Platyptilia carduidactyla Seed Predation on *Cirsium Palustre* and *Cirsium Muticum*:

Invasive and Management Implications

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ABSTRACT

The invasive thistle *Cirsium palustre* invades the region of the native thistle *Cirsium muticum.* These two species share a common seed predator, the larvae of *Platyptilia carduidactyla.* I have conducted three experiments to determine the seed preference, flower head preference and infestation of these two thistles in a common site. The results of these experiments demonstrate the preferred host of the larvae and the level of infestation of each species. The conclusions drawn from these results are suggestive of the degree of *Cirsium palustre's* invasiveness and management measures that can be applied to the invader's population to keep in check.

INTRODUCTION

Invasion by species in an ecosystem is an integral component of the ecosystem's diversity and dynamics. An invasive species is one that is introduced to a region beyond its previous range (Williamson 1996). This introduction can occur naturally or by human transport of the organism. An invasive plant can quickly overrun the range of native species because the invader is often invulnerable to indigenous herbivores and enemies. Therefore an invader's impact on its host environment can be harmful to the native species of the host ecosystem (Williamson 1996). Once an invasive plant becomes a pest that is difficult to control, it is defined as a weed. The question of how to control weeds and the degree of damage they inflict upon the populations of native species is one of great concern to biologists.

The establishment of an invasive species depends on a variety of factors concerning the invader and its host environment. Some of the characteristics of a successful invader are those of a pioneer species: high fecundity, high growth rate, high short-range dispersal rate, short generation time (Kareiva et al. 1993). Invaders usually have an advantage over native species because they lack the natural enemies that attack native species (Williamson 1996). This pattern allows the invader to thrive reproductively while the native species population suffers from herbivory.

The susceptibility of an ecosystem to invasions reflects the stability of the habitat. For example, habitats that endure frequent breaks in the natural plant cover, like roadsides, are more vulnerable to invaders than established ecosystems (Mooney and Drake 1986). The riparian system also is highly susceptible to colonists because it is vulnerable to frequent breaks in the plant cover (Mooney and Drake 1986).

In Michigan, the European swamp thistle, *Cirsium palustre* (L.) Scop., is an introduced species that was brought from western Europe in the early twentieth century, and has since established itself as an aggressive weed. It colonizes primarily alkaline wetland habitats, cedar swamps and regions of great disturbance, like roadsides (two areas known to be vulnerable to invasion). This invader has spread voraciously from the Upper Peninsula, where it was first collected in Marquette County in 1934, to the Lower Peninsula where it was assimilated by 1959; it migrates along roadside ditches and by human transport, and continues to move south (Voss 1996). The European swamp thistle looks similar to the native swamp thistle, *Cirsium muticum* Michaux, with a purple head and bristly stems and leaves (Voss 1996). The invasive *Cirsium palustre* is characterized by a large stature, (over 1.5 m). The height and abrasive prickles that defend its long stem and leaves make *Cirsium palustre* formidable to many herbivores.

There is a history of seed predation of *Cirsium palustre* and *Cirsium muticum* flower heads. A seed predator is an insect or animal that feeds upon the seeds of a plant, thus killing the seeds and reducing the number of propagules that the plant produces (Howe and Westley 1988). Since these thistles are biennials, they invest much of their energy in producing flower heads which makes them appealing to phytophagous guilds (Zwolfer 1988).

At Reese's Swamp in Cheboygan County, Michigan on July 10, 1998, I observed Lepidopteran larvae, *Platyptilia carduidactyla* (Riley) of the Pterophoridae family, feeding upon the ovules within the receptacles of the flower heads. These are larvae of plume moths (Stehr 1987). Plume moth larvae can feed upon the stems, flower heads or leaves of thistles and other hosts in the Asteraceae family (Stehr 1987). Oviposition occurs in mature flower heads where the larvae can feed upon the ripening achenes and receptacle (Zwolfer 1988). Presumably, female plume moths can detect which thistle heads are occupied, so that only one larva is found in each flower head (Zwolfer 1988). Plume moths are iteroperous with two generations/year and an overwintering stage in regions with climates comparable to Michigan.

My experiments will test three hypotheses that will give insight to the *Platyptilia carduidactyla* larval seed preference between *Cirsium palustre* versus *Cirsium muticum*, their preference between the two thistles' flower heads and the infestation of plume moths in the *Cirsium palustre* and *Cirsium muticum* populations of Reese's Swamp. Three null hypotheses will be tested:

(1) There is no difference in seed preference of the *Platyptilia carduidactyla* larvae on *Cirsium palustre* versus *Cirsium muticum.*

(2) There is no difference in head preference of the *Platyptilia carduidactyla* larvae in *Cirsium palustre* versus *Cirsium muticum.*

(3) There is no difference in infestation of *Platyptilia carduidactyla* larvae on *Cirsium palustre* and *Cirsium muticum.*

The results of these tests will demonstrate the preferred host of the predatory plume moth larvae and will compare the degree of larval infestation between the invasive thistle and the native thistle. This information also could reveal the magnitude of invasion by *Cirsium palustre* based on the adaption of common herbivores to feed upon both species of thistle, and could disclose biological management implications.

Methods

In order to test my null hypotheses, on July 10, 1998 and July 17, 1998, I collected specimens of *Cirsium palustre* and *Cirsium muticum* flower heads and *Platyptilia carduidactyla* larvae from Reese's Swamp in Cheboygan County, MI (45°33'N; 84°41'W; T36N, R3W, S3). I used clippers to cut inflorescences from each species of thistle. I took a random sample of every tenth plant of *Cirsium palustre* that I encountered and every seventh plant of *Cirsium muticum* that I encountered. I sampled *Cirsium muticum* more conservatively because its population was smaller and I did not want to damage too many of the native species. I tried to clip inflorescences with heads of comparable maturity because much of *Cirsium palustre* was in seed, whereas *Cirsium muticum* was flowering. If the buds of the plants destined to be sampled were not of similar maturity, they were disregarded and the next plant was sampled instead. To preserve the inflorescences, they were carried in a plant vasculum to the lab and placed in water.

These samples were used to determine the level of infestation in each thistle species. Infestation was detected by the presence of a larva or black frass within the flower heads. I opened each head using a razor blade. There were 869 *Cirsium palustre* heads and 189 heads of *Cirsium muticum.* The level of infestation was recorded as the number of infested heads out of the total number of heads in an inflorescence for each plant.

The thistle samples were also used to determine seed and head preference of the larvae. Head preference was ascertained using 16 larvae from the infested samples. Using forceps, I carefully removed the larvae from their host head and placed each one in one petri dish. I then cut open 16 healthy flowering heads of each thistle type and placed one of each in each of the 16 petri dishes. The heads were placed equidistant from each larva in each dish so that choice was not based on proximity to the heads. The petri dishes were labeled numbers 1-16 and letters P and M to distinguish the species of the heads. After 26 hours, the choice of each larva was recorded based on which head the larva chose to consume.

To determine larval seed preference, ten larvae from the infested heads were separated into ten petri dishes. These larvae were starved for 10.5 hours. Then, twenty seeds from healthy heads of equivalent maturity were removed and placed in each petri dish. Each larva was offered ten healthy *Cirsium muticum* seeds and ten healthy *Cirsium palustre* seeds. The groups of seeds were placed at equal distances from the larva in each petri dish to ensure that seed preference was not based on proximity to the food source. The dishes were labeled using the same number and letter system as the head preference tests. These larvae were allowed 25.5 hours to choose and feed upon their preferred thistle seeds.

The results from these three experiments were statistically analyzed using Chi-squared test. To measure level of disparity between the infestation of each thistle species, the number of infected heads out of the total heads in the sampled inflorescence for each plant was compared. The data were inserted into a Chi-squared test contingency table (Ambrose & Ambrose 1995). The data from infestation of the thistle heads were analyzed further based on the number of infested heads out of the total heads in the inflorescence per plant. This analysis was performed using an independent t-test on unranked arcsine transformed (arcsin $\sqrt{\%}$) data. The data from the head preference tests were compiled based on the number of times the heads of each species was chosen. The data from the seed preference experiment were collected and compared based on the number of consumed seeds of each thistle species. The head and seed preference data were compared by applying the Chi-squared tests (Ambrose & Ambrose 1995).

Results

The Chi-squared test was applied to the data collected from the level of infestation. Of the 869 *Cirsium palustre* heads observed, 110 were infected with larvae, or 13 %. Of the 189 observed heads of *Cirsium muticum,* 17 were infected which is 9% of the heads. A Chi-squared test was applied to compare the infestation of each thistle species and demonstrated that there is no significant difference (x calc=1.97, x crit=3.84, df=1).

Another statistical test were performed on the data concerning infestation. This test compared the two thistle species based on the number infested heads out of the total heads per plant. An independent t-test was applied to unranked, arcsine transformed (arcsin √%), which shows that the infestation between the two species is not significantly different (P=0.255).

The Chi-squared test was applied to the data collected from the head preference experiment. Of the 16 larvae in the sample size, 10 chose to feed upon *Cirsium muticum* and 6 chose to feed upon *Cirsium palustre* which proved to be statistically insignificant (x calc=1, x crit=3.84, df=1).

Finally for the seed preference experiment, the number of *Cirsium palustre* consumed seeds, 15, was compared to the number of *Cirsium muticum* consumed seeds, 54, using the Chi-squared test. This test confirmed that the difference in seed preference based on number of consumed seeds is significant (x calc=22.04, x crit=3.84, df=1).

DISCUSSION

The results of these experiments demonstrate interesting ecological trends of the invasive thistle, *Cirsium palustre.* The two tests applied that compared the level of infestation between the two thistle species show that because there is no difference in the infestation of *Cirsium muticum* vs. *Cirsium palustre,* I fail to reject my null hypothesis. Ecologically, one would expect that the native *Cirsium muticum* would have a significantly higher infestation than the invasive *Cirsium palustre.* A major factor enhancing the success of an invader is that the invader lacks the natural enemies and herbivores of the native species (Williamson 1996). However, in this case the ovipositing female plume moths *Platyptilia carduidactyla* are not distinguishing between the native and invasive species of thistle. *Platyptilia carduidactyla* is a generalist feeder does not discriminate between several species of thistle and will consume leaves, stems and flower buds (Stehr 1987).

The implications of this feeding pattern by plume moth larvae are that *Cirsium palustre* is becoming naturalized into the range of wetlands inhabited by the native *Cirsium muticum* and of disturbed areas like roadsides. This invasive trend is one followed by several members of the Asteraceae, mostly within the Palearctic region (Zwolfer 1988). The invasive pattern weaved by certain genera of the Asteraceae family has spurned several biological control programs because these weeds are presenting a pest problem in agriculture (Zwolfer 1988). The principle of a biological control program to battle invasive plants is that herbivorous predators be introduced to the invasive population to maintain the population at a density lower than would occur in the absence of the predators (DeBach 1965). These programs have resulted in the fruitful translocation of about twelve insect species from Europe that feed upon aggressive invasive thistles (Zwolfer 1988).

In the case of the interaction among *Cirsium palustre, Cirsium muticum* and *Platyptilia carduidactyla* a biological control program would not be a sound endeavor. The plume moth is too expressly a generalist feeder and if introduced, would probably destroy several native species of thistle along with the invasives.

The rejection of the plume as a biological control agent is further supported by the results of the seed preference experiment which was statistically significantly different, meaning that I reject my null hypothesis concerning seed preference. The larvae preferred *Cirsium muticum* seeds over *Cirsium palustre* seeds by a ratio of 54:15. This suggest that the larvae, if given the choice, would rather consume the seeds of the native thistle than those of the invasive thistle.

I failed to reject my null hypothesis stating that the plume moth larvae would prefer to feed upon *Cirsium palustre* heads over *Cirsium muticum* heads because the statistical results from this experiment are not significantly different. However, the seed and head preference experiments are less relevant than the infestation data because the food choice is decided by the ovipositing female. The larvae are obligated to consume the host head that is chosen by the female that lays the egg upon the thistle head. The thistle species chosen by the larvae in the lab is not indicative of the choice made by the female in the field.

The implications made by these experiments could be broadened by further studies. A census comparing the populations of the two species of thistle would give insight to the level of infestation of the thistles. Genetically, *Cirsium palustre* has a greater number of heads per plant than *Cirsium muticum* which may imply that the ovipositing female would encounter the invasive's flower heads more frequently than the native's heads and would suggest that *Cirsium palustre* has a greater infestation based on head. This pattern may change if only plants were censused in which case if only one bud was infected then the entire plant was infected.

The results from these experiments expand the ecological understanding of the invasive species of *Cirsium palustre.* If this invader is vulnerable to the same attack of seed predators as the native thistle species, then its population may be kept in check by virtue of predation. This trend also suggests that the invader is becoming naturalized in its the host environment.

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