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NOTES: EXAMINING THE POTENTIAL COMPETITIVE EFFECTS OF VENTENATA DUBIA ON ANNUAL AND PERENNIAL GRASSES

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NOTES

EXAMINING THE POTENTIAL COMPETITIVE EFFECTS OF *VENTENATA DUBIA* ON ANNUAL AND PERENNIAL GRASSES—Portions of the United States are becoming increasingly dominated by annual species, with cheatgrass *(Bromus tectorum* L.) and medusahead (*Taeniatherum caput-medusae* [L.] Nevski) as the most common and well-known invaders (Bansal et al. 2014). Other invasive annual species also are present and increasing in abundance, including ventenata (*Ventenata dubia* [Leers] Coss.), an invasive annual grass that has been expanding within the Pacific Northwest, Great Basin, and Great Plains regions of the United States. Ventenata was first reported in North America in 1952 in Washington (Old and Callihan 1987) and has since spread to 7 western states in the USA (CA, OR, ID, WY, WA, UT, MT) as well as portions of western Canada (US Department of Agriculture 2016). It is only listed as noxious in the state of Washington (National Weed Control Board 2016). Because it is a relatively new invader to these states, only basic life history traits of this species are documented (Wallace et al. 2015). Ventenata is believed to originate from the Mediterranean portion of Europe and northern Africa (Scheinost et al. 2008). As a winter annual, this species mostly germinates in the fall when temperatures range from 8 to 28° C (Northam and Callihan 1986*a*, Wallace et al. 2015) with optimal germination on the higher end of temperatures, and a small portion of seed emerging in the spring (Wallace et al. 2015). Ventenata grows with slim, erect culms from 10 to 46 cm in height and typically produces about 15 to 35 seeds per plant (Scheinost et al. 2008).

Although its spread has been rapid in the last decade, little is known about how this invasive species will affect plant communities and food webs in either the Pacific Northwest, Great Basin, or Great Plains (Northam and Callihan 1986*b*, Scheinost et al. 2008, Johnson et al. 2013, Wallace et al. 2015). One recent study suggests that ventenata cover of 50% can have cascading effects on survival and fitness of tree swallows (*Tachycineta bicolor*) through reduced plant diversity, plant structure, insect communities, and insect abundances (Mackey 2014). Some report that ventenata is competitive enough to replace other invasive annual grasses and native perennial species (Northam and Callihan 1986*b*, Scheinost et al. 2008). However, to date, there have been no published studies that examine the competitive interactions between ventenata and other species.

We performed a greenhouse experiment to examine if ventenata has a competitive effect on two invasive annual grasses, cheatgrass, medusahead, and one native perennial bluebunch wheatgrass (*Pseudoroegnaria spicata* [Pursh] A. Löve). Given the well-documented ability of winter annuals to outcompete seedlings of perennial species (Melgoza et al. 1990, Mangla et al. 2011), we hypothesized that any competitive effects from ventenata would be greater on the native perennial grass. To test this, we compared the final shoot biomass and calculated a competitive performance index for these species grown alone and in competition with ventenata. A competitive performance index (CPI) represents the percent decrease in a species performance when grown with a competitor and can be used to test each species tolerance to ventenata, independent of differences in plant size (Keddy et al. 1998, Rowe and Leger 2011).

The soil used in the experiment was field collected from a ventenata-invaded area (roughly 20% of the species abundance) in Union County, Oregon (45°32’12.69” N 118°02’11.02” W) in the Veazie-Voats complex. The Veazie-Voats complex is classified as sandy-skeletal, mixed, mesic, Fluventic Haploxerolls (US Department of Agriculture 1999). None of the other species used in this study were present on site at the time of collection. We excavated the top 10 cm, sieved it using a 0.5 cm^2 wire screen in the field, and homogenized it by hand in the greenhouse. We filled pots (Stuewe and Sons, Inc.; D40h; 6.5 cm ´ 25.4 cm; 656 ml) to a standardized mean weight of 482.5 g up to 2 cm from the rim to minimize shading. To reach saturation through capillary action, we placed all pots in standing water for 24 hours. We hand pulled any seedlings from non-target species that emerged from the seed bank for 7 days prior to sowing the experiment.

Using a simple additive design (Keddy et al. 1998), each of the four plant species was grown separately (n = 20 per species, n = 80 total) as a control, and in combination with the other species (n = 20 per combination, n = 120 total) under controlled greenhouse conditions in a total of 200 pots. Two seeds of each species were sown into the pots. We field collected seed for annual grasses and obtained bluebunch wheatgrass (cv. Anatone) seed from a commercial seed supplier (L&H Seed Producer, Connell, WA). To reduce variation due to initial size differences, we thinned seedlings to one plant of each species grown alone or in competition after emergence of all seedlings (2 weeks). Thinning was based upon an average height per species so that all plants were within 3 cm in height of their conspecifics.

For the duration of the experiment, we maintained greenhouse temperatures at a mean high of 26.4° C and a mean low of 13.3° C and no supplemental light was used. We hand-watered pots with 247 mL every 2–5 days to mimick regionally moist spring conditions. Over a 13-day timeframe, we monitored and recorded emergence daily until the last recorded emergence, a 13-day timeframe. We calculated time to emergence as the mean number of days to emergence after seeds of each species were sown (Woods et al. 2014). Similarly, we calculated percent emergence by dividing the number of seedlings by the total number of seeds sown for each species. The plants were all sown in June 2014, grown for 38 days (5 weeks) and harvested once they began to show signs of reproductive shoots. We obtained final shoot biomass by cutting each plant just above the root crown. We dried alll plants in a drying oven at 55° C for 48 hours prior to weighing. We calculated CPI by comparing the relative differences between final shoot biomass from plants grown alone to those grown in competition:

$$\frac{\text{Final biomass without competition-final biomass with competition}}{\text{Final biomass without competition}}$$

We used nonparametric comparisons for each pair using Wilcoxon method to test for significance between species in time to emergence and to compare final shoot biomass and CPI. We performed all analysis using JMP 11.0 (SAS Institute Inc., Cary, North Carolina, USA).

Percent emergence was highest for cheatgrass (98%), medusahead (94%), and bluebunch wheatgrass (66%), while ventenata (27%) had the lowest emergence of all species. Multiple pairwise tests revealed that timing of emergence was significantly different ($Z \geq -12.53$ $P \leq 0.0001$) between all pairwise comparison of species with the order of emergence as follows: medusahead, cheatgrass, bluebunch wheatgrass and ventenata. After 38 days, bluebunch wheatgrass grown in competition with ventenata contained 20% less shoot biomass ($n = 14$, $Z = -2.61$, $P < 0.01$) than when this species was grown alone. Cheatgrass ($n = 20$, $Z = 1.44$, $P = 0.15$) and medusahead ($n = 15$, $Z = -0.15$, $P = 0.88$) showed no significant decrease in mean final shoot biomass when grown in competition with ventenata. Similarly, the percent decrease in a species performance (CPI) when grown with ventenata was significantly greater for bluebunch wheatgrass compared to medusahead ($n = 14$, $Z = -2.33$, $P = 0.02$) and to cheatgrass ($n = 14$, $Z = 2.78$ and $P = 0.01$), which were not significantly different from each other.

Our results did not show any competitive effect of ventenata on cheatgrass or medusahead. However, our results did confirm our hypothesis that the competitive effects of ventenata would be stronger on the native perennial grass. In fact, our results showed that when in direct competition at this stage, only seedlings of bluebunch wheatgrass had a reduction in overall shoot biomass. In addition, the tolerance of bluebunch wheatgrass grown in competition with ventenata was significantly lower than for the other two annual grasses (Fig. 1). These findings suggest that, at this stage of plant development and when grown in single competition, ventenata has more of a competitive effect on the native perennial grass than annual grasses. In contrast, the annual grass species cheatgrass and medusahead seemed relatively unaffected by competition. Although the seedling stage represents only one phase of interaction between species, it is a critical period for establishment and restoration, especially after a disturbance. Consequently, interactions at this stage can be difficult to document in field conditions (Gunnell et al. 2010).

While our study did not test any potential mechanisms of competition or interference, there are two possible explanations for the higher competitive effect between ventenata and bluebunch wheatgrass over other annual grasses. First, it could be that there was no direct interaction between root zones of ventenata and the other two annual grasses. James (2008) reported significantly longer root length for cheatgrass and medusahead while bluebunch wheatgrass and ventenata

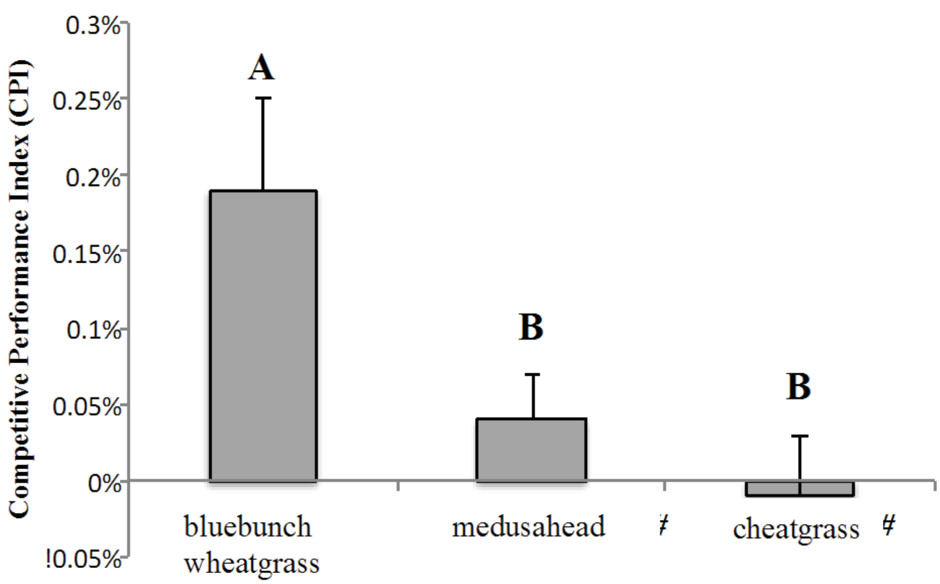

Figure 1. Comparison of competitive performance index (CPI) of ventenata on all other species. Analysis performed using nonparametric comparisons for each pair using the Wilcoxon method with different letters indicating significant differences ($P < 0.01$).

occupied approximately the same root zone at this seedling stage. Secondly, the timing of emergence in our study indicates that ventenata would be more likely to have interactions with bluebunch wheatgrass. In our study, ventenata and bluebunch wheatgrass were the last two species to emerge and thus may have had more overlap in timing of resource use and growth. This is further supported by reports of similar relative growth rates between ventenata and bluebunch wheatgrass at this seedling stage (James 2008). Emergence timing can be an important factor in competition between annuals and perennials (Orloff et al. 2013). Further research should address this interaction as well as potential shifts in root allocation of bluebunch wheatgrass when grown in competition with ventenata.

Finally, our results are consistent with the few early reports on the ecology of this species. Although our results indicate that ventenata has a lower percent emergence than other species in our experiment, we did not run viability test on our limited amount of seed. However, our emergence percentage (27%) is consistent with expectations for ventenata after only 30 days of after-ripening (Wallace et al. 2015). Our results also are in agreement with reports that at the early growth stage, ventenata has a relatively lower overall shoot biomass in comparison to the annual and perennial grasses used in our study (James 2008). We have observed high densities of this invasive plant in the field, and further studies could test competitive interactions in field environments to determine how density affects relative success of ventenata in competition with other common annuals and perennials.

There is growing concern over the potential degradation of native ecosystems from annual grasses, including ventenata (Wallace et al. 2015). Annual grasses that tend to displace native species can lower overall forage quality, reduce wildlife habitat quality, and even alter fire regimes (D'Antonio and Vitousek 1992, Davies and Svejcar 2008). Our results suggest that ventenata may have more of a competitive effect on perennial grasses at the seedling stage than on other annual grasses. If ventenata is not competitive with other annual grasses at this stage, then the reported displacement (Northam and Callihan 1986*b*, Scheinost et al. 2008) of these grasses may have another explanation (e.g., effects of density, interactions with herbivory, novel weapons, or soil conditioning over time). The basic phenology and growth dynamics of this new invader to the USA appears to be different enough from other annual grasses to require closer study of the traits that drive its invasion success (James 2008, Rinella et al. 2014). There should also be more work done to address how ventenata changes the nutritional quality of invaded plant communities. If ventenata is competitive enough to replace other annual and native species, it may change forage quality for both livestock and wildlife. This work should be completed as soon as possible because, even with the recent rapid spread in this species, it may still be within its lag phase of introduction (i.e., a time when control is more feasible and less cost prohibitive; Pysek and Hulme 2005).—*Shawn McKay[1], Lesley R. Morris[1,4], Christopher E. Morris and Elizabeth A. Leger[4]. [1]Department of Animal and Rangeland Sciences, Oregon State University, OSU Ag and Natural Resources Program, One University Blvd., La Grande, OR, 97850, USA. [2]Powder Basin Watershed Council, Baker City, OR, USA. [3]Associate Professor, Natural Resource and Environmental Sciences, University of Nevada Reno, Mail Stop 370, Fleishmann Agriculture, University of Nevada Reno, Reno, NV, USA 89557. [4]Corresponding author email address: Lesley.Morris@oregonstate.edu.*

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