Variability in Achene Weight on Flowering Heads of *Echinacea augustifolia*

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Introduction

Echinacea augustifolia, or the narrow-leaved purple cone flower, are prairie plants native to the central and southwest regions of the United States. *Echinacea* cannot be self-pollinated and cannot be pollinated by close relatives. They produce on average one head per flower but can produce up to ten heads and produces hundreds of achenes (a small, dry fruit containing a single seed) per head (Wagenius, 2006). Achenes containing a fertilized embryo are referred to as “full”, while achenes without a fertilized embryo are considered “empty”. In a previous study on *Erodium brachycarpum*, an annual herb in the western United States, growing conditions were manipulated to simulate a drought to observe how seed size and seed count changed with the manipulated conditions. It was found that as moisture levels dropped, more total seeds were produced at a lower weight than seeds produced under normal conditions (Stamp 1990). To test if this relationship between seed size and seed count was similar in prairie plants, I compared the average weights of achenes with the number of achenes produced and head number (number of flowering heads per plant) in *Echinacea augustifolia* during my time at the Chicago Botanic Garden.

the echinacea project

Figure 1: Echinacea project logo

Methods

Figure 2: Achene separating station

Achenes were separated from their heads by lightly crushing the heads into a plastic or glass dish as seen in figure 2. Achenes that were not removed by crushing were removed by hand. Achenes were then separated from their chaff by hand and placed into separate baggies to be counted and weighed later.

Figure 3: Achene weighing station

A scale and pill counter, normally used to calculate pill weights, was modified to calculate achene weights instead (figure 3). The machine on the far right would shake the achenes to separate them, and one by one they were weighted on the attached scale. Weights were recorded and excel was used for data analysis

HYPOTHESIS

There will be a negative relationship between achene weight and achene count or head number in *Echinacea augustifolia* caused by a trade-off between quality and quantity of achenes

Questions

Q1: Does an increase in production of achenes lead to a decrease in achene mass?
Q2: Does an increase in production of achenes lead to a decrease in embryo mass?

Results

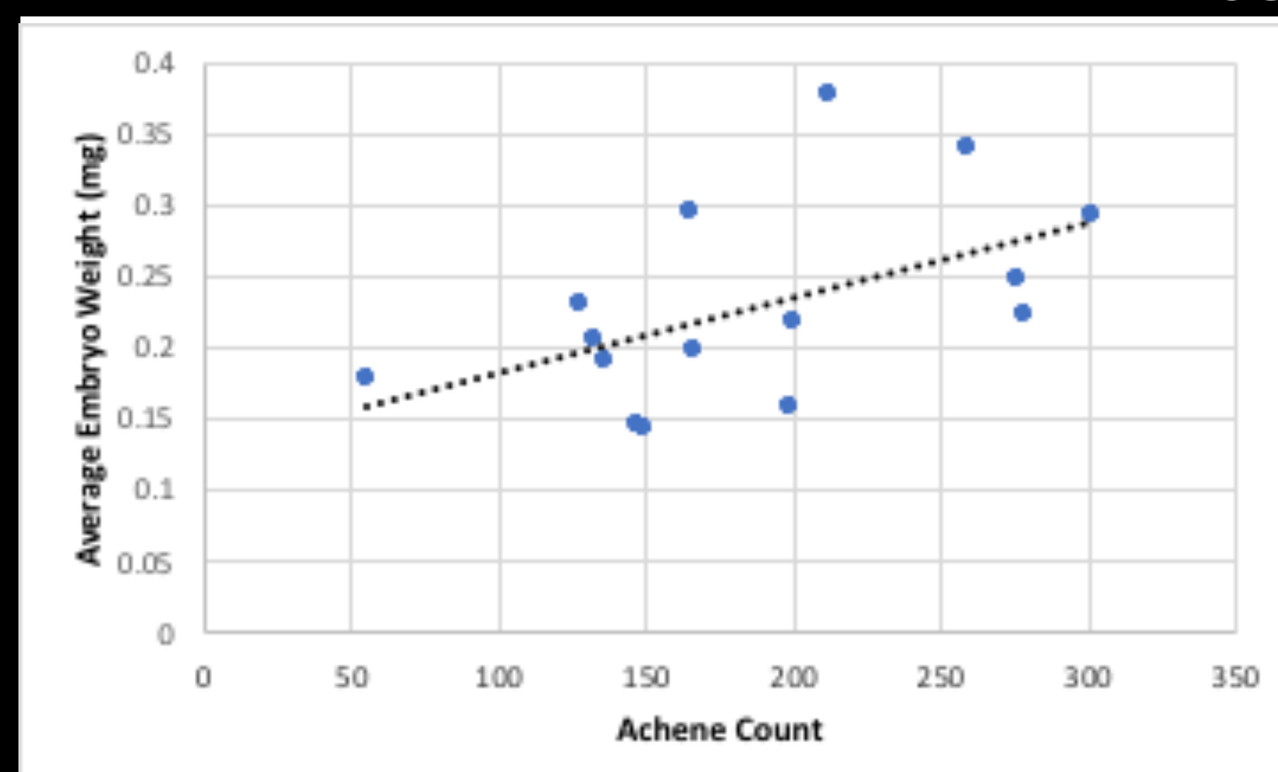

Figure 4: Scatter plot comparing average embryo weight in milligrams (average full achene weight minus average empty achene weight of achenes from the same head) and average achene count per head (total achenes divided by number of heads). Line of best fit shows a positive slope; as achene count increases so does average embryo weight. R_2 value, or the coefficient of determination, was calculated to show model fit.
R_2= 0.04

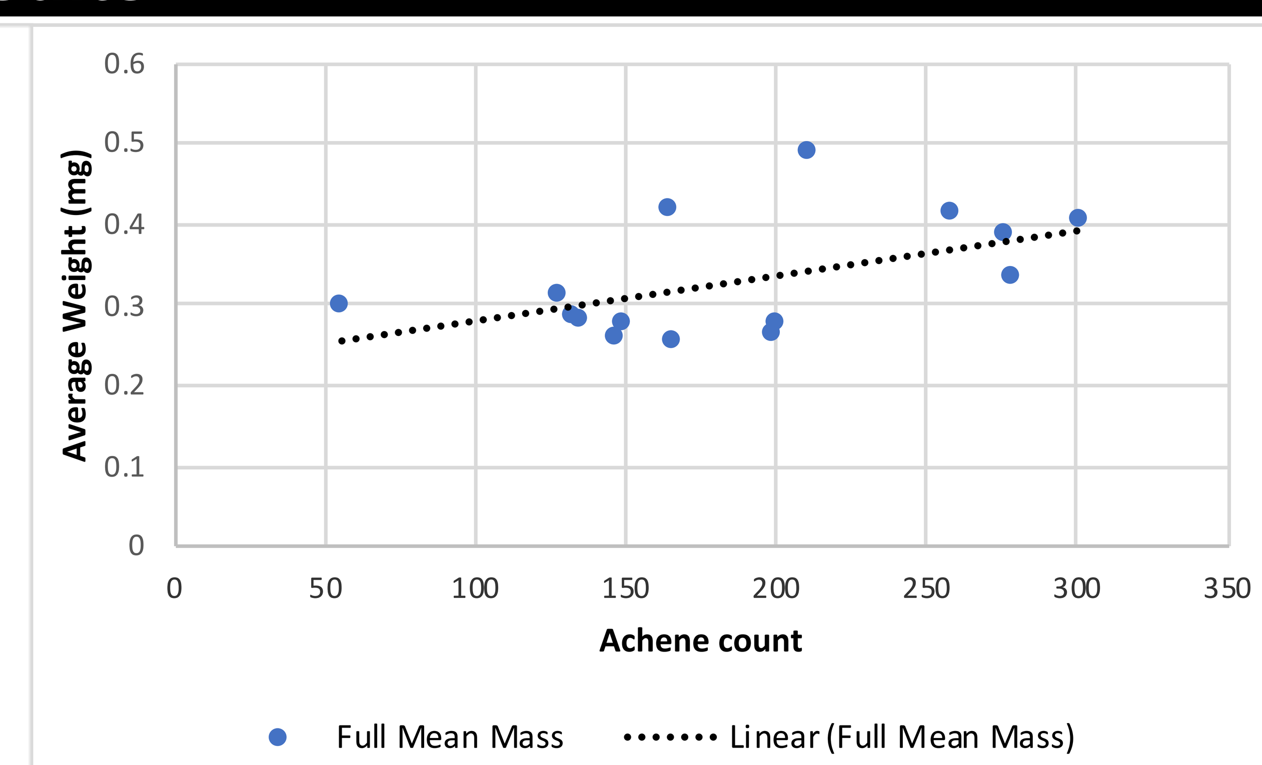

Figure 5: Scatter plot comparing average full achene weight in milligrams and average achene count per head. Line of best fit shows a positive slope; as achene count increases, so does average full achene weight. R_2 value was calculated to show model fit.
R_2=0.27

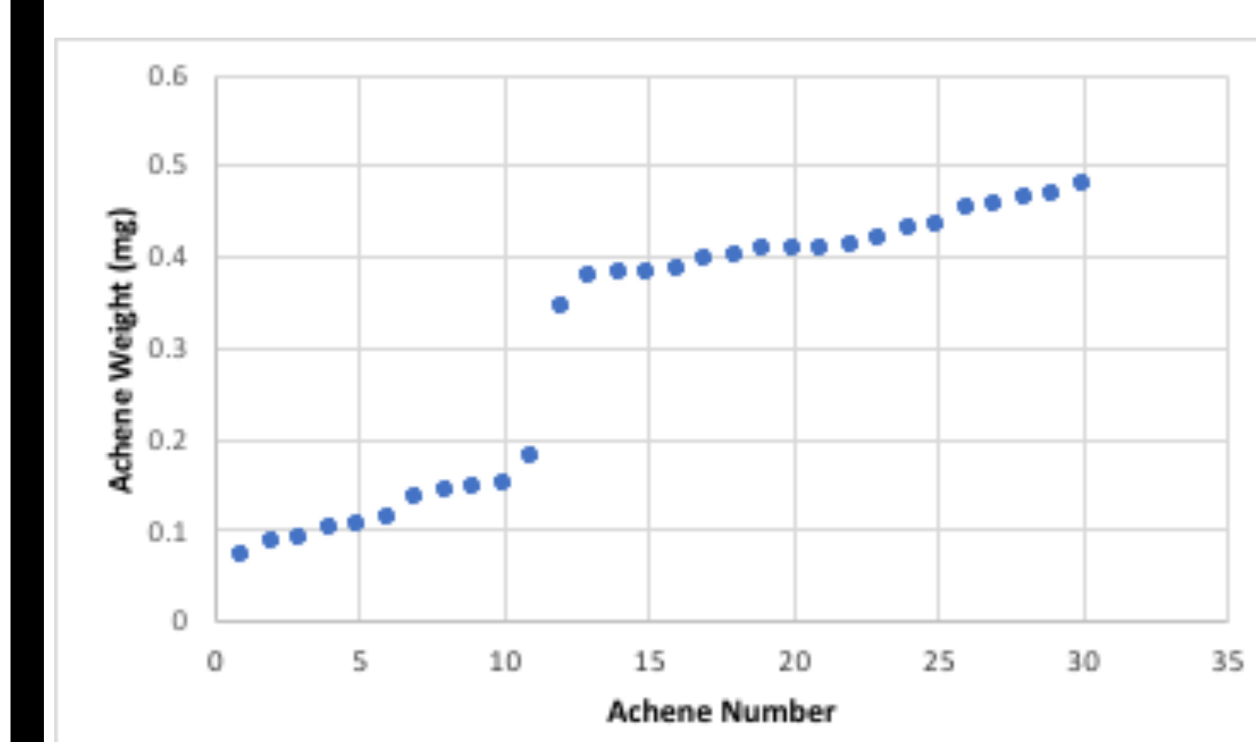

Figure 6: Scatter plot of individual achene weights on a single flowering head. Achenes were sorted by weight from smallest to lightest, with the smallest being labelled as achene number 1 and the largest being labelled as 30.

Discussion

I initially expected there would be a trade-off between achene weight and achene count or head number. Figure 3 shows a large gap in weights between achene 11 and achene 12, increasing from below .2 mg to above .3 mg. This large gap was used to separate full achenes from empty achenes as the fertilized embryo is responsible for the increase in weight. Figures 4 and 5 do not show the trend expected in the initial hypothesis, but instead show the opposite. In both lines of best fit, as achene count increase, the average embryo weight and full achene weights increased, which rejects the hypothesis. It is important to note that both R_2 values are low due to the small sample size. This unexpected trend may be due to the fact that *Echinacea augustifolia* are perennial plants and store energy for following years. The previous study on *Erodium brachycarpum* found that as more seeds were produced, they were produced at a lower weight (Stamp 1990). However, *E. brachycarpum* is an annual herb, not a perennial, and thus does not store energy for the following year. As *E. augustifolia* stores its energy in a large taproot, plants that have the largest energy stores may be able to produce more achenes at a higher weight than those who have smaller taproots due to their larger nutrient stores. Furthermore, as *E. augustifolia* grow larger, achenes may get larger and heavier proportionally to their growth. In the future, a comparison of achene weight to taproot size could provide insight into whether plants with larger taproots produce heavier achenes; however, this study would involve the removal of plants from the soil and may not be possible as a part of the *Echinacea* project. Furthermore, comparing the results from this study with a similarly designed experiment on *Helianthus petiolaris,* the plains sunflower, could provide insight into if the heavier achene trend was only present in perennial plants. It would serve as a better comparison then *E. branchycarpum* since *H. petiolaris* is an annual Midwest prairie flower whereas *E. branchycarpum* was an annual herb native to the west coast and southern Europe. Studies have been performed examining sunflower seed size and predation rates (Alexander et al., 2001), but I was unable to find a comparison between seed size and total seeds produced.

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