ERGO

Weber State University
Undergraduate Research Journal

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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:

Douglas & Shelley Felt Family Foundation, Ltd.

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Michael Vaughan and Kathleen Lukken

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F. Ann Millner – WSU President

On behalf of the entire Weber State University community, it is a pleasure to welcome you to the inaugural issue of *Ergo*, the university's new journal highlighting undergraduate research efforts.

Weber State students have long enjoyed opportunities for close collaboration with faculty members both in and out of the classroom. That collaboration has often taken the form of students participating in faculty research projects and faculty members mentoring research efforts by students.

The benefits of such collaboration have included giving students the chance to apply classroom theories to research and creative projects; enhancing students' ability to think critically and solve problems; and improving graduates' success in competing for employment and access to graduate schools. Faculty members also benefit from joint research efforts that engage students in more in-depth study of their disciplines.

In recent years, the university has taken proactive steps to support and encourage joint faculty-student research efforts. Those steps have included establishing an Office of Undergraduate Research; securing private funding for research projects and the public dissemination of their findings; and hosting an annual symposium highlighting undergraduate research. With this initial publication of *Ergo*, Weber State is opening another chapter in its ongoing efforts to foster undergraduate research.

I hope that you will join me in congratulating the students and faculty members whose research is featured on the pages of this journal.

F. Ann Millner
President–Weber State University

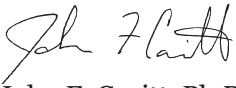
John F. Cavitt – Director, OUR

The Weber State University Office of Undergraduate Research is proud to present the first edition of *Ergo*, an undergraduate research journal. The abstracts and articles within this journal are testaments to many things, but most importantly they demonstrate how both the student authors and their faculty mentors are testing accepted theories, discovering new information and advancing knowledge within their respective disciplines. This journal is also evidence of the superb talent and dedication exhibited by students and faculty at Weber State University.

The students whose scholarly work is presented here have gone beyond the expectations of their coursework and have pushed themselves to excel within their disciplines. The faculty mentors have helped these students by challenging them to think critically, providing expert guidance and encouraging them as they developed their ideas. These student-faculty collaborations reveal all that is best about Weber State University.

This journal would not have come to fruition without the dedication and hard work of Lori Lundell. Her initiative and editorial talents have been critical for the success of this first edition. I would also like to acknowledge the entire *Ergo* staff, faculty advisors and reviewers for their commitment to this project and for providing an outstanding first edition. They have spent countless hours soliciting manuscripts, reading, editing and providing critical evaluations. Tyler Whitby and Ron Proctor should also be acknowledged for their time and efforts managing the layout and design.

The significance of an undergraduate research experience is clearly represented in this first edition. It is our hope that this journal will inspire others to participate in this process and we look forward to supporting many more undergraduate research efforts in the future.



John F. Cavitt, Ph.D.
Director–Office of Undergraduate Research (OUR)

Lori Lundell – Editor-in-Chief

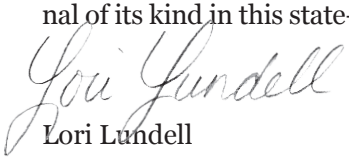
I hope students at WSU pick up a copy of this journal, see what their peers are doing, and realize that they can do the same. I think sometimes it just takes someone else's tangible example to open up new opportunities for people. I hope the journal you are holding is such an example.

It has been exciting to participate in the undergraduate research program at Weber State, both as a novice researcher trying to take full advantage of the opportunities WSU offers, and as a part of the program itself, trying to create new opportunities for other students. That is why this journal had to happen. I knew from working with other campus organizations that many students do not realize their potential as researchers and saw that a journal would augment the opportunities already available here. I also saw that our research program was so successful that we needed to facilitate an increasing need to support student research activities–that, in and of itself, says a lot about our program.

I brought the idea for this journal to the faculty and within a semester the idea was a fully-funded reality. Departments across campus signaled their desire to participate in our experiment–that says a lot about our faculty.

Within a few weeks of starting the journal, we were fully staffed with 14 students dedicated to making this publication happen. These students put in a lot of unpaid time and a lot of unacknowledged work to bring us to where we are now–that says a lot about our students.

Other campuses have research journals. Other organizations publish studies from a variety of disciplines. *Ergo* is exclusively by and for the Weber State community. This is the only student journal of its kind in this state–that says a lot about our university.



Lori Lundell
Editor-in-Chief

Prevalence of *Escherichia coli O157:H7* in Free Range Cattle

Brian L. Anderson
author

Scott Wright
faculty mentor

Escherichia coli O157:H7 has been identified as a human pathogen causing enterohemorrhagic colitis as well as hemolytic uremic syndrome (HUS). The most common route of human infection is contamination of food or water in connection with cattle. Slaughter-yard and feedlot cattle have been found to carry *E. coli O157:H7* as part of their normal intestinal flora. Due to the confined spaces that these cattle generally live in, there is an increased risk of cow-to-cow transmission. This has led to an increased occurrence of *E. coli O157:H7* among cattle living in these conditions. This study is to identify the natural carriage of *E. coli O157:H7* in an isolated free-range cattle herd. A rectal swab from each cow (n=96) of the specified cattle herd was collected. The swabs were immediately plated onto CHROMagar™ for laboratory identification. The presence of *E. coli O157:H7* is easily identified as pink-purple colonies on the primary plating media. Colonies suspected of *E. coli O157:H7* were tested using latex agglutination. Laboratory tests showed a 0% carriage of *E. coli O157:H7* in the free-range herd. The results suggest that cattle may not necessarily be normal carriers for *E. coli O157:H7* but are more likely to harbor the pathogen due to certain living conditions.

Introduction

Escherichia coli O157:H7 has emerged in recent years as a significant cause of enterohemorrhagic colitis (EHEC) in humans. A substantial percentage of those infected develop into a more severe condition known as hemolytic uremic syndrome (HUS). Although not as serious as HUS, EHEC can account for many serious conditions including severe bloody diarrhea. *E. coli O157:H7* is capable of attaching tightly to the intestinal wall of the host by utilizing intimin, an outer membrane protein. Once binding has occurred, *E. coli O157:H7* expresses a receptor Gb3 which attaches to the host cell and regulates toxin movement into the host cell. The Gb3 receptor is not typically found on human intestinal cells but is needed for *E. coli O157:H7* attachment. This suggests the organism can introduce the receptor into the host cell membrane. The result of toxin introduction to the cell is altered protein synthesis which leads to apoptosis (Jones, et al., 2000, p. G811; Zychlinsky & Sansonetti, 1997, p. 493; Philpott, et al., 1997, p. G1349). Enterohemorrhagic *Escherichia coli* obtains its pathogenicity through the production from an enterohemolysin that acts upon the intestinal membrane to disrupt barrier function leading to bloody diarrhea (Reid, et al., 2000, p. 64) .

Once attached to the intestinal wall, *E. coli O157:H7* is capable of producing a Shiga-like toxin (SLT) (Bettelheim, 1995, p. 176). The SLT toxin acts to interrupt protein synthesis in eukaryotic cells. The toxin targets many organ systems but displays the greatest affinity to the brain and kidneys. Extensive kidney damage leads to the development of HUS and the effects on the brain may lead to advanced neurological problems. The organism delivers the toxin directly into the bloodstream via the intestinal tract. HUS is a life-threatening complication that can occur due to *E. coli O157:H7* infection. Although HUS development is not common, about 5-10% of those infected will progress to this condition. The effects of HUS are now known to be the number one cause of kidney failure in children. The greatest occurrence of

HUS is seen in children or the elderly and accounts for the high mortality rate that is often associated with *E. coli O157:H7* infection. Research now suggests that *E. coli O157:H7* is responsible for the vast majority, if not all, of the cases of HUS seen in children. During HUS, micro thrombi form in select target organs causing inflammation and cellular damage. Of the organs affected, the kidneys seem to exhibit the greatest degree of damage (Rowe, et al., 1993, p. 1; Lopez, et al., 1995, p. 594). Antibiotic therapy has proven to be more harmful than beneficial (Wong, et al., 2000, p. 1930). No current treatment exists to stop the progression of HUS. Supportive therapy is used to limit the damage during the acute phase of the infection. The majority of *E. coli O157:H7* infections do not progress to HUS.

The serious complications caused by *E. coli O157:H7* infections, as well as its increasing prevalence, have prompted more research into determining the source of the infectious organism. The majority of cases found has been due to contaminated food or water and traced to cattle as the source of *E. coli O157:H7*. Extensive research has been reported showing a carriage of *E. coli O157:H7* in dairy and slaughter yard cattle of approx. 3-15%. Since its discovery in 1982, *E. coli O157:H7* has received well-publicized attention due to outbreaks connected to undercooked beef products. The vast majority of infections develop as food poisoning due to contamination. During processing, a sufficient barrier is not maintained and contamination can occur. Lack of pasteurization also plays a significant role in allowing the infectious organism into the population. The large role played by beef in the United States' food supply suggests a significant risk to public health as well as a need to better control contamination of beef products (Cameron, et al., 1995, p. 70; Centers for Disease Control, 1993, p. 258).

The percentage of cattle experimentally shown to carry *E. coli O157:H7* has focused primarily on cattle found on dairies or in feedlot herds. As with most infectious agents, occurrence may in-

crease due to certain factors seen in these two cattle populations. The close contact between cattle found on feedlots and dairies may account for a higher transmission rate of *E. coli O157:H7* than is found with free-range cattle. The continual processing of cattle through these environments, both for human consumption and general husbandry practices, increases exposure to a higher number of cattle than would be seen otherwise. This is especially significant with slaughter yards due to the large volume of cattle that pass through the same living space in a relatively short period of time. This allows for feces from one infected cow to contact many more cattle than would be expected in a free-range environment. Increased carriage of *E. coli O157:H7* is directly related to the amount of contamination observed in processed beef (Donkersgoed, Graham, & Gannon, 2000, p. 332).

The prevalence of *E. coli O157:H7* in a free-range closed herd was tested to determine its prevalence in cattle not found in the crowded living conditions observed in feedlot herds. The herd being tested is closed with very limited introduction of new cattle into the group. This greatly reduces the opportunity for *E. coli O157:H7* to be introduced to the herd by means other than the natural environment. Community transmission is reduced due to the cattle being pastured on an open range for the majority of the year. The free-range herd was tested (n=96) using direct plating of rectal swabs to selective CHROMagar™ media to identify the presence of *E. coli O157:H7*. Colonies isolated appearing to be *E. coli O157:H7* were tested using latex agglutination.

Materials and Methods

In this study the prevelance of *E. coli O157:H7* in a closed, free-range herd was determined using direct plating of bovine fecal samples. Conscious effort was made to follow similar isolation techniques employed by other researchers, particularly those determining the prevalence of *E. coli O157:H7* among dairy and

feedlot cattle herds. Although a low concentration of organism may not be isolated by the direct platting method, the comparisons are based on similar direct plating techniques used to determine the prevalence of *E. coli O157:H7* in dairy and feedlot cattle. These efforts were taken to give the greatest correlation between an isolated free-range herd and those found in relatively small and confined living conditions.

The specific cattle tested are used solely for calf cropping. The cows are bred in the winter and early spring then pastured on state-owned land for the duration of the summer and early fall. Calves are born during the fall and early winter months, and then are sold in the spring each year. To maintain the vitality of the herd, a small number of heifer cows are kept to replace the aging cows. In this way cattle from outside sources are not introduced into the herd. Genetic variation is achieved by breeding with different bulls every few years. This scenario allows the elimination of many possible modes of infection observed in other cattle herds.

A health examination is performed on the cows each spring to ensure adequate health prior to being released into pasture. During this routine health assessment a rectal swab was collected using dacron swabs. The specimen was used to immediately inoculate CHROMagar™ O157 which was used as the primary plating media. Disposable sterile loops were used to streak each plate. Once the samples had been collected (n=96) the plates were incubated at 37°C for 48 hours. The plates were examined for growth of purple-pink colonies which indicates *E. coli O157:H7*. Any plates not showing isolation of all colony types were subcultured and allowed to incubate at 37°C for 48 hours.

Colonies identified as possible *E. coli O157:H7* were subcultured onto nutrient agar. Colonies from the nutrient agar were further tested using Pro-Lab™ latex agglutination.

The control strain of *E. coli O157:H7* was obtained from Microbiologics. The CHROMagar™ plates were purchased from

Hardy Diagnostics. The remaining supplies were obtained from Fischer Scientific.

Results

Pink-purple colonies were noted on 6 of the 96 cultures collected (6.25%) (Fig. 3). Confirmation testing using latex agglutination was performed on those colonies exhibiting a pink-purple color. Latex agglutination was performed in duplicate on the 6 colonies suspected of being *E. coli O157:H7*. All colonies tested showed no agglutination resulting in no *E. coli O157:H7* being isolated. A control strain of *E. coli O157:H7* was established and used to test each step of the process (Fig. 1). A non *E. coli O157:H7* strain was used as the negative control (Fig. 2). The control results validated the test method and procedure used.

Discussion

The results of this study suggest the possibility that *E. coli O157:H7* may not naturally occur in cattle without exposure to the organism through unnatural means. Similar studies performed on dairy and feedlot herds yield significantly higher prevalence of *E. coli O157:H7* (Gansheroff & O'Brien, 2000, p. 2959; Laegreid, Elder, & Keen, 1999, p. 291). This free-range herd has not been subjected to high risk techniques which are used in large scale beef slaughter yard operations.

The cattle herd used offers a unique assessment of the natural presence or absence of *E. coli O157:H7* in cattle. The herd is kept self contained by replacing the aged cows with the offspring of the same herd. This greatly reduces the possibility of introducing the infectious *E. coli O157:H7* strain into the herd from other cattle, which may be carriers. Genetic variation is obtained through the introduction of different bulls (n=2) which is done about every other year. The results suggest that the greatest reason for *E. coli*

Figure 1

E. coli O157:H7 positive control strain. Colonies of *E. coli O157:H7* are observed as pink-purple colonies on CHROMagar™.

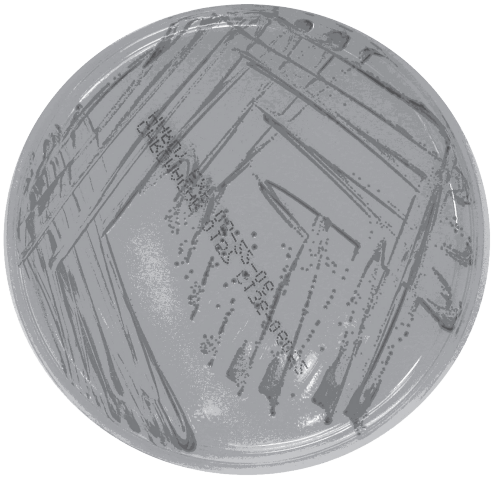


Figure 2

E. coli negative control strain. Normal fecal coliforms including non *O157:H7* strains of *E. coli* are observed as blue colonies.

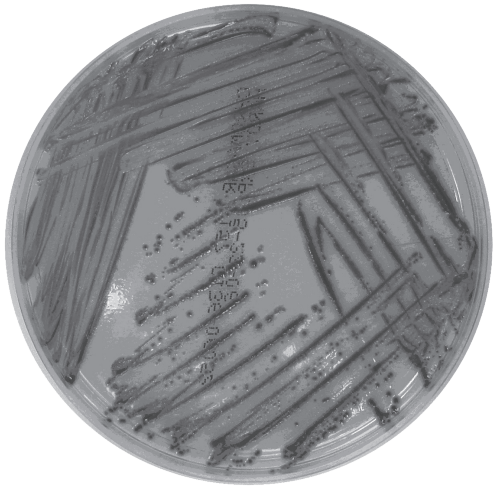
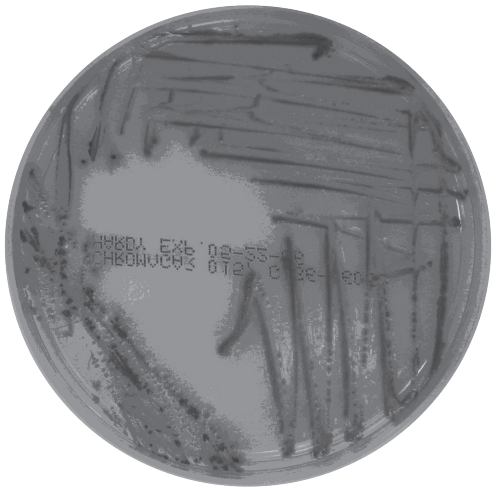


Figure 3

Fecal flora showing possible *E. coli O157:H7*. Possible *E. coli O157:H7* strains are observed as pink-purple colonies among other typical bacterial organisms (blue or white).



O157:H7 carriage in cattle may be due to their living arrangements rather than being natural reservoirs. Although the closed and free-range characteristics of the herd provide a great deal of control over the situation, some possibilities cannot be eliminated.

The results of this study do not eliminate the possibility of environmental factors influencing the carriage of *E. coli O157:H7* in the herd. It is possible that the environmental conditions found in the region where the testing took place are not conducive to the existence of *E. coli O157:H7* in significant numbers. No known testing for carriage of *E. coli O157:H7* has been performed on dairy or feedlot cattle within the region to provide a comparison as is available from other regions (Hancock, et al., 1994, p. 199; Gansheroff & O'Brien, 2000, p. 2959; Laegreid, et al., 1999, p. 291). Other regions were used as the basis for the comparison. Further prevalence studies need to be performed to offer additional support and eliminate these factors.

Certain limitations do exist with the use of the isolating techniques utilized. Research suggests that a higher shed rate of the organism is observed in cattle during times of stress, which results in a greater chance of finding *E. coli O157:H7* in feces (Laegreid, et al., 1999, p. 291). To reduce the occurrence of false negative cultures the cattle were tested 4-7 days after being separated from their offspring. This causes stress to be present which therefore increases the shedding of the organism. The use of CHROMagar™ also decreases false negative results due to its ability to identify *E. coli O157:H7* in lower concentrations.

Although CHROMagar™ has been found to show very high sensitivity to *E. coli O157:H7*, it does not suggest the absence of SLT toxin or eliminate the possible presence of other EHEC causing *E. coli* strains. Some research has shown a correlation of *E. coli O111* to pink colony formation; definitive results have not been obtained. Many less common *E. coli* strains exist that are capable of SLT production and are not identified with the techniques utilized. These additional strains are found as blue colo-

nies on CHROMagar™ and not identified. The vast majority of these blue colony-forming strains also ferment sorbitol suggesting the use of a SMAC plate would also fail to identify these SLT producing strains (Bettelheim, 2005, p. 408).

Conclusion

The serious impact of infection due to *E. coli O157:H7* and its common occurrence in beef cattle make it a particularly problematic pathogen. The continued spread of this pathogen will result in an increase in the number of outbreaks and therefore illnesses associated with its presence. Increased awareness needs to be exercised in the processing of cattle. This includes both in food processing and general handling to avoid the possibility of environmental contamination. Research suggests the decreased contact of large groups of cattle will lower the carriage rate which will result in a decreased probability of an outbreak.

Acknowledgments

The author would like to thank the Eccles Family and Weber State University Undergraduate Research Office for funding the research, and also Scott Wright and John Anderson for their input and ideas on ways to improve the project. Thanks to ARUP for their support in obtaining the proper materials needed to complete the project. A special thanks is extended to Anderson Farms for their consent to allow testing to be performed on their livestock.

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Distribution of Foliar Endophytes in *Sambucus caerulea* Raf. (Elderberry)

Dena Fontaine
author

Ron Deckert, Ph.D.
faculty mentor

Endophytes are fungi that infect the aerial parts of a host plant and live undetected throughout most or all of their life cycle. The objective of this study was to test the infection frequency of endophytes within the leaves and canopy of *Sambucus caerulea* (elderberry) to test the hypothesis that endophytes are not evenly distributed within the canopy of a plant. Three samples were collected from ten elderberry trees from three different heights above the ground. Proximal and distal samples from each leaf were surface sterilized and placed on potato dextrose agar. Plated samples were monitored for several days for hyphal growth. Comparison of mean infection frequency showed no difference between proximal and distal leaf locations ($p = 0.72$) but an analysis of variance demonstrated highly significant differences between low branches ($p = 0.005$) of the canopy and medium and high branches. This supports the hypothesis that endophyte distribution within the canopy is not even and may be explained by patterns of spore dispersal.

Introduction

Endophytes are fungi living asymptomatically within the aerial parts of plants for some or all of their life cycle (Carroll, 1986, p. 216). They are found in nearly all plant species examined to date (Petrini, 1986, p. 176). Endophytes occur systemically in some

plants, for example in grasses. Woody plant endophytes by contrast are highly localized, and numerous (Clay, 1988, p. 15). The relationship between many woody plant endophytes and their host is often not known. In some cases, the production of certain bioactive compounds by the endophytes *in situ* may facilitate habitation within the plant or provide protection to the plant from invading pathogens (Strobel & Daisy, 2003).

Dispersal mechanisms for a particular endophyte's spores are often not known. Each year endophytic airborne spores infect new leaf growth (Carroll, 1986, p. 217). Aerial dispersal either in the wind, rain or on animals is probably the most common mechanism for fungal dispersal to woody plants (Bugs.bio.usyd.edu.au, 2004).

Elderberry was chosen to further a thesis study attempting to understand the potential medicinal properties of elderberry, and to ascertain whether bioactive compounds are produced by the plant or the endophytes. The objective of this study was to determine spatial distribution of foliar endophytes in the leaves and canopy of *S. caerulea* to test the null hypothesis that endophytic infections are dispersed randomly in elderberry.

Materials and Methods

Three samples from ten elderberry trees were obtained along the exercise trail north of Weber State University, Ogden, UT. The three samples were collected from the trees at three different heights above the ground. The heights sampled were approximately 0.75 m., 1.6 m. and 3 m. The samples were immediately placed on ice to delay leaf senescence. Using a sterile paper-hole punch a proximal and distal sample were taken from each leaf. The samples were placed sequentially in 70% ethanol, 50% bleach and sterile distilled water (2x) for approximately 1.5 minutes each. They were then plated on a potato dextrose agar (PDA). Each plate contained a distal and proximal sample from the same leaf. The samples were prepared aseptically in a laminar flow hood.

The plates were scored four days later with a final scoring at seven days. At each observation, emergent hypae were marked by drawing a circle around the sample on the plate. Presence or absence of hyphal growth for each leaf disc was noted and entered into a Microsoft Excel spreadsheet. A t-test was performed to test for differences of the infection means of the distal and proximal leaf locations. An analysis of variance tested for mean infection differences in leaves sampled from different heights of the canopy.

Results

The t-test results indicate no significant difference between the infection rates of the proximal ($x = 0.6$) and distal ($x = 0.5$) locations of the leaf ($p = 0.72$). The ANOVA showed a highly significant difference in frequencies of infection at different canopy heights. The mean proportion of infected leaf discs were 0.2 on the high branches, 0.1on middle branches and 0.8 on the low branches ($p = 0.005$) (Figure 1.).

Discussion

Endophytes are randomly distributed within the leaf. These results support the null hypothesis for within leaf distribution. However there is a clumped distribution of infection among canopy heights. The number of samples in the lower branches had an increased fungal infection than the mid and higher samples but no significant differences were seen between mid and high level sampling positions. Possible explanations for this distribution pattern could be due to the settling effects of gravity on the spores. When released into the air they travel and have a higher probability of settling on lower branches. Another explanation for this clumped distribution could be that the spores are washed to the lower branches because of rainfall, or the spores are splashed up onto the lower leaves. The patterns of woody plant endophyte

distribution depend to a large extent on spore dispersal strategies and the influence of environmental factors such as wind and rain on their eventual distribution. A clumped distribution pattern of endophytes produces heterogeneity within the canopy that presents consumer organisms (e.g. herbivores) with habitat of varying quality that can influence feeding, oviposition and other behaviors. Therefore to understand factors affecting elderberry fitness, it may be necessary to know how endophytes are distributed at within-leaf, within-tree, among tree, and within-site scales. This study found that at the first two scales, one (within-tree), showed non-random distribution of endophytes. Investigation of other scales of endophyte distribution may give us insight into mechanisms of spore dispersal and their potential impact on host tree ecology.

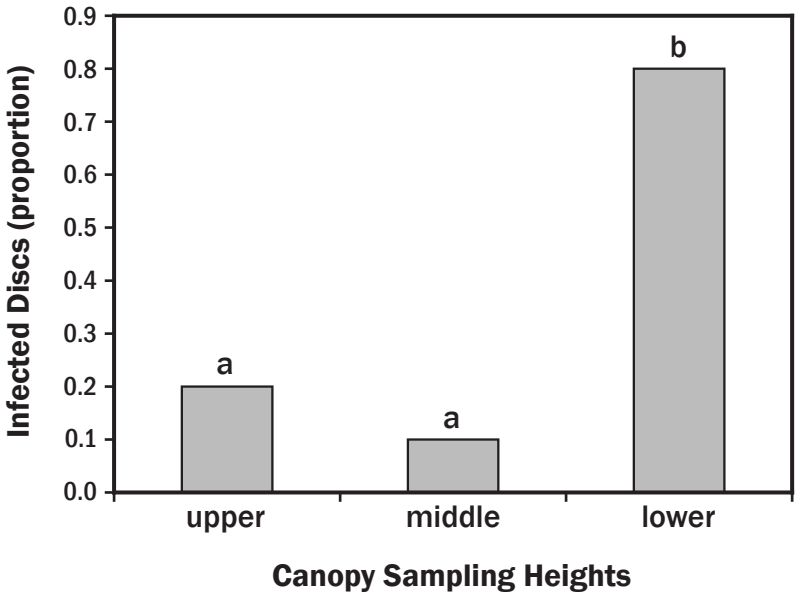

Figure 1

Proportion of discs infected by endophytes at three different levels in the canopies of *Sambucus caerulea*. Different letters on histogram bars indicate statistical significance.

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Comparison of Mycorrhizal Colonization Frequency of *Bromus tectorum* (L.) and Native Grass Species at Antelope Island State Park, Utah

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Bromus tectorum (L.), cheat grass, is a non-native species that affects ecosystems by altering plant community structure. Though much is understood about the role of symbionts in the ecology of native species, little is known about the role of symbionts and invasive species establishment. The objective of the study was to compare thecolonization frequency of root symbionts (arbuscular-mycorrhizal and dark septate endophytes) of *Bromus tectorum* and several species of native grasses. Samples from eighty individual plants were collected from four test sites at Antelope Island State Park—an island in the Great Salt Lake of northern Utah. Samples were examined for root fungal structures and identified. Preliminary results show no AM-mycorrhiza and a higher colonization frequency of an unidentified dark-septate-endophyte (DSE) in *B. tectorum* relative to native grass species. A differential distribution of an unknown Chytridiomycete was found in the non-native species *B. tectorum*, and other native grass species. Inoculum potential of the soil from the test sites was determined by growing *Zea mays* (L.) and the native species in collected soil from the treatment sites.

Introduction

Bromus tectorum in the Great Basin

Bromus tectorum (L.), cheat grass, is a non-native fast growing spring annual. (Torell, 1991, p. 425) that affects ecosystem structure by altering and frequently overwhelming native plant communities resulting in reduced diversity (Rosentreter, 1994, p. 170-175). In the intermountain west, cheatgrass has displaced native bunch grasses and shrubs in the Great Basin (Young et al., 1997, p. 530). Completing its life cycle before the advent of hot summer months, it has also altered the natural fire regime by increasing available fuel and connecting scattered perennial grass stands (Young et al., 1997, p. 530-535).

Introduced into the United States several times throughout the late 1800's from the ballast of ships and contaminated seed, it was first reported in Western North America near Denver, Colorado (Whitson et al., 1996, p. 432-433). Suited to the arid climate of the intermountain west its spread was also hastened by excessive grazing in the 1800's. *B. tectorum* presence on Antelope Island, Utah, followed a similar pattern when the foothills and valleys were grazed to excess by livestock of the early Mormon-pioneer settlers who had initially been drawn to the island by the abundant blue bunch wheatgrass/sage community (Torell, 1991, p. 432). Although the Antelope Island State Park herd of *Bos bison* will forage on the nutrient poor grass *B. tectorum* remains designated as a weed because, it is a plant out of place that interferes with management objectives for a given area of land at a given point in time (New Mexico State University, Cooperative Extension, 1998).

Though much is understood about the role of symbionts in the success of native species little is known about the role of symbionts in the success of invasive species. Most plants depend upon fungal symbionts for the uptake of water and nutrients by their roots (Kendrick, 2000, p. 36). Mycorrhizas are highly evolved, mutualistic associations between soil fungi and plant roots. Some

plants, primarily grasses, in addition to root symbioses also support fungal symbionts in their above ground tissue to deter herbivory and increase drought tolerance (Clay, 1989, p. 331-357).

Arbuscular mycorrhizas (AM) predominantly observed in higher plants are members of the Phylum Glomeromycota. They establish obligate symbioses with plant roots and are unable to grow in axenic culture (Kendrick, 2000, p. 36). Plant root: AM relationships are ancient, and fossil records from the Paleozoic fossils contain *Glomalean* spores (Brundett et al., 1996). These early associations however, may have been parasitic rather than symbiotic. The antiquity of mycorrhizal members of the Glomeromycota is strongly supported by phylogenetic analyses using DNA sequence data from living taxa (Simon et al., p. 67-69).

The object of this study was to document the colonization frequency of the mycorrhizal communities of *B. tectorum* in comparison with select native species to test the hypothesis that AM mycorrhiza colonization frequency present in *B. tectorum* would differ from the select native species. Native grasses were chosen based on their forage potential and the degree to which they are affected by *B. tectorum* invasion: low; *Agopyron cristatum* (crested wheatgrass is a introduced species that has naturalized on the island) and *Aristida purpurea*; medium; *Elymus cristatum* and high; *Oryzopsis hymenoides*. Samples were harvested from Antelope Island which is located within the Great Salt Lake ecosystem. Test sites included: Bridger Bay, Buffalo Point, White Rock Bay and the slopes west of the Mulberry Grove.

Materials and Methods

Inoculum Potential of Soil

In late fall, soil samples were collected from Antelope Island at each site with a spade at maximum depths of approximately 0.75 m and placed into sterile plastic bags. Prior to planting, seed flats were sterilized with 10.0% bleach for one half of an hour, then rinsed

with tap water and air dried. *Zea mays* seed purchased from Good Earth (a local organic market) were then soaked for 10.0 minutes in 10% bleach before being rinsed with sterile distilled water until there was no longer a chlorine odor. The seeds were placed into Petri dishes of sterile distilled water to imbibe for twenty-four hours before planting. The same procedure was followed for the native grass seed that was purchased from Granite Seed Company, Lehi, Utah (seed was not harvested from Utah). However, difficulty in growing the native grass seed and *Z. mays* control in the greenhouse, resulted in their being transferred into growth chambers. Grown at 22°C with alternating twelve hour cycles of light, the seedlings were kept moist and no fertilizer was applied.

After twelve weeks, the plants were harvested and the roots from the five test specimens were cut into twenty separate 10.0 mm sections. They were then cleared and stained with trypan blue in lactoglycerol (0.05%) according to Brundette (Brundette et al., 1996). Colonization frequency was quantified by using the line intercept method of McGonigle (McGonigle, 1990, p. 495-504). Digital images were captured for a comparison of the internal hyphal lengths and other mycorrhizal structures.

Comparison of B. tectorum and Field Samples

To test the hypothesis that colonization frequency differed between the treatment groups, in late spring (May-June 2005), fifteen samples of each test grass and associated *B. tectorum* from each site were collected from random 10 square m areas. Care was taken to ensure that only root samples of each test plant were being harvested for study. Placed into sterile plastic bags, they were stored on ice for transport back to the lab where they were thoroughly rinsed of soil. Afterwards, thirty healthy feeder roots were randomly selected, rinsed and cut into 1.0 cm lengths prior to staining.

Samples were stained according to Brundette, modified by Sondossi (Sondossi, 2004, p. 1-4). Fine root tips were cut and placed into a labeled and perforated plastic capsule. The capsule

was placed into a beaker containing KOH 10%. The beaker was autoclaved at 121°C for ten minutes. After autoclaving the capsule and roots were rinsed in tap water until brown color was no longer released from the roots. The roots were removed from the capsule and placed into a beaker that contained H_2O_2 30% for ten minutes to remove additional color. The roots were then washed in tap water until the water remained clear. Next they were covered with HCl 1% for three to four minutes before they were immersed in trypan blue 0.05% for twenty minutes in a 90°C water bath. The roots were destained in lactoglycerol (1:1:1, glyc:lac: H_2O) until the stain was no longer released and mounted onto a slide for observation.

Results

No AM mycorrhizae were found in the root samples. Dark septate endophytes (DSE) and chytrid resting spores were observed (Figure 1 and Figure 2). Chytrids were found in the roots of *Zea may*,(Gadj: 5.152, $p<0.01$) but no DSE's were present (Figure 3). DSE's were consistently present in *Bromus tectorum* at each site, and the colonization frequency of DSE was above 5% in each 10.0 mm root section of *Oryzopis hymenoides*, *Agropyron cristatum*, and *Aristida purpuea*. *Aristida purpurea* had significantly more DSE than *Bromus tectorum* (Gadj:10.54, $p<0.001$). In comparison to *Bromus tectorum* the other grass species showed no significant difference.

The percent colonization frequency of chytrids of each test grass was compared to *B. tectorum* (Figure 2). The greatest significance was observed between *B. tectorum* and *Agropyron cristatum* (Gadj= 13.208 with $p<0.001$ X^2crit.[0.05%] = 3.841) and *B.tectorum* and *Elymus spicatus* (Gadj = 39.964 $p<0.0001$, X^2crit.[0.05%] = 3.841). While chytrids were observed in both *O. hymenoides* and *A. purpurea* the test of independence, (Gadj.) were not significant when compared to *B. tectorum*.

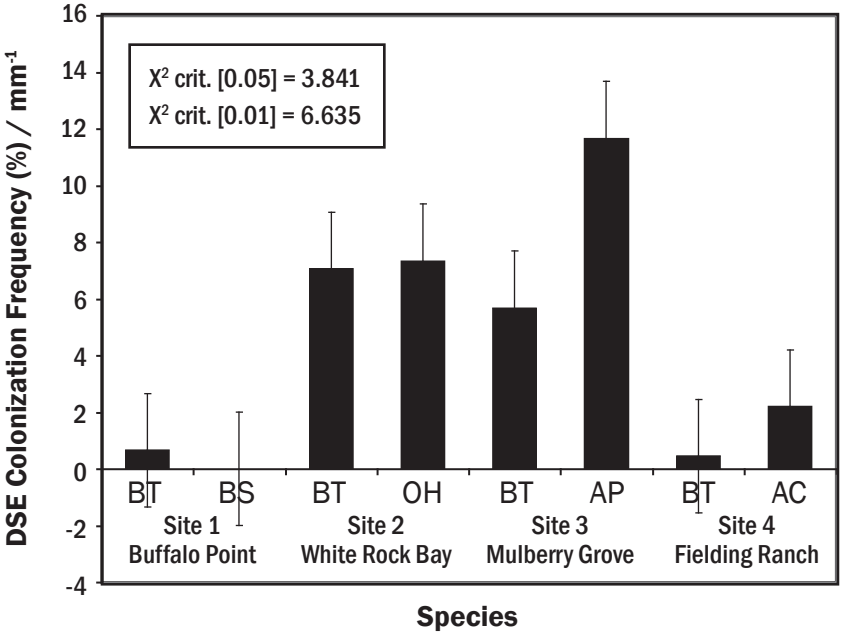

Figure 1

Dark Septate Endophyte percent Colonization Frequency between *Bromus tectorum* and native species. BT:*Bromus tectorum*, ES: *Elymus spicatus*, OH: *Oryzopsis hymenoides*, AP: *Aristida purpurea*, AC: *Agropyron cristatum*. DSE G-*test of Independence* (Gadj.)=0.155 BT: AP =10.54 ($p<0.001$) BT:OH =0.831 BT:ES =3.275 X^2crit.[0.05%] = 3.841.

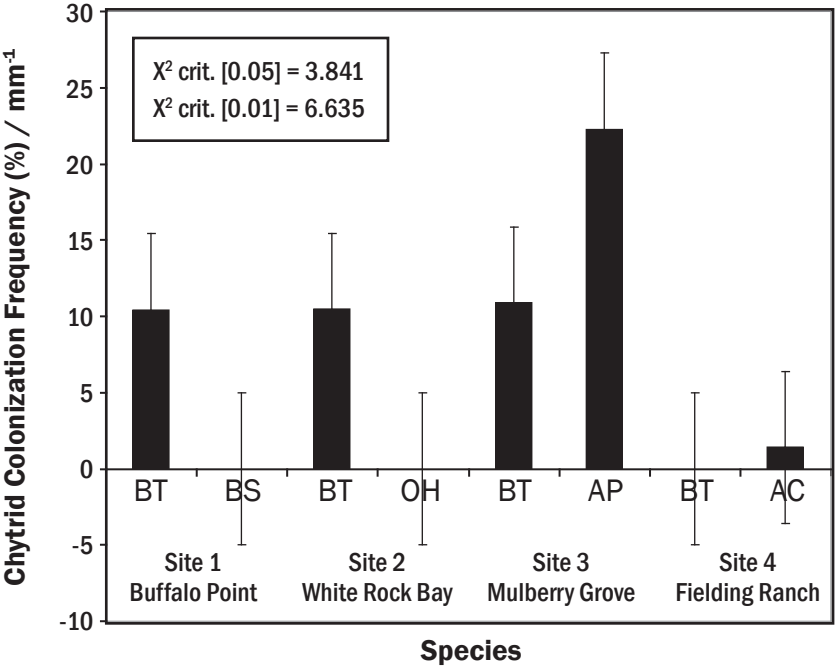

Figure 2

Chytrid colonization frequency percent between *Bromus tectorum* and native species. BT: *Bromus tectorum*, ES: *Elymus spicatus*, OH: *Oryzopsis hymenoides*, AP: *Aristida purpurea*, AC: *Agropyron cristatum*. . Chytrid Gtest of Independence (Gadj.): (BT: AC =13.208, BT: AP =3.019, BT:OH =3.019 BT: ES =39.964 ($p<0.0001$). X^2crit. [0.05%] = 3.841.

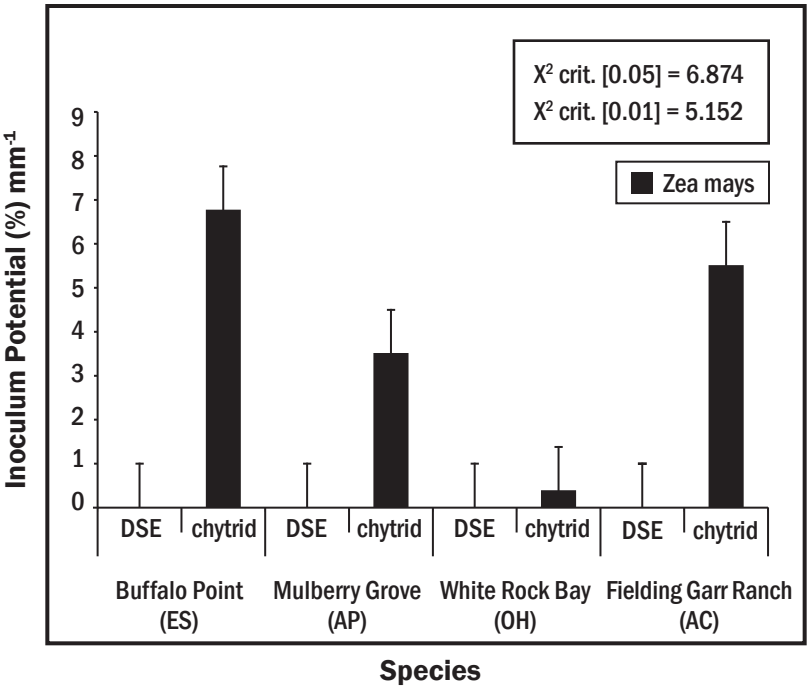

Figure 3

Percent Inoculation potential of soil using *Zea mays*: ES: *Elymus spicatus*; OH: *Oryzopsis hymenoides*; AP: *Aristida purpurea*; AC: *Agropyron cristatu*m from Fielding Garr Ranch. *DSE G-test of Independence for Zea mays*. G test of Independence for chytrids (Gadj.) Buffalo Point (ES) = 6.76 Whiterock Bay (OH) = 0.38 Mulberry Grove (AP) = 3.5 Fielding Garr Ranch (AC) = 5.5. X^2crit.[0.01%] = 6.635.

Conclusion

The lack of AM-mycorrhizas in all samples and parasitic chytrids required rejection of the original hypothesis. Dark septate endophytes, a melanized, sterile ascomycetous fungus that frequently inhabit roots were abundant. This raised the question of the role of DSEs and chytrids in the invasive success of *Bromus tectorum*. A lack of time may be a primary factor contributing to the absence of DSE in *Zea mays*. While twelve weeks is sufficient for the es-

tablishment of AM-mycorrhizal:plant interactions the time necessary for DSE:plant interactions is unknown. Although, one-hundred and thirty seven native species of plants are found at Antelope Island State Park creating plant communities that includes: fresh water marshes, rocky slopes, saline marshes, sand dunes, cultivated lands and rocky slopes, it is primarily comprised of grasslands (Jones, 1985, p. 1-119). Plant diversity is limited due to a history of agricultural development and grazing by domesticated livestock.

In grasslands, the vast majority of mycorrhizas are of the arbuscular mycorrhizal type, formed with the order Glomales (Allen, 2001, p. 184). However, the lack of plant biodiversity may be directly related to a decrease in soil biota that selects for DSE's that were observed in the test grasses and *B. tectorum*. While much is understood about the role of arbuscular mycorrhizas (AM) and how they influence the composition of grassland communities and their ecosystem processes, their effects on the host are varied and range from positive (Gange et al., 1993, p. 616-922), to none (Smilauer, 2000, p. 13-25). While the cost/benefit ratio of mycorrhizal associations varies from the plants perspective the role of DSE varies when host responses such as nutrient uptake, and plant biomass are measured (Jumpponen et al., p. 295-310).

The observations of DSE at Antelope Island State Park agree with other studies that DSE are frequently present in arid, extreme climatic and disturbed sites, however their status as mycorrhiza symbionts is yet unclear. While many believe that DSE, do not establish beneficial associations with plants many researchers are expanding their definition of mycorrhizas.

Whether DSEs are parasitic or mutualistic is often unclear depending on how a mycorrhal association is defined. Moreover, the island's fire ecology, altered by the presence of *B. tectorum* may affect the inoculum potential of the soil. Some studies report a decrease in mycorrhizal function, while others report no effect or an increase in function.(Eom et al., 1999, p. 55-70).

All of the test sites with the exception of White Rock Bay, have a history of fire but further studies would have to be initiated to establish a correlation between fire regimes and inoculum potential. Perhaps the altered fire regime selects for DSE and against AM. To further understand the biology of *B. tectorom* and its interactions with other grass species future studies could examine the effects and interactions of chytrids and DSE in laboratory experiments. Also, studying the effect of *B. tectorum* on the presence of chytrids in native grass populations may aid in understanding the mechanisms of cheatgrass establishment in grassland communities.

Acknowledgments

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Antimicrobial Activity of a Liquid Disinfectant Containing Cinnamaldehyde

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Previous research demonstrates the microbicidal power of cinnamaldehyde, a component of cinnamon bark essential oil. In this study, three different concentrations of cinnamaldehyde were used to produce a liquid disinfectant tested for its possible application in the food, industrial, domestic, and institutional areas. *Escherichia coli*, *Proteus vulgaris*, *Pseudomonas aeruginosa*, and *Staphylococcus aureus* were used in the CEN Basic Bactericidal Activity Test to elucidate the antimicrobial activity of these disinfectant concentrations. The disinfectant containing only 0.3% cinnamaldehyde along with 30% reagent alcohol, necessary for the dissolution of cinnamaldehyde in water, showed substantial reduction in viable organisms after only a one minute contact time with *S. aureus*. At a 0.5 % cinnamaldehyde concentration (with 30% reagent alcohol), the lethal effect occurred in less than 30 seconds against both *S. aureus* and *P. aeruginosa*, making it difficult to calculate the exact time required for the death of a given number of organisms to occur. The 0.3% disinfectant showed a 7-log reduction against *P. vulgaris* and *E. coli* in 30 seconds or less. The neutralizer selected to inhibit the bactericidal properties of this disinfectant seemed to have no effect on the test bacteria. Cinnamaldehyde, at very low concentrations, proved to be an effective compound for use in developing a liquid disinfectant with a broad range of potential applications.

Introduction

The objective of using a disinfectant is to eradicate microorganisms. Depending on the specific application, disinfectants must be bactericidal, fungicidal, virucidal, sporocidal, or have any combination of these properties. Fungistatic and bacteristatic activity is irrelevant when referring to disinfection. Methodologies of disinfectant testing vary according to the area of a disinfectant's primary application. The success of disinfection can only be predicted through extensive studies of the disinfectant's capabilities to significantly reduce microbial numbers under carefully controlled conditions. In addition, an effective neutralizer must be utilized during testing to prevent carryover and this can be challenging, particularly if the disinfectant is not water-soluble.

Herbs and spices have been used for their inhibitory properties over the centuries. Because of their inherent ability to prevent growth of microorganisms, herbs and spices have been used for food preservation and incorporated in medicinal ointments (Bassett et al., 1990; Deans & Ritchie, 1987). Oils extracted from these plants, via steam distillation of their fruit, flowers, roots, bark, or leaves, are complex mixtures of terpines, alcohols, aldehydes, ketones, carboxylic acids, esters, lactones, and sulfides (Kurita et al.,1981; U.S. EPA, 1999). Research has shown that essential oils can inhibit and, in some cases, eliminate gram positive and gram negative bacteria (Inouye et al., 2001; Kishore et al., 1993; Maruzzella & Henry, 1957; Megalla et al., 1980; Pandey et al., 1992), viruses (Oberg et al., 2000), and fungi (Maruzzella et al., 1960; Pattnaik et al., 1996; Singh et al., 1980; Viollon & Chaumont, 1994; Voda et al., 2002). In the plant, chemical components of these essential oils are used to repel insects and to protect against pathogens, especially bacteria, fungi, and, to a lesser degree, viruses.

Cinnamaldehyde, a yellow oily liquid, is a chief constituent of cinnamon bark, which supplies the distinctive taste and odor of cin-

namon. It is generally recognized as safe (GRAS) by the FDA and is currently being used as a flavorant in foods such as ice cream, baked goods, candy, nonalcoholic beverages, and condiments (Pattnaik et al., 1996). In earlier studies in our laboratory, cinnamaldehyde exhibited inhibitory properties against many types of microorganisms including bacteria and fungi (unpublished data).

The purpose of this study was to incorporate a key component of cinnamon essential oil, cinnamaldehyde, into a liquid disinfectant and test it for its possible application in the food, industrial, domestic, and institutional areas following the CEN Basic Bactericidal Activity Test protocol.

Materials and Methods

Preparation of Test Organisms

Pure cultures of four bacteria were used to evaluate the bactericidal properties of each disinfectant concentration. The organisms used were *Escherichia coli* (ATCC 10586), *Pseudomonas aeruginosa* (ATCC 10145), *Staphylococcus aureus* (ATCC 10832), and *Proteus vulgaris* (ATCC 8427). Each organism was obtained from the stock culture collection in the Microbiology Department at Weber State University and grown in Tryptic Soy Broth (Hardy Diagnostics, Santa Maria, CA) at 37° C for 24 hours prior to testing. Stock cultures were stored at -70°C until needed.

Neutralizer Preparation

In order to prevent carryover of disinfectant into the subcultures, a non-nutritive neutralizer was used. It was prepared from a stock phosphate-buffered solution containing 34 g KH_2PO_4 in 500 ml distilled water. The pH of the solution was adjusted to 7.2 and then brought up to a total volume of 1 L using distilled water. The addition of 10 ml 10% sodium thiosulfate, 8 g lecithin, and 10 ml of Tween 80 to the 1 L phosphate-buffered solution constituted the neutralizing solution. Nine milliliters of this solution

was then dispensed into 6 inch test tubes and sterilized for 20 minutes at 121°C.

Disinfectant Production

Three different disinfectants containing various concentrations of cinnamaldehyde (Sigma Chemical Co, St. Louis, MO) were produced and tested (Freidman et al., 2000). A 30% reagent alcohol solution was first prepared using distilled water. Ninety-nine milliliters of this solution was aliquoted into three different 250 ml Erlenmeyer flasks. Cinnamaldehyde was then added to each flask producing disinfectants containing either 0.1%, 0.3%, or 0.5% cinnamaldehyde, respectively. A control for each test culture was also run containing no added cinnamaldehyde.

Bactericidal Activity Test

The bactericidal activity test utilized the basic bactericidal activity test (B-A ES, 1997a) with the suspension test (B-A ES, 1997b) for disinfectants. One milliliter of a pure 24 hour bacterial culture was added to each one of the disinfectants and the initial time noted. Contact times of 15 sec, 30 sec, 1 min, 5 min, 10 min, and 15 min were tested. A one ml sample was aseptically removed from the disinfectant at each time interval and 9 ml of neutralizer was added then the mixture was vortexed. This procedure was followed for each bacterial type at each disinfectant concentration. Controls to determine the effect of the neutralizer and the effect of the 30% alcohol solution on the bacterial cells were also run. After all the samples from one disinfectant concentration were in a tube of neutralizer, one ml of each was aseptically transferred into a sterile plastic Petri plate. Molten 53°C Tryptic Soy Agar (Hardy Diagnostics, Santa Maria, CA) was poured into each plate and swirled 6-8 times in both directions. After solidifying, the plates were incubated at 37° C for 24 hrs. Total CFUs were determined and used to evaluate the effectiveness of each disinfectant concentration.

Results

All disinfectants containing 0.3% and 0.5% cinnamaldehyde substantially reduced the number of viable organisms after only a one minute contact time (Tables 1-4). Even the 0.1% cinnamaldehyde concentration reduced the number of organisms down to 0 CFU/ml after 10 minutes in most cases (Table 1). A control for each test organism was negative showing no inhibition. Beginning with a *S. aureus* culture containing 5.1×10^7 CFU/ml, the 0.3% cinnamaldehyde disinfectant left only 71.67 viable colony forming units per ml after just one minute (Table 1). After a 15 second contact time, the 0.5% cinnamaldehyde disinfectant reduced the culture concentration down to 2.33 CFU/ml, a 7 log reduction (Table 1). The starting concentration of the *P. aerugenosa* was 8.5×10^6 CFU/ml. The 0.1% disinfectant reduced this concentration down 11.33 CFU/ml in only 30 seconds. A total eradication occurred within 15 seconds using the 0.3% disinfectant concentration (Table 3). The pure culture of *E. coli* contained 1.11×10^7 CFU/ml all but one of which was killed by the 0.1% disinfectant in 15 seconds (Table 2). A disinfectant containing 0.1% cinnamaldehyde eliminated all of the 2.04×10^7 CFU/ml of *P. vulgaris* inside five minutes (Table 4). After just 30 seconds in the 0.3% disinfectant, the cell concentration was reduced to 42 CFU/ml and after 15 seconds it was reduced to 1.67 CFU/ml in the 0.5% disinfectant (Table 4).

Discussion

From these results it is apparent that cinnamaldehyde would be an effective compound to use as a disinfectant with a broad range of potential applications since test results show a 7 log reduction in test bacteria in 30 second or less for most replicates. Further testing would still be helpful to quantify cinnamaldehyde's capabilities as a disinfectant, particularly in determining the lowest effective concentration. Bovine albumin or skim milk could be added to the disinfectant as interfering substances following

this same protocol to simulate real life conditions. A carrier test could also be performed to determine if a cinnamaldehyde disinfectant has the same lethal effects on solid surfaces as it does in suspension. Cinnamaldehyde, even at a concentration of 0.1%, killed concentrations of test bacteria higher than normally found in the environment, demonstrating its potential to be utilized as effective disinfectant.

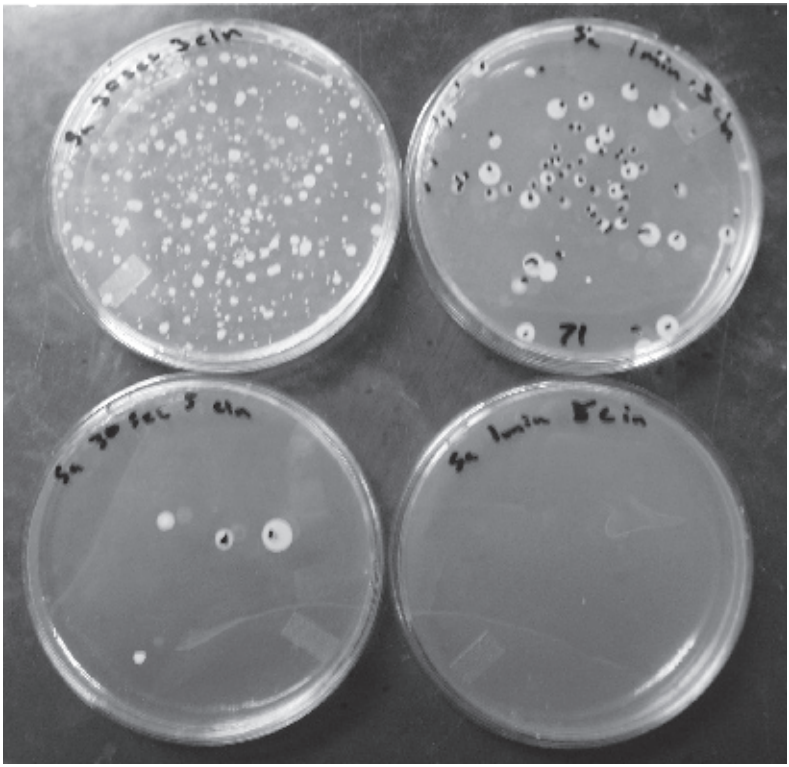

Figure 1

Comparison of 0.3% cinnamaldehyde (top) and 0.5% cinnamaldehyde (bottom) after 30 sec and 1 min contact times with *S. aureus*.

Cinnamaldehyde Concentration	15 seconds			30 seconds			1 minute			5 minutes			10 minutes			15 minutes		
	CFU	Ave.	SD	CFU	Ave.	SD	CFU	Ave.	SD	CFU	Ave.	SD	CFU	Ave.	SD	CFU	Ave.	SD
0.1%	TNTC	TNTC	NA	TNTC	TNTC	NA	TNTC	TNTC	NA	TNTC	TNTC	NA	47	56.00	10.82	20	20.67	0.58
	TNTC			TNTC			TNTC			TNTC			53			21		
	TNTC			TNTC			TNTC			TNTC			68			21		
0.3%	TNTC	TNTC	NA	TNTC	TNTC	NA	68	71.67	4.04	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
	TNTC			TNTC			71			0			0			0		
	TNTC			TNTC			76			0			0			0		
0.5%	0	2.33	4.04	1	1.5	0.71	0	0	0	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
	7			2			0			0			0			0		
	0			0			0			0			0			0		

Table 1

Effect of cinnamaldehyde disinfectant concentrations against *Staphylococcus aureus* after selected contact times.

Cinnamaldehyde Concentration	15 seconds			30 seconds			1 minute			5 minutes			10 minutes			15 minutes		
	CFU	Ave.	SD	CFU	Ave.	SD	CFU	Ave.	SD	CFU	Ave.	SD	CFU	Ave.	SD	CFU	Ave.	SD
0.1%	1	1.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
	1			0			0			0			0			0		
	1			0			0			0			0			0		
0.3%	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
	0			0			0			0			0			0		
	0			0			0			0			0			0		
0.5%	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
	0			0			0			0			0			0		
	0			0			0			0			0			0		

Table 2

Effect of cinnamaldehyde disinfectant concentrations against *Escherichia coli* after selected contact times.

Cinnamaldehyde Concentration	15 seconds			30 seconds			1 minute			5 minutes			10 minutes			15 minutes		
	CFU	Ave.	SD	CFU	Ave.	SD	CFU	Ave.	SD	CFU	Ave.	SD	CFU	Ave.	SD	CFU	Ave.	SD
0.1%	TNTC	NA	NA	18	11.33	6.11	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
	TNTC			6			0			0			0			0		
	TNTC			10			0			0			0			0		
0.3%	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
	0			0			0			0			0			0		
	0			0			0			0			0			0		
0.5%	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
	0			0			0			0			0			0		
	0			0			0			0			0			0		

Table 3

Effect of cinnamaldehyde disinfectant concentrations against *Pseudomonas aerugenosa* after selected contact times.

Cinnamaldehyde Concentration	15 seconds			30 seconds			1 minute			5 minutes			10 minutes			15 minutes		
	CFU	Ave.	SD	CFU	Ave.	SD	CFU	Ave.	SD	CFU	Ave.	SD	CFU	Ave.	SD	CFU	Ave.	SD
0.1%	TNTC	NA	NA	TNTC	NA	NA	TNTC	NA	NA	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
	TNTC			TNTC			TNTC			0			0			0		
	TNTC			TNTC			TNTC			0			0			0		
0.3%	TMTC	NA	NA	33	42.00	7.94	3	3.00	0.00	1	0.33	0.58	0	0.00	0.00	0	0.00	0.00
	TNTC			48			3			0			0			0		
	TNTC			45			3			0			0			0		
0.5%	2	1.67	0.58	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
	2			0			0			0			0			0		
	1			0			0			0			0			0		

Table 4

Effect of cinnamaldehyde disinfectant concentrations against *Proteus vulgaris* after selected contact times.

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Use of Essential Oil Components to Inhibit Common Fungi

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A serious problem in buildings is the unwanted growth of fungi (mold, mildew, yeast, etc.) resulting in health concerns, structural damage, and unpleasant odors. Many cleaning agents currently used are only fungistatic, not fungicidal; allowing the fungus to return once the cleaning agent has dissipated. Previous experiments have shown that many essential oils exhibit antifungal properties. Using the disc assay method, 30 individual components from selected essential oils were screened for fungal inhibition against *Penicillium notatum*, *Alternaria alternata*, *Rhizopus stolonifer*, and *Aspergillus niger*. Many of the components showed some fungal inhibition. Components with the largest zones of inhibition were: benzaldehyde, carvacol, cinnamaldehyde, citral, furfural, jasmone, geraniol, and perillaldehyde. These seven components were selected and tested in triplicate at various concentrations with similar results. The poison media method was then utilized to determine if their inhibition was either fungistatic or fungicidal. Several compound tested appeared to be fungicidal including cinnamaldehyde, citral, and carvacrol. Results indicate that several individual components from essential oils have fungicidal capabilities and could be used to both remove and prevent the growth of fungi in and on structures.

Introduction

Mildew is a fungus found on damp surfaces such as bathroom walls, window trims, flooded basements, and other places where water can accumulate. As mildew grows, it leaves behind a musty, sour-like odor. In the home, mildew often shows itself in bath areas by clinging to walls and ceilings, growing on shower doors, and curtains, and spreading between grout and tile. Mold is a fungus that will grow on materials that are wet from water leaks or condensation. These molds can cause infections, allergies, asthma, and other breathing problems. Some molds can be just a mild nuisance while others can cause serious health problems for those who are exposed. Every year there are thousands of cases of people with adverse allergic responses to molds in the United States and many of these cases occur in the home (Murray & Pfaller, 1998). The issue of mold contamination poses a serious health threat for many people who may be unaware that they are at risk in their homes, schools, and workplaces. Some types of mold produce mycotoxins that can be life threatening especially for infants, the elderly, and persons that are immuno-compromised.

Commercial disinfectants are used in every household. They are often used to clean soap scum, mildew, and mold from showers, bathrooms and kitchens. In addition, most people expect the disinfectant to kill the molds that are causing the problems. Commercial disinfectants are made to kill a wide spectrum of common bacteria and some molds, including those that can cause human disease.

Essential oils are extracted from various plant tissues including leaves, roots and bark (Janssen et al., 1987). These essential oils contain a wide variety of chemical compounds (Megalla et al., 1980). Essential oils have been used as food preservatives and for the treatment of human diseases in many cultures (Chansouri et al., 1992; Dubey & Mishra, 1993; Maruzzella & Sicurella, 1960). Studies have shown that some essential oils from particular plants can inhibit microorganisms (Deans & Singh, 1987).

Essential oils are produced by plants as part of their natural defense mechanism against microorganisms. They contain a variety of chemical compounds including thymol, benzaldehyde, phenyl ethanol, and limonene (Kurita et al., 1981). Currently, there is an increased interest in these oils and their antimicrobial properties due to an increase in resistance of bacteria and fungi to conventional treatments. Essential oils have been shown in previous research to have an inhibitory effect on various infectious organisms (Morris et al., 1979; Pattnaik & Kole, 1996). Past research shows oils inhibit organisms ranging from parasites to common bacteria species such as *Staphylococcus aureus* and many fungal species (Oberg et al., 2000). Inhibition depends on which specific types of oils and organisms are used.

This study looks at how effective selected essential oil chemical components are for inhibiting common molds and attempts to determine if the method of inhibition is fungistatic or fungicidal.

Materials and Methods

Essential Oil Components

Essential oils used in this experiment were provided by Young's Essential Living Oils (Payson, UT). Essential oil components were obtained from Sigma Chemical Co. (St. Louis, MO). These 30 oil components were selected based on a literature search of individual oils that exhibited some fungal inhibition and their individual oil components (Kurita et al., 1981; Singh et al., 1980).

Fungal Cultures

The four fungal strains used were *Penicillium notatum* ATCC 9179, *Alternaria alternata* ATCC 13963, *Rhizopus stolonifer* ATCC 14037, and *Aspergillus niger* ATCC 16404. Stock cultures were grown at 30°C for three days on Sabouraud agar plates then stored at 4°C until needed.

Disc Assay for Fungal Inhibition

In order to determine which oil components were most effective at inhibiting the fungi, thirty selected oil components were tested against the four fungi using the disc assay method (Janssen et al., 1987; Rios et al., 1988). Experimental plates were prepared by streaking each fungal strain from the stock culture plates onto sterile Sabouraud agar plates. Following inoculation, a 6 mm paper disc (Sterile Blanks, Difco, Detroit MI) was aseptically placed in the center of each plate with sterile tweezers then the appropriate volume of oil components were dispensed on the disks. For the initial screening, oil components were dispensed in 5.0 µl amounts on the discs. The plates were incubated for 3 days at 30°C. All oil components were tested against all four fungal strains. After incubation, plates were examined to see which oils produced zones of inhibition. The zone of inhibition was measured in millimeters as the distance from the edge of the disk to the edge of observable fungal growth.

Minimal Inhibitory Concentration Procedure

To determine approximate minimal inhibitory concentration (MIC) ranges, "poisonous media" (Rios et al., 1988) was prepared using the five oil components that showed the highest degree of inhibition from our initial disc assay results. To create this media, 200 mls of Sabouraud agar was prepared and the appropriate amount of each oil was added to create either 1000 or 3000 ppm of the oil component in the agar. This procedure was followed for each of the oil components. An agar plug 8 mm in diameter containing confluent mycelial growth was taken from 4-day-old cultures of the four test fungi and placed in the center of each MIC Petri dish. Plugs were placed separately in the center of each "poisonous" plate for both the 1000 ppm and 3000 ppm plates. All tests were done in duplicate. Two control plates using Sabouraud agar without oil addition were used for each fungi. Plates were incubated for 3 days at 30°C and then observed for growth. The

8 mm mycelial plugs were then transferred to Sabouraud agar "rescue" plates that contained no oil components. The plates were incubated for 3 days at 30°C and then observed for growth. The diameter of fungal growth was measured in millimeters across the entire mycelial mat.

Results

Disc Assay

The disc assay method, using individual essential oil components at 5.0 µl, showed that most of the selected components exhibited some inhibitory effect on the fungi (Table 1). In order to select which oil components were most successful, zones of inhibition were measured for each oil component against all four fungi. Eight oil components were selected from the original 30 for a second disk assay test to confirm their inhibitory effect. Perilladehyde had the largest zones on all four of the fungi averaging 40.0 mm. Based on results, benzaldehyde, carvacrol, cinnamaldehyde, citral, furfurol, geraniol, jasmone, and perillaldehyde were selected and confirmed as the best fungal inhibitors from the 30 components tested.

Table 1

Zones of inhibition for essential oil components.

	Zone of Inhibition (mm)			
	Alternaria alternata	*Penicillium notatum*	*Rhizopus stolonifer*	*Aspergillus niger*
Benzaldehyde	26 ± 3.2*	2 ± 1	0 ± 0	0 ± 0
Carvacrol	40 ± 0	26.7 ± 3	14 ± 1	30 ± 0
Citral	40 ± 0	31 ± 1	2 ± 0.5	40 ± 0
Cinnamaldehyde	26.7 ± 2.5	27 ± 1	3 ± 1	24.5 ± 3
Furfurol	40 ± 0	32.5 ± 2.5	0 ± 0	40 ± 0
Geraniol	17 ± 1.6	11 ± 1	3 ± 0	4 ± 1.5
Jasmone	18 ± 1	13 ± 2	8 ± 0	11 ± 0.5
Perillaldehyde	40 ± 0	40 ± 0	40 ± 0	40 ± 0
Control	0 ± 0	0 ± 0	0 ± 0	0 ± 0

* Each value is the mean with SD of three replicates.

MIC Quantification

Five of the oil components were selected for this test based on the results from the second inhibitory test. Carvacrol, cinnamaldehyde, citral, furfurol, and perillaldehyde were screened on the "poisonous media" to determine their mode of anti-fungal activity. The 8 mm mycelial plugs placed on the "poisonous media" showed evidence of the fungicidal effects of several essential oil components because the test fungus on the plug would not grow on the rescue plate. Carvacrol, cinnamaldehyde, and citral were fungicidal at both 1000 ppm and 3000 ppm exhibiting no growth on the rescue plates. Furfurol and perillaldehyde were fungistatic with growth occurring on the rescue plates (Table 2). Furfurol was shown to be the least fungistatic exhibiting since it did not inhibit fungal growth on any plates.

Table 2

MIC determinations for selected essential oil components.

Component (ppm)	*Alternaria alternata*	*Penicillium notatum*	*Rhizopus stolonifer*	*Aspergillus niger*
Carvacrol				
1000 ppm	NG	NG	NG	NG
3000 ppm	NG	NG	NG	NG
Cinnamaldehyde				
1000 ppm	NG	NG	NG	NG
3000 ppm	NG	NG	NG	NG
Citral				
1000 ppm	NG	NG	NG	NG
3000 ppm	NG	NG	NG	NG
Furfurol				
1000 ppm	40mm	40mm	40mm	40mm
3000 ppm	25mm	23mm	26mm	22mm
Perillaldehyde				
1000 ppm	15mm	11mm	40mm	40mm
3000 ppm	8mm	9mm	31mm	28mm
Control				
0 ppm	40mm	40mm	40mm	40mm
0 ppm	40mm	40mm	40mm	40mm

Discussion

Results of the disc assay and "poisonous media" MIC determination showed that essential oil components, even at very low concentrations, can both inhibit and kill common fungi. The disc assay test specifically showed benzaldehyde, carvacrol, cinnamaldehyde, citral, furfurol, geraniol, jasmone, and perillaldehyde to be essential oil components exhibiting the greatest fungal-inhibiting potential. For most oil components tested, a volume of only 5 µl of compound resulted in some inhibition of each fungus tested. Most oil components seemed to reduce the amount of visible spores on the test plates, when compared to the control plates, suggesting that they could help reduce the fungi from spreading. Although this observation was not quantitatively measured, it may provide an interesting follow-up study. The "poisonous media" MIC assay confirmed the results of the disc assay tests. In addition, this method indicated which of the oil components were fungicidal by demonstrating that certain compounds can both inhibit and prevent the reoccurrence of fungi on common surfaces. A MIC of 1000 ppm showed complete fungal inhibition for cinnamaldehyde, citral, and carvacrol. With furfurol and perillaldehyde, fungal growth was significantly reduced when compared to growth on the control Sabouraud plates at 3000 ppm. The next step would be to develop and test a storage and delivery system for these oil components. The pleasant odor and general non-toxicity of essential oil components make them prime candidates for use against common household fungal growth. Selected essential oil components show great promise in reducing and controlling fungal growth in man-made structures.

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Unequal–Arm Michelson Interferometer for Laser Characterization and Atom Trapping

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For an atom trap to run efficiently and effectively, the lasers of the apparatus must be completely controlled. Based on research by other groups, an unequal-arm Michelson interferometer promises the most success in analyzing the laser beams at the required resolution. The interferometer, through adjusting its arm length, quantifies incredibly fine changes in wavelength. This system has been tested and installed in the atom trap at Weber State University and has proven successful for analyzing and defining the lasers.

Introduction

The first successful trapping of atoms occurred in 1986 at the University of Colorado. In 1999 Dr. John E. Sohl at Weber State University engineered a quest to achieve the same feat with physics majors at WSU generating the entire experiment under his mentorship. This has culminated in the creation of a nearly functional atom trap and requires only some fine-tuning and finishing touches. One problem that needed to be solved was to fashion a system that lets the operator know at any instant the scanned wavelength range of the lasers. The most effective way of accomplishing this characterization was to use an unequal-arm Michelson interferometer.

Laser light plays an integral role in the trap. It does most of the work in slowing down (i.e., cooling off) the atoms. The lasers emit

photons that correspond precisely to the energy levels of the rubidium atoms. The atoms absorb these photons then reemit them in a random direction, effectively cooling them off. The laser light is directed at the atoms in six directions, targeting them from all sides (see Fig. 1 for the idealized trap; Fig. 2 shows the actual trap at WSU). It is crucial that the lasers are completely controllable.

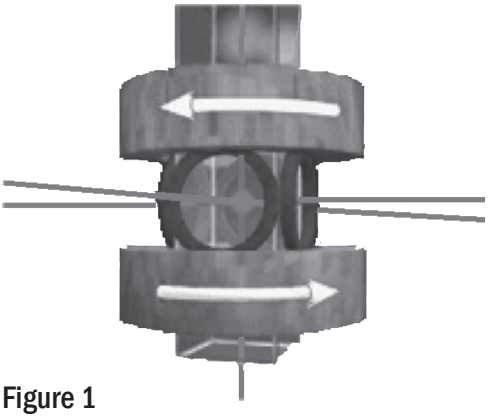

Figure 1

This is an idealized image of an atom trap. The six laser beams enter the chamber from the top, bottom, and sides. The discs with arrows represent the magnetic field coils and the direction of their electric currents. Together they cause atoms to cool. (Picture from Goldman, Martin V. (2000). BEC Apparatus. *Physics 2000*. University of Colorado.)

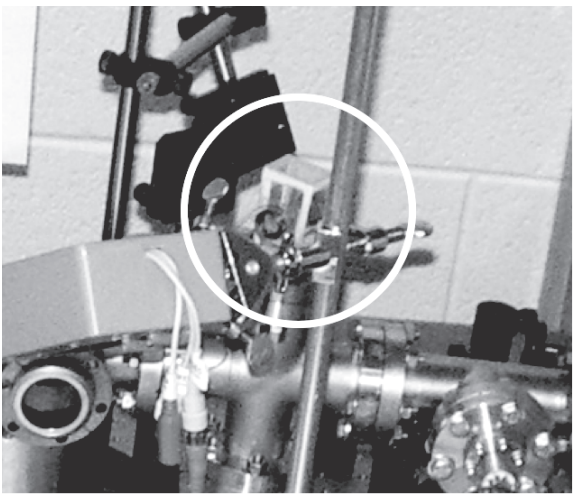

Figure 2

This is the atom trap at WSU. The magnetic field is provided by coils of copper wire on the front and back of the chamber.

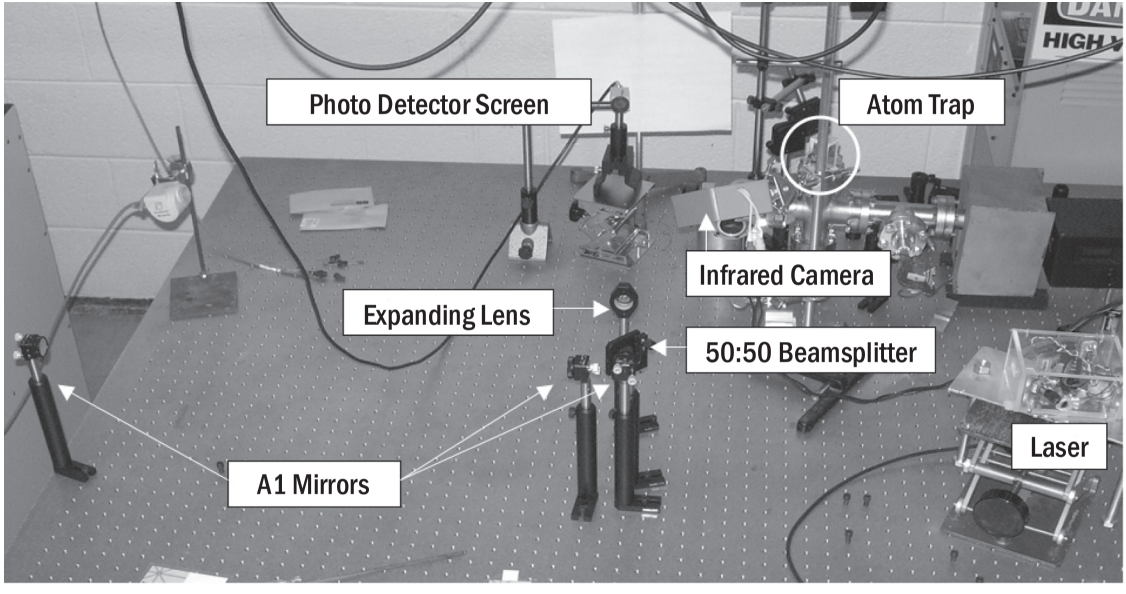

Figure 3

An overview of the unequal-arm interferometer setup. The main constituent parts are labeled. The atom trap itself is partially obscured from view by a pole.

Interferometer Setup

Fig. 3 is a bird's eye view of the atom trap and unequal-arm Michelson interferometer setup. The laser beams originate from the laser. It is a diode laser peaking around 780 nm with an external cavity, which reduces the linewidth by a factor of 100. (See Fig. 4.) *Very* small changes in the wavelength of the laser can be made by custom-designed control electronics. It is this precise change that the experiment is attempting to measure to better than one part in a million.

The laser beam hits a 50:50 beamsplitter (50% of the light passes through the beamsplitter while 50% is reflected). The two resulting beams now travel along different paths where they bounce off mirrors and reunite back at the beamsplitter. By this time, because the paths the split beams travel have different lengths there is constructive and destructive interference. This results in bright and dark fringes, which cannot be easily observed unless they are expanded. This is accomplished using a lens. To view the fringe pattern an infrared camera is hooked up to a TV monitor. In order to quantify the fringe pattern, a photo detector is placed where the fringes will cross it. The photo detector then measures the relative brightness of the fringes.

Virtues of an Unequal-Arm Interferometer

Very fine changes can be made in the wavelength (and, concomitantly, the frequency) of the laser light. Thus, the laser frequency can be tuned to a very precise location on the rubidium spectrum in order to trap atoms. The problem is that there is no way that the user can currently measure that fine of a change. In fact, there is a double blow: because the laser does not sweep perfectly smoothly, the user cannot tell even generally where he or she is on the rubidium spectrum because the bumpy sweeping results in a distorted view of the frequency spacing. Thus for the lasers to be characterized both wavelength and sweep rate need to be easily quantified and analyzed.

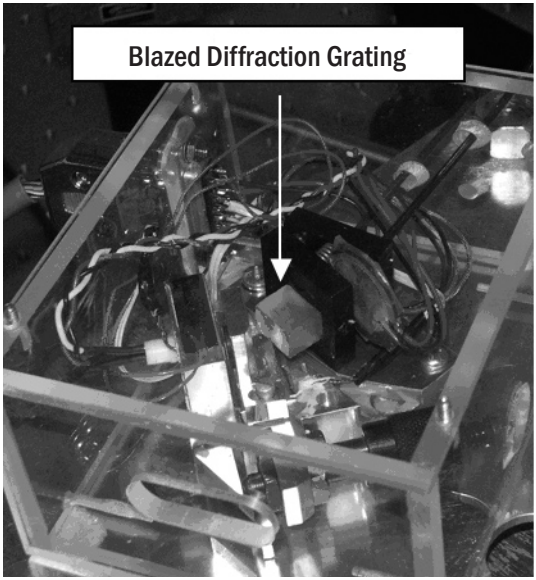

Figure 4

A close-up view of the laser box in Fig. 3. The blazed diffraction grating in the center creates the external cavity. The metal strip to the left of the blazed diffraction grating (which allows the user to alter the temperature of the laser), the wires (for the injunction current), and, most importantly, the piezo to the right of the blazed diffraction grating are all used to produce very fine changes in the wavelength of the laser. The laser itself is very small and is located in the rectangular slab under the temperature strip. The light exits the box through the oval aperture (bottom center).

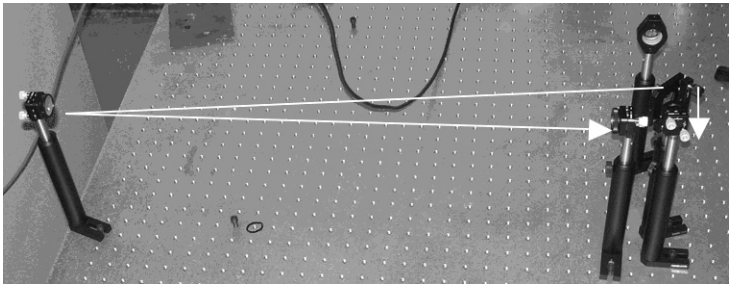

Figure 5

The arrows on this close-up of the interferometer show the two paths that the split laser beams travel after hitting the beamsplitter. The first mirror that the beam on the longer path hits is called a “folding mirror” because it bends or “folds” the path. This is done to increase the path length without having to buy a longer table.

The solution is a finer ruler, such as the unequal-arm Michelson interferometer. Before embarking on a mathematical discussion of *why*, a very key term must be defined:

$$\Delta L = \text{path difference.} \qquad (1)$$

This is the difference in the length of the arms that the two beams travel (the net path difference would be twice ΔL). Fig. 5 illustrates the paths of the split beams in the interferometer setup.

For constructive interference of the beams to occur they must be in phase upon reuniting, which means that one beam must have completed an integer number (m) of wavelengths upon recombining with the other beam. This will result in a bright spot on the screen or detector. The phase difference between the two beams is caused by the path length difference. The relationship between that path length difference and the number of completed wavelengths is

$$2\Delta L = m\lambda\,, \qquad (2)$$

where λ is the wavelength of the laser. The factor of two in Eq. (2) references the fact that a photon on the path goes down and comes back (it is a two-way trip). Since the laser will actually be swept when the experiment is run it would be helpful to know how changing the wavelength (i.e., sweeping the laser) is related to changes in the number of bright fringes the experimenter will see (i.e., the change in the number of completed wavelengths, m). Therefore, take a derivative of Eq. (2) to obtain

$$\frac{d\lambda}{dm} = -\frac{2\Delta L}{m^2}\,. \qquad (3)$$

For the system tested typical values are $\Delta L = 1.5$ m and m is 3.8 million. Then for $dm = \Delta m = 1$, the measured change in wavelength is 2×10^{-13} m. To keep this in perspective, this change is

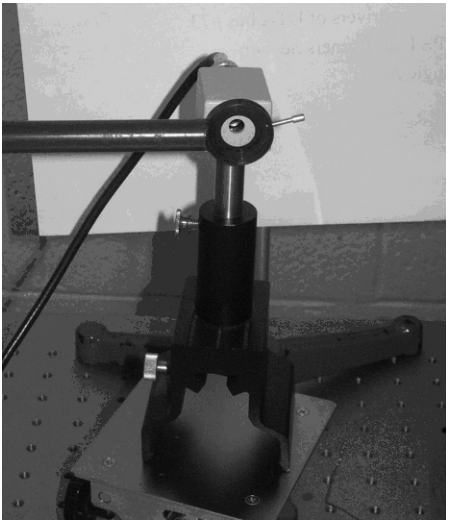

Figure 6

The photo detector. The variable aperture is where the light enters the photo detector. In the actual experiment this aperture was made as small as it could be so that (1) the photo detector would not become saturated with the beams and (2) individual fringes could be isolated and identified.

equivalent to 200 fm and recall that the Bohr radius is ~50,000 fm; thus changes in wavelength a hundred times smaller than the radius of an atom can be measured! The key lies with the path difference, ΔL: because there is a difference in path length, the one laser beam completes a large number of wavelengths before reuniting with the other, which in turn produces fringes only femtometers apart.

The optimal value for ΔL needs to be determined. It can be shown that

$$\Delta L = \frac{c}{2\Delta\nu}. \qquad (4)$$

Eq. (4) is a relationship between ΔL and $\Delta\nu$ (where $\Delta\nu$ is the frequency change or "spacing" between every bright fringe) (Band, 2006, p. 70). Notice that only ΔL limits the precision!

The atom trap at WSU requires a resolution of $\Delta\nu \approx 100$ MHz for the frequency peaks of the laser operating at 780 nm. At this resolution $\Delta\lambda \approx$ 200 fm—a small value, but, as was shown above, easily measured with an unequal-arm interferometer. Evaluating Eq. (4) with this required resolution reveals that the path length difference, ΔL, needs to be 1.5 m.

Results

Testing the unequal-arm interferometer involved sweeping the frequency of the laser and measuring the intensity of the resulting fringes with a photo detector (see Fig. 6). Both the triangle-wave input used to sweep the laser and the photo detector were connected to an oscilloscope enabling the user to easily analyze the output. This procedure was repeated for various ΔL values where the associated frequency spacing was determined with Eq. (4). Keep in mind that it is the fringe pattern that carries the information of the frequency spacing with two bright (or, equivalently, two dark) spots spaced $\Delta\nu$ apart. Fig. 7 is an image of a typical fringe pattern.

Figure 7

This is a negative image of an interference pattern during one of the runs of the experiment. Each bright fringe acts as a tick mark. When the laser is being swept these fringes move back and forth in synchronization with the sweeping.

For $\Delta L = 135$ cm the frequency spacing obtained is $\Delta\nu = 111$ MHz. This corresponds to a wavelength difference of $\Delta\lambda = 2.25 \times 10^{-13}$ *m*. The oscilloscope trace, shown in Fig. 8, becomes a fine ruler with six tick marks spaced 111 MHz (or 225 fm) apart. Doing the math, about 700 MHz of the laser's spectrum was swept.

Not only does the operator obtain precise tick marks with the interferometer but he or she also measures the stability of the laser through the physical spacing of the peaks. If peak B is closer to peak C than peak A then the user knows that the frequencies are more concentrated in the sweep between B and C than between B and A. Using this knowledge of the sweep rate the experimenter can easily identify where he or she is scanning and thus zoom quickly in on the particular frequency needed.

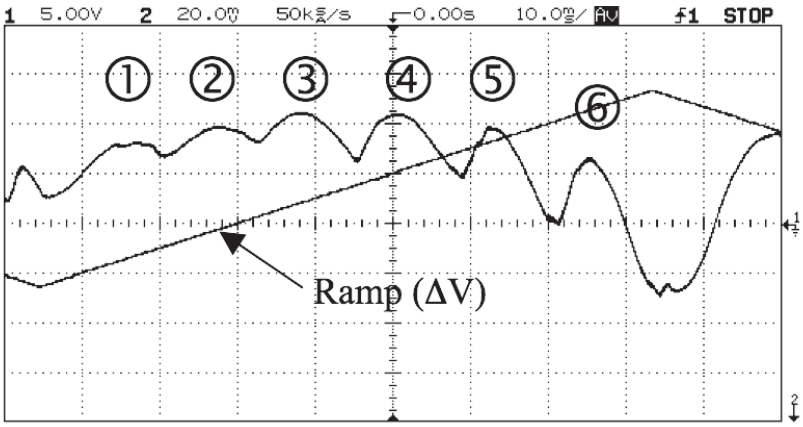

Figure 8

An oscilloscope trace for ΔL = 135 cm, $\Delta\nu$ = 111 MHz. The actual values of the abscissa and ordinate axes are not important. What is important is that there are six peaks (i.e., tick marks) spaced 111 MHz apart.

A value of ΔL = 69 cm resulted in a frequency spacing of 220 MHz ($\Delta\lambda = 4.5 \times 10^{-13}$ m). The oscilloscope trace for this run is shown in Fig. 9. Notice that one of the peaks is demolished (peak 3); this is due to mechanical vibrations in the laser box. These mechanical vibrations are even more grossly apparent when the path length difference was reduced further to 28 cm ($\Delta\nu$ = 540 MHz) (see Fig. 10). This will not pose a problem for the atom trap, however, because notice that as the frequency spacing becomes progressively shorter, the peaks become progressively less irregular (Fig. 8 peaks are less irregular than Fig. 9 peaks which are less irregular than Fig. 10 peaks). Thus, the atom trap, requiring a $\Delta\nu$ of 100 MHz (even shorter than the case in Fig. 8), should have peaks that are very distinct with very little deformation. The results from these runs are summarized in Table I.

The power that comes with using an unequal-arm interferometer is the ease with which the user can attain great precision. Take the data in Table I as an example. Notice that for the first two cases the user knows ΔL to two significant figures and thus

is measuring changes in wavelength accurate to 10 fm—pretty small and pretty precise. However, by increasing the number of significant figures in the path length difference to three (the case where ΔL = 1.35 m) suddenly measurements are accurate to 1 fm—the size of a nucleon! If more precision is desired then the path length difference can be made longer by adjusting the arm length. This is a very powerful feature of the unequal-arm Michelson interferometer.

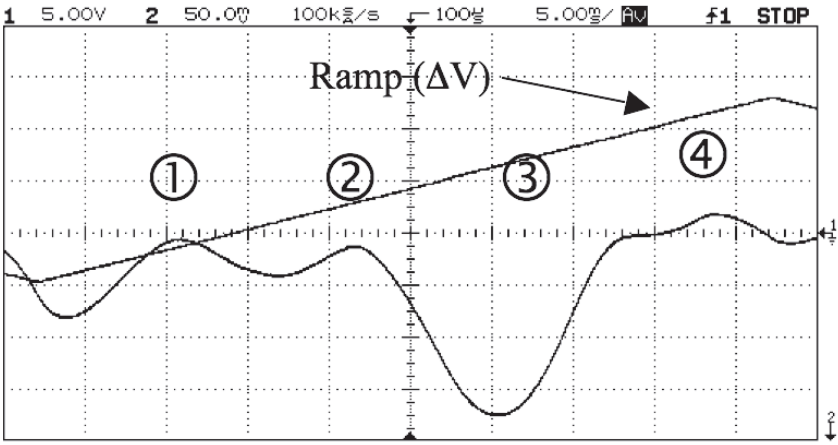

Figure 9

An oscilloscope trace for ΔL = 69 cm, $\Delta \nu$ = 220 MHz. Peak 3 is obscured because of mechanical vibrations in the system.

ΔL (m)	$\Delta \nu$ (MHz)	$\Delta \lambda$ (fm)	No. of Peaks
0.28	540	910	2
0.69	220	450	4
1.35	111	225	6

Table 1

Average values from three test runs for the unequal-arm Michelson interferometer. For each run a ΔL was chosen and then the laser was swept. Remember, 1 peak = 1 tick mark.

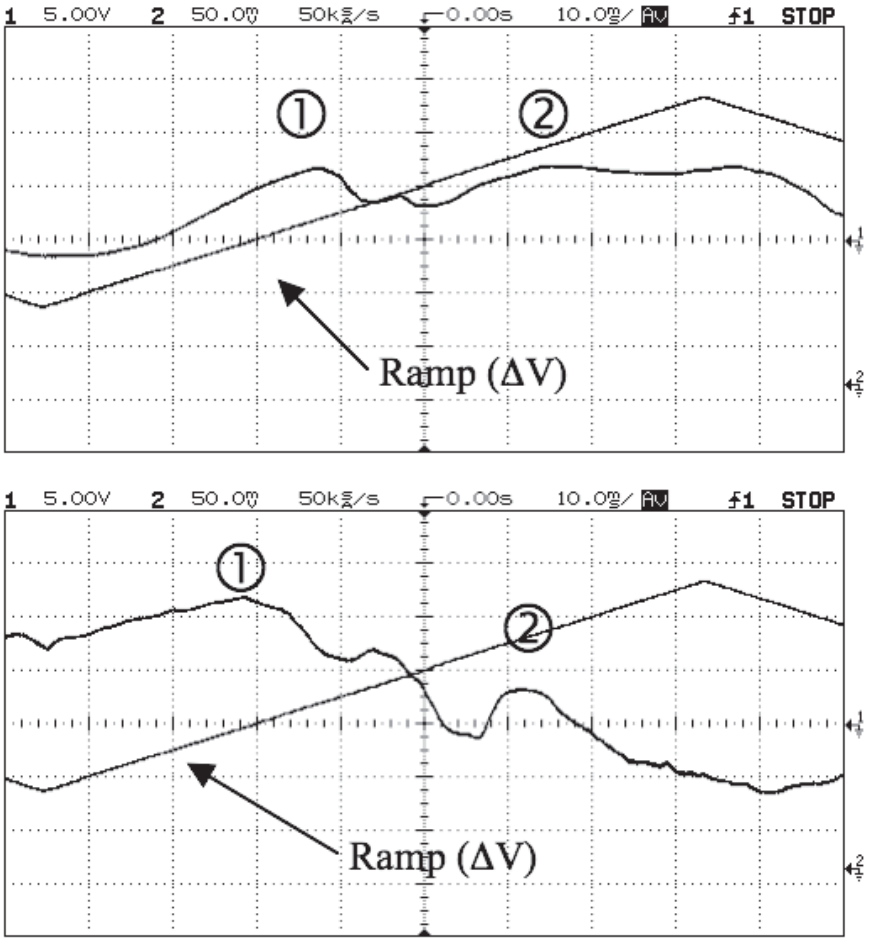

Figure 10

These are two oscilloscope traces made during the same run for the case ΔL = 28 cm, $\Delta \nu$ = 540 MHz. Here the mechanical vibrations become very evident, as it is hard to differentiate two peaks from the data even when there are two traces provided.

Ultimately, the experimenter will pick an appropriate path length difference to yield a desired frequency spacing using Eq. (4) (e.g., need $\Delta\nu$ = 100 MHz, so let ΔL = 150 cm), and then will adjust the arm length of the unequal-arm interferometer to make it so. The operator is at liberty to make the frequency spacing as accurate as he or she wishes. Then the user will ramp the laser until the desired frequency range is being swept (e.g. 600 MHz), which is evidenced by the appropriate number of peaks. This results in a gauge (i.e., tick marks on a ruler) to which the user can then match the rubidium spectrum, and quickly and accurately identify where the laser needs to be tuned. This process is visually summarized in Fig. 11.

A recent improvement has replaced the photo detector shown in Fig. 6 with one that is more stable. This new detector has variable built-in amplification which will allow researchers to measure lasers with a wider range of output power. Additionally, improved electrical shielding has significantly reduced the noise level in measurements.

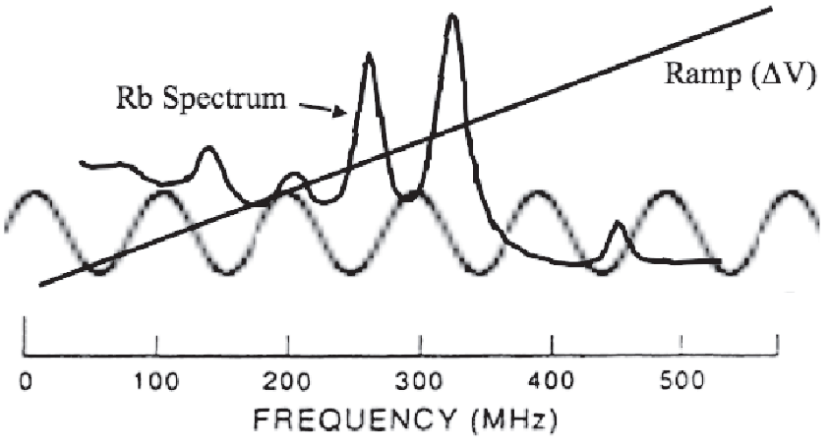

Figure 11

A graphical summary of how the unequal-arm interferometer will be used to characterize the lasers in the atom trap. In order to attain a resolution of $\Delta\nu$ = 100 MHz the path length difference must be 1.50 m.

Conclusions

An unequal-arm Michelson interferometer is a very powerful tool for analyzing and defining the lasers used in the atom trap. With it the user can know the frequency and wave content of the laser at any moment in time to great accuracy. The interferometer also informs the experimenter whether a particular laser is aligned and stable based on what the fringe pattern looks like and the appearance of the oscilloscope traces. Its compact size and simple setup allows for easy assembly and troubleshooting without sacrificing accuracy or convenience. Ergo, an unequal-arm Michelson interferometer is an outstanding system for characterizing lasers in an atom trap.

Acknowledgments

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The Effects of Cheatgrass on the Relative Abundance of a Northern Utah Snake Community

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Cheatgrass (*Bromus tectorum*), an invasive exotic annual plant, is known to diminish many shrub-dependent organisms; however relatively little research has been done on how it affects snake communities. This study was conducted at Antelope Island State Park, Davis County, Utah, where cheatgrass is abundant and may be negatively impacting snake populations. Study sites with differing cheatgrass cover were established to measure relative abundance of snakes. Snakes were trapped from June to September 2005 using funnel traps attached to drift fence arrays. Linear regression was used to determine if a relationship existed between the percent of cheatgrass cover and species relative abundances. A negative relationship was found between the relative abundances of both snake species and increasing cheatgrass density. These results suggest that cheatgrass may negatively affect the snake community in shrub-steppe habitat.

Introduction

Cheatgrass (*Bromus tectorum*), an invasive annual plant introduced from Eurasia, was detected in the western U.S. as early as the 1890's (Mack, 1981; Novak & Mack, 2001). Since its introduction in the Intermountain West, cheatgrass has come to dominate at least 200,000 km² of the shrub-steppe landscape (Mack,

1989). Characteristics of cheatgrass that allow it to out-compete native perennials include abundant seed production, rapid germination (Stewart & Hull, 1949) and its superior competitiveness (Holmgren, 1956; Harris, 1967; Melgoza et al., 1990). Cheatgrass alters plant community structure (Hulbert, 1955; Brooks, 2000), soil nutrient cycling (Walker & Smith, 1997; Evans et al., 2001; Wolfe & Klironomos, 2005), microclimate (D'Antonio & Vitousek, 1992) and fire frequency (Stewart & Hull, 1949; Young & Evans, 1978; Walker & Smith, 1997).

Cheatgrass has diminished many shrub-dependent organisms (Pimentel et al., 2000) such as shrubland birds (Wiens & Rottenberry, 1985; Knick & Rotenberry, 1995, 2000), small mammals (Yensen et al., 1992; Gitzen et al., 2001), and lizards (Newbold, 2005); however, little is known about how it affects snake communities. Cheatgrass cover does reduce the detectability of snakes (Hirth et al., 1969; Mortensen, 2004), but there may be potentially negative implications to the management and preservation of snakes inhabiting cheatgrass areas that have yet to be studied (e.g., prey carrying capacity may be limited in dense cheatgrass and locomotive performance may be hindered). In northern Utah, cheatgrass is widespread in shrub areas with native grasses and may negatively impact snake communities. The objective of this study was to determine if cheatgrass adversely affects snake abundance.

Materials and Methods

Study Area

This study was performed at Antelope Island State Park (UTM: Zone 12; 395,961 E; 4,545,924 N; elevation 1,310 m; 11, 311 ha) located in Davis County, Utah. Antelope Island is the largest island in the Great Salt Lake (Figure 1) and is not a true island due to its causeway and a naturally occurring land-bridge during dry years. Cheatgrass is one of the most abundant plants on the island; oth-

er common shrub vegetation includes grasses and plants such as bluegrass (*Poa spp.*), buckwheat (*Eriogonum spp.*), wheatgrass (Agropyron spp.), rabbitbrush (*Chrysothamnus spp.*), and sagebrush (*Artemisia spp.*) (Marshall, 1940).

Field Procedures

From April to July 2005 four study sites (3 ha each) were selected. Sites were located ≥ 0.5 km of one another; sites C and D were established in Bridger Bay and sites A and B in White Rock Bay (Figure 1). These bays were chosen for their like habitat and variety of cheatgrass densities. Cheatgrass is common throughout the island, and each site included some; however, sites differed in percent of cover. Cheatgrass coverage was determined by walking 20 transects from the center of each plot, placing a 1-m^2 wooden frame on the ground every 10 m and estimating cheatgrass cover within the square to the nearest 5% (Daubenmire, 1959), for a total of 200 samples per site. Samples were then averaged to find the mean cheatgrass percentage / m^2 for each site.

In the center of each site, a hardware cloth drift fence trap array (0.635 cm^2 mesh, 40 cm high × 30 m long) was established in an "X" pattern. To eliminate gaps between the fence and soil irregularities, fences were buried at least 5 cm. Attached to each fence were 10 double-ended, hardware cloth funnel traps (0.635 cm^2 mesh, 38 cm high × 1 m long)(Cavitt, 2000) placed 5 m apart. Traps were covered with white corrugated plastic to reduce heat stress of captured animals. Funnel traps were used as the primary method for data collection (Fitch, 1987). Snakes captured by hand within sites were also recorded.

Captured snakes were identified (Collins & Taggart, 2002) and sexed by hemipenal probing (Schaefer, 1934) with the exception of some neonates, in which case hemipenal eversion was performed (Rosen, 1991). Snout-vent lengths (SVL) were measured by contouring a metric vinyl tape along side the individual's snout to its vent. Tail lengths (TL) were also recorded by mea-

suring from the vent to the tail tip. Snakes were weighed to the nearest ±1 g using a Pesola® spring scale. Captured snakes were individually marked by clipping unique combinations of ventral scales (Spellerberg, 1977). Once marked, snakes were released at the point of capture.

As a result of an abnormally wet and cold spring, sites C and D were first opened in early-June. Sites A and B however, were relocated to White Rock Bay to avoid bison (*Bos bison*) grazing areas and were reopened in mid-June and early-July, respectively. Traps were closed from mid-July to early-August to prevent heat stress and trap mortality due to air temperatures exceeding 38° C. Traps were closed in late September after an early frost.

Data Analyses

Site-specific relative abundances (number of snakes trapped / 10 trap-array days) were calculated for each species. Linear regression was used to determine if a relationship existed between species relative abundance and the percent cover of cheatgrass. SVL measurements were averaged to find the species mean according to site. Linear regression was performed for both species to determine if dense cheatgrass cover affected snake SVL. Chi-square analyses were used to verify if sex ratios (males: females) differed significantly from parity. Statistical tests for regression and nonparametric analyses were conducted using Statistical Package for the Social Sciences (SPSS) software, version 13.0. Significance level was set at $\alpha = 0.05$ for all statistical tests.

Results

The cheatgrass cover analysis determined that all four study sites were distinct in cheatgrass cover percentage (Table 1). Twenty-eight western yellow-bellied racers (*Coluber constrictor mormon*) and seven Great Basin gopher snakes (*Pituophis catenifer deserticola*) were the only species of snakes observed and trapped

during 221 trap-array days. Racers were captured in all four sites, whereas gopher snakes were found in only three sites (A, B and C; Figure 2). The desert-striped whipsnake (*Masticophis taeniatus taeniatus*) was not observed during the course of this study despite its recorded presence on the island (Mortensen, 2004).

Site	Mean %	SD
A	37.90	± 15.74
B	39.78	± 19.51
C	54.88	± 20.69
D	69.23	± 18.80

Table 1

Mean (% cheatgrass / m²) and standard deviation (SD) for each set of cheatgrass samples (n = 200) from each site.

Relative Abundance

Only one marked snake (*C. constrictor*; site C) was recaptured. Consequently, no estimates of population size could be derived. Relative abundance of racers was negatively associated with percentage of cheatgrass cover ($F = 22.065$; $df_{\text{model, error}} = 1, 2$; $P = 0.042$; $R^2 = 0.917$; Figure 2). Likewise, gopher snake relative abundance showed a significant negative relationship to increased cheatgrass cover ($F = 18.582$; $df_{\text{model, error}} = 1, 2$; $P = 0.049$; $R^2 = 0.903$; Figure 2).

SVL Analyses

There was no significant relationship between racer and gopher snake SVL with the percent of cheatgrass ($F = 0$; $df_{\text{model, error}} = 1, 2$; $P = 0.994$; $R^2 = 0$; $F = 4.895$, $df_{\text{model, error}} = 1, 2$; $P = 0.270$; $R^2 = 0.830$).

Sex Ratios

The sex ratio (males:females) for racers did not significantly differ from parity (11:16; $\chi 2 = 0.46$, $df = 1$, $P > 0.05$). There were too few data to statistically compare the sex ratio for gopher snakes (3:4).

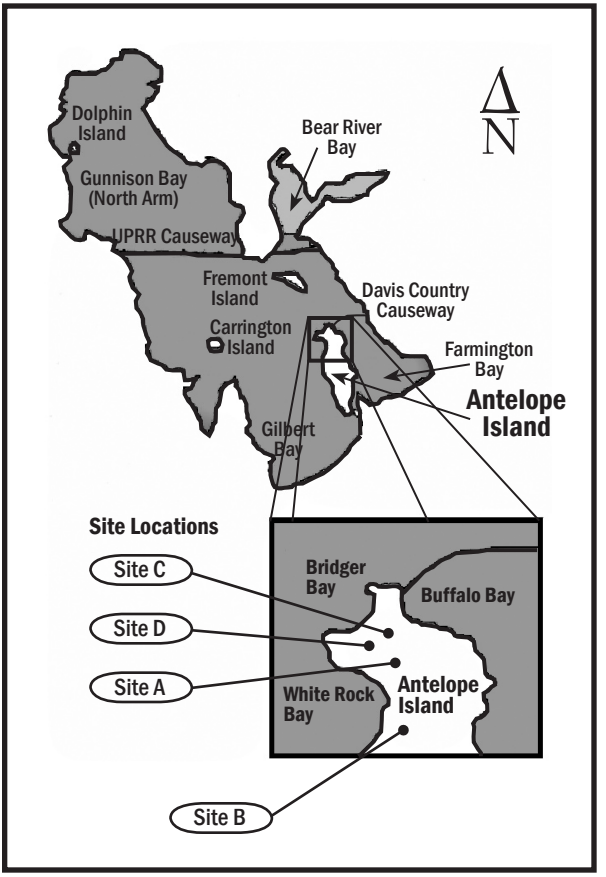

Figure 1

Map of the Great Salt Lake with enlarged area of Antelope Island study sites.

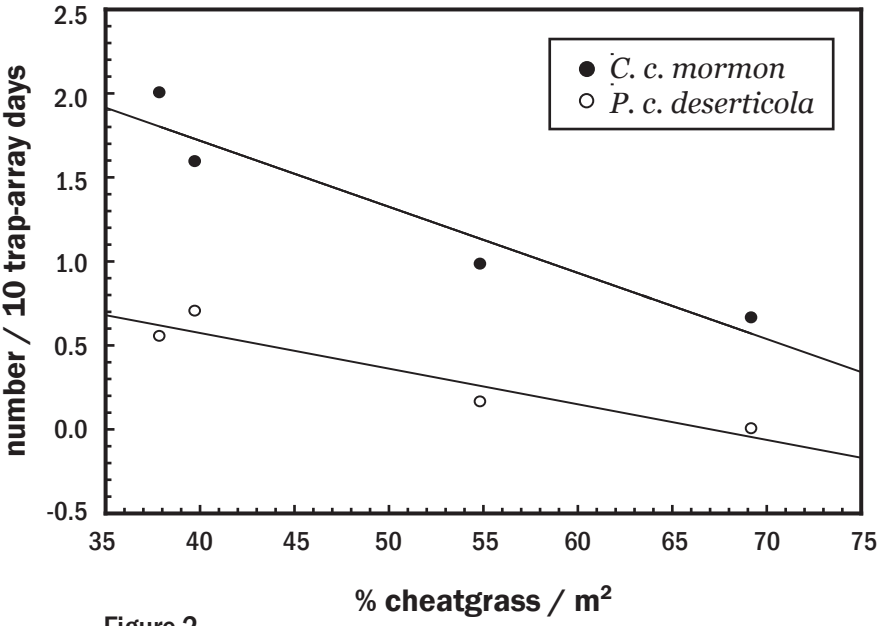

Figure 2

Relative abundances (number trapped per 10 trapping days) of *Coluber constrictor mormon* (Y = -0.040× + 3.321) and *Pituophis catenifer deserticola* (Y = -0.021× + 1.437) as a function of cheatgrass percent cover.

Discussion

These findings show that snake abundance is comparatively lower in cheatgrass on Antelope Island, suggesting that increasing cheatgrass density negatively impacts snake communities. However, during a replicate study (one performed 20 y after the original to monitor changes in reptile status in Idaho) Cossel (2003) found that snake abundance was not impacted by exotic annuals, including cheatgrass. Yet, the difference between our results may lie in the method through which we ranked vegetation abundance. Cossel used transect walk-through and point / line intercept surveys to classify all the major cover types of vegetation on a four-point scale. Subsequently, he could not detect a percentage difference among his highest (four, on his scale) cheatgrass rank-

ings. Furthermore, since Cossel's study was a replicate, he was required to utilize previous study sites which exemplified an array of habitat variables. Thus, he was unable to directly measure cheatgrass effects on snake abundance using similar habitat with the sole variable being cheatgrass percentages.

Cheatgrass may negatively affect prey abundance, as seen in some lizard species. Though lizards do not represent the majority of gopher snake and racer diets (Klimstra, 1959; Rodriguez-Robles, 1998), their negative association with cheatgrass is noteworthy. Working in northern Utah, Newbold (2005) showed that cheatgrass decreased desert horned lizard (*Phrynosoma platyrhinos*) locomotive performance and abundance. Mortensen (2004) found lizard abundance and diversity to be considerably lower in areas dominated by cheatgrass on Antelope Island. This may tentatively explain the absence of the lizard-consuming whipsnake (Parker & Brown, 1980; Camper & Dixon, 2000) during this survey and provide some explanation for the reduced abundance of gopher snakes and racers in high cheatgrass sites.

Birds and their eggs make up a small percentage of gopher snake and racer diets (Fitch, 1963; Parker & Brown, 1980; Rodríguez-Robles, 1998). Decreasing populations have been observed among Sage Sparrows (*Amphispiza belli*), Brewer's Sparrows (*Spizella breweri*), and Sage Thrashers (*Oreoscoptes montanus*) because of habitat loss due to wildfire and consequently, exotic grass invasions (Wiens & Rottenberry, 1985; Knick & Rottenberry, 1995, 2000). This, in turn, would reduce nesting sites of shrubland birds in areas dominated by cheatgrass, discouraging snake foraging in them.

Small mammals are important in gopher snake and racer diets (Fitch, 1949, 1963; Klimstra, 1959; Rodríguez-Robles, 1998; Shewchuk and Austin, 2001). In a small mammal survey performed in the shrub-steppe of Washington, Gitzen et al. (2001) found that small mammal capture rates were reduced in cheatgrass sites. Furthermore, in southern Idaho, Townsend's ground

squirrels (*Spermophilus townsendii*) and their burrows were also less abundant in areas with cheatgrass (Yensen et al., 1992; Van Horne et al., 1997). During spring and summer censuses on Antelope Island in 2006, deer mouse (*Peromyscus maniculatus*) relative abundances were found to steadily decrease as cheatgrass density increased (L. Hall, unpublished data). Reduced small mammal abundance does not only limit prey abundance for snakes, but also diminishes burrow system availability. Both snake species use rodent burrows for oviposition (Fitch, 1949; Parker & Brown, 1972) and thermoregulation (Brown, 1973; Huey et al., 1989).

Insects, principally orthopterans, constitute the bulk of racer diet (Klimstra, 1959; Fitch, 1963; Brown, 1973), whereas gopher snakes rely less on insects (Parker & Brown, 1980; Rodríguez-Robles, 1998). Among orthopterans, acridid grasshoppers are favored by racers (Brown, 1973; Shewchuk & Austin, 2001). In Colorado, Craig et al. (1999) discovered acridids in a variety of habitats, some of which included cheatgrass. In a related study from south-central Idaho, Fielding and Brusven (1993) found relatively high density, but reduced diversity of acridids in exotic annual sites. Unfortunately, partially digested grasshoppers recovered from racer stomachs are only identified to family level, probably due to the difficulty in recognizing distinguishing species features beyond that level. Furthermore, a grasshopper survey has not been performed on Antelope Island that could clarify the status of the acridids that persist in cheatgrass. Therefore, it is problematic to conclude that racers are selecting the potential cheatgrass acridids. Nevertheless, it could be a reason for racer occurrence in sites C and D.

Gopher snakes exhibited lower relative abundances than racers in all sites, particularly in site D, where gopher snakes were absent. Their absence could be attributed to lower vertebrate prey abundance upon which they are dependent (Fitch, 1949; Rodríguez-Robles, 1998). Racers were perhaps more abundant

because they can maneuver more easily in cheatgrass (Hirth et al., 1969) than the slower, more robust gopher snakes (Mosauer, 1935). However, dense cheatgrass may hinder locomotion in both snake species (personal observation). In studies measuring garter snake (*Thamnophis elegans*) locomotion in differing push-point densities (representing vegetation stalks by inserting nails into a board), speed was reduced in both experimental populations of garter snakes as push-point densities surpassed intermediate levels (Jayne, 1986; Kelley et al., 1997). Dense vegetation would also impede burst speed, a selected trait among garter snakes (Jayne and Bennett, 1990). In addition, decreased burst speed could affect the ability to forage (Fitch, 1963) and escape predators.

Invasive plant species are important contributors to biodiversity declines (Parker et al., 1999; Davis, 2003). Racers and gopher snakes are essential predators and prey to a variety of organisms in shrub-steppe food webs (Fitch, 1949, 1963; Parker and Brown, 1980). Consequently, negatively impacted population dynamics of these snakes could lead to biological disruptions in shrub ecosystems. The results from this study support the initial hypothesis that cheatgrass cover negatively affects snake abundance. It may do so by encumbering locomotion and by not supporting an adequate density of potential vertebrate prey species.

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Norwegian Foreign Policy: Issues of Isolationism and Globalism

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Despite having a reputation of being a nonentity when it comes to power politics, Norway has played an integral role in international cooperation and mediation. The policies of Norway can be traced in its relations domestically as well as internationally. Norway, while wrestling with the sentiment of isolationism, continues to take steps towards a more global approach to its foreign policy. This study follows the changes, both historical and political toward globalization as they remain at the forefront of many issues; namely humanitarian and peacekeeping.

Introduction

Nearly every student of United States foreign policy learns of the 1993 Oslo accords between Israel and the Palestine Liberation Organization (PLO) as well as the critical role the US had in bringing the two sides together. The accords, officially known as the Declaration of Principles on Interim Self-Government Arrangements or Declaration of Principles (DOP), were a culmination of years of diplomacy and secret agreements which marked the closest that region has reached towards a permanent peace solution. One thing we may ask ourselves is, why is it that Oslo was the site for the bulk of negotiations?

Norway has positioned itself as an international mediator through decades of cooperative efforts. In the case of the 1993

DOP, Johan Jørgen Holst, the Norwegian Minister of Foreign Affairs with Terje Rød-Larsen and Mona Juul, both Norwegian diplomats, were the chief architects in designing the peace talks. The DOP is just one example of how this country of 5 million has been behind many major peace and humanitarian advancements in the 20th century.

Brief History of Norway

Over one hundred years ago the country of Norway gained its independence after 600 years of foreign rule by its Scandinavian neighbors. It was June 1905 that Norway ceded from Sweden, its neighbor to the east. Previous to its ownership by Sweden, Norway was considered part of the Kingdom of Denmark.

In the beginning of Norwegian foreign policy, the country struggled between isolationist and globalist views. Many had the attitude that the country should not be involved in foreign affairs, but that government should focus solely on domestic issues (Blakkisrud, 2006). However, there were some who viewed international cooperation as having great validity. Thortsen Olesen refers to the struggle between isolationism and globalism as

> A general small-state dilemma: to reach an acceptable balance between the need to engage in various forms of international cooperation as a means of fostering or supporting economic or political interests and at the same time to ensure that the loss of sovereignty and independence linked to this international intercourse is reduced as much as possible. (Olesen, 2000, p. 3)

This balance has created interesting policies in relations to economic and security intergovernmental organizations (IGO's) such as the North Atlantic Treaty Organization (NATO), the European Union (EU), and the United Nations (UN). The foreign policies of Norway can be separated into three groups, National Securi-

ty, Economic ties, and International Cooperation and consensus building through the UN.

Norway and National Security

During the time period following their independence and before World War II, Norway insisted on its neutrality; officially following a strict guideline of non-alliance. The country focused instead on domestic issues.

Norway continued this policy until the war broke out when it became evident that due to the geographical location of Norway, it was no longer isolated. Rather, it became an ideal location for the allied forces. Thus, it became near impossible to maintain the neutrality they desired to uphold. Due to ideological and economic reasons, Norway entered the war on the side of the allies. Norway entered the war quite grudgingly. On April 9, 1939 Germany invaded a rather unprepared Norway. After two months of fighting, Norway surrendered allowing Germans to occupy.

The government was not fully controlled by the Germans; the majority of government officials had fled to Britain, leaving the bare minimum to keep order. The top political leaders maintained contact with and continued to do business by correspondence to their subordinates from afar.

Not completely in agreement with the allied forces on all issues, Norway realized that it must look to the future beyond the war. It thus started to create relations with the Soviet Union which became a major player during this time period. These relations continued through the first part of the Cold War.

Foreign Policy after WWII

During its exile in Britain, Norway's government had developed considerably. And so upon their return in 1945 they were able to reorganize quickly, and govern more efficiently. The war forced

Norway to realize that isolation was not the preferable policy due to threats of sovereignty.

Following the war, Norway became a staunch advocate of international cooperation, initially attempting to forge peace talks between the Soviet Union and the United States; though quickly realizing these efforts were ineffective.

Norway and NATO

Norway, though a founding member, has been branded as a "feet dragging member" of NATO due to their hesitations of national security on an international scale. The introduction of Norway to NATO marked an actual stance of foreign policy on the international stage.

Being a founding member of NATO, Norway was allowed to include some exceptions exclusively for them. These self imposed limitations included:

1. Norway would not open bases for allied forces on Norwegian soil as long as the country was neither attacked nor under threat of attack.

2. Norwegian authorities did not permit the deployment of nuclear weapons on Norwegian territory.

3. Allied aircraft and naval vessels were not to be granted access to areas east of longitude 24 degrees east and allied army forces were not permitted to carry out military exercises in Finnmark, the northernmost part of Norway (Blakkisrud, 2006).

These limitations highlight the reservations Norway had against joining this international body. This move also allowed them to support NATO and receive its benefits, while allowing for its own expansion and freedom. Once again this internal battle of isolation versus globalization comes to the forefront. On account of NATO, Norway receives military support from the United States. They also become more tangibly connected with the West-

ern Powers. These ties become important when security issues were a concern during the Cold War.

Norway and Economic Ties

The European community accounts for the majority of Norwegian exports, roughly eighty percent (*Country profile: Norway*, 2006). However the hesitancy of joining IGOs was present during further integration of the European Community (EC); reservations that joining an international community would somewhat relinquish their short lived independence. Pressures to join the EC came to a head in 1962 and later in 1967 when the Norwegian government officially sought membership in the community. This was largely in part due to the fact that Denmark, its neighbor to the south, was already a member and also due to the movements of Britain, its longtime ally, seeking membership. Despite the sponsorship of the leaders in Oslo, the Norwegian people voted down the proposal of joining the EC. Nevertheless, this move did not stop Norway from taking part in other European organizations such as the European Free Trade Association (EFTA).

The EC transformed into the EU and underwent several changes during the seventies and the eighties, dealing mostly with growth. In the early nineties, the proposition was once again brought to a vote of whether or not Norway should join the EU. Once again, the Norwegian people voted it down. The Norwegian government was dealt a setback in what their minds considered the best move for the country's future.

In 1999 the EU unveiled the Euro, the currency of many union members, which gave the union a more binding character. As Helge Blakkisrud explains, this presents a predicament for Norway:

> Today the EU stands as a central European forum for cooperation and plans for a further expansion of the union to include Central and Eastern Europe will further strength-

> en this development. At the same time Norway is becoming increasingly dependant on trade with the EU. Today more than 75% of Norwegian exports go to the EU countries. The EFTA pillar within the EEA is, however, both shaky and fragile after EFTA shrunk in 1995 to embrace only three small countries, Iceland, Liechtenstein, and Norway. EFTA's, and *thereby Norway's possibilities of influencing EU development is slight*. (Blakkisrud, 2006)

Without being a full member of the European Union, Norway has little control over its policy, while at the same time becoming more dependent on the Unions decisions through economic ties. Because of this, Norway has resorted to throwing its weight around in those forums where it does have full membership and control such as The Organization for Security and Cooperation in Europe (OSCE). The OSCE has been an outlet for Norway to voice its concerns.

Norway and Scandinavia

As of today, Norway stands alone as the only Scandinavian country not part of the EU. This independence was not always the case. During the Cold War each of the Scandinavian countries had chosen different policies, but despite their differences the countries of the north banned together to form the Nordic Council in 1952. The Nordic Council has provided not only security benefits for each of the member countries, but it also created an economic stimulus. This paved the way for a Nordic passport union, a common labor market and an integrated policy for air traffic.

Though they have had their disputes over land and territories, the nations of Scandinavia enjoy a bond that transcends the economic and political ties; they share history, language, and ideology. This dictates into strong ties of cooperation, and is a sign of Norway's increasing willingness to create economic and social ties with other countries.

Norway and International Consensus Building

While having slight reservations about IGO's which deal with economic and security issues, Norway remains at the forefront of peace keeping and humanitarian issues especially through the UN. Some of Norway's credentials include: supporter of Woodrow Wilson's League of Nations, and a staunch supporter of the UN, with the first Secretary General of the UN being Trygve Lie, a Norwegian diplomat. However it seems that the issues that Norwegians hold close to their hearts involve Development aid and Human Rights. In the year 2000, the UN launched a program that would alleviate poverty and the problems of illiteracy, hunger, discrimination against women, unsafe drinking water and a degraded environment. The format for which they decided to accomplish this was a list of goals, now commonly known as the Millennium development Goals (UN, 2006). Norway donates countless millions to developing countries and has traditionally held a high ranking in amount of foreign aid given as a percentage of GNI. In 2003 and 2004 they maintained this position as they ranked first among all developed countries (Shah, 2006).

They are actively involved in peacekeeping operations. Leading up to 1993, Foreign Minister Johan Jørgen Holst was instrumental in forging the Oslo Accords between Israel and the PLO. Thorvald Stoltenberg was part of the mediation team involved in the Bosnian civil war. With its responsibilities in the UN, Norway has been involved in several peace keeping missions, including UNAMSIL, in Sierra Leone 1999-; UNTAET, in East-Timor 1999-2002; UNMIK in Kosovo 1999-; and UNMIS, in Sudan 2005- (Norway and Peacekeeping, 2006). Through these and other peace keeping and humanitarian missions, Norway has proven itself as a leader in consensus building

Conclusion

Though hesitant to join international organizations that deal with

security issues, Norway has been increasingly involved on an international stage through their economic ties. The small state dilemma between international actor and domestic, neutral state has been shifting to the former; first through humanitarian and peacekeeping efforts, and eventually, and increasingly through economic interdependency. Norway's position as a reluctant player in international security issues is a positive factor in their ability to mediate.

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Depression: A Comparative Look at Prevalence among Psychology versus Non–Psychology Undergraduates

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The belief that personal problems influence students to choose psychology as a major has been a controversial issue. King, Bailly and Moe (2004) found that psychology students have significantly higher rates of suicide attempts and parental divorce than the other majors that were studied. However, they did not differ significantly in other areas including mental health, abuse, violent or deviant behavior, or in their scores on the Beck Depression Inventory (BDI). Conversely, Pillay, Edwards, Gambu and Dhlomo (2002) found that psychology students scored significantly lower on the BDI than their non-psychology counterparts. For further investigation into the discrepancy between these studies, this study administered the BDI to 30 psychology and 63 non-psychology undergraduate students at Weber State University's main campus in Ogden, Utah. We expected to find depression greater among psychology undergraduates than non-psychology undergraduates. The present study tested this hypothesis by comparing the mean scores of the two groups of students in a two-sample t-test. However, this view was not supported, as even though psychology undergraduates scored slightly higher on the BDI (8.63) than their non-psychology counterparts (7.03), there was no statistical difference between these

two groups. Significance of the relationships between age and depression, and gender and depression were also tested; even so, no statistical significance was found on either dimension. Although the hypothesis was not supported by the data, the study has presented some new roads that may assist future research. Some of the speculation about inconsistencies among studies may be investigated more fully.

Introduction

In many of today's research studies, psychology students are commonly recruited as the sole participants. The implications of this may have consequential importance to the external validity of many of these studies, especially those dealing with personal problems. It has been speculated that the role of personal problems might influence students to choose psychology as a major in order to compensate for past problems. One might expect to find that psychology programs have higher levels of depression than other university departments. Moreover, further understanding of this topic might help university counselors to identify students who are at-risk for psychological maladjustment and academic failure during their university career.

To investigate differences between those choosing psychology versus non-psychology majors, Lunneborg and Lunneborg (1991) found that psychology students had better high school grades in english, math, and science than did physical and health communications, sociology, and social work majors. It was also found that psychology majors were academically superior to physical and health communications and sociology majors in social studies measures; as well as, to social work and sociology majors in language grades. Prospective psychology majors had better high school grades in elective courses than future sociology majors. Moreover, psychology graduates were not inferior on any of the tests compared to the other four groups. In addition, they scored

significantly higher than at least one group on all achievement tests except for mechanical reasoning.

To further examine dissimilarities between psychology and non-psychology undergraduates, Harton and Lyons (2003) concluded that people who scored high on empathy assessments are more likely to choose the helping professions, like psychology. Thereby, noting a difference in those who choose psychology as a major and those who do not.

To explore the issue of students being drawn to psychology as a major due to personal problems, Pillay, Edwards, Gambu, and Dhlomo (2002) recruited 129 first year students at a traditionally black university in South Africa to complete the self-report Beck Depression Inventory (BDI). When they compared psychology students to those who were not, they found that psychology students scored significantly lower on the BDI than their non-psychology counterparts. Conversely, King et al. (2004) also looked at differences among majors with respect to measures of psychosocial functioning but found drastically different results. King et al. (2004) used college students from psychology classes, (e.g. introductory, personality and abnormal courses) that are popular among students from all majors. They not only evaluated psychology classes but also conducted surveys with students from at least 11 different majors. They also used the Coolidge Axis II Inventory to assess personality disorders among the students. The study revealed that psychology majors have significantly higher rates of suicide attempts and parental divorce than the other majors that were studied, but that they do not differ significantly in other areas including mental health, abuse, violent, deviant behavior, or in their scores on the BDI.

The difference in findings between the studies done by Pillay et al. (2002) and King et al. (2004) are perplexing. It is not understood what caused the difference, and clearly, further investigation will be necessary. However, Kidd and Caldbeck-Meenan (1966) found a relationship between BDI scores and geographic

location. These researchers used 15 measures of psychiatric illness and found no significant difference between students at the University of Edinburgh in Southeast Scotland and the Queen's University of Belfast in Northern Ireland. The universities are in close proximity to one another, but differed greatly in student demographic background.

The discrepancy between studies is interesting because in order to generalize findings to other college students or even the greater population one must be certain that the sample is truly representation. It is expected that a significant difference between psychology and non-psychology students would be found; that there would be a greater proportion of depressed psychology majors than other majors.

Method

Participants

Participants consisted of 93 undergraduate students who were solicited in computer labs, classrooms, and the cafeteria on the campus of Weber State University. Students of both genders were recruited with ages ranging from 18 to 47. The mean age was 26 years old. Of the participants who filled out the demographic information 38 were females and 39 were males; 16 were unanswered. The participants were volunteers and were not compensated for their time.

Materials

Students were evaluated for depression using the Beck Depression Inventory. The BDI is a 21 item self-report inventory that assesses the level of depression in an individual. Answers to the 21 questions are based on a rating scale format ranging from 0 to 3 for a possible score ranging from 0 to 63. The scores ranging from 0 to 9 are considered normal, 10 to 18 is mild-moderate depression, 19-29 is moderately to severe depression and 30 to 63 indicate extremely severe depression.

Procedure

Each participant was informed about the purpose and confidentiality of the results of the survey. They were given a consent form along with the BDI explaining in more detail the purpose, BDI contents, and their rights as a participant.

Results

Completed surveys were divided according to psychology and non-psychology majors. Results of a two-sample t-test showed psychology majors (M=8.63, SD=6.54) score no differently on the BDI than did non-psychology majors (M=7.03, SD=6.24), $t(91) = .26$, $p>.05$, ns. The psychology major's BDI score was .25 standard deviations higher than the non-psychology major's, resulting in a small effect size.

A Pearson r was used to assess the relationship between age of the participants and their scores on the BDI. A correlation of .03 was found not to be significant at the .05 level ($r(75) = .03$, $p>.05$, ns). Pearson r was also used to evaluate the relationship between gender and the corresponding BDI scores. It was found not to be significant at the .05 level ($r(75) = -.06$, $p>.05$, ns).

Discussion

It was originally hypothesized that there would be a higher prevalence of depression among psychology majors than other majors. In accordance with the results found by King et al. (2004) the present study found slightly higher scores among psychology majors on the BDI than non-psychology majors. However, the slight dissimilarity was not found to be statistically significant, and the data did not support the hypothesis that psychology students have a significantly higher rate of depression than their non-psychology counterparts.

Although the results obtained through the study done by Pillay et al. (2002) differed from this study, the difference may be explained by external factors. The study conducted by Pillay et al. (2002) was done in South Africa, whereas the present study took place in the United States. Cultural differences might affect the validity of the BDI in non-Western cultures because it was written in English which was not the primary language of the participants in the South African study. Moreover, it has also been speculated that prior experience with psychology classes may influence students' answers on self-report questionnaires (Pillay et al., 2002). Prior exposure to the pathology of depression might have prompted the participants who were majoring in psychology to answer less candidly than those of other majors.

In the present study, external validity may be affected because participants were only surveyed on Weber State University's main campus. As Kidd and Meenan (1966) discovered, differences in depression scores may be attributed to less dramatic cultural contrasts. Undergraduate students in other similar geographic regions differing only on socioeconomic or ethnic status will have different life experiences. Even minor demographic differences may be factors in the way participants answer the questions of self-report depression inventories.

In addition, the sample was not completely random. Recruitment was based more on convenience than randomization, i.e. only students who were present at the same location as the researchers were approached for participation. Furthermore, a mishap resulted in the demographic page being left off of 16 of the surveys. The effect was missing demographic information for scores involving gender and age. When statistical tests were run using gender and age in these cases, corresponding scores were not used. Statistical tests that included major, however, were used since all of the flawed surveys were distributed solely in an upper-level psychology class (i.e. it was assumed that all of these participants were psychology majors).

In the future, similar research studies may wish to refine self-report questions in order to assess for previous depression or by gather archival data on the participants' psychological history. An additional factor that future studies may investigate is broadening their dependent variable to include all of the "helping" majors, for example sociology and nursing. These majors were grouped into the non-psychology group but, the students in these majors may be more similar to psychology students in terms of personal problems, such as depression. In this study, it was not considered early enough to obtain a sufficient number of additional helping majors to ascertain statistical significance.

Although the hypothesis was not supported by the data, the study has presented some new roads that may assist future research. Some of the speculation about inconsistencies among studies may be investigated more fully.

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Research Abstracts

Research is the academic's response to the human thirst for knowledge. It is curiosity put into action, and its reach knows no bounds. Research has been conducted for centuries in an ongoing effort to understand the world in different and revolutionary ways. The student researchers at Weber State University continue this legacy. Though all of the research done at Weber State could not be included in this journal, the abstracts that follow are meant to showcase students who have done a wonderful job representing Weber State University at professional conferences. These abstracts represent dedication, discovery, and hours of teamwork between professor and pupil. They are a glimpse into what nature and humanity holds for the future of humankind.

Samantha Balaich
Assistant Editor

Phosphate Utilization in Halophilic Organisms of the Great Salt Lake

Brigette Beyer

Phosphate, although an essential nutrient, contributes to significant eutrophication of aquatic systems by stimulating algal and bacterial growth and thus depleting the oxygen available for other aquatic life. Hypersaline environments are understudied with respect to phosphate cycling, and halophilic microorganisms may play a critical role in determining the impact of excess phosphate on hypersaline ecosystems. Sediment and water samples were collected from two environments of the Great Salt Lake, Utah, and used to inoculate media, developed for this project, to isolate hypersaline organisms and to test their abilities to use defined organic (*o*-phosphorlethanolamine, 1-aminoethylphosphonic acid, or *o*-phospho-DL-serine) or inorganic phosphate (KH_2PO_4, or H_3PO_4) sources. Bacterial growth occurred on all introduced phosphate sources, including minimal media with no phosphate added. DNA was isolated from unique colonies and the 16S ribosomal RNA gene was amplified and sequenced. The isolates were related to other halophilic or marine gamma-*Proteobacteria*, including the genera *Halomonas*, *Marinobacter*, *Salinivibrio*, and *Idiomarina*. In addition, the isolates were able to use multiple phosphate sources. This indicates that halophilic microorganisms have the ability to use a broad spectrum of phosphate sources and may have alternative mechanisms for obtaining phosphate in phosphate-limited environments.

Faculy Mentors – Craig Oberg, Ph.D. & Michele Zwolinski, Ph.D.
This research was presented at the Intermountain branch meeting of the American Society for Microbiology in Provo, Utah (March 18, 2006).

Feeding Ecology and Diet of American Avocet and Black–necked Stilts at Great Salt Lake, Utah

Christian Edwards & Karla Terkelson

Both the American Avocet (Recurvirostra americana) and Black-necked Stilt (Himantopus mexicanus) overlap in breeding and foraging sites throughout much of their ranges. However, very little is known about the feeding ecology and diet of these species at Great Salt Lake, Utah, where the largest breeding assemblages in the western United States occur. We examined foraging strategies and diet of these species during the 2005 breeding season at three study sites within the Great Salt Lake ecosystem. Dietary information was obtained by direct examination of gut contents. Birds were randomly collected after being observed feeding for more than 15 minutes. Esophageal, proventricular and ventricular contents were removed and placed in 80% ethanol. Invertebrates were identified to family, counted and percent volume and dry mass of samples was determined. Following each shorebird observation/collection, invertebrates were sampled from the benthos and water column within each foraging area. The results of this study indicate that both diet and foraging behavior was significantly different between species. For example, Chironomid larvae made up over 90% of the invertebrates identified in American Avocet stomachs but accounted for only 20% in Black-necked Stilts. These dietary differences may serve as a mechanism for niche partitioning during the breeding season.

Faculty Mentors – John F. Cavitt, Ph.D. & Theron Miller, Ph.D.
This research was presented at the Shorebird Science in the Western Hemisphere Meeting in Boulder, Colorado (February 27 - March 2, 2006).

Two Methods of Detection for *Streptococcus mutans*

Leesa Gabrielsen

Streptococcus mutans has been shown to be a major causative agent for dental caries. Two methods of detection have been developed to identify *S. mutans*: one involving polymerase chain reaction (PCR) and another using Dentocult SM Strips. In the first phase of the project, the PCR procedure was validated and optimized in our laboratory. For the PCR procedure, two primers specific to *S. mutans* were used to identify the presence of the bacterium. In the second phase, the Dentocult SM Strips were validated. The Dentocult procedure involved a 48-hour incubation in a selective nutrient broth for detection of *S. mutans*. In phase three, dental plaque samples from fifty individuals were analyzed using both methods and the results were statistically compared. The Dentocult procedure was used as the standard to determine the sensitivity and specificity for PCR. According to the manufacturer, the sensitivity and specificity for the Dentocult Strips are 98% and 85% respectively. Based on the results of this experiment, the sensitivity and specificity for PCR were determined to be 75% and 74% respectively. Although the PCR process was shown to be a quicker method of detection, the Dentocult proved to be more accurate in detecting *S. mutans*.

Faculty Mentor – Scott Wright
This research was presented at the National Conference for Undergraduate Research in Lexington, Virginia (April 2005) and at the Utah Society for Clinical Laboratory Sciences Spring Seminar (April 2005).

Timing and Location of the Elastic Extracellular Matrix Protein, MAGP, in Zebrafish Embryos

Justin Harper

A specific set of proteins designed to function in tissues (such as blood vessels, lungs and skin) that undergo repeated stretching and recoil is collectively called the "elastic extracellular matrix." While the elastic extracellular matrix is comprised of multiple components, the protein upon which this study focuses is known as "microfibril associated glycoprotein," or MAGP. This study investigates the translation, timing, and deposition of MAGP in Danio rerio (zebrafish) during their embryonic development. Because very little is known about MAGP production in zebrafish during this physiologic process, the information obtained during these studies will likely contribute to the understanding of the assembly of this important protein mixture. To accomplish this we have used RT-PCR, molecular cloning, in-situ hybridization, northern blotting, gel electrophoresis and other molecular biology techniques. The project was initiated by extracting zebrafish RNA from whole embryos from different developmental stages. Using RT-PCR with degenerate oligonucleotide primers, a 300 bp probe specific for Danio MAGP was generated. The creation of these primers was accomplished by aligning known sequences of MAGP from different organisms. Initially this probe was used to analyze relative levels of MAGP through embryonic development. Whole mounted embryos were then used to assess the spatial deposition of this protein more specifically.

Faculty Mentor – Barbara Trask, Ph.D.
This research was presented at the 20th National Conference on Undergraduate Research in Asheville, North Carolina (April 2006).

Dr. Briant Stringham Jr.: Progressive Physician

Janice LeFevre

This project's purpose was to research and assess Dr. Briant Stringham Jr.'s impact on social issues and medical reform in Davis County, Utah from 1892 to 1927. I read every issue of the local newspaper—*The Davis County Clipper*—from that time period; I viewed these newspapers online, through the Utah Digital Newspapers Collection, and on microfilm housed at the Davis County Library. These newspapers augmented and enhanced extensive research that I had previously completed.

My research revealed that Stringham's influence was not only on his local community, he also impacted Utah. He served on the State Board of Medical Examiners from 1897 to 1904. This board was responsible for examining and licensing all Utah physicians, thus assuring the population that its doctors were well qualified.

Bountiful City organized its first board of health in 1894; Stringham served on it and on succeeding ones until about 1904. In this capacity, he helped write sanitation ordinances, prepared annual reports on contagious diseases, cared for indigent travelers, and purchased antitoxin. Briant was Bountiful's first quarantine officer, beginning in 1892; he also served as a Davis county quarantine officer and medical examiner.

One of Dr. Stringham's most important contributions to Davis County was his persistence in encouraging the county to create a board of health. When the county commissioners refused to create one, Briant (an otherwise staunch Democrat) and two other prominent men organized the "Citizen's Party" in 1898, whose platform was based on progressive issues such as roads and medical reform. Although his party did not win the election, the publicity and pressure placed upon the elected officials because of this campaign finally convinced the county to create a health board, which they did in December 1898.

Faculty Mentor – Stanford Layton, Ph.D.
This research was presented at the annual meeting of the Utah State Historical Society at the Salt Lake City Library in Salt Lake City, Utah (September 15, 2006).

Searching for Tertiary Companions to Eclipsing Binary Systems in the LMC

Michael Malmrose

We use a new method to search for possible tertiary companions to EB's in the MaCHO database. By binning the light-curve data and averaging the magnitude, we derive an average light curve by linear interpolation. This curve is directly compared to the observed data. The O-C phase is determined by subtracting the phase of a data point from the phase when the average curve has the same magnitude. This is done for both the primary and secondary eclipses. The O-C data are then plotted as a function of time. We use a Lomb periodogram to search the O-C data for high power signatures in a range of frequencies, yielding periods of possible tertiary companions. We phase-fold the O-C data from both red and blue filters. We currently observe the signature sinusoidal variations of a tertiary companion in two systems for both wavelengths. We suspect that these two objects are stellar in nature.

Faculty Mentor – Stacy Palen, Ph.D.
This research was presented at the APS Four Corners Meeting at Utah State University in Logan, Utah (October 6-7, 2006).

Nest Site Selection and Nesting Success of Snowy Plover at Great Salt Lake, Utah

Trina Nixon

The Great Salt Lake is one of the most important inland breeding sites for Snowy Plover (Charadrius alexandrinus) in North America. It is estimated that approximately 10,000 Snowy Plovers breed within the Great Salt Lake ecosystem representing close to 55% of the entire breeding population west of the Rockies. We examined nesting success and the factors influencing nest-site selection of Snowy Plovers during the 2003-2005 breeding seasons. Study sites were searched for nests throughout the breeding season and once located, were monitored every three to four days until either the eggs hatched or the nest failed. Following termination of the nest, we measured percent vegetative cover, maximum vegetation height, percent bare ground, density of vegetation, visual obstruction caused by vegetation, and percent rock cover. Nesting success was highly variable between sites and ranged from 24-54%. Snowy Plovers chose sites with significantly more bare ground and lower, sparser vegetation relative to unused sites. In addition, sites used by Snowy Plovers had a higher percentage of rocks less than 1 cm in size when compared to unused sites. The results of this study provide critical information on both the nesting success and habitat selection of a highly imperiled species.

Faculty Mentor – John F. Cavitt, Ph.D.
This research was presented at the Shorebird Science in the Western Hemisphere Meeting in Boulder, Colorado (February 27 - March 2, 2006).

Association of TGF Polymorphisms with Severity of Hepatitis C Virus

Masoud Rostamkhani

Hepatitis C virus (HCV) is an infectious blood-borne virus that usually persists as a chronic liver infection. There are four million people in the USA that are infected with HCV. The process HCV uses to infect the host is unknown. However, there has been increasing interest in the influence of genetic polymorphisms and whether they can identify subjects at risk of developing HCV. Several studies indicate that variants of Transforming Growth Factor-alpha and beta-1 genes stimulate the liver cell growth by inducing production of cell proteins and preventing their degradation. Our study involved Restriction Fragment Length Polymorphism (RFLP) method to analyze TGF alpha and beta-1 genes from DNA samples in HCV infected and healthy individuals. We used Polymerase Chain Reaction (PCR) to amplify the specific portions of the TGF genes from DNA samples and then used an endonuclease enzyme to cut the synthesized DNA at specific polymorphic sites and then visualized the generated bands on gel electrophoresis. Statistical Chi square analysis of the genotype frequencies between the HCV infected and uninfected individuals showed a significant association of these genes with HCV. This study demonstrated that Caucasians who have inherited these TGF alpha and beta-1 polymorphisms in their genes are genetically predisposed to have a higher chance of HCV infection.

Faculty Mentor – Scott Wright

This research was presented at the Utah Society for Clinical Laboratory Sciences Spring Seminar (April 2006) and at the Associated Society for Clinical Laboratory Scientists in Chicago, Illinois (July 2006).

$CD4^+$ T Lymphocyte Reconstitution in Gut Associated Lymphoid Tissue (GALT) and Peripheral Blood in Advanced HIV–1 Infection in the Setting of HAART

Derek L. Shenefelt, Joy M. Folkvord, Joseph Gathe, Sunita Lundy, Stephen Becker & Elizabeth Connick

Treatment of Human Immunodeficiency Virus Type 1 (HIV-1) infected individuals with highly active antiretroviral therapy (HAART) slows productive infection and initiates the reconstitution of $CD4^+$ T lymphocytes. Reconstitution of $CD4^+$ T cells is most frequently measured in peripheral blood. However, gut associated lymphoid tissue (GALT) harbors a majority of the body's CD4+ T cells. It is unclear to what extent peripheral blood mirrors immune reconstitution in GALT, and previous studies have suggested that there is less complete reconstitution in GALT than peripheral blood. Utilizing fluorescent immunostaining to detect GALT $CD4^+$ T cells in frozen lymph node sections and peripheral blood $CD4^+$ T cell counts, $CD4^+$ T cell reconstitution was assessed at baseline, 6 months and one year after initiation of HAART in 5 patients with advanced HIV-1 infection. $CD4^+$ T cell increases were numerically larger in GALT (median, 1,704 cells/mm^3/year) than in peripheral blood (median, 86 cells/mm^3/year). Furthermore, after one year of HAART the proportion of $CD4^+$ T cells as compared to controls was larger in GALT (44%) than in PBMC (11%). When $CD4^+$ T cell increases were expressed as a percentage of baseline values; however, peripheral blood $CD4^+$ T cell increases were substantially larger (460%) than those in GALT (175%). These data suggest that substantial numbers of $CD4^+$ T cells are reconstituted within GALT, and that peripheral blood $CD4^+$ T cell increases do not necessarily reflect those in GALT.

Faculty Mentor – Sam Zeveloff, Ph.D.

This research was presented at the Annual Biomedical Research Conference for Minority Students (ABRCMS) in Anaheim, California (November 2006); at the Utah Conference on Undergraduate Research (UCUR) in Salt Lake City, Utah (February 2007); and at the Conference on Retroviruses and Opportunistic Infections (CROI) in Los Angeles, California (February 2007).

Precipitation by Wetting and Drying Mechanisms Observed on Calcite and Gypsum Surfaces with Atomic Force Microscopy and Scanning Electron Microscopy and X–ray Fluorescence Microscopy

Steven Toller

Crystallization of gypsum and calcite is very common in soils of Eastern Utah. Gypsum and calcite crystallization by wetting and drying cycles occurs frequently in soils of the Utah region and deserve to be studied. Studies involving wetting and drying cycles of gypsum and calcite in such environments have been limited. Three research techniques were used to study the crystallization patterns of calcite and gypsum resulting from wetting and drying cycles in variable acidic environments on calcite and gypsum surfaces: atomic force microscopy, scanning electron microscopy, and X-ray microscopy. An AFM allows formation of a three dimensional image of a surface, ranging in size from 0.5 to 80 micrometers. The Scanning Electron Microscopy (SEM) produces higher resolution images in the order of 30 to 1000 microns, characterized by three dimensional appearances. The X-ray fluorescence microscopy allows determination of elemental composition.

Findings of this study showed that gypsum surfaces that were wetted and dried with variable solutions yielded variable crystallizations between solutions. Calcite surfaces wetted and dried with variable solutions and phosphates also showed crystallizations that varied between solutions and surfaces. Crystallization of gypsum yielded both homogeneous and heterogeneous growth. At low pH elliptical dissolution occurred. On calcite surfaces crystallization phosphates were observed to alter calcite's crystallization pattern. X-ray analysis of the tested samples was performed to provide the chemical composition of the tested samples. The results of this study could be used to preserve the integrity of gypsum and calcite containing soils which experience similar wetting and drying cycles.

Faculty Mentor – Marek Matyjasik
This research was presented at the Sigma Xi conference in Detroit, Michigan (November 4, 2006).

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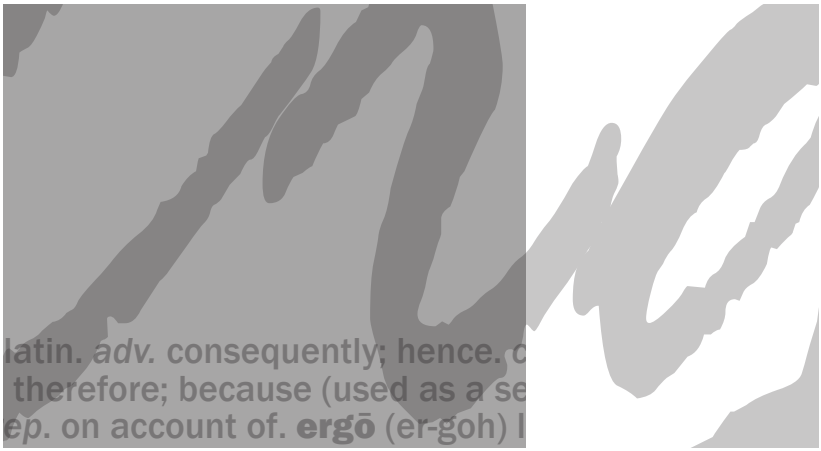

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