12): 1739-1744.

Verrel, P. and E. Van Buskirk. 2004. As the Worm Turns: *Eisenia fetida* Avoids Soil Contaminated by a Glyphosate-Based Herbicide. *Bulletin of Environmental Contamination and Toxicology*. 72(2): 219-224.

World Health Organization. 1996. World Health Organization/FAO data sheet on pesticides, No. 91 Glyphosate. Retrieved February 2009, from http://www.inchem.org/documents/pds/pds/pest91_e.htm.

Has the Great Salt Lake Become a 'Wilderness Industrial Complex?

Greg Fryer & Dan Bedford

Abstract

The Great Salt Lake has undergone numerous chemical, ecological, and societal changes over the past several years. Much of these changes can be attributed to human involvement, namely large corporations invested in the mineral content of the lake. This paper reviews and outlines the complexities and outcomes of man's influence and the difficult choices that the State of Utah has ahead.

Introduction

Since the early settlers first came to occupy the Wasatch Range, the Great Salt Lake (GSL) has been altered substantially. Public perception of the lake during this period has oscillated along with the lake's level. In the 1920s the construction of Saltair brought a peak in visitation to the lake, but since, interest in the lake has been lacking (Nicholson 2004, p. 24). The most frequent patrons of the lake today are industrialist entrepreneurs and a hefty size of the western hemisphere's bird population. The lake's chemistry, ecology, and size have experienced a wide range of natural transformations since the period of Lake Bonneville. However, since it has been in its current salty status, which is a shallow flat remnant of the once dominant Lake Bonneville, the transformation to its ecology, hydrology, and landscape has been less natural.

What was once a natural and wild, uncultivated region, has become manipulated and controlled into a resource-producing complex. This has left the GSL looking less like an ordinary lake and more like a manmade basin for production. One need only look at an aerial photo (Figure 1) of the lake to see mans' impact, and visualize the rendering that has taken place for "society's needs" (Hung 2005). Arguably, man's "conquering" of the lake has been an economic gold mine for the several industries that are dependent upon the control of this wilderness.

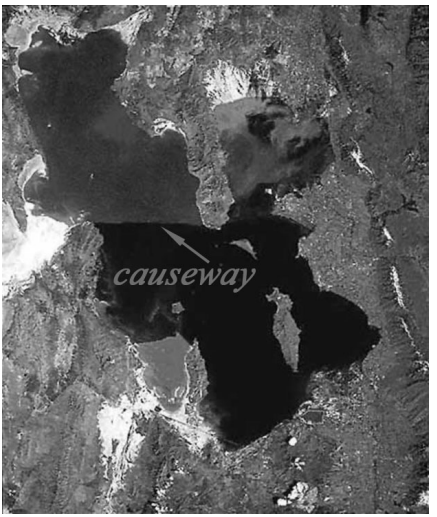

Figure 1. Great Salt Lake & Railroad Causeway
Source: ut.water.usgs.gov/greatsaltlake/images

Many industries that are dependent on the lake's resources and are established within close proximity of the lake seem to operate with an "out-of-sight, out-of-mind" mentality in their relationship with the general public. Bedford describes six components of the "societal system" in which public and private entities use the lake in different ways. These components include: "chemical extraction, recreation, water use, waste disposal, the brine-shrimp industry, and transportation" (2005, p. 87). Chemistry, level, and ecology of the lake when altered, have the ability to strengthen or weaken the health of any of these components depending on the industry. Dams, jetties, irrigation, and pumping projects have all been implemented to control the "status-quo" of growth economically. These human diversions, such as the West Desert Pumping Project, have mitigated drought and thwarted flooding by managing the amount of water within the lake.

Most noticeable in Figure 1 is the Northern Railroad Causeway that stretches across the center of the lake, dividing the lake up into the two arms (north and south). This makes the salinity content different on either side, changing the chemical makeup and ultimately the color. Even though the trestle-causeway has gone through many changes through its hundred plus years (Gwynn 2002b), it was in the 1950s when the change in the lake became most dramatic. Even though the change was very evident, the railroad kept hauling freight; no one seemed to mind as long as the trains arrived faster. This is just one example of how the lake has changed from its natural state in order to support industrial endeavors.

Methods

Amongst the several industries that rely on the GSL for their source of revenue, the two largest are U.S. Magnesium (Magcorp), and Great Salt Lake Minerals. Both have multi-million dollar enterprises that rely on extracting minerals from the lake. Both are in a unique situation: the Great Salt Lake is the only place where the products they harvest are found in great quantity in the United States, and their products are vitally important to economic stability (i.e. potash for agriculture, magnesium for metal production). The salt and metal products are processed after 95% of the water has been evaporated, when high-magnesium-chloride brines and the potassium and magnesium salts are left over (Gwynn 2002a, p. 211).

In order to accomplish the task of evaporating copious amounts of salt water to get its product, GSL Minerals has constructed several dozen enormous ponds on the east side of the lake below the Bear River Migratory Bird Refuge. These ponds, very visible with remotely sensed imagery (i.e. plane, satellite), are used to break down the water into five different ionic components (Butts 2002, p. 211). GSL Mineral's ponds can also be found on the western shores of the lake, just above the causeway as well, which were built to meet heavy demand. From here, heavy brines are transported through a 21-mile dredged canal called the Behrens trench. With the trench in place, and numerous square miles of open land on the west side, GSL Minerals is trying to acquire the land to build more evaporation ponds. With the new ponds, their total footprint on the lake would span 76,000 acres (FRIENDS 2008). This amounts to a sizable portion of the north arm, and a dramatic change of the landscape will occur. However, GSL Minerals will be able to meet demand and increase profit. The question is when does the vast amount of open land become less of a wilderness and more of a factory.

U.S. Magnesium, after collecting the salty brine, and letting it evaporate into magnesium chloride, uses electricity to split the product and separate the magnesium. Chip Ward (1999) has noted, "for every pound of magnesium thus produced, three pounds of free chlorine also results"(p. 193). This by-product is extremely toxic, and even though they claim to be disposing of it properly, much of the chlorine finds its way to the lake and surrounding area (Ward 1999, p. 193). Despite much protest and stronger EPA regulation, they still operate today, taking home substantial profits. Their use of the lake does not take into consideration the impact they ultimately have on the very land and lake upon which they rely.

The harvesting of brine shrimp in the GSL is also a very profitable industry, and one that depends on the lake to remain in a stable condition. Throughout the world, the aquaculture industry is experiencing substantial growth. As a result, the need for brine shrimp (Artemia) has also increased. The brine shrimp from the GSL are "widely regarded as some of the best in the world due to their small size and consistent nutritional quality" (Kuehn p. 259). As the lake changes, as it did in the 1980's, the brine shrimp are adversely affected. The brine shrimp industry is beholden to the natural cycles of the lake; they rely on certain salinities, and if these conditions change, then the shrimpers have to change their practices and adapt to nature. This adaptation to changing levels is a contrary strategy to other industries reliant on the lake.

Results and Discussion

Due to long years of manipulating the lake to industry's needs, both public and private, the lake does not resemble what we would normally call a lake. Yes, it is a big body of water, and yes, it is a basin catching incoming river flow, but compared to a lake such as Lake Tahoe or Lake Michigan, it would seem quite out of place (salt content excluded). It has been heavily managed and manipulated for so long that industry could not survive without constant oversight. The phrase "you broke it, you bought it" comes to mind. Of course we have not "broken" the lake, but we have mismanaged it. Some industries, which have a lot of economic weight, have become so dependent on the lake that it is to the point we, both industry entities and the public, have the obligation to better manage the lake. Utahans will have to decide whether to let the lake go to industry altogether, or try and keep balancing nature and industry as we have in the past. Now that the lake is reaching record lows, the population size of surrounding areas is increasing (which demands more water), and the harmful externalities of various companies have come to light. The lake has become an increasingly important political issue. The Governor has signed an executive order (2008-0008), which allowed for the creation of the Great Salt Lake Advisory Council. Amongst the responsibilities of the council is to:

> "...make policy recommendations concerning the long-term viability of the entire Great Salt Lake ecosystem while taking into account the need to balance ecological, economic, recreational, private property and other concerns regarding the Great Salt Lake ecosystem in its entirety" (D.A.R., 2008).

Economic sustainability and private property ownership are often given priority over the lake's ecology or natural existence. Viability, or the capacity for survival of the lake, is dependent on accomplishing sustainability. Hopefully the GSL's economic sustainability versus environmental sustainability dilemma might be better managed with this appointed council, with more support provided to the environment in the future.

The industrial economic benefits that the GSL's "wilderness" has to offer have been the catalyst for its dramatic change over the last 50 to 100 years. Companies wishing to exploit the lake have done so at a cost to the lake's overall characteristics. Change brought upon the lake was done slowly over time and generally out of sight. Do we continue to expand evaporation ponds and expose the lake and surrounding area to harmful toxins in the name of economics? The GSL has definitely become a "wilderness industrial complex." What matters now is what we do to develop a vision for the future of the GSL. What kind of a lake do we leave to our grandchildren and great grandchildren? Is it a lake that is all natural, which has become a staple of the state, or one that has been fully altered for economic purposes, or maybe a combination of both? The State of Utah and its citizens have some difficult choices ahead.

References

Bedford, D. (2005) Utah's Great Salt Lake: A Complex Environmental-Societal System. *Geographical Review*. 95(1), p. 73-96.

Butts, D. (2002). Kalium Ogden Corporation- Extraction of non-metals from Great Salt Lake. Gwynn, J. W. (ed.) *Great Salt Lake: An Overview of Change*. Salt Lake City: Utah Geological Survey, p. 227-233.

Division of Administrative Rules (DAR). (2008). Governor, Administration: Governor's Executive Order 2008-0008: Creating the Great Salt Lake Advisory Council. Issued: August 25, 2008. Retrieved November 3, 2008 from http://www.rules.utah.gov/execdocs/2008/ExecDoc142139.htm.

FRIENDS of the Great Salt Lake (n.d.). FACT Sheet for the GSL Minerals Expansion and Application. Retrieved October 20, 2008 from http://www.fogsl.org/index.php?Itemid=53&id=90&option=com_content&task=view.

Gwynn, J. W. (2002a). Extraction of mineral resources from Great Salt Lake, Utah: History, Development milestones, and factors influencing salt extraction. Gwynn, J. W. (ed) 2002. *Great Salt Lake: An overview of Change*. Salt Lake City: Utah Geological Survey.

Gwynn, J. W. (2002b). The Railroads Proximate to Great Salt Lake, Utah. Gwynn, J. W. (ed) 2002. *Great Salt Lake: An overview of Change*. Salt Lake City: Utah Geological Survey.

Hung, M. C., Wu, Y. C. (2005). Mapping and Visualizing the Great Salt Lake landscape Dynamics Using Multi-Temporal Satellite Images. *International Journal of Remote Sensing*. 26(9), 1815-1834.

Kuehn, D. (n.d.). The Brine Shrimp Industry in Utah. *Sanders Brine Shrimp Company, L.C.* Gwynn, J. W. (ed.) *Great Salt Lake: An Overview of Change*. Salt Lake City: Utah Geological Survey, p. 259-264.

Nicholson, B., Marcarelli, A. (2004). The Paradox of a Great Salt Lake. *Southwest Hydrology*. July/August, p. 24-25

Ward, C. (1999). *Canaries On The Rim: Living Downwind in the West*. London; New York: Verso

A Portrait of Teen Risk-Taking: Risk Intentions, Behavior, and Norms

Kimberlee A. Taylor, Eric Amsel & Leigh Shaw

Abstract

Adolescent risk-taking is meaningful, normative, and deliberate, as it is salient to the teen's experience, prohibited/proscribed within their peer group, and fosters intentions regarding the risky behavior(s). Adolescents (ages 14-19) read hypothetical scenarios describing risk-taking in three realms (alcohol, drug use, reckless driving). Results showed that teens' Risk Intentions (*Avoidant, Opportunistic, Curious, Risk-Seeking*) were related to risk-taking frequency, Subjective Norms, (peer risk engagement and opinion of risk-taking) and Behavioral Expectations (self-reported likelihood of future engagement in risk-taking). These components of adolescent risk-taking are salient to their decision-making process.

Introduction

In the lifespan, adolescence is generally viewed as a transitional period (Dahl, 2004); risk-taking is often widespread and resistant to intervention efforts designed to minimize/prevent it, despite the fact that such behaviors are often detrimental to adolescents' health and well-being (Arnett, 1992; Johnston, O'Malley, Bachman, 2002). The present research explores adolescents' risky behavior from the adolescents' perspective and presumes that teens consider risk-taking as: meaningful, as they think about the significance of the behavior; normative in that they seek to "fit in" with their peer group; and deliberate, in that they have intentions regarding risk-taking.

Previous research promotes that teens are spontaneous, yet not impulsive or lacking deliberation in their risk-taking (Gibbons, Gerrard, Blanton, and Russell, 1998). However, all risk-taking is not directly intentional and proactive; it is often a response to risk-conducive circumstances. Indeed, teens' subjective norms (perceptions of peers' and friends' engagement in and opinion of risk-taking), are central to their own willingness to take risks, and highlight that risk-taking may be normative within and responsive to pressures to "fit in" with some peer groups.

Moreover, research has revealed crucial findings regarding how teens evaluate risky behaviors, yet has yielded limitations (Nucci, Guerra, & Lee, 1991). First, risk-taking occurs in multiple realms; the present study examined risk-taking in three realms (alcohol use, drug use, reckless driving). Second, frequency measures do not capture the reasons why the individual engaged/did not engage in the risky behavior (Nucci et al., 1991); teens may take risks in different realms for different reasons, and risk-taking consistency may be artificially inflated if many in the sample never had the opportunity to take risks.

In response, Shaw, Amsel, & Schillo (submitted 2008, p. 10) developed the Risk Intention Scale to show that teens take risks for different reasons in different risk realms. According to this measure, two possible risk intentions exist for teens who do not take risks: *Avoidant*, who are concerned with endangering their health, welfare, and violating personal values, and *Opportunistic*, who simply lack the opportunity to take risks. In addition, two possible risk intentions exist for teens who do take risks: *Curious*, who have the opportunity and desire to explore the risk-taking experience, and *Risk-Seeking*, who actively seek out and/or create opportunities to take risks.

The present study also drew on the prototype-willingness (P/W) model (Gibbons et al., 1998), and is consistent with its central assumptions: (1) risk-taking is responsive to risk-conducive circumstances, (2) risk-taking is a social event, and (3), risk-taking is associated with social images that impact adolescents' decisions about risk-taking. Moreover, previous research shows that greater behavioral willingness to *engage* in risk-taking is associated with *positive* subjective norms, or with the perceptions of significant others (e.g., friends, peers) engagement in and proscriptions of the risk behavior (Gibbons et al., 1998). Thus, the P/W model asserts that the *frequency* of adolescent risk-taking is predicted by adolescents' behavioral expectation (the perceived likelihood of future engagement in the behavior), and subjective norms (Gibbons et al., 1998). The present study investigated the relation of behavioral expectations and subjective norms to risk-taking *intentions* in both middle (14-17 years) and older (18-19 years) adolescents.

Methods

Participants

The sample consisted of 159 male and female adolescents: 86 older (M= 18.4 years, range 18-19 years) and 73 middle (M=15.9 years, range 14-17 years) adolescents. Parental consent (78% return rate) and

adolescent assent was obtained for all middle adolescent participants; individual consent was obtained for all older adolescent participants.

Design and Assessments

Participants completed a two-section questionnaire and were asked about risk-taking in three risk realms: alcohol use, drug use, and reckless driving. The risk realm was varied within subjects and counterbalanced within each age group using a Latin-square design. The questionnaire assessed participants' own risk-taking intentions, risk-taking frequency, behavioral expectation, and subjective norms. The Risk Intention Scale assessed participants' reasons for/against taking risks. In each risk realm, participants selected one of the following statements as the best characterization of their risk intention:

> *Avoidant*: "I did not and never would have engaged in any of these risk behaviors because I felt that these behaviors were very dangerous for my health, welfare, and violated my sense of values."
>
> *Opportunistic*: "I did not engage in any of these risky behaviors, but I might have if the timing or circumstances had been different. I didn't really think about the consequences of these behaviors, and I wasn't too worried about them anyway."
>
> *Curious*: "I tried these risky behaviors a few times because I was curious and the opportunity presented itself. I did not brag about it to my friends and I wasn't trying to look cool or anything, I just wanted to know what it felt like."
>
> *Risk-Seeking*: "I was a person who participated in these behaviors and I hung out with others who also did so as well. I wanted to engage in these behaviors and I never hid having done them from those who I wanted to know."

The Risk-Taking Frequency Scale assessed participants' frequency of risk-taking for three risky behaviors in each risk realm (e.g., "In the past year, how many times did you drink alcohol alone?).
Participants rated their perception of their peers' and friends' frequency of risk-taking (e.g., "How many people your age/of your close friends have drank alcohol?") and their reactions to the teens' own risk-taking (e.g., "How do you think people your age/your close friends would respond if they thought you had drank alcohol?"). Participants also rated their behavioral expectation (e.g., "Do you think that you will drink alcohol in the future?").

Scoring and Reliability

Risk Intention Scale responses were scored as 1 = Avoidant, 2 = Opportunist, 3 = Curious, 4 = Risk-Seeking. Responses to the Risk-Taking Frequency Scale were scored on a 5-point Likert-type scale (1 = "never" to 5 = "frequently"). Participants' subjective norms of their peers' and friends' frequency of risk-taking were scored on a 5-point Likert-type scale (1 = "none," to 5 = "almost all") and their reactions to the teens' own risk-taking (1 = "have a strong negative reaction and tell me to stop," to 5 = "have a strong positive reaction and tell me to continue"). Finally, participants' behavioral expectation ratings were scored on a 5-point Likert-type scale (1 = "I definitely will not," to 5 = "I definitely will").

Results

Relations between risk intentions, subjective norms, behavioral expectations, and frequency of risk-taking behavior were assessed. An overall frequency of Risk-Taking Intention score was obtained by summing the frequency of each of the four Risk Intentions across risk realms. Mean Risk-Taking Frequency scores were obtained by computing the mean frequency of each of the three risk behaviors across risk realms. Mean Subjective Norms and Behavioral Expectation scores were obtained by averaging each score across risk realms. Partial correlations (controlled for Sex and Group) were conducted between the frequency of Risk Intention, overall mean Risk-Taking frequency, mean Subjective Norm scores (mean Peer and Friend Risk-Taking, and Peer and Friend Reaction scores) and Behavioral Expectation.

Partial correlations showed stable and unique patterns, in that Risk-Taking Frequency was strongly and positively related to teens' tendency to be *Risk Seeking* ($r = .70$, $p < .001$), strongly and negatively related to teens' tendency to be *Avoidant* ($r = -.620$, $p < .001$), moderately and positively related to teens' tendency to be *Curious* ($r = .31$, $p < .001$) and unrelated to the tendency to be *Opportunistic*($r = -.120$). Thus, Risk Intention differentially predicted teens' frequency of risk-taking independently of group and sex.

With the exception of *Opportunists*, Risk Intentions were correlated with Subjective Norms. *Avoidant* teens more negatively reported the risky behaviors and reactions to risk-taking of their Peers ($r = -.427$, $p < .001$, & $r = -.350$, $p < .001$, respectively) and Friends ($r = -.536$, $p < .001$, & $r = -.622$, $p < .001$, respectively). In contrast, *Risk-Seeking* teens more positively reported the risky behavior and reactions to risk-

taking of their Peers (r = .316, p<.001, & r = .274, p<.001, respectively) and Friends (r = .458, p<.001, & r = .495, p<.001, respectively). A similar but weaker pattern was obtained for *Curious* teens. Here, risk-taking appears to bear on the social context of peers and friends in that teens reflect upon the subjective norms of their peers and close friends when evaluating their own risk-taking.

Finally, teens' Behavioral Expectation (BE) was correlated with Risk Intention. The more teens were *Avoidant* the less they expected to take future risks r = -.694, p<.001; the more teens were *Risk-Seeking* the more they expected to take future risks r = .622, p<.001. *Curious* tendencies were positively yet moderately related to Behavioral Expectations, while *Opportunistic* tendencies were not related. Teens' assessment of their expectations to engage in future risky behaviors may therefore bear upon Risk Intention.

Discussion

The present research examined risk-taking from the adolescents' own perspectives regarding their risk intentions, subjective norms for peers and friends, and their expectations of future risk-taking. Critical findings were apparent in that Risk Intention was demonstrated as an active component of risk-taking. *Avoidant* teens were less likely to take risks, while *Risk Seeking* teens were more likely to engage in risk-taking; *Curious* teens showed similar patterns as *Risk-Seeking* only less strongly so. These findings support our hypotheses that teens' intention for taking risks can be meaningfully differentiated, and not simply indexed by their risky behavior(s).

Adolescents also find meaning and social significance in risk-taking, as evidenced in that Risk Intentions differentially predicted teens' subjective norms and behavioral expectation. *Avoidant* teens judged the risky behavior as not engaged in by peers and friends, and as not likely to be engaged in by the teens themselves. This pattern was not found for *Opportunistic* teens. Thus, the different reasons for not engaging in risk-taking bear distinct relations to subjective norms and behavioral expectations. Similarly, *Risk Seeking* teens judged the risky behavior as engaged in by peers and friends, and as likely to be engaged in by the teens themselves. *Curious* showed a similar but weaker pattern, again suggesting that the different reasons for engaging in risk-taking bear distinct relations to subjective norms and behavioral expectations.

Additionally, the relation of risk-taking frequency to Risk Intention indicates that how teens evaluate their intentions regarding risky behaviors may impact their actual risk engagement. Subjective norms appeared to support teens' reported Risk Intention status, and it appears that teens utilize this social information when evaluating their own risky behavior, thus indicating that adolescent risk-taking is a normative effort to fit in with peers and friends. Therefore, teens' ability to evaluate their own intentions and behavioral expectations regarding risky behaviors and to appreciate the subjective norms associated with the behavior is salient concerns of adolescent risk-taking, and contributes to teens' decision-making processes.

References

Arnett, J. (1992). Reckless behavior in adolescence: A developmental perspective. *Developmental Review*, 12(4), 339-373.

Dahl, R. (2004). *Adolescent brain development: A period of vulnerabilities and opportunities*. New York, NY, US: New York Academy of Sciences.

Gibbons, F., Gerrard, M., Blanton, H., & Russell, D. (1998). Reasoned action and social reaction: Willingness and intention as independent predictors of health risk. *Journal of Personality and Social Psychology*, 74 (5), 1164-1180.

Johnston, L., O'Malley, P., & Bachman, J. (2002). Monitoring the future—National results on adolescent drug use: Overview of key findings. *National Institute on Drug Abuse*, 1-56.

Nucci, L., Guerra, N., & Lee, J. (1991). Adolescent judgments of the personal, prudential, and normative aspects of drug usage. *Developmental Psychology*, 27(5), 841-848.

Shaw, L., Amsel, E., Schillo, J. (2008). Adolescent Risk-taking: Relations between Socio-Moral Reasoning, Intention and Behavior. Manuscript submitted for publication.

Research Abstracts

Performing Arts

Group Teaching 101: the Dos & Don'ts

Linda Clement, Emily Inderrieden, Shing Yau Kai, Rosann Owen, Alyson Robinett, Whitney Wasden & Yu-Jane Yang

Why should you consider doing group instruction? How can teachers incorporate group teaching into private studios? This session will focus on the discussions of the "dos" and "don'ts" of group teaching. The presenters will illustrate some essential principles of successful group teaching strategies and creative tactics by showing ample examples of video clip teaching with live narration. Come discover how you can successfully utilize fun music learning of group teaching in your studio without chaos!

This research was presented at the Music Teachers National Association 2009 National Conference in Atlanta, Georgia, March 28 - April 1, 2009.

Clinical Laboratory Sciences

Macrolide Resistance Rates in *Streptococcus Pyogenes* Along The Wasatch Front

Todd Keskey, Bruce Jolly, Lauren Jackson & Travis Price

The Centers for Disease Control maintain there are over 10 million cases of strep throat infection every year in the United States. The antibiotic of choice for treating *Streptococcus pyogenes*, the bacteria that causes strep throat, is penicillin. When a patient presents a potential allergy to penicillin that would counter-indicate its use, physicians prescribe macrolide drugs, such as azithromycin, erythromycin, and clarithromycin. With the growing antimicrobial resistance in various types of bacteria, many drugs are becoming ineffective. This causes physicians to prescribe different drugs that have to be taken for a longer period of time, have more detrimental side effects, and often require intravenous administration.

Studies performed around the world are finding an average resistance rate of 7% to the macrolide drugs used to treat Strep throat. These rates vary year to year, and from region to region, thus supporting the need for a study along the Wasatch front. We will collect swabs positive for strep and grow the bacteria. The bacteria will then be tested for antimicrobial susceptibility to penicillin, azithromycin, erythromycin, and clarithromycin. Using these data, we can determine the resistance rates of Strep to each of these antimicrobials.

This research was presented at the National Conference for Undergraduate Research Annual Meeting, Salisbury, Maryland, April 10-12, 2008.

Clinical Laboratory Sciences

Mechanisms of Resistance for *Streptococcus Pyogenes* in Northern Utah

Ryan A. Rowe, Ryan Stephenson, Destry East & Scott Wright

There is a growing distress among health care professionals regarding antimicrobials that no longer work against human pathogens. *Streptococcus pyogenes* has demonstrated two main mechanisms of resistance against antimicrobials like erythromycin and other macrolides. The first mechanism, efflux, allows the bacterium to pump the antimicrobial out of the cell. The second mechanism is the modification of the bacterium's ribosomes, making the target of the macrolide ineffective. Both of these phenotypic mechanisms are associated with *MefA, ErmA*, or *ErmB* genes. The objective of this study is to determine the rate of resistance to erythromycin in the northern Utah area, and identify if any single genotype is more prevalent among the resistant strains. Throat swabs were received from surrounding laboratories. Researchers isolated and identified the organism based on three diagnostic criteria commonly used in clinical laboratories. Susceptibility patterns were conducted utilizing an agar diffusion method (Kirby-Bauer). Of the 400 organisms tested, and 1.5% were resistant to erythromycin. The erythromycin resistant strains were separated into phenotypic groups based on reactions from the clindamycin disk induction test. Each phenotypic group was analyzed by polymerase chain reaction (PCR) to identify the frequency of *MefA, ErmA*, and *ErmB* genes responsible for the resistant phenotypes seen.

This research was presented at the National Conference for Undergraduate Research Annual Meeting, Salisbury, Maryland, April 10-12, 2008.

Clinical Laboratory Sciences

Second Trimester Referance Intervals for TSH and FT4 on the Roche Modular E170

Rechelle A. Silvio, Karly J. Swapp, & Kara Hansen-Suchy

Diagnosis of thyroid disorders are complicated by changes in hormone levels during pregnancy. Disease diagnosis can be missed if the clinician uses non-pregnant reference intervals. The objective of this study was to determine TSH and FT4 reference intervals for women in their second trimester of pregnancy. Testing was conducted on specimens with no detectable thyroid antibodies and a gestational age of 14 to 21 weeks. We focused on thyroid-stimulating hormone (TSH) and free thyroxine (FT4) assayed on the Roche Modular E170 at Associated Research and University Pathologists (ARUP). In addition, a method comparison was performed between the Roche Modular E170 and Abbott ARCHITECT *i*2000$_{SR}$ to determine if results were interchangeable.

Our study demonstrated a significant decrease from the non-pregnant package insert values for TSH and FT4. No clinical significance was found between the Roche expected ranges and our second trimester ranges for TSH, however clinical significance was observed for FT4. The method comparison between the Roche and the Abbott analyzers showed that TSH values are interchangeable but not interchangeable for FT4. The results clearly demonstrate that it is necessary for FT4 reference intervals to be established on all instruments, ensuring the best interpretation of thyroid function during pregnancy.

This research was presented at the American Society for Clinical Laboratory Science Annual Meeting, Washington D.C., July 26-August 2, 2008.

Clinical Laboratory Sciences

Survey on Pretransfusion Compatibility Testing Methodologies in the United States

Brianne Dahl, Kelsey Farnsworth, Teresa Patterson & Bill Zundel

The purpose of pretransfusion compatibility testing is to prevent incompatible red blood cell (RBC) transfusions that could lead to immune mediated hemolytic transfusion reactions. Several different elements are included in the process of pretransfusion testing such as ABO grouping and Rh D typing, screening for unexpected antibodies, identifying unexpected antibodies, selecting appropriate donor cells for transfusion, and crossmatch between recipient and prospective donor cells. While these procedures are essentially universal in transfusion practices, the specific methods used to perform the procedures can vary somewhat from one facility to another. As technology advances, the array of available methods is ever growing. Transfusion service facilities are being presented with these methods and we predict that an increasing number are choosing to stray from tradition and to implement these innovative methods. The purpose of this survey is to assess the current testing practices for ABO grouping, Rh D typing, antibody screening, antibody identification, and crossmatching in the United States. We have chosen to use the online survey engine, Zoomerang, to administer and review the survey. The survey was launched on February 5, 2008 to approximately 750 transfusion centers in the United States in hopes of having at least 60% participation. The information is being compiled for statistical review as it is received. We foresee this information providing beneficial insight for educators, the health care industry, and blood bank product manufacturers.

This research was presented at the American Society for Clinical Laboratory Science Annual Meeting, Washington D.C., July 26-August 2, 2008.

Clinical Laboratory Sciences

The Effects of Secondary Centrifugation on a Comprehensive Metabolic Panel

Allison Barto, Ryan McGary, Brady Tucker & Gary Nielsen

Physicians typically order laboratory tests for their patients in conjunction with either the annual physical exam, or if the patient is ill. One of the most common tests is the comprehensive metabolic panel (CMP). This panel gives a fairly good indication of the patient's overall health. It is standard practice for clinics to centrifuge samples initially after collection. The sample is then sent via a courier to the testing facility. Problems with specimen integrity arise when the specimens are not kept upright during transportation or the tubes were centrifuged in such a way that the gel becomes slanted. Slanted gel can interfere with the pipetting device of the analyzer, resulting in errors. A simple fix is to re-centrifuge the samples before they are analyzed. The purpose of this research project was to evaluate the effects of secondary centrifugation on serum and plasma separator tubes. Using the Paired t Test statistical analysis method, research showed that the majority of the analytes in a CMP showed minimal variation. However, potassium showed an increase of almost 20 percent. This false increase in potassium, pseudohyperkalemia, can cause misdiagnoses, unnecessary treatments, and/or mask disease processes that have abnormally low potassium levels.

This research was presented at the American Society for Clinical Laboratory Science Annual Meeting in Washington D.C., July 26-August 2 , 2008.

Botany

Distribution of Woody Decomposer Fungi Within The Great Salt Lake

Leslie Patterson & Ron Deckert

Fungi play important roles in the decomposition and recycling of plant litter, due to their capacity to produce enzymes that digest cellulose and lignin. The Great Salt Lake (GSL) is an extreme saline environment, yet some fungi survive these conditions. The GSL varies in salinity at different locations from a low concentration of 5% to a high of over 30%. Every year coarse woody debris (CWD) is washed into the lake creating a potential substrate for fungi. I studied the differential dominance of decomposing fungal species within areas of differing salinities. I collected CWD from six areas of the lake with differing salinities. I then plated the samples on agar with water collected at the site. Plates were incubated for two months. Filamentous fungal growth only occurred on two areas. After the two month period I replated half the samples onto agar with 5% salinity to observe possible dormancy effects. Results suggest that areas of lower salinity allowed for a greater diversity of filamentous fungi than that of the higher salinities. Areas near salt saturation showed no filamentous fungal growth.

This research was presented at the 10th International Conference on Salt Lake Research & 2008 FRIENDS of Great Salt Lake Issues Forum Saline Lakes Around the World: Unique Systems with Unique Values at the University of Utah, Salt Lake City, Utah, May 11-16, 2008.

It was also presented at the National Conference for Undergraduate Research Annual Meeting, Salisbury, Maryland, April 10-12, 2008.

Geosciences

Constructing a Baseline Model of Alpine Wetlands of the Uinta Mountains, Utah, USA

Sonya B. Welsh, Lee M. Bartholomew, Kevin S. Severson, Marek Matyjasik, Rick Ford & Michael Hernandez

Alpine wetlands of the Uinta Mountains, northeastern Utah, contain a variety of groundwater-dependent ecosystems. Unlike their counterparts in other areas of the Rocky Mountains, these systems have been relatively unstudied. The primary goal of this interdisciplinary study is to establish the functional links between the geomorphology and hydrogeology of these high mountain wetlands and their constituent plant communities. In addition to traditional field studies and water chemistry, geospatial technologies are being used to organize and analyze both field data (water chemistry and wetland vegetation) and archived multispectral imagery (2006 NAIP images). The hydrology of these wetlands is dominated by groundwater discharge and their surface is dominated by string-and-flark morphology of various spatial scales, making these montane wetlands classic patterned fens. Small-scale patterning occurs along the margins of the wetlands and in sloping-fen settings. Major plant communities have been identified within the wetlands for example: a *Salix planifolia* community associated with the peaty strings; *Carex aquatilis, Carex limosa*, and *Eriophorum angustifolium* communities associated with flarks; as well as a *Sphagnum sp*.- rich hummocky transition zone between wetland and non-wetland areas. On-going analyses of water-chemistry data will be used to identify discrete water sources and to characterize the degree of horizontal and vertical water mixing within the system, as well as to help identify the biochemical requirements of the different plant communities. Results indicate that the chemical composition of the main creek reflects the accumulative effect that the peaty flarks have on the creek as it passes through the wetland system, with pH overall decreasing from 7.3 to 7.0, dissolved oxygen decreasing from 9400 to 8400 micrograms per liter and total dissolved solids increasing from 9 mg/L to 13 mg/L. String ground water is characterized by relatively high pH (ranging from 6.0 to 7.1), high oxidizing-reducing potential (ORP) (ranging from 50 mV to 180 mV), high dissolved oxygen (from 2500 µg/L to 9600 µg /L) while flark ground water has relatively lower pH (5.6 to 6.8), low oxidizing reducing potential (ORP) (ranging from -66 mV to 150 mV), low dissolved oxygen (from 900 µg/L to 9000 µg/L).

This research was presented at the American Geophysical Union Fall Meeting in San Francisco, California, December 15-19, 2008.

Geosciences

AFM Arctic Study of Calcite Surface

Sara Summers, Marek Matyjasik, Colin Inglefield & Maciej Manecki

This study focused on direct observation of chemical weathering of calcite surfaces in the newly forming arctic soil of the foreland of the Werenskiold glacier, in Spitsbergen. Two samples of freshly cleaved calcite (calcite1 and calcite2) were buried in the soil at distances of 100 m and 2500 m from the glacier's front respectively and retrieved after one year. The samples were analyzed using atomic force microscopy (AFM) and compared with the non-exposed control sample, calcite0. The length of observed images varied from 150 nanometers to 10 micrometers. Overall, calcite1 and 2 have more rounded edges modified by chemical weathering, while calcite0 has a smoother surface with more angular edges controlled by crystallographic properties. Region and line roughness parameters, which quantitatively characterized two dimensional and one dimensional surface topography respectively, were calculated as a deviation from the mean depth value. The most pronounced changes were observed along top and bottom step edges. Top step edge average region roughness increased from calcite0 (1.82nm) by 241% to 6.2nm in calcite1, and by 486% to 8.84nm in calcite2. Bottom step edge average region roughness increased from 2.08nm in calcite0 by 98% to 4.52nm in calcite1 and by 149% to 5.67nm in calcite2. Top step line roughness increased form 2.04nm in calcite 0 by 191% to 5.93nm in calcite1 and by 276% to 7.67nm in calcite2. Bottom step line roughness increases from 2.28nm in calcite0 by 198% to 4.52nm in calcite1 and by 249% to 5.67nm in calcite2. The results indicate increased rate of chemical weathering with shorter distances from the glacier's front.

This research was presented at the Sigma Xi Student Research Conference held in Washington D.C, November 20-23, 2008.

Geosciences

AFM Observations of Weathering and Microbiological Alterations on the Surface of Calcite Buried in Arctic Soil (Spitsbergen)

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This study focused on the direct observation of chemical weathering and biological activity on mineral surfaces in the newly forming arctic soil of West Spitsbergen. Chemical weathering and soil forming processes associated with glaciers may affect several geochemical cycles including global carbon cycle and as a result have negative feedbacks on the global climate. Study areas are the foreland of the Werenskiold glacier, continuously retreating by several meters a year. Several samples of freshly cleaved calcite had been buried in the soils for one year. Samples were analyzed with the use of Atomic Force Microscopy (AFM). Results of AFM investigation show changes observed on a calcite samples located respectively about 2500 meters (sample calcite 1) and 100 m (sample calcite 2) from the glacier front as compared to a control sample calcite 0, that has never been exposed to glacier environment. Samples calcite 1 and calcite 2 were recovered from Spitsbergen after 1 year. Compared to the control sample calcite 0, which displays sharp edges and smooth surfaces, both field-treated samples calcite 1 and calcite 2 display rounded edges, irregular surfaces, numerous dissolution features and rounded pitches associated with bacterial activities. The observations suggest that both samples calcite 1 and 2 undergo intensive and rapid chemical and biological weathering when exposed to relatively unsaturated with respect to calcite glacial meltwaters. Several types of analyses have been applied to various regions and lines on the calcite surface. Selected regions on the calcite surface included (a) the entire area of the observed surface (b) top step region roughness, and (c) bottom step region roughness. Selected line parameters have been calculated along: (a) three randomly selected parallel lines, (b) top step line roughness, and (c) bottom step line roughness. Both surface area roughness and line roughness are calculated as the mean deviation of the height. Significant differences have been observed between the samples in calculated roughness parameters, with increase of these parameters

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ranging from 28% to 241% in calcite 1 located 2500 m from the glacier front and from 100% to 486% in calcite 2 located 100m from the glacier front, as compared to calcite 0. Roughness of the entire surface area for the control calcite 0 was 5.73nm, which increased by 28% in calcite 1 and by 100% in calcite 2. Top step edge roughness increases from calcite 0 (1.82 nm) by 241% to 6.2 nm in calcite 1 and by 486% to 8.84 nm in calcite 2. Bottom step edge roughness increases from 2.08 in calcite 0 by 98% to 4.52nm in calcite 1 and by 149% to 5.67 nm in calcite 2. Line roughness for calcite 0 is 3.26, which increased by 102% in calcite 1 and by 217% in calcite 2. Top step line roughness increases from 2.04 nm in calcite 0 by 191 % to 5.93 nm in calcite 1 and by 276% to 7.67nm in calcite 2. Bottom step line roughness increases from 2.28 nm in calcite 0 by 198% to 4.52 nm in calcite 1and by 249% to 5.67 nm in calcite 2. In calcite 0 bottom step edge roughness and bottom step line roughness are very similar to top step roughness. In both calcite 1 and calcite 2, top roughness is much greater than bottom roughness.

This research was presented at the American Geophysical Union in San Franscisco, California, December 14-21, 2008.

Microbiology

Phosphate and Phosphonate Use by Microorganisms Isolated from Hypersaline Environments of the Great Salt Lake, Utah

Jay P. Nichols, Chase L. Sessions, Michele D. Zwolinski, & Craig J. Oberg

The Great Salt Lake (GSL) contains high levels of phosphate (PO_4^{3-}), however most is precipitated with minerals such as calcium and magnesium and is not bioavailable for microorganisms. We hypothesize that organisms from the GSL will be versatile in the types of PO_4^{3-} sources they can use and may be able to scavenge PO_4^{3-} at low concentrations. Using a non-specific saline medium, organisms were isolated from water and sediment from the south arm (8% saline) and the north arm (22% saline) of the GSL. These isolates were characterized by colony morphology, Gram stain, and 16S rRNA gene sequence. Isolates that amplified with Bacteria specific primers from the north arm were related to the halophilc genera *Salicola, Halomonas,* or *Marinobacter*, while isolates from the south arm were related to *Halomonas and Salinivibrio*. Two isolates from the north arm amplified only with Archaea primers and were related to the genera *Natronococcus* and *Haloarcula*. The ability of the isolates to grow with organic phosphate esters (*o*-phosphorylethanolamine, *o*-phospho-DL-serine), organic phosphonates (1-aminoethylphosphonic acid, n-(phosphonomethyl)glycine), or inorganic PO_4^{3-} (KH_2PO_4, or H_3PO_4) as the sole P source was determined. Each isolate was inoculated into a row of a 96 well plate containing a PO_4^{3-}-free minimal medium, and triplicate columns were amended with 1 mM of one of the PO_4^{3-} sources listed above. Growth was monitored by measuring absorbance at 595 nm. Compared to the no-phosphate control, most isolates could use several of the PO_4^{3-} sources, but individual isolates preferred some PO_4^{3-} sources over others. All of the isolates could grow on media containing KH_2PO^4 as the sole phosphate source. However, several also grew quickly on 1-aminoethylphosphonic acid indicating the ability to cleave the C-P bond of the phosphonate molecule. Conversely, organisms grew slowly, or not at all, with n-(phosphonomethyl)glycine, the active component of the herbicide *Roundup*, suggesting toxicity. Some isolates grew slowly with no added PO_4^{3-}, indicating these organisms may have efficient mechanisms for scavenging low levels of available PO_4^{3-}.

This research was presented at the American Society For Microbiology 108th General Meeting in Boston, Massachusetts, June 1-5, 2008.

Physics

Computational Astrophysics Software for the Study of Nearby Planetary Systems

Ryan Haynes, John Sohl & John Armstrong

In an effort to bring computational Astrophysics to the undergraduate level, a simplified analysis tool for simulating gravitational interaction of planets orbiting stars is needed. Many tools to integrate planetary systems and study their behavior have been developed. This project focuses on combining a well-developed N-body planetary integrator (Mercury) with a web application (Rails) to automate the simulation process, making studies of Extra Solar Planetary systems much easier. Ultimately this application will have the ability to simulate any system including objects such as test particles and planets, and then store this data for later scientific inquiry. One instance of this software has already been implemented on Weber State Universities computing cluster (Workhouse). Much work is still needed to perfect and distribute this software.

This research was presented at the Texas and Four Corners American Physical Soceity Joint Meeting at the University of Texas in El Paso, Texas, October 17-18, 2008.

Physics

High Altitude Ballooning and Site Selection

John Metcalf & John Sohl

High altitude ballooning provides a near-space platform for amateur research projects in science and engineering. This venue allows new experiments, otherwise not conducted from costs or lack of transportation, from WSU and surrounding areas to be flown into the upper atmosphere. A highly skilled and motivated group of scientist and engineering students from WSU have contrived its own high altitude balloon to lift payload capsules filled with experiments and tracking equipment up to 120,000 feet where it then bursts and payload capsules are parachuted into a landing zone. Launch site selection is based upon the safety of those that come within the balloons projected flight path and terrain accessibility from the launch and landing zones. Restricted ground and airspace, mountainous regions, lakes and rivers, and densely populated or high air traffic areas were obstacles to be avoided. Computer flight simulations and region analysis show that there are several viable launch and recovery sites in Utah as well as SE Idaho, SW Wyoming, and NW Colorado.

This research was presented at the Texas and Four Corners American Physical Soceity Joint Meeting at the University of Texas in El Paso, Texas, October 17-18, 2008.

Physics

Improvements to a Michelson Interferometer Based Wavemeter for Precision Laser Wavelength Measurement

Bryce McClurg & John Sohl

The Michelson wavemeter developed by Fox, *et. al.*, is basically a solid design but has problems with speed and single pass accuracy. The main problem is associated with the speed of the fringe detection and the fringe contrast. Electronic noise can also be an issue if the detector is not carefully laid out. Standard op amps and counting circuits are not fast enough to keep up with the fringe counting which needs to be at least 5 Mhz. The quality of the fringes is not reliably high and a way to increase the fringe contrast is critical to allow for a reliable fringe count. We have created a high speed counting circuit and a possible fringe detection system. Our current status and results will be reported.
P. J. Fox, R. E. Scholten, M. R. Walkiewicz, and R. E. Drullinger, Am. J. Phys. 67 (7), July 1999.

This research was presented at the Texas and Four Corners American Physical Soceity Joint Meeting at the University of Texas in El Paso, Texas, October 17-18, 2008.

Physics

Multi-sensor Array for High Altitude Balloon Missions to the Stratosphere

Tim Davis, Bryce McClurg & John Sohl

We have designed and built a microprocessor controlled and expandable multi-sensor array for data collection on near space missions. Weber State University has started a high altitude research balloon program called HARBOR. This array has been designed to data log a base set of measurements for every flight and has room for six guest instruments. The base measurements are absolute pressure, on-board temperature, 3-axis accelerometer for attitude measurement, and 2-axis compensated magnetic compass. The system also contains a real time clock and circuitry for logging data directly to a USB memory stick. In typical operation the measurements will be cycled through in sequence and saved to the memory stick along with the clock's time stamp. The microprocessor can be programmed to adapt to guest experiments with either analog or digital interfacing. This system will fly with every mission and will provide backup data collection for other instrumentation for which the primary task is measuring atmospheric pressure and temperature. The attitude data will be used to determine the orientation of the on board camera systems to aid in identifying features in the images. This will make these images easier to use for any future GIS (geographic information system) remote sensing missions.

This research was presented at the Texas and Four Corners American Physical Soceity Joint Meeting at the University of Texas in El Paso, Texas, October 17-18, 2008.

Zoology

A Role for Microfibril-Associated Glycoprotein-2 in Wound Repair

Christian Francom, Thomas Broekelmann, Russel Knutsen, Robert P. Mecham & Barbara Crippes Trask

The principle components of 12nm microfibrils are members of the fibrillin family, although other proteins, including microfibril-associated glycoproteins-1 and -2 (MAGP-1 and -2), may contribute to the function of these structures. Both fibrillin and MAGP-1 have been shown to interact with members of the TGF-β family of growth factors and modulate their activity *in vitro* and *in vivo*. To investigate whether MAGP-2 might also interact with growth factors, the binding properties of recombinant MAGP-2 were studied using surface plasmon resonance. Solid-phase binding assays were also performed to identify insoluble binding partners. These studies revealed novel interactions including an MAGP-2 self-association and an interaction with the active forms of TGF-β family members. The association between MAGP-2 and TGF- β_1 is of particular interest given the biological importance of binding between the latent form of this growth factor and fibrillin. Because a delay in wound closure has been observed in MAGP-1 deficient mice, cutaneous wound-healing assays were performed in MAGP-1/MAGP-2 null (DKO) mice and wound closure rates relative to WT and MAGP-1 knockout animals were compared. Although no obvious abnormalities were evident in histological sections of skin from either of the MAGP-null animals, a significant lag in the initial rate of wound closure was observed in both groups of transgenic mice. MAGP DKO animals displayed a greater initial delay followed by quicker overall wound closure when compared to MAGP-1 null and WT animals. These studies suggest a biological role for MAGP-2 different from that of MAGP-1 in wound repair.

This research was presented at the American Society for Cell Biology Annual Meeting in San Francisco, California, December 13-17, 2008.

Zoology

Nest-site Selection of Shorebirds at Great Salt Lake: Implications for Development of Water Quality Standards

Lindsay Cole & John Cavitt

The "Clean Water Act" requires that states develop water quality standards for the beneficial use of its water bodies. The Great Salt Lake (GSL) is a critical stopover and breeding site for shorebirds. Approximately 5 million birds utilize the GSL each year. Despite its importance, water quality standards do not exist. The state of Utah and the USEPA have initiated projects to develop water quality standards for GSL. In order for these standards to provide optimal breeding habitat for shorebirds, it is imperative that habitat conditions are identified which sustain healthy populations of coexisting species. Consequently, I monitored the nesting success of two shorebird species, American Avocets (AMAV) and Black-necked Stilts (BNST) at GSL, and characterized the vegetation surrounding each nest. I measured the following variables at nests and at random non-use sites: substrate, percent cover, cover height, distance to water, and vertical concealment of nests. My results identified key habitat features used in selecting nesting sites. For example, BNST selected sites with significantly greater vertical concealment relative to AMAV and random sites. The results of this study also documented habitat features which increased nesting success. Successful AMAV nests had less bare ground relative to those nests later consumed by predators. In addition, successful nests of both species were significantly closer to water than depredated nests. The results of this study provide clear information on breeding habitat preferences. These data will be utilized to ensure that water quality standards and management guidelines promote optimal breeding habitat for these species.

This research was presented at the Council on Undergraduate Research Posters on the Hill in Washington, D.C., April 30, 2008.

Zoology

Quantification of Biotransformation Enzymes Implicated in *Neotoma lepida's* Ability to Consume Creosote

Cody Nebeker, Shannon Haley[1], M. Denise Dearing[1] & Michele M. Skopec

Two populations of the desert woodrat (*Neotoma lepida*) have different tolerances for creosote bush (*Larrea tridentateI*). Very few animals consume creosote bush since the leaves are coated with a toxic phenolic resin that deters herbivory. However, a population of the desert woodrat from the Mojave Desert consumes creosote as a large part of its diet. The Mojave Desert population seems to have evolved a superior ability to detoxify the resin present on creosote bush when compared to a population of the desert woodrats from the Great Basin desert where creosote bush is not present. A previous study in the Dearing lab showed that the Mojave woodrats have higher activity of two detoxification enzymes glutathione S-transferase (GST) and cytochrome P450 2B (CYP2B) compared to Great Basin woodrats when fed a diet containing creosote resin as well as a control diet. In our present study we quantified the amount of enzyme present using western blots. We found that similar to enzyme activity, there was a trend for GST protein levels to be higher in the Mojave woodrats than the Great Basin woodrats when fed a diet containing creosote resin as well as a control diet ($F_{3,20}$=2.363 p=0.05). For CYP2B however, their was no difference in the amount of protein between the two populations ($F_{3,20}$=0.225 p=0.878) . This leads us to assume the Mojave population has evolved a new isoform of CYP2B that is more effective and therefore has higher activity per unit protein. Our next step is to sequence the gene for CYP2B in both populations to determine if there is a functional difference between the two populations of woodrats.

This research was presented at the Society for Integrative and Comparative Biology in Boston, Massachusetts, January 3-7, 2009.

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Zoology

Sexual Dimorphism of Syringeal Muscles in Songbirds

Amiko Uchida, Jared Green, Sarah Ahmad, Ron Meyers & Franz Goller[1]

Male songbirds typically sing more frequently and more complex songs than females; in some species females do not sing at all. This behavioral difference is paralleled by sexually dimorphic syringeal muscle mass, but whether it is also reflected in syringeal muscle architecture is unknown. Fiber type composition of these muscles was investigated using myosin ATPase and immunohistochemistry. Female and male members of 5 oscine species (European Starlings, *Sturnus vulgaris*; White-crowned Sparrows, *Zonotrichia leucophrys*; Red-winged Blackbirds, *Agelaius phoeniceus*; Brown-headed Cowbirds, *Molothrus ater*; and Bengalese Finches, *Lonchura domestica*) all showed similar syrinx muscle fiber morphology, with larger superfast fibers outnumbering smaller fast fibers (for starlings: superfast fiber mean diameter 31-38μm and ~70% of fiber population; fast fiber mean diameter 14-20μm and ~30% of fibers). In contrast, Zebra Finches (*Taeniopygia guttata*) showed pronounced sexual dimorphism, with males possessing a majority of superfast fibers (as in the other species examined) and females a majority of fast. This finding provides a structural explanation for equal twitch durations in male and female starlings and faster twitch times in male Zebra Finches relative to females. Whereas female starlings, sparrows, and blackbirds sing occasionally, female Zebra Finches, cowbirds and Bengalese Finches do not. Thus the presence of superfast fibers does not parallel the occurrence of singing in females. These findings suggest that superfast fibers may be a basal character of the oscine syrinx, or are essential for other vocal or non-vocal functions. Further investigation of closely related species and behavior is needed.

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Psychology

Risk Taking, Religiosity, and Personality: Who does drugs and why?

Katie Lang & Matthew Schmolesky

Novelty seeking (NS) is a personality trait defined by impulsivity, excitability, and the need to seek out novel stimuli, qualities that may lead to increased risk-taking behavior. The objective of this study was to assess the relationships between NS, risk-taking behavior, and the cognitive assessment of risk related to three drug use activities: heavy drinking of alcohol, smoking cigarettes, and smoking marijuana. A group of college students (n = 83) from northern Utah completed Cloninger's Temperament and Character Inventory (TCI), a Physical Risk Frequency Inventory (PRFI), and a Physical Risk Assessment Inventory (PRAI). Subjects also provided information on their age and religious activity. While the majority of participants (67%) reported never having engaged in the drug use behaviors and rated them as extremely risky, other subjects have experimented with the activities (23%) or regularly engage in them (10%). Significant correlations were found between the PRFI and PRAI (r = -.43), NS and PRFI (r = .34), and NS and PRAI (r = -.34). Subjects that reported more frequent religious activity tended to be lower NS scorers (r = -.34), engaged in drug use less often (r = -.46) and gauged the risk of drug use as higher (r = .34). No significant gender effects were found for PRFI, PRAI, or religiosity scores. These findings extend previous research on the role of NS and cognitive assessments in determining physical risk taking behavior.

This research was presented at the Sigma XI Annual Meeting and Student Research Conference in Washington D.C, November 20-23, 2008.

Psychology

Underlying Mechanisms of Decrements Associated with Stereotype Activation

Gregorio Coronado & Matthew Schmolesky

There remains no clear consensus of the underlying mechanisms responsible for changes in memory performance associated with stereotype activation. Preeminent hypotheses hinge upon either an ideomotor or stereotype threat explanation (Wheeler & Petty, 2001). When age-related changes to cognitive function, which are ignored by both theories, are examined, an executive function explanation emerges. In this study, the relationships between past contact and stereotype activation regarding the elderly effects on memory performance were investigated. College age subjects (n=190) were given a survey, a sentence completion task embedded with either neutral or stereotype consistent words, and the Deese/Roediger-McDermott (DRM) paradigm, a free recall memory task comprised of semantically related words. In accordance with previous findings, those who were primed with words associated with the elderly who also spent a moderate amount of time with the older age population exhibited veridical memory patterns qualitatively similar to those of older adults (Dijksterhuis, Aarts, Bargh, &Knippenberg, 2000). However, they also exhibited false memory patterns qualitatively similar to older adults across study test trials. False recall is not associated with the stereotype and therefore cannot be explained by the ideomotor or stereotype threat theories. Both false and veridical recall patterns could be the result of a diminished cognitive control function. By focusing on frontal –executive function changes, such as decreases in source monitoring, both the current and previously published results can be accommodated.

This research was presented at the Sigma XI Annual Meeting and Student Research Conference in Washington D.C., November 20-23, 2008.