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Michigan

Undergraduate
Research Forum

Published by the University of
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Letter from the Editor

Dear Readers,

I would like to welcome you to the second issue of the University of Michigan Undergraduate Research Forum. The Forum is a cross-disciplinary undergraduate research journal, which we have created with the goal of showcasing the wide range of student research activities, which take place on the University of Michigan campuses. It is the goal of the Forum to join various local symposia, poster sessions, and lecture series in making research more accessible to undergraduates. We intend the Forum neither to act as the sole outlet for experienced student researchers nor as a gateway for newcomers, but we encourage both to publish in our journal so that we may bring both types of undergraduates together.

Through the past three years, the journal has flourished with submissions from student researchers, and applications from students interested in helping this fledgling tradition remain strong. We have also made several positive adjustments to our infrastructure since the unveiling of our first issue. In particular, we have expanded our journal to include the University of Michigan – Flint campus in order to add intellectual diversity to the publication. We feel that the only true way to display the strength of undergraduate research at the University of Michigan is to consider the various campuses of the University.

The production of this issue was invigorating for our editorial board and staff, as it required great coordination to ensure successful continuity in the production of our journal. It has been a pleasure working with an experienced editorial board and eager staff, who have been involved in all aspects of the journal from reviewing and copyediting the article submissions to publicizing and reviewing applications for staff and editorial board positions. I encourage all undergraduates who are interested, no matter your field of study, to apply for a position on the journal staff.

Lastly, I would like to emphasize the diversity of articles, which can be found in this issue. Our articles come from sources and departments such as the University of Michigan Biological Station, Department of Psychology, Department of Pharmacology, and Department of Sociology at UM-Flint. I also encourage our readers to take a look at our advice to undergraduates interested in pursuing a research project at the University, as well as a very informative “Letter to the Editor” submitted by the group for Biotechnology Education on Campus. With that I invite you to enjoy the Forum and encourage you to actively participate in the creation of our journal.

Thank you,



Shailesh Agarwal

Editor-in-Chief

University of Michigan Undergraduate Research Forum

Dear Colleagues,

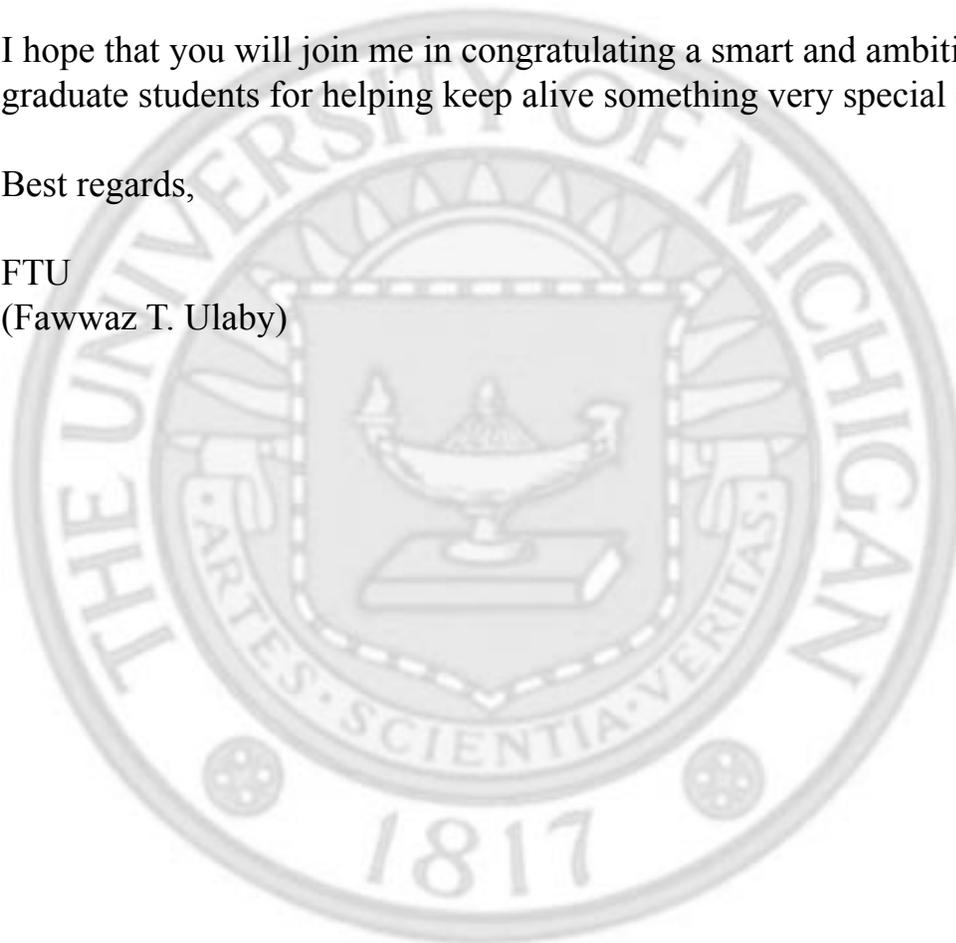
I am very pleased to welcome you as a reader of the second edition of the University of Michigan Undergraduate Research Forum. This journal -- with articles written by students, article selection and review guided by students, and journal operations overseen by students -- is another milestone in the University of Michigan's long tradition of preparing students to become the next generation of scholars and researchers. In particular, Michigan has taken great pride in providing significant opportunities for undergraduates who wish to engage in serious research.

With this second volume of the Forum, these students accomplish something that can often be more difficult than creating a new journal. That is, they have succeeded in sustaining this fine project. There is never as much fanfare for the second issue of any publication. It is a tribute to the dedication of the Forum editorial board that this issue has been published.

I hope that you will join me in congratulating a smart and ambitious group of undergraduate students for helping keep alive something very special on our campus.

Best regards,

FTU
(Fawwaz T. Ulaby)



Dear Forum Staff and Editorial Board:

I am delighted to hear that the second issue of the University of Michigan's Undergraduate Research Forum (UMURF) is about to see the light. When your group presented the first issue to the Board of Regents a year ago, I was impressed with the seriousness of the endeavor. Soon after, when I read the publication, I was impressed again—this time by the quality of the research and the writing.

It seemed clear to me that a publication that highlights undergraduate research should extend its reach to the entire university; that is, to all the campuses. When you graciously accepted my invitation to join me for lunch at UM-Flint, I was pleased to learn that you had decided to open the Forum to research by our undergraduates and that we could distribute this publication on the Flint campus. Aside from the obvious benefits of making broadly available the excellent research of University of Michigan undergraduates, this approach reinforces the understanding that we are different campuses but one university.

Congratulations on the arrival of the Forum's second issue. A full year is too long to wait for your excellent publication.

Best regards,

Juan E. Mestas

Chancellor
University of Michigan-Flint

Opinions and Advice on Undergraduate Research

The following is a compilation of opinions on research for undergraduates by the members of the Editorial Board.

What is your advice to those without research experience seeking a research position?

The massive number of research faculty on our campus offers great opportunities, although it presents great challenges as well. Many students find their first research project through a supporting program such as UROP or departmental setups. Regardless of the program, it is important for the student to take personal responsibility and be proactive in seeking advice and finding a position, which suits his or her objectives. A student with a specific interest should find and seek specific advice from senior undergraduates, graduate, or post-doctoral students in his or her area of interest. One can often ask class instructors (lecturers, GSIs, undergraduate instructors), advisors, or experienced researchers in discipline-related student groups. They may know which professors are currently accepting undergraduates for funding in the lab. Almost every department has a central webpage that leads to specific research descriptions (but often outdated) of labs. Seminars, symposia, poster sessions, news reports, and publications (such as this) are other sources which can allow one to get a general idea of the type of research being conducted in a particular field.

A lack of research experience is not a reason for worry, as principle investigators often value interest and potential commitment as well as a strong academic background. A demonstration of genuine interest in a professor's research will often be enough to encourage a professor to take the student on. If one is looking to do research at another university many places have summer undergraduate research programs, which are often geared toward assisting students with their first research experiences.

What motivated you to pursue/continue research?

Many enjoy the idea of contributing to the research community, where one's work can have lasting effects. Researchers are generally enthusiastic about their work and driven to discover new knowledge and capabilities. Research represents the exploration of a previously

uncharted intellectual territory. It is one thing to learn the fundamentals of a field, but it is another to apply these fundamentals to complex studies of tangential fields. Research provides the freedom to brainstorm, to think outside of the box, and to explore one's own ideas in a quest to solve interesting and relevant problems. An upbeat attitude and keeping the big picture in mind helps. Professors are usually happy to take on students who are going to contribute to the field of study. Furthermore, undergraduate research is an important gateway in the path to graduate work, which is almost exclusively research based in many disciplines. Without some type of in-depth research experience, it is hard for a student to evaluate whether a particular field of research is in his/her spectrum of interests. Interest in a field based on classes can vary drastically from the interest in a field based on research experience.

What was the biggest challenge that you encountered and how did you address it?

One may encounter times when observed results are not expected or trite technicalities may become discouraging. Some have the misfortune of experiencing many challenges during a research experience, while others breeze through their project. However, even if one does experience a multitude of problems, it is important to remain positive and to focus on the goals of research. Often, this requires the student to make a series of reasonable goals, which can be approached in a stepwise manner. Sometimes mistakes and surprises can lead to better opportunities. Research requires repetition, as this is the only way to ensure reliable results.

Another challenge which students often encounter in the lab in conjunction with the external challenges presented by the experiments themselves, is the challenge presented within oneself. The constant challenge for a researcher in the lab is maintaining patience. Rushing experiments and data analysis leads to skewed results and frequent repetition of experiments. The immediate goal in the lab as an undergraduate should not necessarily be to publish ASAP, but rather, to learn as much as possible. This includes learning different techniques

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in the lab, depending on the field of research, as well as learning about the various projects that are being conducted in any one particular lab. At the same token, students should not spread themselves thin, but rather they should be prepared to make an appreciable contribution to one particular project.

Some students are challenged by the massive volume of literature available on their field of research. In truth, all students are challenged by the volume of literature – some ignore it and some attempt to tackle it. It is important for a student to make an effort to tackle the literature – there is no use in conducting experiments without understanding the big picture, and to some extent the details of the project. Why are people interested in this field of research? What opportunities does this field present? Interest in reading the literature is generally a good indicator of interest in the field of research, and literature can provide hints of what the future may hold for research in the field – something which may affect the future of the student.

What you do think are the 2 or 3 most important features of a successful undergraduate researcher?

A successful undergraduate researcher brings initiative, independence, and commitment to his or her research project. Though not as experienced as graduate students, undergraduate researchers should be able to contribute innovative ideas to their projects. To become a future leader in any profession, one needs to have the ability to bring initiative and novel ideas into work. Moreover, undergraduate researchers should be independent, and be able to design and conduct their own experiments without excessive instructions from supervisors. This is instrumental in enhancing one's ability to think criti-

cally. Finally, a successful undergraduate researcher should be willing to contribute a significant amount of time on the project. Since many experiments can be time-consuming, commitment is a necessary ingredient to meaningful results. These are important qualities that can lead the student to develop a sharper mind and better decision-making skills. Furthermore, it is important for the student to be proactive in reading the literature and making an honest attempt to learn independently at least the basic knowledge necessary for the research experience to be educational. These attributes, in turn, will be crucial in increasing the chances for success in future professions, whether they are research, medicine, law, or business.

Any other research advice you've been itching to tell first-years?

Seek both role models and mentors in the principal investigator. It is to one's advantage to be socially compatible with one's boss and co-workers. Also, one should balance the amount of time spent conducting experiments and thinking. Research can only be successful with thinking and acting – performing hundreds of poorly-constructed experiments is unlikely to be successful, and constructing experiments theoretically without execution cannot yield data. Research is all about thinking and acting. Finally, one should be familiar with information technology such as Google, PubMed, and other resources provided by the University. The answers to many questions can be found in literature on these sites, and they can shave off crucial time in the development of experiments and collection of data.



Our Genetic Future: Dream or Nightmare

Sumeet Goel

Sumeet Goel is a third year undergraduate student at the University of Michigan majoring in biopsychology. He is the President and Founder of the student group Biotechnology Education on Campus (BEC) which aims to inform the public about biotechnology, emphasizing the promise of research as well as the ethical, legal, and social issues within the field. Sumeet hopes to attend medical school after graduation and is considering studying public health.

Introduction:

Unlocking the mysteries of life, advancements in genetics give us hope that we may someday use them to cure diseases and save lives. The nobility of the field cannot be argued. With new biotechnology, doctors and researchers hope to improve the quality of our food, enhance the efficacy of medication, cure illness by harvesting organs; essentially improve the quality of life. They want to end disease and make medicine perfect, flawless.

But certainly it is not that easy. Perfection is imperfection all on its own. It is much more complicated than simply finding the code to a lock. To understand the essence of life, scientists need to experiment, some would argue, with life itself. Others question our desire to know so much in the first place.

This controversy has drawn attention from all

areas, including the nation's highest offices in Congress and the White House. However, these parties have been unable to state the facts about stem cells and advancements in genetics, making the public largely unaware of many details on the subject. This article hopes to answer questions and correct misconceptions about two major topics in biotechnology: stem cells and personalized medicine (pharmacogenomics).

Stem Cells: What are they?

Stem cells have been a major topic in the media and were recently a primary issue in the latest presidential election. Stem cells are important because they differ from other kinds of cells in the body. All stem cells—regardless of their source—have three general properties: they are capable of dividing and renewing themselves for long periods; they are unspecialized; and they can give rise to specialized cell types. There are two types of stem cells, embryonic and adult.

Embryonic Stem Cells:

Embryonic stem cells, as their name suggests, are derived from embryos. Specifically, embryonic stem cells are derived from embryos that develop from eggs that have been fertilized *in vitro*—in an *in vitro* fertilization clinic—and then donated for research purposes with informed consent of the donors. They are *not* derived from eggs

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fertilized in a woman's body. The embryos from which human embryonic stem cells are derived are typically four or five days old and are a hollow microscopic ball of cells called the blastocyst. Most of the political controversy regarding the usage of embryonic stem cells revolves around the question, "is an *in vitro* egg a life?" This question challenges the age-old abortion issue with a new angle on procreation involving scientific manipulation.

Adult Stem Cells:

Adult stem cells are undifferentiated cells found among differentiated cells in a tissue or organ. They can renew themselves, and can differentiate to yield the major specialized cell types of the tissue or organ. The primary roles of adult stem cells in a living organism are to maintain and repair the tissue in which they are found. Some scientists now use the term somatic stem cell instead of adult stem cell. Unlike embryonic stem cells, which are defined by their origin, the origin of adult stem cells in mature tissues is unknown. Adult stem cells are thought to reside in a specific area of each tissue where they may remain quiescent (non-dividing) for many years until they are activated by disease or tissue injury. The adult tissues reported to contain stem cells include brain tissue, bone marrow, peripheral blood, blood vessels, skeletal muscle, skin, and liver tissue. Scientists in many laboratories are trying to find ways to grow adult stem cells in cell culture and manipulate them to generate specific cell types so they can be used to treat injury or disease. Some examples of potential treatments include replacing the dopamine-producing cells in the brains of Parkinson's patients, developing insulin-producing cells for type I diabetes and repairing damaged heart muscle following a heart attack with cardiac muscle cells.

Scientists are still trying to answer the following questions about adult stem cells. Until these questions are answered, an applicable clinical stem cell therapy will be difficult to implement.

- How many kinds of adult stem cells exist, and in which tissues?
- What are the sources of adult stem cells in the body? Are they "leftover" embryonic stem cells, or do they arise in some other way? Why do they remain in an undifferentiated state when all the cells around them have differentiated?
- Do adult stem cells normally exhibit plasticity, or do they only transdifferentiate when scientists manipulate them experimentally?
- Does a single type of stem cell exist—possibly in the bone marrow or circulating in the blood—that

can generate the cells of any organ or tissue?

- What are the factors that stimulate stem cells to relocate to sites of injury or damage?

What is the Difference between Embryonic and Adult Stem Cells?

Human embryonic and adult stem cells each have advantages and disadvantages regarding potential use for cell-based regenerative therapies. Adult and embryonic stem cells differ in the number and type of differentiated cell types they can become. Embryonic stem cells can become all cell types in the body. Adult stem cells are generally limited to differentiating into different cell types of their tissue of origin. However, some evidence suggests that adult stem cell plasticity may exist, increasing the number of cell types a given adult stem cell can become.

A potential advantage of using stem cells from an adult is that the patient's own cells could be expanded in culture and then reintroduced into the patient's body. The use of the patient's own adult stem cells would mean that the cells would not be rejected by the immune system. This represents a significant advantage, as immune rejection is a difficult problem that can only be circumvented with immunosuppressive drugs. Embryonic stem cells from a donor introduced into a patient could cause transplant rejection. However, whether the recipient would reject donor embryonic stem cells has not been determined in human experiments.

Controversy:

In the case of embryonic stem cell research, the end that scientists hope to achieve is the relief of human suffering. That this is a humanitarian and worthy end is not in dispute. The controversy is about the means: namely, the consumption of donated embryos. More particularly, embryonic stem cell research and therapy would use donated embryos that, by virtue of donor instructions, will never enter a uterus. Is it moral to use this means to try to relieve human suffering? Ancient religious texts provide little guidance. The ancients did not understand embryology, did not imagine that scientists might create and nurture what we now understand as embryos in the laboratory. Nor can we get an answer from laboratory experiments. There is no test for whether an embryo is a person. Instead, we are left to our own devices, to our own moral reasoning.

Current Policy:

On August 9, 2001, President George W. Bush

announced that federal funds may be awarded for research using human embryonic stem cells if the following criteria are met:

- The derivation process (which begins with the destruction of the embryo) was initiated prior to 9:00 P.M. EDT on August 9, 2001.
- The stem cells must have been derived from an embryo that was created for reproductive purposes and was no longer needed.
- Informed consent must have been obtained for the donation of the embryo and that donation must not have involved financial inducements.

This policy was considered a compromise between parties for and against embryonic stem cell research. However, it placed serious constraints on the feasibility of such research within the United States; most researchers rely heavily on federal funding. This legislation is not an end-all for stem cell research, as the NIH's official interpretation of Bush's policy (August 2002) stated that there were 78 eligible lines. However, this policy only involved government funding and embryonic stem cell research continues unregulated among privately funded laboratories.

Legal Situation:

Human Cloning Prohibition Act of 2001 and 2003: The bill seeks to prohibit both therapeutic and reproductive cloning by making it illegal to perform or attempt to perform human cloning, to participate in an attempt to perform human cloning, and to ship or receive an embryo produced by human cloning. The Senate did not act on the bill, and therefore no legislation has resulted from the passage of this bill. Opposing bills were introduced before the 2001 and 2003 votes that would ban reproductive cloning, but legalize therapeutic cloning.

State Regulation: Seven states (California, Michigan, Louisiana, Rhode Island, Virginia, Missouri, and Iowa) have laws against cloning, which range from restriction of state funding of research to restriction of the conduct of therapeutic and reproductive cloning research.

UN Cloning Ban: In 2004, the United Nations attempted to impose a worldwide ban on human cloning research and practices. This proposition, however, reached stiff opposition from the Bush administration because the United States was seeking a broader resolution banning embryonic stem cell research entirely. The UN has since dropped the resolution and has left the issue unresolved.

Pharmacogenomics (Personalized Medicine):

Pharmacogenomics examines how a person's genetic makeup affects his or her response to drugs. Researchers in the field are working on applying human genome knowledge to pharmaceuticals by identifying genes that account for varying drug reactions in different people. Eventually, they hope to be able to customize drug therapies for specific patient populations or even individuals. Currently, much of the research in the field of pharmacogenomics is focused on genes encoding either metabolic enzymes that can alter a drug's activity or defective structural proteins that result in increased susceptibility to disease.

How Pharmacogenomics Could Change the Way Medicine is Practiced Today:

Currently, physicians prescribe medication through a trial-and-error method of matching patients with the right drugs. If the prescribed medication does not work for the patient the first time, the physician will try a different drug or dosage, repeating the process until the patient improves. As pharmacogenomics becomes more advanced, physicians eventually will be able to prescribe medication based on an individual patient's genotype, maximizing effectiveness while minimizing side effects.

Anticipated Benefits of Pharmacogenomics:

Eventually, pharmacogenomics will provide tailored drug therapy based on genetically determined variation in effectiveness and side effects. This will mean:

More powerful medicines:

- Pharmaceutical companies will be able to produce therapies more targeted to specific diseases, maximizing therapeutic effects while decreasing damage to nearby healthy cells.

Better, safer drugs the first time:

- Recovery time will go down and safety will go up as the likelihood of adverse reactions goes down or is eliminated altogether.

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More accurate methods of determining appropriate drug dosages:

▪ Current methods of basing dosages on weight and age will be replaced with dosages based on a person's genetics - how well the body processes the medicine and the time it takes to metabolize it.

Better vaccines:

▪ Vaccines made of genetic material, either DNA or RNA, could provide the benefits of existing vaccines without all the risks. Theoretically, they would be able to activate the immune system but would be unable to cause infections.

Economic benefits:

Pharmacogenomics eventually can lead to an overall decrease in the cost of healthcare because of decreases in the:

- number of adverse drug reactions,
- number of failed drug trials,
- time it takes to get a drug approved,
- length of time patients are on medication,
- number of medications patients must take to find an effective therapy, and
- effects of a disease on the body (through early detection).

Some Ethical Issues:

Ethical Issue #1: "Good" or "Bad" Allocation of Scarce Resources?

- Many believe that pharmacogenomics, like other new fields spawned by the Human Genome Project, represents a misallocation of resources. Global efforts should be directed towards solving more urgent problems facing humanity, such as global famine and accessibility to potable water.
- However, opposing forces arguing in favor of pharmacogenomics state that:
 - In the U.S. alone, adverse drug reactions are thought to kill about 100,000 hospitalized patients annually. Another 2.2 million incur serious, but non-fatal, reactions. Physicians, in view of their Hippocratic Oath, are obligated to do no harm. Can physicians fulfill this obligation when the information available regarding the effectiveness of particular medicines is so meager?
 - This situation is further compounded by the fact that most adverse drug reactions result from the

fact that medicines are a "one-size-fits-all." In other words, although medicines are taken in different dosages depending on symptoms, patient age, weight and other clinical factors, these criteria may not be adequate in ensuring that a particular medicine will be safe and effective for a particular individual. Until recently, there has been no alternative to either developing or prescribing medicines.

Ethical Issue #2: Are Genes Really the Answer?

• Genes are not the only key to cures. Environment plays a role, too. Dietary and lifestyle behaviors are still likely to affect the safety and efficacy of medicines for particular individuals. Additionally, variation in drug response is not limited to micro polymorphisms. Environmental factors also play a role (such as sun exposure, drug/drug interaction, drug/food interaction). Additionally, scientists are poised to uncover why the metabolism of particular individuals absorbs and dispels pharmaceuticals in a particular manner.

Ethical Issue #3: Whose Right Predominates?

• The father of a tested subject opened a letter addressed to his child and learned that his child was susceptible to an x-linked genetic disease, thereby stating that the child's father was also susceptible. The father feels his privacy has been invaded, since he was not the one who consented to being tested.

Legal Situation:

The State of Michigan has employed a relatively cautious approach to genetics legislation as compared to other state legislatures. It has defined genetic testing as: "information about a gene, gene product or inherited characteristics derived from a genetic test, including family history" and has banned discrimination in health insurance and employment based on genetic testing.

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The Bohemian Club: An Empirical Investigation of the Power Elite

Brian Kamal
Mentor: Dr. Roy Barnes

Brian Kamal is a first year law student at Thomas M. Cooley Law School. The author has also written a work entitled, "Games, Ethics, and Reification," that deals with the origins of legal corporate personhood. That work was published in the 2003 edition of the Meeting of the Minds Journal.

Abstract

Social networking patterns pervade societal institutions. This academic endeavor empirically examines the link between one's participation in an exclusive social club (in this case the Bohemian Club), and one's occupation, which is discerned by examining that member's respective biographical information as stated in *Marquis Who's Who in America*. Through data analysis of the Bohemian Club membership lists coupled with biographical referencing of *Marquis Who's Who in America* lists, the aim is to examine the relationship between specific occupational attributes (e.g., business, professional, etc.) and membership in the Bohemian Club. The hypothesis is that there is a strong, positive correlation between being a member of the Bohemian Club and one's occupational attribute.

Introduction

Social networks pervade society and act as a mechanism for cohesion, information exchange, pathways of power, and economic transactions. Each party in these social networks gains something through its relationship with the other. Examples of social networks include alliances between parents and teachers, coalitions between military personnel and businesspersons, and partnerships between businesspersons and politicians.

This article will examine one such social network, the Bohemian Club, as a representative sample of the more general category of the power elite, and will measure the change in occupational composition of those members of the elite from the 1960's to the 1980's [1,2].

The Bohemian Club, a somewhat secretive institution, serves to foster group cohesion among the members

of the ruling elite (though the pertinent data cannot address this issue). This club is hidden from the public purview, and membership is difficult to attain. It is comprised of various influential people, including former presidents, congressional representatives, foreign ambassadors, businesspersons, educators, and lawyers. Under the guise of a recreational club, this institution allows for information transfer among some of the most influential Americans. *Marquis Who's Who in America* will serve as a biographical frame of reference to occupational information about these members of the power elite [3,4].

Literature Review

Pluralism

The pluralist model of American governance argues that the key features of democracy are interest groups and a decentralized governmental infrastructure. Scholars, such as political scientist Robert Dahl, claim that the basic rule of pluralism is that power is not centrally concentrated, but rather is diffuse and balanced out among competing factions so that no one group dominates the others. Divided authority, decentralization, and open access are the key aspects of pluralism [5].

One example of decentralization would be where a compromise is made to resolve a dispute between competing entities. Suppose that there are two locales adjacent to one another, City A and Town B. City A is a densely populated, industrial city whereas Town B is a rural agrarian town that is sparsely populated. Presume that a river runs along the border between the two geographic regions. Rather than granting one or the other exclusive control over the river, a governmental body exercising dominion over both would order the two entities to share the river. Such an apportionment would arguably be conducive with the pluralist model.

Another example of the pluralist model at work would be the United States Congress. The structure of this federal legislative body is intended to create a diffusion of power by creating two different sub-structures within

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Congress: the House of Representatives accords legislative seats in proportion to the states' comparative populations as measured by the Census, whereas the Senate proportions legislative seats equally among states irrespective of population (each state has two senators). It was thought that such a juxtaposition of sub-structures would create less concentration of power among states because legislative proposals must generally be ratified by both houses to become law.

As an ideal model of how democracy ought to work, this theory seems plausible, but as a reflection of how American governance usually operates in action, it seems misguided. It is true that when countervailing interests compete, one side will not always completely overpower the other. However, even when power is shared among various political groups, it is clear that some groups will dominate (politically, economically, etc.) over others. Therefore, the pluralist theory often misses the mark.

The Power Elite

Various scholars contend that a small percentage of the American population holds a disproportionate amount of power [6,7,8,9]. More specifically, power elite theory holds that the United States government is an oligarchical system, which means that a few powerful groups dominate over and impose their wills on the general population [5].

According to the power elite theory, "wealth dominates politics" [5]. Though oligarchies are not necessarily a negative conception, such consolidation of power often leads to dire societal consequences. When great masses of wealth become concentrated in the hands of a few individuals, essential societal elements increasingly become commoditized. According to the Gini coefficient, a figure utilized by economists to determine comparative wealth distribution, in 1993 the wealthiest 30% in America possessed 52.5% of disposable income whereas the poorest 30% possessed a meager 11.8% of disposable wealth (the disparity is presumably increasing over time) [10]. That is to say, essential goods and services (such as life-saving medicine and medical treatment) become things to be bought and sold on the "market." Many of these medicines are cost-restrictive, which means only those who can afford to pay have "legitimate" access to the drug (by legitimate it is meant legal recognition under the law). Consequently, a conflict arises as to whether all individuals within a society have access to such goods, or whether only those with enough wealth can buy such goods. As resources become increasingly scarce and competition ensues, each party strives to protect and promote its interests. Because these interests are structured in an irreconcilable fash-

ion, the most frequent result of such conflicts is that the more powerful factions impose their wills at the expense of less powerful groups within society. The effect of such domination is exemplified in the precise nature of private property, or personal ownership, which grants individuals power and control over tangible, physical items and abstract ideas (*e.g.*, cars, houses, copyrights, patents, etc.). For the intents and purposes of the present study, the members of the Bohemian Club represent the 'fortunate few' because they possess utterly disproportionate amounts of power.

The question may be raised, who are these 'fortunate few' that hold a disproportionate amount of wealth, status, and power? Sociologist C. Wright Mills coined the phrase, "the power elite," to describe "the select individuals who are in command of the major hierarchies and organizations of modern society, *e.g.*, corporations, government, and the military" [7].

Mills's triangle of power, also known as the Big Three, includes the economy, the political order, and the military establishment [7]. Following the lead of Mills, sociologist Domhoff reformulated the previous notion of the power elite to include a fourth element, the ideological establishment [8]. These entities rely on one another and interact with one another [8]. Under Domhoff's model, the ideological network is concerned with the perpetuation of worldviews, the economic network creates social classes and exerts control over such economic processes as consumption and distribution, the military network oversees "organized physical violence," and the political network regulates territorial borders [8].

A crucial factor in differentiating the power of social networks, like those mentioned by Domhoff and Mills is the ability to find access points [8]. One aspect of access points is that an individual or a group has the ability to communicate with another group or individual. Take the case of Vice President, Dick Cheney, and his relationship with Halliburton as a former CEO. Through its previous professional ties with the Vice President, that company has access to him.

A more important aspect of access is the ability to influence outcomes. In the past, when consumer advocates pushed for increased safety in automobiles via air bags, automobile corporations successfully lobbied to prevent the enactment of legislation requiring installation of such safety measures. Because of their power, the Big Three automakers were able to delay such legislation for years:

Auto manufacturers fought a long and hard war against air bags from 1969 to 1988, despite evidence that they were technically feasible and would save thousands of lives. The Supreme Court found in a 1983 suit over the Reagan administration's revocation of the airbag

standard that, ‘the automobile industry waged the regulatory equivalent of war against the air bag and lost — the inflatable restraint was proven sufficiently effective [...] the industry was not sufficiently responsive to safety concerns’ [11].

This phenomenon indicates that corporate entities do have the power to delay, alter, or eliminate potential legislation that would be beneficial to society. The lobbying efforts of automobile companies show the potential for successful response to the desires of the elites, in this case, the delay of legislation requiring air bags, which some elites found to be financially burdensome.

Though the automobile industry succeeded in delaying air bag legislation for a significant period, pluralists would argue that another interest eventually trumped the interest of the automobile industry. Specifically, the interest of insurance companies to have air bags in cars prevailed over the automobile industry’s interest against such measures. The power elite model would depict this as a battle between two powerful entities where one side eventually won over another. Proponents of power elite theory would go on to say that air bag legislation may never have been enacted if a powerful group such as the insurance industry did not have a stake in this issue.

Understanding the methods by which the ruling class perpetuates its ideology is fundamental to understanding societal machinations. Education is one such conduit for capitalist ideology. This manifests itself in the hegemonic mode of function of educational institutions: “The intellectuals are the dominant group’s ‘deputies’ exercising the subaltern functions of social hegemony and political government” [12]. Intellectuals serve as conduits for the elite; using their selective focal points, they influence what society does or does not think about and sometimes how society thinks about people. A primary example of a distortion of history so that atrocities of the past are marginalized or even unstated to suit the purposes of the state and capitalism is the case of Christopher Columbus, a figure frequently venerated and romanticized in educational and social settings. Common accounts of the explorer examine his art of persuasion and his accidental success in allegedly “discovering” America. In contrast, scant attention is devoted to the fact that Columbus and his crew were responsible for the death of Native Americans in shocking numbers. Consequentially, Americans typically learn only of the legendary greatness of Columbus, but not of the genocide perpetrated by him and his crew. This illustrates that educators have the ability to shape lasting definitions of reality, regardless of their accuracy:

To emphasize the heroism of Columbus and his successors as navigators and discoverers, and to de-emphasize

their genocide, is not a technical necessity but an ideological choice. It serves—unwittingly—to justify what was done. [...] [T]he easy acceptance of atrocities as a deplorable but necessary price to pay for progress (Hiroshima and Vietnam, to save Western civilization) [...] is still with us. [...] The treatment of heroes (Columbus) and their victims (the Arawaks)—the quiet acceptance of conquest and murder in the name of progress—is only one aspect of a certain approach to history, in which the past is told from the point of view of governments, conquerors, diplomats, leaders. It is as if they, like Columbus, deserve universal acceptance [13].

The institution of telecommunications also perpetuates capitalist ideology. In particular, the mass media often serves as a mechanism to bombard citizens with messages favorable to capitalism:

[T]he [...] [elite] media that [...] set [...] [the] agenda [...] are corporations ‘selling’ privileged audiences to other businesses. [...] Furthermore, those who occupy managerial positions in the media [...] belong to the same privileged elites, and might be expected to share the [dominant capitalist] perceptions, aspirations, and attitudes of their associates, reflecting their own class interests as well. Journalists entering the system are unlikely to make their way unless they conform to these ideological pressures, [...] those who fail to conform will tend to be weeded out by familiar mechanisms [14].

In addition to the ideological importance of the institution of education and the mass media, the power elite depend on some level of class cohesion with other members of the capitalist class as illustrated by the reciprocity generated through the social networking of corporate directors. Social networks are comprised of relationships based on reciprocity:

Generalized norms of reciprocity among CEO’s who also serve as outside board members may represent a primary, social psychological mechanism hindering increased board independence. [...] generalized norms of reciprocity refer to the situation in which ‘an individual feels obligated to reciprocate another’s action, not by directly rewarding his benefactor, but by benefiting another actor implicated in a social exchange situation with his benefactor and himself’ [15].

The crucial factor in such an exchange is that the two parties be of equal status and of equal prestige [15].

Research Questions

One research question for this endeavor was who were the members of the Bohemian Club? Second, how

Research Articles

has the occupational composition of the power elite changed from the 1960's to the 1980's?

Methods

For this endeavor, the Bohemian Club is assumed to represent a segment of the power elite. Occupational composition is studied in the two time periods for those members who are listed in *Who's Who* in order to detect any major changes.

In order to answer these questions, several data sets were assembled, including the following: Bohemian Club membership lists for the years of 1964 and 1986 and *Marquis Who's Who in America* for 1964 and 1986. Once the Bohemian Club data sets were compiled, *Marquis Who's Who* list was examined to determine which Bohemian members were also listed in the *Who's Who* list. Four primary empirical questions were investigated. First, what were the occupational attributes of Bohemian Club members? Second, did membership in the Bohemian Club increase, decrease, or stay about the same? Third, what percentage of Bohemian Club members was listed in *Who's Who*, and did the percentage change over time? Fourth, of those Bohemian Club members listed in *Who's Who*, what percentage self-reported their membership in the Bohemian Club, and did this percentage change over time?

Results

The percentage of Bohemian Club membership listed in *Who's Who* declined from 1964 to 1986. The percentage of Bohemian Club members listed in *Who's Who* indicating membership declined drastically. It is difficult to ascertain how representative the samples are because information regarding this social organization is so limited and because little is known about roughly 85% of the subjects in 1986 and 78% in 1964 because their biographical information is not available in *Who's Who*. Self-reporting appears to be declining over time [Table 1]. Such a decrease may be attributable to a number of factors such as inaccuracy in the listings, a strong desire for privacy, and/or fear of public disclosure.

A surprising finding of this data was that the percentage of Bohemian Club members listed in *Who's Who* as having the business/corporate executive attribute declined from 50% in 1964 to 38% in 1986. Another interesting finding was the increase from 1964 to 1986 of Bohemian Club members listed in *Who's Who* who possessed the culture/entertainment attribute: 9% of members listed in *Who's Who* in 1964 compared with 14% in 1986. A similar pattern occurred with regard to the education/science attribute: 13% of members listed in *Who's Who* for 1964 compared to 17% in 1986. There was also an increase in

Bohemian Club members listed in *Who's Who* possessing the lawyer/professional/engineer attribute over time: 20% in 1964 compared with 24% in 1986. The percentage of members listed in *Who's Who* with the government/military attribute changed negligibly. Taken together, Bohemian Club members with Business/Corporate Executive, Education/Science, and Lawyer/Professional/Engineer attributes account for approximately 75% of all Bohemian Club members listed in *Who's Who*. If the Cultural/Entertainment attribute is added, over 90% of all Bohemian Club members listed in *Who's Who* are accounted for [Table 2].

Discussion

It is unclear whether these findings are representative of a general trend or if they represent an aberration. The sample size of this endeavor is small and may therefore not be representative of Bohemian Club members as a whole. Additionally, Bohemian Club membership lists exist for the years of 1972 and 1990. If these data sets are analyzed, they may give greater credence to claims about trends over time. Further research on this matter should involve compiling the other two lists and attaining occupational information about the members via the *Who's Who* list.

From the data collected here, it may be concluded that occupations of the Bohemian Club members listed in *Who's Who* were comprised mostly of lawyers, physicians, scientists, businesspersons, CEOs, politicians, judges, professors, bankers, venture capitalists, and so on.

Also desirable would be more information about all Bohemian Club members since the organization's inception as well as all their respective occupations. Given the somewhat secretive nature of the Bohemian Club, the lack of a more comprehensive biographical frame of reference, and given the relatively limited scope of this research, these shortcomings are currently difficult to resolve.

Acknowledgements

This work was done in consultation with Dr. Roy Barnes, Professor of Sociology at the University of Michigan-Flint in conjunction with the University of Michigan-Flint Office of Research, which awarded the said author and co-author a Research Initiative Partnership. Research assistant Rachel Sharrard edited errors in the data. The author would like to thank Dr. Roy Barnes for his patience and assistance, the Office of Research, and the Philosophy, Political Science, and Sociology Departments for their continuous encouragement of his endeavors. The author would also like to thank his family and friends for their endless support and affection.

Table 1: Who's Who Coverage of Bohemian Club Members

| | Year | |
|---|------|------|
| | 1964 | 1986 |
| Number of Members in the Bohemian Club | 1927 | 2300 |
| Number of Members Listed in <i>Who's Who</i> | 424 | 355 |
| Percent of Members Listed in <i>Who's Who</i> | 22.0 | 15.4 |
| Number of Members Listed in <i>Who's Who</i> | 424 | 355 |
| Number of Members Listed in <i>Who's Who</i> Indicating Membership in Bohemian Club | 299 | 199 |
| Percent of Members Listed in <i>Who's Who</i> Indicating Membership in Bohemian Club | 70.5 | 56.1 |

Table 2: Occupations of Bohemian Club Members as Listed in *Who's Who*

| | Year | | | |
|------------------------------|------|--------|------|--------|
| | 1964 | | 1986 | |
| | N | % | N | % |
| Business/Corporate Executive | 212 | 50.00 | 134 | 37.75 |
| Cultural/Entertainment | 38 | 8.96 | 49 | 13.80 |
| Education/Science | 57 | 13.44 | 61 | 17.18 |
| Government/Military | 32 | 7.55 | 25 | 7.04 |
| Lawyer/Professional/Engineer | 85 | 20.05 | 86 | 24.23 |
| Total | 424 | 100.00 | 355 | 100.00 |

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Classroom Organizational Practices and Home Literacy Environment Affecting First Graders' Early Reading

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Mentors: Dr. Carol Connor and Dr. Frederick Morrison

Abstract

This study examined how teachers' organizational practices and children's home literacy environment related to first graders' early reading skills. To obtain the results for this study, 104 first graders across 44 classrooms were assessed using standardized reading evaluations in both the fall and spring. Home literacy environment was examined using a questionnaire completed by the parents of the first graders regarding parenting practices and beliefs. Results demonstrated that both the teachers' classroom organizational practices and the home literacy environment were associated with improvements in children's reading recognition scores in the spring from previous baseline measurements in the fall.

Introduction

In recent studies, researchers observed that the most efficient teachers in their studies were those who had smooth and brief transitions (while switching between different academic subjects) and fewer interruptions so that more class time could be devoted to academic activities [1]. These teachers frequently provided clear instructions and organized classroom procedures for their students, which appeared to help students stay organized during classroom time. The time that teachers spend familiarizing their students with classroom procedures, organizing the class for certain assignments, and clarifying the objectives of these activities for their students, is referred to in this study as "orient-organize" [1]. These practices appear to help students focus on learning by helping them understand the tasks to be accomplished. Moreover, in an organized class, teachers have more time to focus on educational activities and to address individual student needs, which relates to student outcomes although there is little research evidence regarding this issue [2]. In this study, we examine the effect of teachers' classroom organizational practices on students' early reading abilities.

There is converging evidence that classroom instruction and parenting both influence children's literacy

development [3]. Parental support of children's literacy development involves not only learning opportunities such as shared book reading but also the three critical parenting dimensions: (1) home literacy and language environment, (2) warmth and responsiveness, and (3) control and discipline. Studies show that these dimensions directly or indirectly affect the child's cognitive growth. Home literacy and parenting practices strongly predicted children's academic achievement even beyond the first grade [3]. Research suggests a positive correlation between mothers' warmth and sensitivity, which refers to how a mother emotionally responds to her children, and cognitive and language skills for children in preschool, kindergarten, and the first grade. In fact, researchers argue that these three dimensions apply to both parents, not just to mothers. The following effective parent-child interactions influence a child's cognitive development: parents' participation in problem-solving tasks with their child, regulation of information shared between adults and children, and encouragement of a child's exploratory tendencies [3]. In addition, while parents' control/disciplinary behaviors did not directly predict literacy outcomes, these actions were significantly related to a child's social interaction (*e.g.*, cooperation, independence, and responsibility), which was then linked to academic performance [4]. For instance, authoritative parenting is often associated with the endorsement and upkeep of higher levels of academic competency and school adjustment in children, whereas non-authoritative parenting styles are associated with the accumulation over time of adverse effects such as poorer classroom engagement and inconsistent homework completion [4]. These findings show how influential parenting can be on children's literacy skills, particularly in the younger years. In this study, we examine the effect of home literacy environment: What are the effects of orient-organize in a child's classroom and home literacy environment on his or her early reading performance? We anticipate that organized classrooms and strong home literacy environments will predict stronger reading outcomes in first graders' early reading levels.

Table 1: Summary of individual child assessment findings.

Descriptive information for PIAT-R gain scores.

| | Number Measured | Mean | Standard Deviation |
|---|-----------------|---------|--------------------|
| Growth in reading recognition raw score | 108 | 16.3611 | 10.08141 |
| fy1 PIAT RRR raw score | 108 | 23.27 | 13.140 |
| sy1 PIAT RRR raw score | 108 | 39.63 | 15.225 |

Methods

Participants

In this study, 104 first grade children and 44 certified teachers were recruited from schools within the same urban-fringe community of a large city in the Midwest; 44% of the children in the study were boys, 38% of the children in the study were African American and the remaining 62% were Caucasian. Furthermore, the child's socioeconomic status, which is the combination of economic and social factors that describe his or her family's level of income, education, and occupation, was based largely on his or her mother's years of education because it was assumed that the more education the mother had, the more she could promote literacy at home. The mother's year of education for this study was approximately 16 years on average (SD = 3.10). All the teachers in this study were certified by the state to teach elementary school students in grades kindergarten through fifth.

Individual Child Assessment

The children in this study were assessed in both fall and spring using the Peabody Individual Achievement Test-Revised (PIAT-R). The PIAT-R measures the recognition of printed letters and the ability to read words aloud. Children's growth in reading recognition from fall to spring was measured by their spring PIAT-R raw score (fy1 PIAT RRR raw score) minus fall PIAT-R raw score (sy1 PIAT RRR raw score). For descriptive information, see Table 1.

Parent Questionnaire: Home Literacy

A parenting practices and beliefs questionnaire measured the home literacy environments of first grade children. The parenting questionnaire contained 45 questions related to parental beliefs and practices with regard to child rearing. The survey included questions regarding the frequency of library card usage, the number of adult and child magazine subscriptions, the number

of newspaper subscriptions, how often the family read together, the number of children's books, the hours of television the child watched per week, and how frequently the parents themselves read [5].

Instructional Classroom Variables

Classroom variables were measured through classroom observations over the course of the school year, which occurred during three all-day sessions in the fall, winter, and spring [2]. For this study, only the fall observation variables were used. Trained observers recorded a description of the school day as well as a measure of the amount of time spent on specific instructional activities. The classroom variables were time the teachers spent in orient-organize (orient-organize FY2) in the spring; non-instructional time (transition, non-instructional FY2); disruption, non-instructional time (disruption, non-instructional FY2); and the time the teacher spent in management/discipline (management/discipline FY2). For descriptive information, see Table 2 (all variables are in minutes).

Analytic Strategy

Correlations and multiple regression using SPSS v11.5 (Statistical Package for the Social Sciences) were utilized to examine the relations among child, home, and classroom variables.

Results

Gains in PIAT-RR (reading recognition gain) were positively correlated with time spent in orient-organize ($r = .195, p < .05$). Thus, when teachers spent more time in orient-organize in the fall, students demonstrated greater gains in reading recognition scores. In addition, reading recognition gain was significantly positively correlated with the home literacy environment score ($r = .201, p < .05$). Therefore, children with parents who provided enriching home-literacy environments demonstrated greater reading recognition gains than did children whose parents did not provide home environments as rich in

Table 1: Summary of instructional classroom variables findings.

Descriptive information for classroom variables.

| | Number Measured | Mean | Standard Deviation |
|-----------------------------------|-----------------|---------|--------------------|
| Orient-organized FY2 | 108 | 19.2593 | 6.89761 |
| Transition, non-instructional FY2 | 108 | 54.4722 | 15.56443 |
| Disruption, non-instruction FY2 | 108 | .7404 | 1.53081 |
| Management/discipline FY2 | 108 | .7870 | 1.86483 |

Note: all instructional variables represent minutes per day.

literacy materials. Furthermore, a mother's education (in years) was significantly positively correlated with the home literacy environment score ($r = .551, p < .01$). This suggests that mothers with more years of education may be more likely to provide literacy-enriched home environments with activities that enhance their children's reading development.

Time spent in orient-organize was negatively correlated with transition, non-instruction ($r = -.372, p < .01$), and management/discipline ($r = -.310, p < .01$). This means that when teachers spent more time in orient-organize, less classroom time was spent on non-instructional transitions (such as switching between academic subjects) and disciplinary actions.

Multiple regression, with reading recognition gain as the outcome, revealed that when the home literacy environment score and orient-organize were used as predictors, both independently predicted reading gains (orient-organize coefficient = .29, $t = 2.071, p = .041$; home literacy environment score coefficient = .64, $t = 2.144, p = .035$). This demonstrates that both the classroom organizational practices and home literacy environment predict first graders' early reading independently, while controlling for the effect of mother's education.

Limitations

The statistics used in this study were calculated using regression instead of Hierarchical Linear Modeling (HLM). This is a limitation because regression treats each child in the study as being in a separate classroom, which is not the case in this study. In this study, there were 104 children divided over 44 classrooms. This means that some classrooms contained more than one target child in the study. Therefore, the nested nature of the data means that we cannot assume each child to be independent from the other students in his or her classroom because they share a classroom environment. However, these suggestive relations among classroom time, home literacy environments, and children's reading outcomes should be further investigated.

Discussions

This study reveals that students with teachers who spent more time in orient-organize activities in the fall exhibited significantly greater growth in reading recognition in the spring than did students whose teachers spent less time in orient-organize activities, taking into account the influence of the home literacy environment. Furthermore, teachers who spent more time in orient-organize activities, spent less time in both non-instructional transition and management/discipline activities. This orient-organize time is the time that teachers spent familiarizing their students with classroom procedures, organizing the class for certain assignments, and clarifying the objectives of these activities for their students [6]. In addition, parents who incorporated literacy successfully into their child's home life also had a positive effect on their child's early reading skills.

There are several possible explanations for these results. As the results exhibit, teachers who were more organized spent less time in non-instructional transition and management/discipline; thus, these teachers maximized the time that students spent participating in academic activities, such as working on assignments. These teachers minimized their time in transitions, and decreased the amount of time that children took to start activities, had nothing to do, or behaved inappropriately [7]. It may be that by orienting students to learning activities and organizing the classroom, first-grade teachers were able to spend more time on language arts each day, which may have then increased the early reading growth of their students.

In addition, a positive measure of students' self-regulation or work-related social skills (e.g., following directions, participating appropriately in groups, and taking on tasks) predicts growth in mathematics and reading skills between kindergarten and the second grade [8]. Could the time teachers spend organizing their students affect their reading levels in the early elementary grades, perhaps by improving the students' self-regulation skills? This may be the case, especially in the first grade when

most children have had at least one year to participate in a formal classroom environment; however, there is little research evidence to support this claim.

Researchers Morrison and Connor [9] provide further insight as to why more time spent in orient-organize is related to greater student decoding growth. They studied the effects of different teaching patterns on growth in vocabulary and decoding skills, which are the skills that children use to translate alphabet letters into familiar syllables and words. The two teaching patterns studied were teacher-managed explicit instruction and child-managed implicit instruction. Teacher-managed instruction included activities in which the teacher focused directly on the components of decoding, such as letter-sound correspondence. Child-managed learning opportunities are activities such as group work, during which students manage their own experiences and attention. They discovered that child-managed learning opportunities in addition to explicit decoding instruction, contributed to students decoding skill growth although the effect depended on students' entering vocabulary skills. Since orient-organize was found to increase the time that children spent managing their own activities, and time in child-managed instruction was associated with increased reading scores, perhaps time in orient-organize was also related to children's reading outcomes.

Research also reveals that teachers who spent more time organizing in the fall spent less time organizing the rest of the year, on average [6]. Results showed that more time spent on organizational activities in the fall was associated with greater amounts of class time devoted to child-managed activities in the spring. This empirical finding is corroborated in other earlier theoretical research, where increased levels of child-managed explicit instruction (e.g., cooperative writing opportunities) were found in highly organized classrooms where assignments, expectations, and objectives of activities were explained clearly to the students [10]. In addition, structuring fundamentals, such as thorough overviews, reviews of objectives, and outlines of content, not only facilitated children's memory for information, but also helped them recognize that parts of information connect to create a cohesive whole [10]. Therefore, teachers who spent more time in orient-organize may have had more time to spend on academic subject material, such as practicing letter-word recognition during language arts. This organization may have helped the students systematize what they had just learned, leading to increased learning.

This study demonstrates that both classroom organizational practices and children's home literacy environments can significantly affect students' reading skills in the first grade. It also indicates, "What takes place

in a school is critical, but it's not sufficient. And what happens between three in the afternoon and seven in the morning is at least as important as what happens during the school day" (quoted by the education consultation for the New Haven school district) [8]. Parents who provide a literacy-enriched home environment with activities that maximize reading development can make a difference in their child's reading skills. For example, parents' book reading styles, including labeling and describing the illustrations or encouraging and supporting children's storytelling attributes, bolstered their children's vocabulary [8]. Parental literacy-promoting behaviors can cut across all socioeconomic statuses, including low socioeconomic statuses. Behaviors promoting literacy include parents using correct grammar and complex vocabulary and sentence structure, encouraging knowledge of the alphabet, subscribing to newspapers and magazines, and providing children with books and educational toys [8]. However, it may be more difficult for parents in families with a low socioeconomic status to foster strong home literacy environments. They are frequently busy working to provide for the family; additionally, they cannot always afford to purchase as many literacy-promoting resources for their children.

Findings from the present study demonstrate that both the first graders' teachers' classroom organizational practices and children's home literacy environments can significantly affect children's early reading skills. Greater emphasis on how teachers can provide a quality educational environment, which includes an optimally organized classroom, and how parents can foster strong home literacy environments is vital for improving children's achievements in early reading.

Acknowledgements

The author thanks everyone in the Pathways to Literacy lab for their assistance and encouragement that they have offered over the past few months. The author also gives a thank you to Carol Connor, Frederick Morrison, Claire Cameron, Kristall Knieper, Samuel Wedes, and Christine Pirozzo for their patience and guidance.

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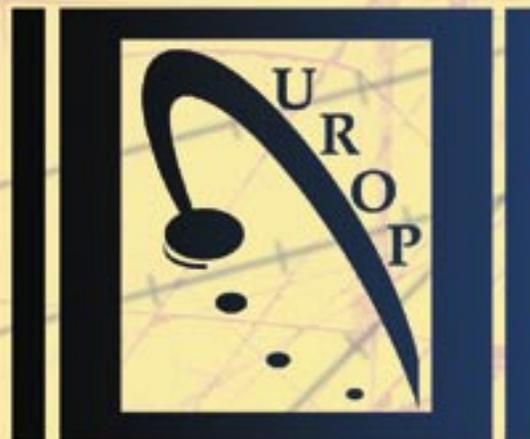
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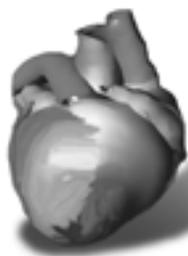
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Cardioprotective Action of Selective Estrogen-receptor Agonists against Myocardial Ischemia and Reperfusion Injury

Nabeel R. Obeid

Mentors: Erin A. Booth and Dr. Benedict R. Lucchesi

Abstract

Cell death due to ischemia is observed frequently under conditions in which an organ is deprived of blood flow and is subsequently reperfused, or restored with blood supply. Myocardial ischemia occurs when there is an interruption in the blood supply to the heart muscle, most often the result of a thrombus (arterial blood clot). Subsequent reperfusion of ischemic tissue results in extension of the tissue injury beyond that due to the deprivation of blood flow; it is due to the reintroduction of oxygen to the previously ischemic heart muscle, a paradoxical event referred to as “reperfusion injury.” Estrogen, a steroid sex hormone, has been shown to protect against such cell death. It is still unknown which of two estrogen receptors ($ER\alpha/\beta$) mediates the mechanism for the protective effects against reperfusion injury.

An *in vivo* rabbit model was used in which ER-specific compounds were administered, and the extent of myocardial protection was examined. The $ER\alpha$ agonist PPT along with 17β -estradiol produced significant reductions in myocardial infarct size when compared to vehicle-treated controls, whereas the $ER\beta$ agonist DPN did not. The results of the experiment support $ER\alpha$ as a mediator of estrogen’s cardioprotection against myocardial ischemia and reperfusion injury.

Introduction

One of the most common types of cellular damage in clinical medicine is a result of ischemia. Ischemia is a deficiency of blood supply to a tissue or organ. Clinical examples include arteriosclerosis, thrombotic arterial occlusions, and reduced cardiac output. As the center for blood circulation and distribution, it is evident that the heart plays a major role in proper blood supply to tissues and organs. The heart muscle (myocardium) is itself susceptible to an ischemic incident, usually due to an obstruction of one or more of the coronary arteries, the vessels which provide nutrient blood flow to the heart muscle. Myocardial ischemia leading to the progressive

death of heart muscle cells represents the most common cause of heart failure. The sudden obstruction of a major coronary artery, most often due to the rapid formation of a thrombus is the immediate cause of a myocardial infarction (heart attack) and sudden cardiac death.

When myocardial tissue is subjected to a brief ischemic insult (less than 30 minutes), it is possible for the cells to recover fully. However, if ischemia is prolonged (45 minutes or more), there exists a subsequent transformation of cells from reversible damage to a state of irreversibility [1]. With restoration of blood flow, termed reperfusion, a paradox is manifested, in which oxygen-rich blood, essential to tissue survival, causes an increase in the extent of irreversible cell damage [1]. This escalation of cellular damage is referred to as reperfusion injury. Although it frequently occurs in the myocardium, reperfusion injury can also affect any other ischemic tissue or organ that is subject to restoration of blood flow [1]. Such cases include organ transplantation and some types of surgery (e.g., open-heart surgery) in which blood flow must be interrupted in order to provide a bloodless field to permit the surgical procedure to be conducted under direct visualization.

Damage to cells after myocardial ischemia/reperfusion injury arises through several mechanisms. The cells of ischemic tissue recruit neutrophils (the most abundant of leukocytes, acting as phagocytes against foreign particles) to the site of damage and in turn, become activated. Upon neutrophil activation and accumulation, release of reactive oxygen free radicals as well as cytotoxic constituents (hydrogen peroxide, hypochlorous acid, proteolytic enzymes) released from the invading neutrophils cause further damage [1,2]. Previous studies have shown that inhibitors of neutrophil activation and accumulation attenuate damage to ischemic tissue after reperfusion. Aside from neutrophil activation, tissue damage can result from activation of the complement system, which is composed of two pathways, converging to form the membrane attack complex (MAC), which forms a pore in the cell membrane. When activated, the products

of the complement cascade can damage cells indirectly through recruitment of neutrophils (anaphylatoxins C5a and C3a), or through cell lysis elicited by assembly of the MAC (C5b-9) on the cell membranes in the area of reperfusion [2].

The incidence of coronary vascular disease increases two-fold among women after menopause, which is associated with a decrease in the synthesis and release of estrogen. However, it has been demonstrated that the administration of estrogen may have adverse effects due to the lack of specificity for heart muscle. Thus, hormone replacement therapy, once believed to be beneficial for the prevention of cardiovascular events in the post-menopausal patient, has limitations to its usage [3]. Several controlled, double-blind clinical trials have generated unfavorable outcomes, and the recommendation is for short-term usage of hormone replacement therapy for the relief of vasomotor symptoms (*e.g.*, hot flashes). However, recent experimental studies have shown estrogen (17 β -estradiol) to be cardioprotective in terms of reducing the extent of reperfusion injury. Two estrogen receptors (ER) have been identified, mainly ER α and ER β . The exact mechanism by which estrogen protects against reperfusion injury is still unknown [3]. The focus of the study was to learn more about the mechanism behind this cardioprotection, and specifically, whether it is mediated through ER α or ER β . Experimental data show 17 β -estradiol, the naturally occurring form of the hormone estrogen, to be protective, but finding a more selective compound would provide the benefits without the adverse effects exerted upon the uterus, breast and blood clotting system. To do this, estrogen receptor-specific compounds were used and examined for the extent to which they offered cardioprotection against myocardial ischemia and reperfusion injury.

Materials and Methods

Surgical Preparation

Female New Zealand White rabbits were anesthetized with ketamine and xylazine, administered intramuscularly. Sodium pentobarbital was administered intravenously as needed throughout the duration of the experiment to maintain a state of surgical anesthesia. An endotracheal tube was inserted that allowed for controlled respiration with the use of a positive pressure respirator. The left jugular vein was isolated and a catheter was inserted for drug administration and blood sampling. A Millar™ micro pressure transducer was inserted into the left carotid artery to record the aortic blood pressure, and an electrocardiogram was monitored throughout the duration of the protocol. The chest was opened through the left side to expose the heart, and the pericardium was opened to expose the surface of the heart and in order to visualize the coronary arteries, thereby concluding the preliminary surgical preparation [Figure 1].

Administration

The animals were allowed to equilibrate for 15 minutes after the surgery. After the stabilization period, one of four drug treatments was administered: vehicle (n = 8), composed of 20% dimethyl sulfoxide (DMSO) and 80% polyethylene glycol (PEG); 17 β -estradiol (10 μ g; n = 8), non-selective, binding to both ER α and ER β ; 4,4',4''-(4-Propyl-[1H]-pyrazole-1,3,5-triyl)triphenol, or PPT (3 mg/kg; n = 8), a selective ER α agonist; or 2,3-bis(4-Hydroxyphenyl)-propionitrile, or DPN (3 mg/kg; n = 8), a selective ER β agonist. After 30 minutes, the left anterior descending coronary artery was occluded by passing a suture underneath the artery and tying it around a segment of plastic tubing thereby occluding the vessel [Figure 2]. Regional myocardial ischemia was maintained for a period of 30 minutes and was confirmed by a distinct

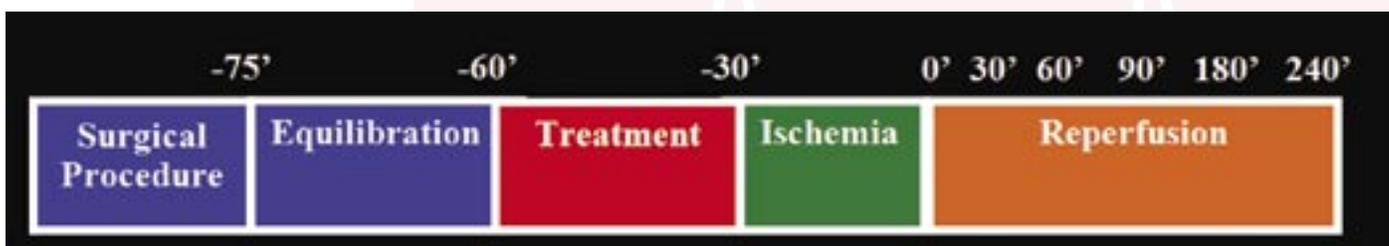


Figure 1: Experimental Protocol: A schematic representation of the entire experimental protocol. The study began with a surgical preparation, then allowing the heart to equilibrate for 15 minutes. After equilibration, one of the four compounds was administered intravenously, and allowed to circulate for 30 minutes. After this, ischemia was induced by ligating the coronary artery, and lasted for 30 minutes. Following ischemia, the ligature was removed and the heart was reperfused for 4 hours.

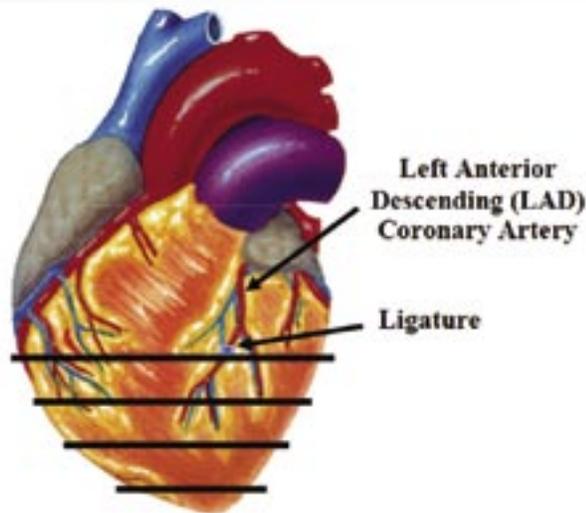
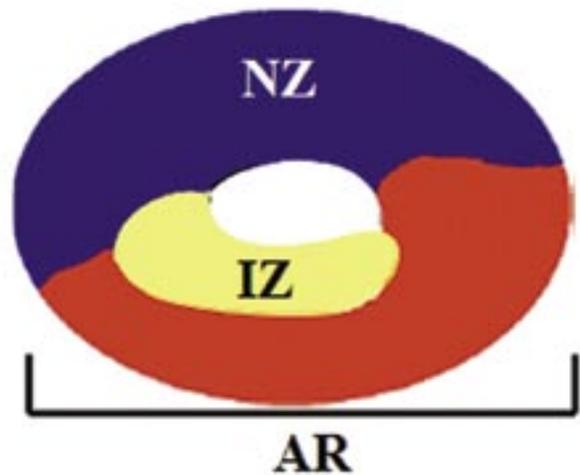


Figure 2: The Heart: A picture of an animated heart. The left anterior descending (LAD) coronary artery is identified. The location of the ligature is also marked, and some tissue below the occlusion was subject to ischemia. Finally, three cross-sectional slices of left ventricular tissue were examined for infarct size.



NZ = Normal Zone

IZ = Infarct Zone

AR = Area at Risk

purple color demarcating the ischemic myocardium and accompanied by elevation of the ST-segment in the Lead II electrocardiogram. The final surgical step was the restoration of blood flow to the previously ischemic region by removal of the occlusive ligature and reperfusion of the heart for 4 hours at which point the surgical portion of the experimental protocol was completed.

Analysis

The degree of protection afforded by each treatment was assessed by determining the extent of myocardial tissue undergoing irreversible tissue injury (myocardial infarction). After the 4 hours of reperfusion, the hearts were removed and placed on a Langendorff perfusion apparatus that circulated buffer through the heart, clearing the coronary vascular bed of blood cellular elements and plasma. A solution of 1% triphenyltetrazolium chloride (TTC) in phosphate buffer was passed through the heart, staining the viable, non-infarct tissue that was subject to ischemia a bright red color. The cells with irreversible damage do not stain, and remain a pale yellow color. The coronary artery was then ligated just above the original point of occlusion that induced myocardial ischemia to insure the same region of myocardium was now tied off (area at risk). After stopping the perfusion pump, a solution of Evans blue dye was infused through the heart, marking all tissue that was

Figure 3: Cross-Sectional Tissue: Once the experimental protocol was completed, the heart was hung on a Langendorff apparatus. A solution of TTC was passed through the heart, staining all viable cells a red color, while leaving the infarct cells a pale yellow color. The red and yellow regions together make up the area at risk, the region subject to ischemia. After this, the coronary artery was occluded at the same location of the initial ligation (the one inducing ischemia during the protocol) and an Evans blue dye was passed through the heart staining the remainder of the myocardium a blue color. This demarcated the normal zone, or the tissue never subjected to ischemia throughout the entire experiment.

not subjected to ischemia. The heart was then removed from the apparatus and three cross sections of the left ventricular tissue were obtained and examined [Figure 3]. Heart sections were traced and scanned. Adobe Photoshop was used to calculate the number of pixels for the areas of total left ventricle, area at risk, and infarct size. Along with examining the myocardial tissue, blood samples were also analyzed. Samples were taken at different time points in the experiment for all treatment groups and were assessed for troponin I levels. Troponin is a protein complex, an isoform that exists in the cardiac muscle (cTnI), and its levels correlate positively with tissue damage. Antibodies

specific to cardiac troponin I were used to detect levels of the complex at different stages during the experiment.

Results

Administration

The area at risk as a percent of the total left ventricle was calculated to ensure consistency with the amount of tissue subject to ischemia from animal to animal. In determining the area at risk (AR) as a percent of the total left ventricular tissue (LV), the treatment group averages were as follows: 59.2 ± 3.0 with vehicle, 55.2 ± 2.8 with 17β -estradiol, 59.4 ± 4.2 with PPT, and 58.7 ± 2.2 with DPN [Figure 4].

Analysis

The infarct size as a percent of the area at risk (tissue subject to ischemia) was calculated to determine the extent of damage in each treatment group. When calculating the infarct zone (IZ) as a percent of the area at risk (AR), there were significant differences among

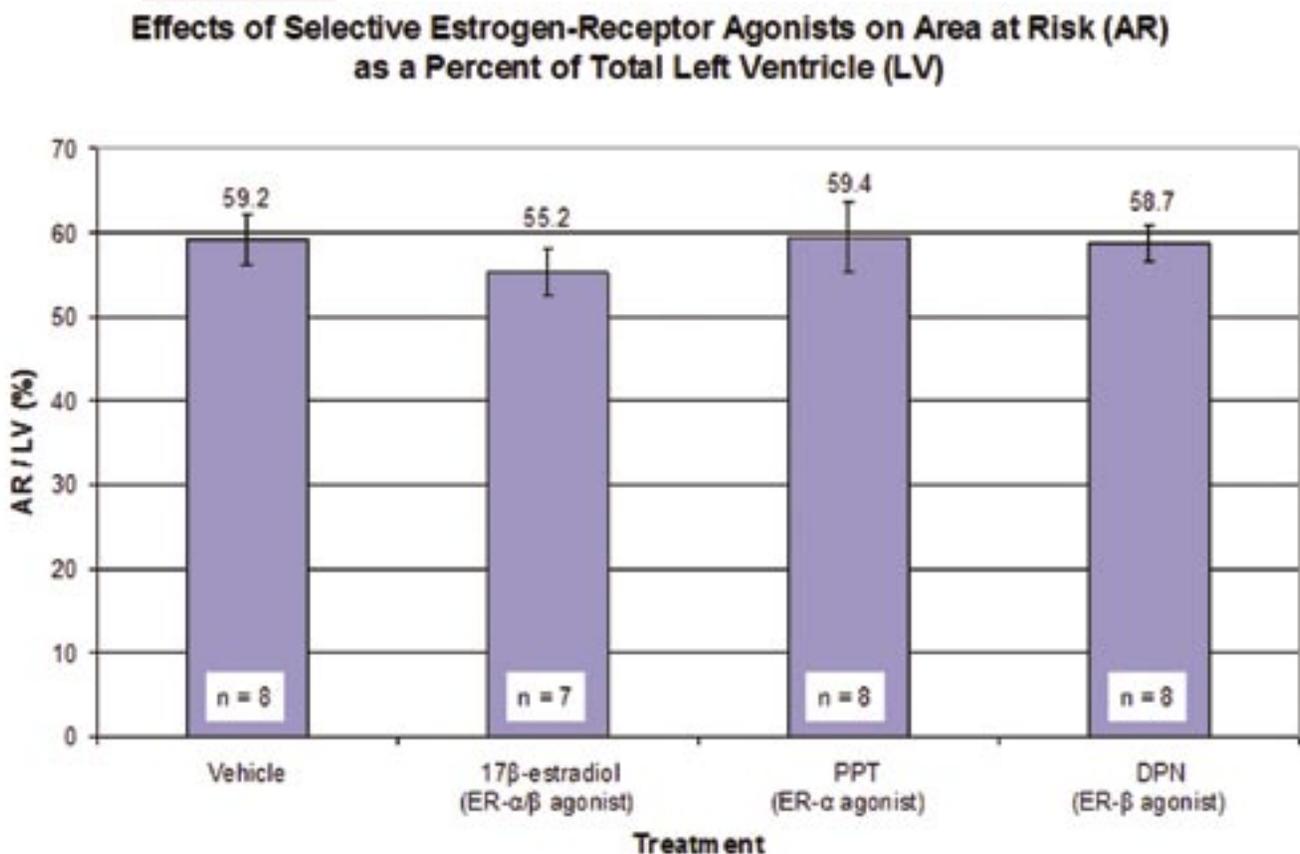
the treatment groups. The average infarct size decreased among the 17β -estradiol (ER α/β agonist) group (17.7 ± 2.9) when compared to the vehicle group (45.3 ± 2.4 ; $p < 0.001$). The group pretreated with PPT (ER α) also showed a similar decrease in infarct size (18.1 ± 2.3) when compared to vehicle ($p < 0.001$). The ER β agonist DPN, however, showed no significant reduction of infarct size (44.5 ± 4.1) as compared with vehicle [Figure 5].

Troponin levels seemed to increase from the baseline to the 2-hour reperfusion mark, and even more at the 4-hour reperfusion mark. However, the rabbits treated with 17β -estradiol and PPT showed a lesser increase in troponin levels than in vehicle or DPN treated animals [Figure 6].

Discussion

When analyzing the results, the data showed that a consistent amount of tissue was subject to ischemia during the surgical procedure across all treatment groups. Therefore, any differences in infarct size were due to the drug treatment interventions. The calculations indicate that both 17β -estradiol and PPT result in a smaller region

Figure 4: Area at Risk: This graph depicts the amount of tissue that was considered at risk (AR) as a percent of the total left ventricle tissue (LV) among all four treatment groups. The four groups had similar percentages of area at risk, demonstrating the consistency in the amount of tissue subject to ischemia throughout the experiments.



Effects of Selective Estrogen-Receptor Agonists on Infarct Zone (IZ) as a Percent of Area at Risk (AR)

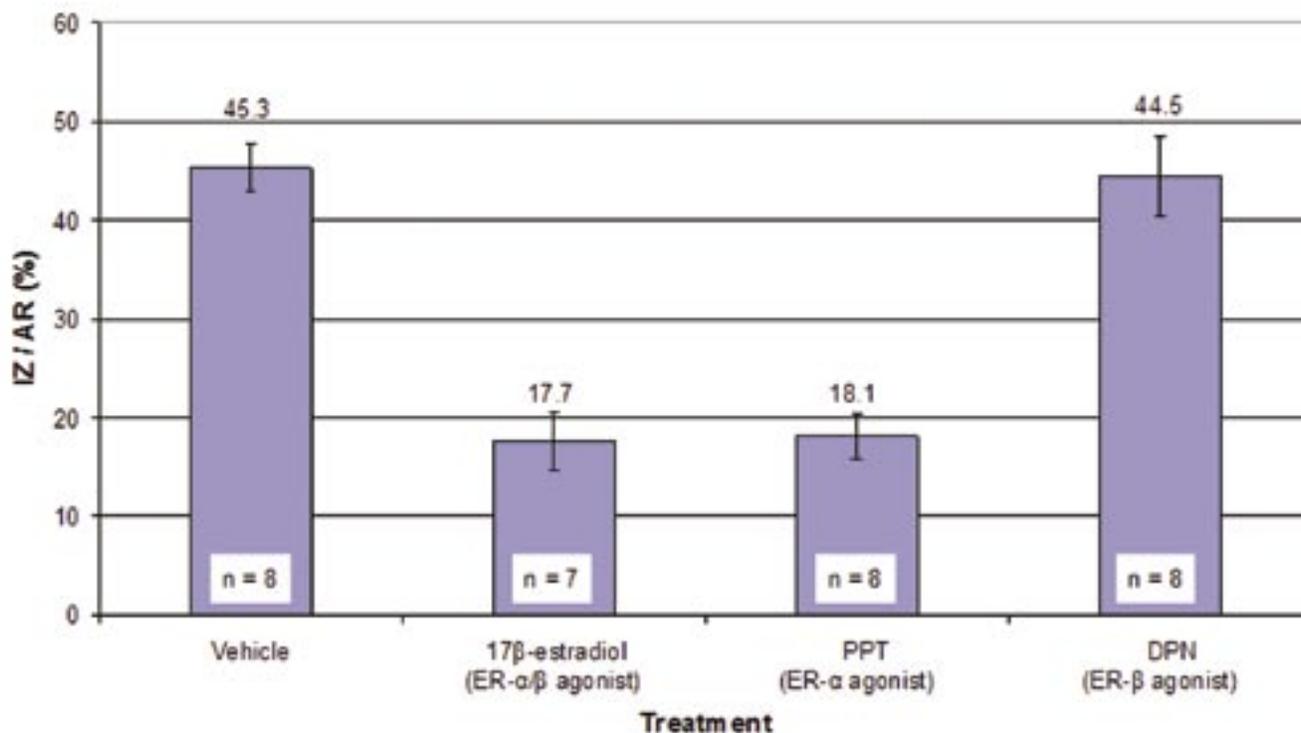


Figure 5: Infarct Size: This graph shows the relative percentage of infarct zone (IZ) among the area at risk (AR) for all treatment groups. When compared to vehicle, 17β-estradiol (ERα/β agonist) and PPT (ERα agonist) both showed significant decreases in infarct size. The ERβ agonist DPN, however, did not exhibit similar reduction when compared to vehicle.

of infarct tissue, suppressing the damage caused by reperfusion injury. The DPN group did not show this decrease in tissue damage, exhibiting similar results to the control group. The reduced troponin levels in the 17β-estradiol- and PPT-treated groups further support the evidence for cardioprotection elicited by these drugs. The data compiled from this study, consequently, do not support ERβ as having a major role in mediating estrogen's protective activity. However, results from this experiment do indeed show evidence for ERα as a primary component in estrogen's mechanism for cardioprotection against myocardial ischemia and reperfusion injury. With these results and future studies, more will be known of the mechanism behind estrogen's cardioprotection. The adverse effects of current hormone replacement therapy will be minimized without compromising the benefits through novel therapeutic interventions.

Acknowledgements

The author would like to thank Benedict R. Lucchesi, M.D., Ph.D., Erin A. Booth, and the members of the laboratory team at the Department of Pharmacology, University of Michigan Medical School for their constant guidance and patience. Nabeel R. Obeid was the recipient of an ASPET Summer Undergraduate Research Fellowship. Financial support for the study came from the Cardiovascular Research Fund (B. R. Lucchesi – Principal Investigator). The author wishes to thank his family for their continuous love and support.

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Troponin Levels for Each Treatment Group at Baseline, 2-Hour Reperfusion, and 4-Hour Reperfusion Time Points

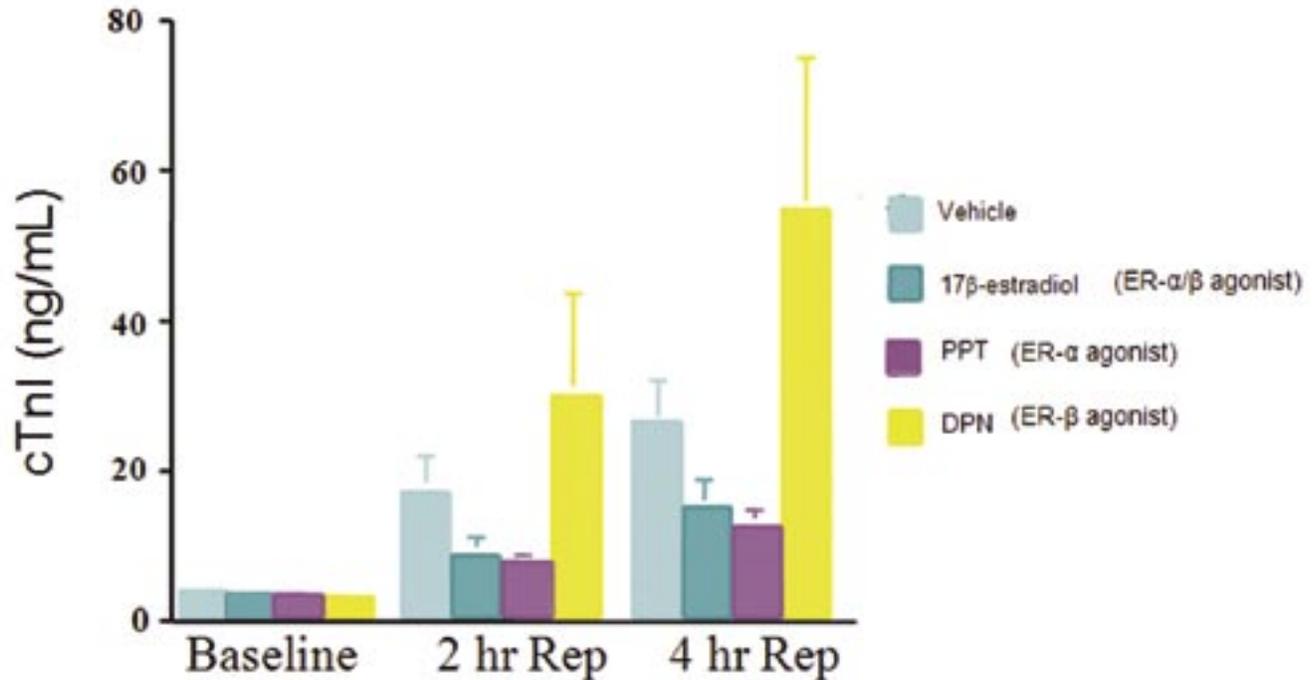


Figure 6: Troponin Levels: Troponin is a protein complex released in damaged muscle cells. The more damaged a cell becomes, the higher its concentration of troponin release. Plasma samples were obtained for all treatment groups at time points, and troponin levels were examined using antibodies. All treatment groups showed an increase in troponin level from baseline to 2-hour reperfusion, and from 2- to 4-hour reperfusion. However, the vehicle and DPN (ER β agonist) groups showed a much larger increase in troponin levels than did either 17 β -estradiol (ER α/β agonist) or PPT (ER α agonist).

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Sexual Dimorphism in the Dark-Winged Damselfly *Calopteryx Maculata*

Margaret M. Hopeman and Zachary R. Abramson
Mentor: Dr. Ola Fincke

Abstract

Pronounced sexual dimorphisms are suggestive of sexual selection. In *Calopteryx maculata*, a pronounced sexual dimorphism is seen in the degree of wing pigmentation; males have significantly darker wings than females. Territoriality in *C. maculata* makes it difficult to discern the function of sexual dimorphism. Previous studies have suggested that the degree of male wing pigmentation in a related species *Calopteryx haemoroidalis* may serve as a sexual signal to females or other males indicating their genetic quality. Various studies have shown that males of the species *C. haemoroidalis* with a higher degree of wing pigmentation are more likely to defend a territory, obtain more matings, have fewer gut parasites, and have larger fat reserves. In contrast, we found that there is no correlation between the degree of wing pigmentation and male mating or territorial success in *C. maculata*. We found that females were selective of territories but not of males. Our results suggest that the degree of wing pigmentation may play a role in species recognition by females.

Introduction

The spatial and temporal distribution of resources is a major determinant of mating systems. Territoriality is a male response to this sort of uneven distribution of resources and results in two forms of sexual selection based on female mate choice. Females may choose their mates indirectly based on the quality of their territories or directly by honest signals reflecting the male's genetic composition. Both of the above means of female mate choice can lead to sexual dimorphism, which is the existence of physical differences between males and females of the same species.

Sexual dimorphism can function as a sexual signal either in species recognition or as an indicator of male phenotype. Therefore, measuring the effect of sexual dimorphisms on mating success and behavior is key to understanding the dynamics of sexual selection and

mating systems. If the sexual dimorphism is a result of sexual selection, then variation in sexually dimorphic traits should have an effect on mating success. One example is the damselfly *Calopteryx maculata*, in which males have varying degrees of wing pigmentation, body size, and color. Our purpose is to investigate whether the sexually dimorphic wing pigmentation of *C. maculata* functions as a sexually selected signal to females.

Calopteryx maculata is a dark-winged stream damselfly that exhibits sexual dimorphism, territoriality, and post-copulatory guarding due to sperm competition. The males defend discrete clumps of aquatic vegetation in areas of fast flowing water that females need in order to deposit their eggs. Females also benefit from an energetic male to guard them while ovipositing [1].

Studies of a related species *C. xanthostoma* have shown that degree of wing pigmentation is heritable, correlates directly with the size of fat reserves, and is inversely related to the number of parasites hosted. This suggests that wing pigmentation is an honest signal of physical health [2,3].

We are interested in investigating whether degree of wing pigmentation is an honest indicator of male quality in *C. maculata* and whether it correlates with both mating and territorial success of males.

Materials and Methods

We recorded all observations of the natural population of *C. maculata* in July 2004 along the east branch of the Maple River in Cheboygan County, Michigan. Data collected on site consisted of male mating success, male-male interactions, territory characteristics, and territoriality. First, we captured male *C. maculata* with insect nets, marked them with a gold paint-pen, and then released them. We then plotted out ten observable territories based on the uneven distribution of local vegetation on the bank of the river. The start and end times for the recording of the following data for all the damselflies in each territory were noted: male number,

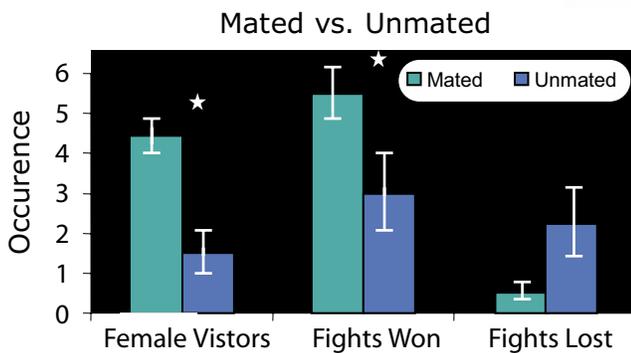


Figure 1: Male damselflies who mated vs. male damselflies who did not mate are compared in three categories: occurrence of female visitors, occurrence of fights won, and occurrence of fights lost.

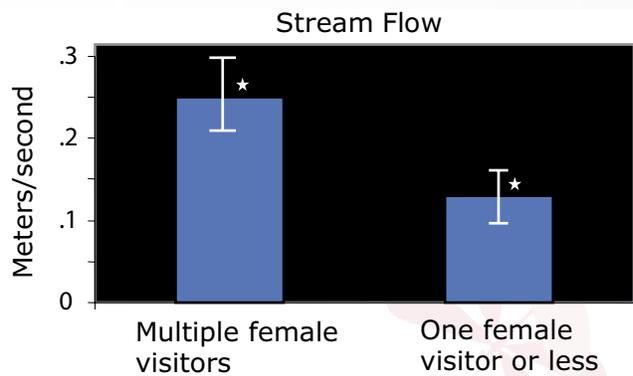


Figure 2: Males with multiple female visitors are compared to males with one female visitor or less. Males with multiple female visitors were, on average, found in areas of higher stream flow.

location (territory number), height of male above water when first observed, number of female visitors to specific male's territory (if dominance of territory is clearly established), number of copulations, fights won, and fights lost. All observed damselflies were captured, scanned for degree of wing pigmentation, weighed, and measured for forewing length and width and abdomen length. Males were then released at our site on the Maple River.

After scanning all the observed male damselflies, actual-sized black and white scans were ranked in order of wing pigmentation from lightest to darkest. Rankings were repeated by the same group of people and an average value for each male was recorded. Separate rankings were shown to be highly correlated, as expected ($r^2 = .81$). Tabulations from the original data taken on site included total fights and wing area.

After data on marked males were collected, we recorded information on all observed territories. Observations included territory length, width, area, substrate level (vegetation on which to oviposit), territory shape, substrate density (low, medium, or high), and flow rate.

Using the statistical software SPSS, data of mated/non-mated, fought/not-fought, and high/low pigment were compared.

Results

Male damselflies visited by females more than once had significantly more copulations ($p = .001$, $t = -4.00$), and their territories had a faster river flow ($p = .036$, $t = -2.294$) and higher vegetation density ($p = .006$, $t = -3.161$). Males who fought at least once had significantly shorter forewing lengths ($p = .01$, $t = 2.765$), lighter wing pigmentation ($p = .024$, $t = -2.376$), and territories with a higher density of vegetation ($p = .041$, $t = -2.149$). Mated

males (defined as males who were observed in copulation with a female on at least one occasion) had significantly more visits from females ($p = .004$, $t = -3.316$), won more fights ($p = .043$, $t = -2.15$), held slimmer territories ($p = .055$, $t = -2.052$) that were smaller in area ($p = .029$, $t = 2.366$), and held territories with greater density of substrates ($p = .014$, $t = -2.738$). Mated males were also observed to follow a trend of losing fewer fights than unmated males ($p = .066$, $t = 1.937$). The fifteen males that were ranked the darkest in wing pigmentation were, on average, significantly heavier ($p = .005$, $t = 2.954$), had larger forewing lengths ($p = .031$, $t = 2.219$) and larger wing areas ($p = .03$, $t = 2.237$) as compared to the twenty lightest males.

Ten damselflies sampled from the study site revealed no parasites upon dissection.

Discussion

Females of *Calopteryx maculata* showed no preference with respect to degree of male wing pigmentation. This contrasts the findings that wing pigmentation in the sister species *Calopteryx haemorrhoidalis* evolved via sexual selection [2]. Females did display preferences for territories with certain characteristics such as high substrate density and faster flow rates, but males defending those territories were not significantly different in wing pigmentation from the rest of the male population. This suggests that the sexual dimorphism seen in *C. maculata* cannot be explained by either direct female mate choice based on male phenotype or indirect female mate choice based on territory quality.

Our finding that males' ability to fight was correlated with mating success but not with wing pigmentation suggests that wing pigmentation does not serve as an intra-sexual signal communicating a male's fighting ability to other males. These findings are supported

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by the fact that a sample of the population dissected for an intestinal parasite known to affect fat reserves in *C. xanthostoma* showed no evidence of infection. Marden and Waage found that the difference in fat reserves among males is the best predictor of the outcome of a fight [4]. Siva-Jothy documented that parasite load was inversely proportional to both wing pigmentation and fat reserves [3]. Since parasites are not limiting the acquisition of energy during foraging, it is unlikely that differences in fat reserves resulting from parasitic infection explain differences in fighting ability.

An alternative explanation for the sexual dimorphism in wing pigmentation exhibited by *C. maculata* supposes that darker male wings aid in species recognition by females. Such species recognition is observed between *C. splendens* and *C. virgo* [5]. At our study site, another closely related species *C. aequabilis* was present. Since similar courtship displays are expressed and unproductive interspecific matings are known to occur, selection against these matings should occur [2]. Cordoba-Aguilar suggests that females might use degree of wing pigmentation to identify conspecific males [2]. This is supported by the finding that the sexually dimorphic wing patterns of *C. aequabilis* differed more in sympatry than allopatry [4].

Complicating our ranking of male wing pigmentation was the fact that we did not have access to computer software capable of ranking pigmentation as was done by Siva-Jothy in 2000 with *C. xanthostoma*. While repeated rankings were correlated ($r^2=.81$), it is important to note that subjective rankings such as those carried out by human beings inherently carry a potential bias. Secondly,

even if degree of pigmentation was accurately assessed, it is unclear whether possible selection on wing pigmentation would be based on overall degree of pigmentation or uniformity of the distribution of pigment.

In order to discern the exact function of the pronounced sexual dimorphic wings of males in *C. maculata*, more investigation is needed. It is important that all possible functions of sexually dimorphic wings, as outlined in our study, be thoroughly explored before concluding the mechanism by which sexually dimorphic wings evolved and persist in the population of *C. maculata*.

Acknowledgments

The authors thank Dr. Ola Fincke and Mary Wolf for their support and guidance throughout this project. Thanks also to the evolution class of summer 2004 at the University of Michigan Biological Station for their help in data collection.

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The Effects of a Recent Zebra Mussel Invasion on the Phytoplankton Community in Lake Leelanau in Northern Michigan

Erika L. Shankland
Mentor: Dr. Rex L. Lowe

Abstract

The discovery of zebra mussels was made in 1998 in Lake St. Clair, Michigan. Through recreational boating, canal building, and shipping, *D. polymorpha* soon colonized lakes around Michigan. Lake Leelanau, located in Leelanau County, Michigan, was invaded in 1996. Inland lakes as well as the Great Lakes have suffered invasion leading to altered water quality caused by toxic blue-green algae blooms and soiled beaches. This research project was an attempt to understand the impacts of zebra mussels on phytoplankton density and community structure.

Introduction

Urban, agricultural, and anthropogenic activities are not part of natural disturbance regimes [1]. Unlike a natural disturbance, such as fire, human induced change (like construction or soil excavation) or introduction of an exotic species, often leads to irreversible changes in community structure that are characterized with a lack of native species [1]. In many estuaries and rivers, disease, over-harvesting, and pollution have led to declines in bivalve populations. On the other hand, shipping, canal building, and recreational boating have led to the introduction of many exotic, or foreign, species of bivalves [2,3].

The introduction of zebra mussels (*Dreissena polymorpha*) has disturbed local ecology in much of the eastern United States [3]. The primary vectors for the dispersal of zebra mussels into inland lakes appear to be anthropogenic [2,3]. Zebra mussels exercise active filtration, which can lead to declines in phytoplankton over time [4]. Active filtration of water is one method of obtaining nutrients for a species' survival.

The grazing pressure, a measure of how intense the zebra mussels are filtering the water and ultimately, the phytoplankton, has increased since zebra mussels have been introduced. The increase in grazing pressure by *D. polymorpha* has been directly linked to a decrease

in the phytoplankton community structure of freshwater bodies [3]. Zebra mussels filter particulate matter, such as phytoplankton, out of suspension in water [5]. Water clarity is increased, and the remaining nutrients (after the phytoplankton has taken dissolved nutrients out of the water) become sequestered into the benthos, not in the water column. By the decrease in nutrients in the water column and the zebra mussels removing particulate matter from the water, zebra mussels can alter plankton abundance [6]. Furthermore, benthic feeders, species that feed off the bottom of the water body, can be major consumers of phytoplankton, therefore decreasing phytoplankton biomass, or population size [7]. In addition to depletions in phytoplankton biomass, actual phytoplankton community structure can change [8]. One of the most frequent changes in the phytoplankton composition due to zebra mussel invasion is the appearance and increase of cyanobacteria [7]. Because of the decrease of nutrients in the photic zone, phytoplankton that cannot fix their own nitrogen are decreased, and there is an advantage given to nitrogen-fixing blue-greens, or cyanobacteria, which can convert elemental nitrogen (only breakable by cyanobacteria) into nitrates and nitrites (forms needed by the cell).

Visual clarity of water can change as a direct result of a decrease in the phytoplankton community. The Secchi disk is commonly used to measure changes in visual clarity with increasing depth by measuring the depth at which the disk disappears from the view of a surface observer [9]. The filtering of suspended particles from the water by zebra mussels can have an effect on algal growth, which in turn alters the transparency of the water [6,9]. Many studies have shown a decrease in phytoplankton biomass of up to 90% due to zebra mussel invasion, which has resulted in increasing Secchi depth [10,8]. In order for phytoplankton to play a role in increased visual clarity, decreases in algal growth must occur above the Secchi disk [9]. Although nutrients in the water column are also very important for algal growth, if there is an insufficient amount of light, nutrient enrichment will have little or no effect on growth [11].

Phosphorus and nitrogen concentrations in a water body are an important indicator of algal community structure. These two nutrients are most likely to be growth limiting [11]. In the northern United States, phosphorus has been found to be the primary growth-limiting factor [11]. Fairchild *et al.* manipulated nitrogen and phosphorus in Douglas Lake, Michigan, to study the quantities of nitrogen and phosphorus that are growth limiting [12]. They found that biomass of benthic algae was greatest with a combined increase of nitrogen and phosphorus, compared to a large increase with only phosphorus added and no change when only nitrogen was added [11]. Stephens and Gillespie found that a reduction in nitrogen in May was accompanied by a decline in the phytoplankton community in Great Salt Lake, Utah [13].

Caraco *et al.* found a massive decline in phytoplankton biomass concurrent with the invasion of *D. polymorpha* in the Hudson River Estuary. The zebra mussels became established in the fall of 1992 and reached high biomass levels in 1993 and 1994 [2]. Grazing pressure on phytoplankton was 10-fold greater than it had been prior to the zebra mussel invasion [2]. Over this same period, light availability increased and phosphate concentrations doubled, therefore these factors were not responsible for phytoplankton declines [2].

Zebra mussels invaded the south basin of Lake Leelanau in Leelanau County, Michigan, in 1996 [14]. The mussels spread north with the natural flow of the system and as a result of anthropogenic influences [8]. *D. polymorpha* now resides in both the north and south basins [8]. In 2003, the north end of the lake had a density of 3249 zebra mussels/ m², central Lake Leelanau had a density of 398 zebra mussels/ m² and south Lake Leelanau had a density of 1378 zebra mussels/ m². Lime Lake of Leelanau County, Michigan, has not been invaded by *D. polymorpha* [14].

My objective is to compare algal community structure between a zebra mussel invaded lake (Lake Leelanau) post-invasion and pre-invasion, using Lime Lake (non-invaded) as a control for the study. During the time periods being studied for Lake Leelanau, there was no significant difference in the phytoplankton densities and community structure in Lime Lake. Based on the findings of previous studies, I predict that the phytoplankton samples taken from Lake Leelanau in 1993 will have a higher density and greater diversity of algae compared to the samples taken in 2004 after the invasion. I also predict that Lake Leelanau will have greater clarity in the 1997-2001 samples when the disturbance of zebra mussels was prominent than in the 1990-1996 samples because the algal density decreased due to zebra mussel invasion.



Figure 1: Map of Lake Leelanau area in Leelanau County, Michigan. The north and south basins are marked by arrows (Wearly 2004).

Materials and Methods

Study site

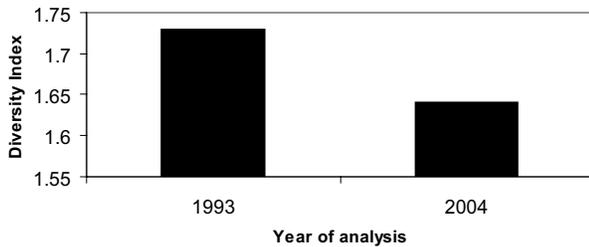
My study sites were two oligotrophic inland lakes (Lake Leelanau and Lime Lake) located in northern Michigan (Lake Leelanau, Latitude: **N45° 01.18'** Longitude: **W85° 44.51'**; Lime Lake, Latitude: **N44° 52.19'** Longitude: **W85° 57.84'**). Lake Leelanau is characterized by two basins (north and south) [Figure 1]. Lake Leelanau is 21 km. long, with a mean depth of 13 m. in the north basin and 8m. in the south basin [14]. Lake Leelanau is an ultra-oligotrophic to oligotrophic lake [8]. Lime Lake is an ultra-oligotrophic lake with its deepest point at 22.3 m. and its length being 0.32 kilometers long [8].

Sample collection

The Lake Leelanau Nature Conservancy collected phytoplankton (870 ml. whole-water samples) from Lake Leelanau in April and June of 2004. Samples were also collected from Lime Lake in May and June of 2004. The Lake Leelanau Nature Conservancy did a quantitative study of the phytoplankton in 1993 on Lake Leelanau and Lime Lake. In both water bodies, samples were collected at a depth of 1m. and 6-8m. Samples were preserved in 2% glutaraldehyde. Samples were settled for a minimum of six days prior to concentrating samples to a final volume of 5 ml. A hand-held siphon and pipette were used to concentrate samples. Care was taken to avoid siphoning floating algae (*i.e.*, blue greens) during each stage.

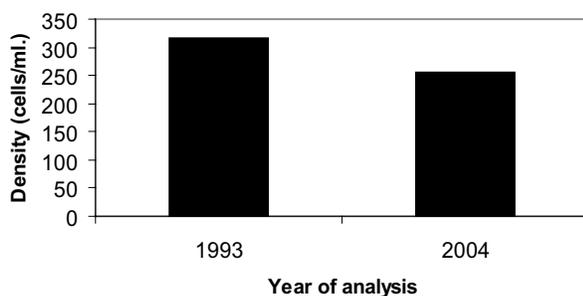
The Lake Leelanau Nature Conservancy estimated zebra mussel densities from photographs taken of the lake bottom in 2003 [15].

Lake Leelanau Phytoplankton Diversity Indices



Graph 1a: Diversity indices of the phytoplankton samples in the two years of analysis.

Lake Leelanau Phytoplankton Density



Graph 1b: Density of phytoplankton samples in the two years of analysis.

Sample analysis

The Nature Conservancy hired Jan Stevenson to analyze the samples taken in 1993 from Lake Leelanau. I analyzed samples taken from May and June of 2004 at the University of Michigan Biological Station. Using a Palmer-Maloney counting cell, 0.1 ml. of each sample was examined. I used two different microscopes, one with 43x magnification (10x oculars) and the other with 45x magnification (10x oculars), to examine random points of view in the Palmer-Maloney cell. Three hundred cells in each sample were counted, with a minimum of 10 fields of view and a maximum of 150 fields of view when samples were especially dilute. Cells were categorized according to genera and species. Burn mounts of each sample were made to analyze relative percentage of diatoms under 100x magnification.

Statistical analysis

The Shannon diversity index (H) was used to characterize the species diversity in Lake Leelanau (pre- and post- invasion), as well as Lime Lake. $H = -\sum p_i \ln p_i$, where p_i is the proportion of species i relative to the total number of species and \ln is a natural log function. A t-test was used to compare the diversity, density, phosphorus,

Table 1: Mean total phosphorus, mean nitrate nitrogen and mean Secchi depth values for Lake Leelanau and Lime Lake during the time period 1990-1996 (pre-invasion) and 1997-2001 (post-invasion) (Keilty and Woller 2002).

Lake Leelanau and Lime Lake Values for the Years (1990-1996) and (1997-2001)

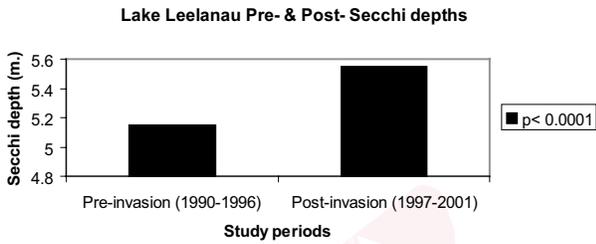
| | Mean Total Phosphorus ($\mu\text{g/L}$) | Mean Nitrate Nitrogen (NO_3) ($\mu\text{g/L}$) | Mean Secchi Depth in April, May & June (m.) |
|---------------|---|---|---|
| 1990-1996 | | | |
| Lake Leelanau | 5.74 | 242.59 | 5.15 |
| Lime Lake | 5.03 | 230.12 | 3.01 |
| 1997-2001 | | | |
| Lake Leelanau | 4.7 | 168.43 | 5.55 |
| Lime Lake | 4.56 | 203.24 | 3.125 |

nitrogen and Secchi depth values of Lake Leelanau pre-invasion and post-invasion. The same values were used to compare Lime Lake from 1990-1996 and 1997-2001.

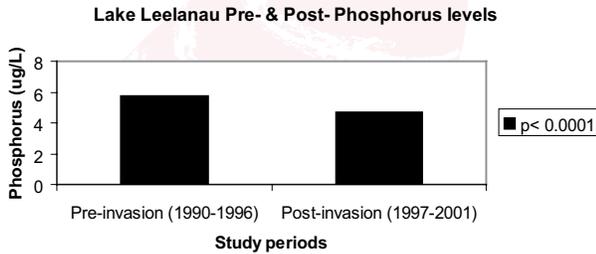
Results

Based on the quantitative study done by the Lake Leelanau Nature Conservancy and counts done by myself, in the control lake, Lime Lake, there was no significant difference in diversity and density between the years 1993 and 2004. There was also no significant difference found between the phosphorus, nitrogen and Secchi depth values for the years 1990-1996 and 1997-2001.

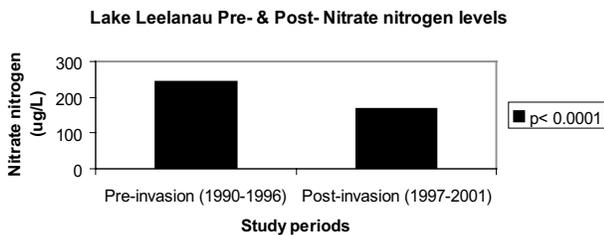
In the samples taken from Lake Leelanau in 1993, the Shannon's diversity index is 1.73, which is higher than the 1.64 diversity index for the samples taken in 2004 [Graph 1a]. The average density for the pre-invasion samples was 315.32 cells/ml, which is higher than the post-invasion samples measured to be 254.00 cells/ml [Graph 1b]. There was no significant difference found for either density or diversity values. As shown in Table 1 and Graph 2, the Secchi depth increased in the post-invasion samples, and the phosphorus and nitrogen values were lower in the post-invasion samples. The average Secchi depth in Lake Leelanau from 1990-1996 was 5.15 m., which is significantly lower than the average Secchi depth of 5.55 m in Lake Leelanau from 1997-2001 (t-value = -1.747, $p < 0.042$, $df-t = 122$) (Graph 2a). There is also a significant difference in the variance of the two study sites (f-value = 1.556, C.V. = 1.53, $p = 0.05$). There is a significant difference in the phosphorus values of the two study sites, with the pre-invasion samples having a mean total phosphorus value of 5.74 ($\mu\text{g/L}$), and the post-invasion samples having a mean total phosphorus value of 4.70 ($\mu\text{g/L}$) (t-value = 5.488, $p < 0.0001$, $df-t = 523$) [Graph 2b]. The mean nitrate nitrogen of the pre-invasion samples is 242.59, and the mean nitrate nitrogen value for



Graph 2a: Secchi depths obtained from samples pre- and post-invasion.



Graph 2b: Phosphorus values obtained from samples pre- and post-invasion.

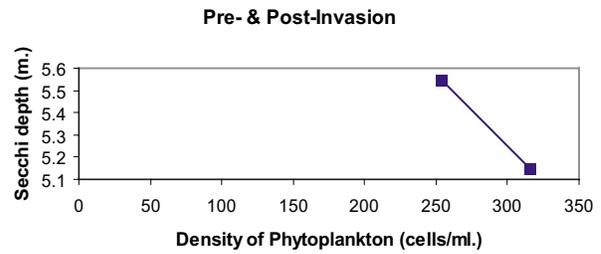


Graph 2c: Nitrate nitrogen values obtained from samples pre- and post-invasion.

the post-invasion samples is 168.43. Additionally, there is a significant difference in the mean nitrate nitrogen values of the two study sites (t -value = 7.077, $p < 0.0001$, $df-t = 519$) [Graph 2c], as well as a significant difference in the variance found for the mean nitrate nitrogen values of the two study sites (f -value = 4.197, $C.V. = 1.53$, $p = 0.02$).

Discussion

As expected, the phytoplankton samples taken during the spring bloom in 2004 are less dense and less diverse than those taken in 1993 [Graph 1]. Significantly deeper Secchi disk readings were obtained for the post-invasion samples (1997-2001) compared to the pre-invasion samples (1990-1996) [Table 1 and Graph 2a]. This result supports my hypothesis and compares to Holland's study (1993) that concluded zebra mussels can have an effect on algal growth leading to a change in the transparency of the water. Secchi disk readings are a reflection of the amount of light penetrating the



Graph 3: As the density of phytoplankton in Lake Leelanau decreased after zebra mussels invaded, the clarity of the water became greater.

epilimnion. My results show a direct correlation between the phytoplankton density measurements and the clarity of the water [Graph 3]. Furthermore, in 2004, zebra mussels had become established with up to 3249 zebra mussels/ m^2 in Lake Leelanau, with a correlation to decreasing densities in the phytoplankton community. Zebra mussels filter and digest necessary nutrients and phytoplankton, making it nearly impossible for a present phytoplankton community to survive an invasion. In addition to the decrease in biomass of the phytoplankton after the invasion of zebra mussels, the community structure of the phytoplankton changed, shown by the decrease in diversity of species in 2004 [Graph 1]. Community structure can change as a result of competition between species of algae. Since the zebra mussels filter nutrients, there are fewer available for the usually large amount of phytoplankton [6]. The algae that can survive in environments with low nutrients (such as nitrate nitrogen and phosphorus) will be able to live simultaneously with *D. polymorpha* better than those that need more nutrients to live [7]. Furthermore, a species of algae that can synthesize its own nitrates and nitrites from elemental nitrogen is going to be able to live much more successfully than an alga that is not able to make its own useful forms [7]. The decrease in phytoplankton diversity in the post-invasion samples is shown in Graph 1a.

Similar to studies done by Stephens and Gillespie and Fairchild *et al.*, I found that there is a significant decrease in both phosphorus and nitrogen in the post-invasion samples. This was expected since zebra mussels filter the particulate matter out of water. My results suggest that as zebra mussels become more prominent in Lake Leelanau, they filter more growth-limiting nutrients, which leads to a decrease in the density and diversity of the phytoplankton community. Phosphorus has been found to be the primary growth-limiting factor for phytoplankton in the northern United States [11]. Because phosphorus is such an important nutrient for phytoplankton, the abundance of algal communities is expected to decrease when less phosphorus becomes available.

Research Articles

In past years (2001-2003) between May and August, there have been phytoplankton analyses of Lake Leelanau. These analyses have concluded that the most obvious impact on Lake Leelanau by the zebra mussel invasion has been the mid to late summer blooms of *Microcystis aeruginosa* [15]. These blooms occur during the peak recreational use period. *M. aeruginosa* is a toxic blue-green alga that is altering the water quality and is therefore affecting human use and enjoyment [15]. Since *M. aeruginosa* is a toxic alga, it also has the potential to affect wildlife and human health [8]. Furthermore, in Lake Michigan (Leelanau County), *Cladophora* growth is increasing due to the recent invasion of zebra mussels [15]. Zebra mussel pseudofeces in the benthic region of the lake are apparently supplying the necessary phosphorus to promote luxuriant *Cladophora* growth that ultimately washes up to the shore and soils beaches with decaying plant material [15]. This research project was an attempt to understand the zebra mussel growth occurring in the inland lakes of Michigan. Further studies can extend the current research and aim toward gaining awareness on the biology, life history and dispersal mechanisms of zebra mussels in order to slow the spread of invasion by this exotic species to the lakes in Leelanau County and other lakes in the region. Preventing any further invasion will help keep Michigan lakes pristine and beautiful.

Acknowledgements

The author thanks her mentor and dear friend, Rex L. Lowe, as well as Jared Rubenstein and Paula Furey for their technical help. Dr. Rex L. Lowe funded this work.

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