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A CASCADE OF EFFECTS CAUSES A POPULATION CRASH IN RESIDENT MAMMALS

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ABSTRACT

We spent the late-summer and fall of 2011 through 2013 studying the habitat use and population characteristics of mammals located on two tracts of farm ground at the Prairie for Biodiversity research site in Decatur, Illinois. During the study, population crashes were observed in Peromyscus maniculatus and Microtus ochrogaster. During the first year of the study, a seemingly in hospitable (urban) agricultural area revealed a diverse population of inhabitants. mammal populations had been observed. In the third year, population numbers of Peromyscusmaniculatus and Microtus ochrogaster had also plummeted. Blood samples obtained from the carcasses of deceased animals revealed a population impacted by disease. Due to an initial population explosion from a pulsed resource, the physical effects of enduring the third year of a drought cycle adversely impacted the mammal populations. Resident mammals shifted their energy into survival rather than immune function, which allowed their immune systems to become compromised by parasitic invaders and hastened the population crash.

Keyword: Population characteristics, Mammal populations, Population explosion

INTRODUCTION

Warm season perennial grasses (*Panicum virgatum, Sorghastrum nutans* and *Andropogon gerardii*, etc.) as well as exotic grass species (such as *Miscanthus giganteus*),have been identified as a possible bio-mass based agricultural crop for use in cellulosic ethanol production, as a household heating source and as an additive in coal fired electrical generating plants. Due to the removal of millions of acres of marginal ground from the Conservation Reserve Program (CRP), corn and soybean production is expected to rise and damage to the environment as a result of increased agricultural production is also expected to rise (John & Watson, 2007).

Switchgrass (as well as other cool and warm season grasses planted) can provide cover for animals, forage for ungulates and habitat for nesting birds and various mammals, all while protecting waterways. Perennial grass based agriculture has the potential to protect the erosion of soils and runoff of nitrates and phosphate as a result of agricultural production methods, all while providing structure and cover for organisms in the community.

While there is no doubt that warm season perennial grasses are beneficial for the environment, the extent of the benefit is questionable. In order to maximize the potential of bio-mass based agriculture, the production of bio-mass based agricultural products must be economically viable for farmers and there must be a sustainable market in Illinois for the end consumption of the product. Historically, perennial grass agricultural strategies have been planned and implemented similar to traditional production agriculture, in monoculture ecosystems (Hartman et al, 2011). When grown in large monocultures, research has shown that *P. virgatum* (switchgrass) has an increased susceptibility to some strains of the yellow barley dwarf virus (Hartman et al, 2011) and researchers suggest that any Conservation Reserve Program (CRP) land converted to biofuel production should focus on a combination of warm and cool season grasses to maximize the potential benefits for wildlife (Hartman et al, 2011).

Millikin University was contacted by the Agricultural Watershed Institute (AWI) to conduct a third party collaboration research study. The AWI was in need of a survey of birds, arthropods and mammals occupying a parcel of property owned by Caterpillar, Inc. The AWI and Caterpillar, Inc. have invested in planting several varieties of warm season perennial grasses to be used as a bio-mass crop in lieu of a normal corn / soybean rotation. Because of the elimination of millions of acres from the CRP, AWI wanted to know if bio-mass production is a viable alternative (i.e. profitable) when compared to corn and soybeans. Caterpillar, Inc., as an agricultural machinery producer, was interested in knowing the results of this study on bio-mass, as well as knowing what animals currently reside on the bio-mass production ground.We spent the late-summer and fall of 2011 to 2013 studying the habitat use and population characteristics of mammals located on two tracts of farm ground at the Caterpillar, Inc. research site in Decatur, Illinois. The site had been planted in warm season perennial grasses, including: *P. virgatum*, *A. gerardii* and *S. nutans*.

Many studies have been conducted in an effort to explain the reasons for population crashes. Researchers have hypothesized that predation could have an impact on numbers in a population (Maron & Pearson, 2011), drought (Reed et al., 2007;Shenbrot et al., 2010), trap induced mass decline (Pearson et al., 2003), increased trapping elevates stress levels among mammals (Suazo and Delong, 2007), disease due to elevated populations (Pedersen & Grieves, 2008) and resource availability (Harper et al., 2008). In Derting and Compton (2003), the authors stated that population crashes due to impacted immune function can be induced by an increase in environmental stressors, such as overcrowding, drought, lack of shelter, reduction in food availability and increases in predation. Winternitz, et al. (2012) stated that population declines can be caused or exasperated by infectious diseases, but that parasites can have a stabilizing or de-stabilizing effect on local populations. Pederson and Grieves (2008)stated that increases in parasitic infection have been observed to increase directly with population size.

During the 2012 trapping period, we observed eleven *P. maniculatus* lying dead in the research area due to unknown causes and collected the carcasses. During the 2013 trapping period, we observed that population numbers of *Peromyscus maniculatus* and *Microtus ochrogaster* had plummeted when compared to the 2012 trapping numbers. We hypothesized that a cascade of effects driven by adverse environmental conditions and disease resulted in the local population crashes of *P. maniculatus* and *M.ochrogaster* in our study.By collecting blood from deceased animals and observing under a microscope, we could identify if vectors aided in the population crash. In 2013, any dead carcasses found were also collected for future examination.

MATERIALS AND METHODS

We trapped two parcels of ground on the north-eastern edge of Decatur, Illinois (N 39° 50' 25.3638", W 88° 57' 17.2872"); bordered by US Route 48, Illinois Route 121 and the Caterpillar, Inc. property. The site is bisected by a local road and is in two parcels. The north parcel is approximately 2.63 hectares and had been planted on approximately June 8 - 13, 2011 by a custom seed applicator from the local area. The ground was planted with six different varieties of grasses: *Thinopyrumintermedium* (intermediate wheatgrass), a variety of Cave-in-Rock switchgrass (*P. virgatum*) known as "Blade" (Blade Energy Crops®, Thousand Oaks, CA.), *A. gerardii* (big bluestem), *Schizachyrium scoparium* (little bluestem), *Bouteloua curtipendula* (sideoats grama) and *S. nutans* (Indian Grass).

The southern parcel is approximately 22.26 hectares and was planted in four separate plots of four differing grass blends, between June 8 and 13, 2011. Plot 1 is a three grass warm season perennial mix of big bluestem, switchgrass and Indian grass. Plot 2 is solely the "Blade" variety of switchgrass. Plot 3 is a blend of 4 grasses and 6 forbs, as well as two pounds of Indian grass (Quail Unlimited, Albany, GA.). Plot 4 is a diversity mix of 11 grasses and 22 forbs (Pheasants Forever, St. Paul, MN.). During the 2010 growing season, both parcels had been planted in *Zea maize* (corn).Using geographic information systems (GIS) available from the Macon County, Illinois Supervisor of Assessments website (http://gis.co.macon.il.us/), I noticed that this parcel of ground is a land locked fragment of environment with no apparent natural travel corridors and the nearest water source being in excess of 2,000 meters away to the south east. As a habitat for anything other than small mammals or birds, it appeared to be unsuitable to sustain life.

In the Multiple Species Inventory and Monitoring Technical Guide developed by the United States Department of Agriculture (2006), it was recommended that eight transects, 200 meters long, be used to trap small mammals. This type of arrangement was not useful for my purposes, sincethe schematic of the USDA would require a parcel of land that encompassed an area 200 meters long and 200 meters wide, with traps located on transects 20 meters apart. The arrangement of traps that I chose to use was in roughly a diamond shape, 50 meters in total length and width, with four tiers or layers of traps that have been staggered in placement at set depths, emanating from one central point. The traps averaged 4 to 5 meters apart, even though in a study of small mammal trapping (Jones, et al. 1996), researchers hypothesized that most small mammal species had a 20-meter radius home range that was travelled and only one trap per 20 meters was needed. I hypothesized that since some small mammals are social animals, one trap per 20 meters would not be as effective in determining the true population of a given area. Utilizing this trapping method, only one reference point (determined by Global Positioning System) and a compass would be needed in order to conduct subsequent trapping sessions in the same locations. Reference stakes could be removed from the research area in order for the AWI to mow the area.

Fifty-two small and medium sized mammal traps were used to capture and identify vertebrate species occupying the parcels of ground. Forty-eight small Sherman ™ (H.B. Sherman Traps, Inc., Tallahassee, FL.) live traps were used to capture small mammals, as well as four larger Tomahawk™ (Tomahawk Live Trap Co., Tomahawk, WI.) live traps for medium sized wild or feral mammals. The bait that used was crushed oats (oatmeal) with shelled peanuts (used for an olfactory component) for small mammals and commercially available salt wheels and canned cat food to lure larger mammals. The cotyledon of the peanuts was broken to ensure that they would not germinate prior to use. All animal life captured was measured to the nearest millimeter with a portable ruler, weighed using a 60 gram Pesola® (Pesola AG, Baar, Switzerland) Micro-line 20060 hanging spring scale to the nearest .5 grams, ear tagged (National Band and Tag Company, Newport, KY.) in order to identify repeat captures, photographed and then released on site utilizing scientifically accepted methods and guidelines developed by the American Society of Mammalogists (Sikes et al., 2011). Animals found deceased in the research area were transported immediately to Millikin University and placed intact into a freezer at -4° C until they could be studied further. Carcasses were removed and allowed to thaw for 24 hours, then opened by abdominal incision using a number 1 scalpel. Blood samples were obtained by incision of the heart and liver. Blood smear slides were prepared using standard procedure, fixed in methanol, then stained using Wright-Giemsa stain. The slides were then observed using an oil immersion lens microscope at 1000 power and photographs of vectors were obtained using an iPhone.

RESULTS

P. maniculatus (deer mouse) was the predominant species captured in 2011, 2012, and 2013 (Fig. 1). *P. maniculatus* population numbers initially rose from 57 captures to 266 captures in 2012; falling to 11 captures in 2013. *Microtus ochrogaster*(prairie vole)numbers also dropped from 2012 to 2013.*Blarina brevicauda* (short tailed shrew)populations appeared unchanged, as they were both caught in similar numbers all three years of the study. Blood smear slidesfrom the heart and liver were obtained from four*P. maniculatus* carcasses and one *M. ochrogaster* carcass collected in August 2013. Comparisons were made between the deceased animals and blood smear slides from *P. leucopus* caudal veins provided by Dr. Travis Wilcoxen of Millikin University. Evidence of parasitic infection in both *P. maniculatus* and *M. ochrogaster*was observed under microscope, possibly identifying a strain of *Falciparum* spp. (malaria) targeting the rodents.

Table 1. Species captured and number of captures by year at Prairie for Biodiversity research area, Decatur, Illinois

Species	Number of Captures by Year 2011	2012	2013	Total
Deer mouse *(Peromyscus maniculatus)*	57	260	11	328
White footed mouse *(Peromyscus leucopus)*	20	0	0	20
Norway rat *(Rattus norvegicus)*	0	1	0	1
Prairie vole *(Microtus ochrogaster)*	4	8	2	14
Short tailed shrew *(Blarina brevicauda)*	1	2	1	4
House mouse *(Mus musculus)*	1	0	0	1
Eastern cottontail *(Sylvilagus floridanus)*	0	1	4	5
Total	83	272	18	373

DISCUSSION

Many studies have been conducted regarding the impact of warm season perennial grasses on game and song birds, however,very few studies have concentrated on the long term impact of biomass agricultural production on small mammals. Since the area was cultivated and planted in the aforementioned manner prior to the start of the research, there is no data regarding former resident birds and mammals that were dependent on the corn / soybean production and that were possibly displaced as a result of the agricultural shift.As a result, it is assumed that the mammal species present when the study began were already represented in the corn / soybean agricultural matrix. This study focuses solely on the carcasses of deceased mammals found in the research area during2012 / 2013 and the subsequent impact of a cascade of events including parasitic infection on the resident mammals.

We believed that the change in agriculture would have an initial positive impact on the mammal community. As the numbers of small mammals increased, eventually, raptors and larger mammalian predators would be attracted to the research area, but they would not remain due to a lack of water. Without natural predators remaining near the research area to control the population of small mammals, we hypothesized that the small mammals would see an exponential growth over the coming months and years that could have a detrimental effect on the population by increased competition for resources and increased disease.

In Murray and Best (2006), the researchers hypothesized that the late autumn / winter harvest would enhance bird reproductive fitness because agricultural activity would not disturb nesting. The initial phase of trapping appeared to support previous research regarding the benefits of warm season perennial grasses to birds, but researchers also found that food availability was terribly low in switchgrass monocultures due to lack of desirable forbs and excessive grass density after 5-6 years (Harper et al. 2008). The plant composition in the research area changed dramatically over the 3-year trapping period.

In the first year of the study, the research area was primarily occupied by warm season perennial grasses, old field grasses, forbs, and *Amaranthus rudis*. Initially, the vegetation was not thick, with only about 50 percent coverage of the available ground.

An observation that I had early on was the association between the captured mice and water hemp plants. It appeared that the mice were utilizing the bases of the water hemp plants as entrances to their burrows, since the ground around the large water hemp plants was split open due to the drought conditions and in other locations of the research area, the ground was hard and smooth (compacted). I observed that all throughout my trapping periods, the water hemp plants were the predominant seed available for mammals, while the warm season perennial grasses did not drop their seed until the first frost.

Maron and Pearson (2011) stated that predation could have an impact on numbers on an isolated population. Scat was located on one occasion in 2011 from a large mammalian predator. A field examination of the scat revealed bones from unidentified mammals within it, proving that at least one mammalian predator had been on the fringes of the research area. It is not believed that predators had a large impact on population numbers, since there is no readily available ground water and no further evidence was located in the research area of their presence. This instance was probably an isolated nomad travelling through the area.

At the onset of the study, drought conditions overcame the region and continued into 2013. Disturbance events like natural disasters or severe climatic extremes allow for rapid population shifts and for the establishment of invasive species (Brown, 2010). Due to an absence of available ground water and shelter from the extreme temperatures that season, the drought conditions may have hastened the decline in mammal populations, forcing mammals to find a habitat that was less harsh and the species may have moved from the study area.

While these explanations are plausible, we did not believe that this is the full story. We had photographic evidence from 2012 of *M. ochrogaster* with evidence of barbering, due to insect infestation (Fig.1). Under microscopic inspection of the slides, a schizont was discovered on the

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blood smear slide from the liver of *M. ochrogaster* (Fig. 2), as well as an ookinete and merozoites (Fig. 3,4).A search of the Center for Disease Control website identified the vectors as belonging to the *Falciparum* species of malaria (Fig. 5).

Figure 1. Photograph of *M. ochrogaster with* evidence of barbering in September 2012 at the Prairie for Biodiversity research area,

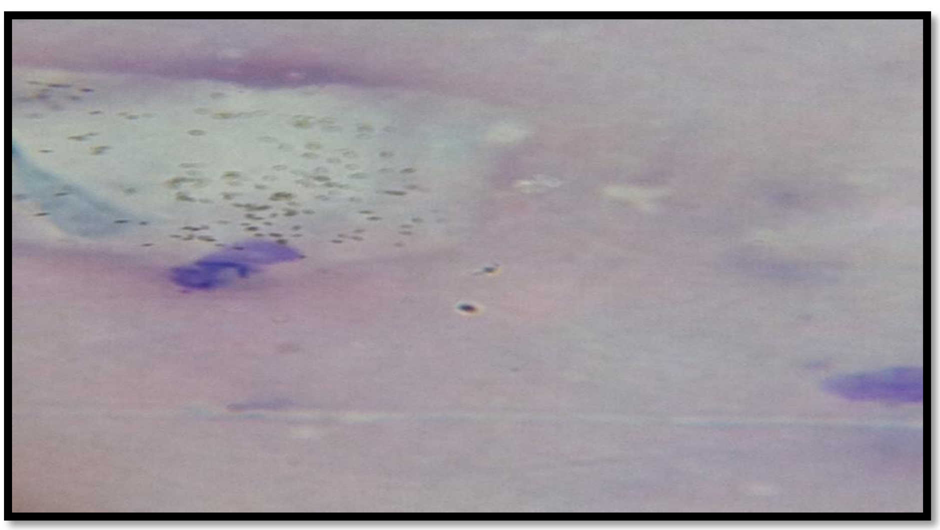

Figure 2. Photograph of *M. ochrogaster* blood smear slide utilizing oil immersion microscope lens. (Photograph: D. Leimbach, 2014

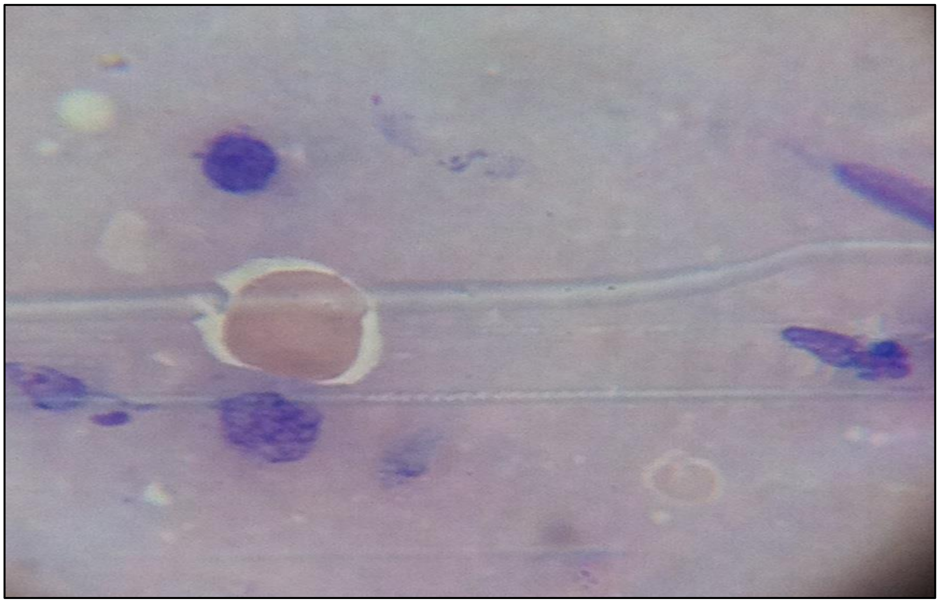

Figure 3. Photographs taken of *P. maniculatus* blood smears showing possible malaria ookinetes and merozoites.
(Photograph: D. Leimbach, 2014)

Figure 4. Photographs taken of *P. maniculatus* blood smear slides showing possible malaria ookinetes and merozoites.
(Photograph: D. Leimbach, 2014)

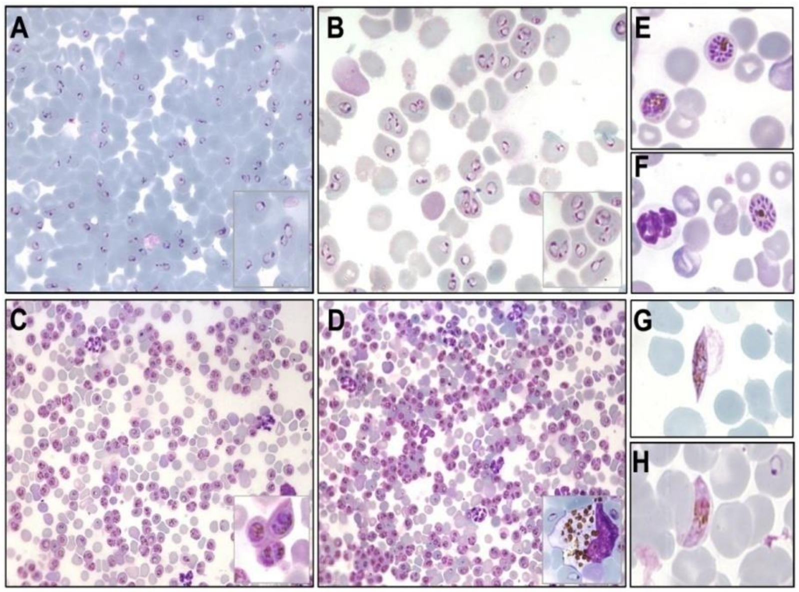

Figure 5. Photograph of *Falciparum* spp. (malaria) schizont (D) from mouse blood smear slides used for visual identification.
(Photograph: Center for Disease Control, 2014)

CONCLUSION

In the early succession field, *A. rudis* had become a pulsed resource (Marcello et al. 2008, Pedersen et al. 2008) causing a large population increase. A high death rate in the 2012 breeding cohort to maintain population stability (Boonstra et al. 1998), the third year of drought conditions, reduced immuno-competence to aid in survival and a reduction in resources, *P. maniculatus* population numbers could not be sustained and the population crashed. *M. ochrogaster* feeling the stress of a third year of drought (and a changing environment), physiologically reduced their immune systems in order to increase survival. Internal and external parasites seized the opportunity to invade the *M. ochrogaster* population and aided in the population crash. Future research could include conduct research to determine the impact of parasites and disease in relation to population fluctuations and attempting to definitively identify vectors impacting the mammal populations.

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