DALMATIAN TOADFLAX EFFECTS ON WESTERN INSECTS DIVERSITY IN THE NATIONAL BISON RANGE

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Abstract

Since early 1990's Dalmatian toadflax (*Linaria dalmatica*) made its appearance on the National Bison Range, in Moiese Montana. This invasive forb is classified as a noxious weed in 14 states including Montana, and it's known for overcrowding native vegetation and decreasing biodiversity. This study sampled bug populations through sweeping nets and pitfall traps to see if there was a relationship with Dalmatian toadflax presence. Dalmatian toadflax counts were made in each sample on five sites in the National Bison Range during the summer of 2019. Also, pitfall traps and sweeping nets were used to estimate insect diversity index. A total of 38 families were sampled and identified down to family taxonomic level, using sweeping nets and pitfall traps. Diversity index were estimated using the Shannon-Wiener index. There was not a significant relationship between Dalmatian toadflax (*Linaria dalmatica*) counts and Shannon-Wiener index for insects. Results suggest that other factors, within complex interactions, besides Dalmatian toadflax presence, could be driving and changing insect diversity indexes.

Introduction

Grasslands covered much of North America ground once and cover up to 40% of earth's terrestrial area (Omara, 2018). It is one of the most endangered biomes in the world. Because of its situation we can study how disturbed ecosystems react and maybe bounce back to their original condition with the help of restoration. But the real situation is that most of the grasslands are showing signs of habitat degradation. Grasslands provide such an important ecosystem for many organisms including us. They also provide many ecological services that are essential for the sake of the environment such as a better quality of the atmosphere and hydrosphere (Lemaire, 2007).

Historic aspect of grasslands

Grasslands are considered an environment of historical significance because they held much of the history of Native Americans and their way of living, besides the process of colonization. Now, it has been, and it is still being used for agriculture. And many of the anthropogenic pressures are reflecting on the wellness of this ecosystem. They had been attenuated by fire suppression practices and cattle grazing. Activities that had diminished the biodiversity and percentage cover area of grasslands.

Biological and chemical control

There is a record of the various attempts to control invasive species but most of them can severely affect native species, even more so when the native and invasive species are similar (Corblin & D'Antonio, 2010). Trying to control invasive species in grasslands

has proven to be a hard and complex subject. If plants have different phenology and life-history characteristics, a certain type of control can be considered. But if plants are similar, that they share a set of characteristics, then applying a control will be difficult because it will target both plants (Corblin & D'Antonio, 2010).

Restoration efforts

Because of the high threat grasslands are facing, restoration efforts had been made with the purpose of recovering the biodiversity that characterizes this ecosystem. This process has been hard because of the competition that invasive species present. Also, with this competition comes the decrease of native species, which will need to be reintroduced in the near future (Holl et al., 2014). Dalmatian toadflax appeared in the National Bison Range since the early 1990's, which clearly was a concern for the National Wildlife Refuge. Because Dalmatian toadflax can overcrow native plants and affect the big game grazing, like bison, it could have a negative effect on bugs that need native plants to survive, too. So recent like June of this year, volunteers and employees from different agencies have gathered to pick up weevils at the National Bison Range, that are one of the ways to control the Dalmatian Toadflax (Reilly, 2019).

Dalmatian toadflax

Dalmatian toadflax (*Linaria dalmatica)* is originally from Eurasia and its name comes from the district where it is native: Dalmatia. It was introduced to North America in the late 1800's as a plant for ornamental gardens (Sing, et al., 2016). Since then, Dalmatian

toadflax has established in different places. It preferes disturbed soils such as roadsides, along railroads and overgrazed places among others (Sing, et al., 2016).

Dalmatian toadflax its distributed among the 31 states of the USA and in 10 provinces of Canada. In the case of Montana, it is listed as a noxious weed which means that this forb has a negative impact of huge dimensions, such as increasing soil erosion, decreasing wildlife habitat and displacing native plants ("Montana Noxious Weed List", 2019). In Montana it has a priority of 2B that means that this plant is highly abundant and widespread, requiring eradication . Dalmatian toadflax is known for its broad and alternates leaves; its stems can grow to a meter tall. Its root system is deep and has thick rhizomes, a feature that allows them to compete really good with other vegetation. Flowers start around June and can go through September, they are bright yellow and snapdragon shaped. Dalmatian toadflax can produce a huge amount of seeds and they are known to survive in the soil for as long as ten years (Jacobs & Sing, 1970).

Management

Dalmatian toadflax has a high genetic variability that makes the management of this invasive specie harder. Because of its waxy leaves, herbicides are not that efficient, and because Dalmatian toadflax likes dry and sandy soils, the herbicide can percolate having more negative effects on the future. Hand pulling can be done at early stages of the plant, because one it madurates its harder to completely pull of the floor because its root system. If han pulling is the chosen strategy it has to be done consistently over the years. Mowing does not work because it doesn't get to the root system. Another

technique that has been put to practice is burning, at first it can work really good removing the standing toadflax but at the same time it favors reproduction and spread of Dalmatian toadflax(Dodge, Fulé, & Hullsieg, 2008).Grazing practices has also been used, but cattle don't graze on toadflax, they usually avoid it completely. But sheep can graze on them, and suppress toadflax population (Montana Natural Heritage Program, 2019). On the other hand, biocontrol has been proved to be effective, species of weevils, stem borers and moths can decrease the Dalmatian toadflax. Six species of insects have been approved to work as biocontrol not only for Dalmatian toadflax but for its cousin Yellow toadflax, too.

Relationship with insects

Besides the competition between invasive and native plants that has been studied, where Toadflax takes advantages in places with low competition between species, invertebrates play a key role inside the ecology of grasslands. Some of them have economic importance because they are considered pests and they had been studied for better management. Invertebrates are involved in important ecological process in grasslands such as the modification of soil properties by decomposition of organic matter (Lavelle, 2006).

There is another research that has studied how invertebrates respond to the influence of invasive species. It has been observed that some species of invertebrates are restricted to native vegetation, concluding that the presence of exotic or invasive plants can lead to vulnerability in native invertebrates. Which is a major concern with

Dalmatian Toadflax that tends to overcrowd native vegetation. Reason why vegetation management is crucial and can influence invertebrate species assembles (Samways, 1996).

Methods

Study area

This research was conducted in the National Bison Range in Montana. Sites were selected making sure of the presence of Dalmatian toadflax in the area. Two locations were selected to choose sites. Two sites at the North Boundary Road near Mission Creek in NBR and three more on the Lower Pauline area on the NBR. Transects and plots were randomly located. Transects were located 20 meters away from the road. Six transects of 30 meters were placed in each site, with a separation of 10 meters between them. The transects alternated between sweeping with nets and pitfall traps. Sweeping was done at three random plots with seven sweeping motions. One pitfall trap was located in the other transect, at three random plots in the 30 meter transects.

Data collection

A total of five sites were measured for the invasive forb Dalmatian toadflax species and insect biodiversity through sweeping and pitfall traps. Species counts for Dalmatian Toadflax were recorded in each plot and sweeping or pitfall trap techniques were used, depending on the transect. After recording species count for Dalmatian toadflax, a pitfall trap was placed perpendicular to the transect. For pitfall traps, 18 oz plastic cups with a metal griddle on top, to prevent unwanted animals from getting into the trap, were filled

with five to seven centimeters of soapy water. Pitfall traps were collected every two days, and insects were identified to family level in the lab as well.

A sweeping net was used to collect a possible different communities of insects that could not may be recorded from the pitfall traps. Sweeping was done in every other transect, random distances along the transect were selected to do the sweeping. Insects collected from the sweeping net were put into killing jars charged with acetone to be identified later in the lab. All collected bugs were processed in a solution of ethanol and then identified down to the level of family using field guides. Insect biodiversity was calculated using the Shannon-Weiner Diversity Index.

Statistical analysis

All analyses were done using Mystat free student version 13. The results of all the families identified in the five selected sites were analyzed using linear regressions for each of the sampling methods; sweeping and pitfall traps. Linear regressions were done between Dalmatian toadflax counts and Shannon diversity index. A two sample t-test was done to see if there was a significant difference between the sampling methods.

Results

A total of 38 families were identified amongst the five sites using sweeping and pitfall methods. Mean values for Shannon diversity index and toadflax counts were obtained (Table 1). There was not a significant relationship between Dalmatian toadflax counts and Shannon-Weiner diversity index (Fig 1.). After running a two sample t-test there was not a significant relationship either between each sampling method (Fig. 2, p value = 0.427, t = 0.820, df = 13.000).

Discussion

Dalmatian toadflax is known for overcrowding native vegetation, enabling them to outcompete other species. Research has demonstrated that places with higher diversity and species richness to be less invaded and affected by invasive species. That suggests that diversity inhibits invasion, meaning that a community with a higher diversity could survive an invader impact much better (Maron & Marler, 2008). Dalmatian toadflax, although it is widespread and known for a good amount of years, still poses risks to environmental health as an invasive weed, such as competitive displacement of native plant species. Therefore, my main question was to see if Dalmatian toadflax had any negative effect on insect diversity index.

It has been a long time debate what kind of methods are the best to sample different kinds of bugs and estimate their diversity. In this study I used two methods; sweeping and pitfall traps, to ensure I obtain data that is representative of flying and non-flying insects. However each technique will have its own limitations. For instance pitfall traps

require a certain kind of activity such as insects crawling on the ground. It requires them to fly or not and each of them requires an activity level. It's important to take into account the specific behaviour and ecology of the target group. (Yi, Jinchao, Dayuan, Weiguo, & Axmacher, 2012).

According to my results, Dalmatian toadflax did not have any effect on insect diversity index. So, there is something else driving the insect diversity, besides Dalmatian toadflax presence. New aspects should be researched at the same time while studying an invasive species to understand its success. Most of the times, the invasive species are studied in an isolated way with its herbivore, and other relationships are completely excluded. Interactions like soil, above ground organisms, and plant microorganisms fauna under the ground, should be taken into consideration to get a better picture of what is really happening (Harvey, Bukovinszky, & Putten, 2010). Complex interactions such as native insects between their native vegetation should be known first to be capable to understand the consequences and effects of plant invasions on native insects communities (Sunny, Diwakar, & Sharma, 2015). The impact of invasive plants on insect populations has been rarely studied, besides which one could be a good form of bio control. The presence of a different plant species that are not native could mean a complete change in insect behavior and knowing now, that invasive plants can change the landscape in so many ways, not just for insects, it should be given more importance in general (Bezemer, Harvey, & Cronin, 2014).

Conclusions and future recommendations

Dalmatian toadflax did not have any effect on the Shannon diversity index for insects for this research project. There was not a significant relationship, which means that Dalmatian toadflax alone is not a driving factor. Something else, or a combination of factors and complex interactions are what could be changing the diversity index. If I were to do this project again, or continue it, I would add more sites not only in the National Bison Range, but in other counties of Montana where Dalmatian toadflax is more abundant and where there is the possibility that there is no action to fight Dalmatian toadflax. Which will be a good comparison of different locations with high and low densities of this invasive forb.

In relation to the sampling methods, a higher frequency sampling and even sampling on different seasons like summer and winter, will add more context to this kind of project. Using more than two sampling methods besides sweeping and pitfall traps could be a good idea to add more variety to the samples. Focusing on a genus or even on a species could be a better approach to understand invasive species plant impact on that specific organism. Also, looking for insect preferences between native and invasive forbs such as Dalmatian toadflax could be one path that other projects could take on.

Invasive species are a worldwide problem that many countries are trying to attack on the best way to protect their resources and the economy depending on them. There are many examples where the invasive species situation can go wrong and be very hard to

treat. But with the right tools and long term research, the best approaches can be made to ensure the protection of ecosystem services and values.

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Table 1. Mean values for Shannon diversity index and Dalmatian toadflax count for each site and method.

Site	Shannon diversity index	Dalmatian toadflax count	Method
1	1.150	10.667	Sweeping
1	1.249	7.667	Pitfall traps
2	1.444	59.667	Pitfall traps
2	1.437	49.000	Sweeping
3	1.503	0	Pitfall traps
3	1.377	1.667	Sweeping
4	1.643	5.000	Pitfall traps
4	1.514	1.000	Sweeping
5	1.369	0.333	Pitfall traps
5	1.629	0.333	Sweeping

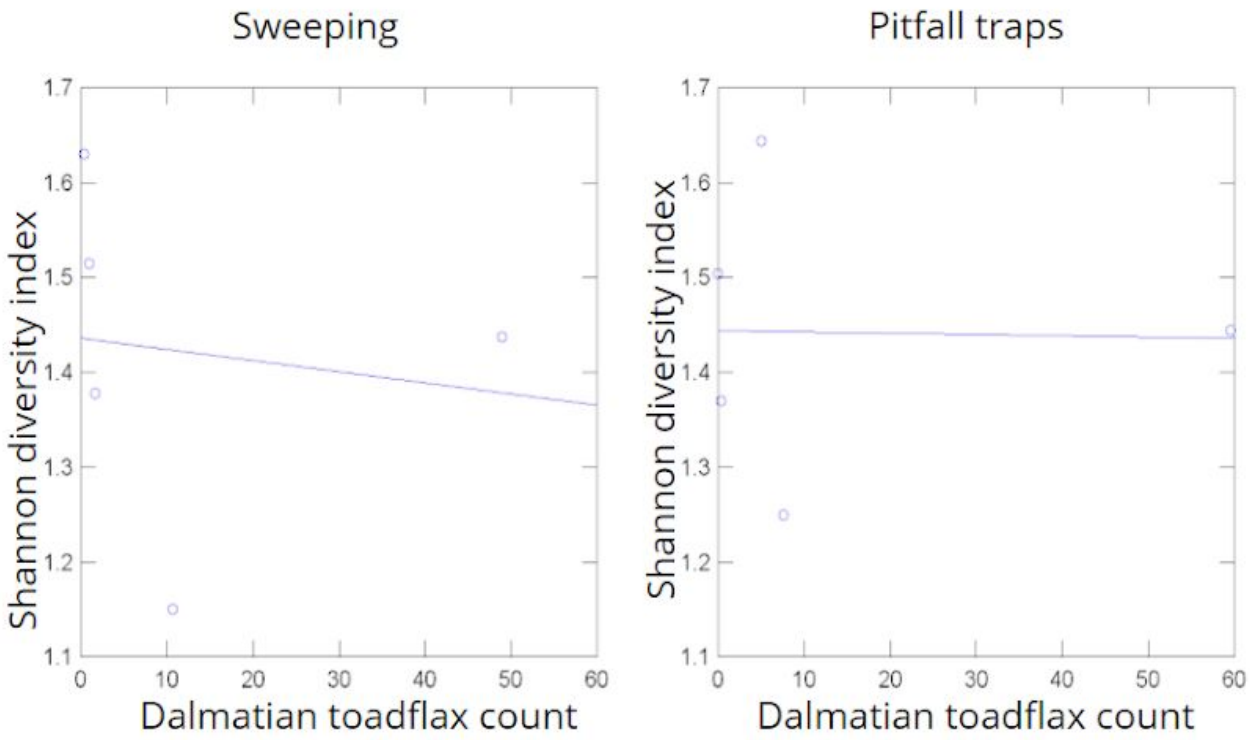

Figure 1. Dalmatian toadflax counts against Shannon diversity index for sweeping and pitfall traps.

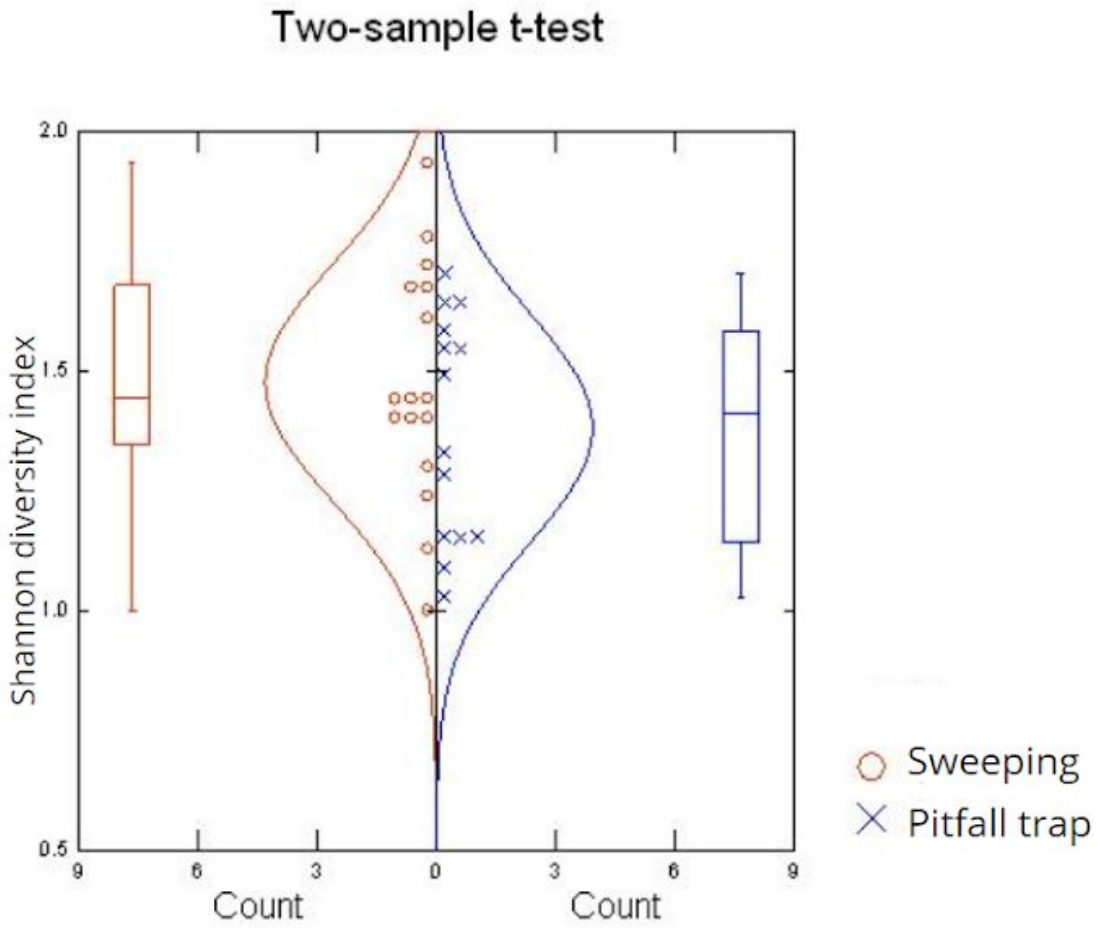

Figure 2. Two sample t-test for Dalmatian toadflax count and Shannon diversity index for sweeping and pitfall traps. (p = 0.427, t = 0.820, df = 13.000)

Appendix

- Map with sampled sites in the National Bison Range, three sites on West Boundary Road (yellow) and two sites on North Boundary Road (green).