3/01/16

Results:

* Figure 4: Germination rate of each local population of each species. Local populations in gray, continental averages in color, with standard error bars.
* Figure 5: germination rate by temperature, origin, and stratification length for each species, with standard error.
* Figure 6: Germination date of each local population of each species. Local populations in gray, continental averages in color, with standard error bars
* Figure 7: germination date by temperature, origin, and stratification length for each species, with standard error.
* Figure 8: Growth rate of each local population of each species. Local populations in gray, continental averages in color, with standard error bars
* Figure 9: growth rate by temperature, origin, and stratification length for each species, with standard error.
* Figure 10: coefficient of variation
  + 10a. germination rate coefficient of variation
  + 10b. germination date coefficient of variation
  + 10c. growth rate coefficient of variation
* Supplement: height vs. number of days since germination for each individual, fitted with a linear fit line for each continent. The slope of this line was treated as the growth rate.
* Tables
  + Table 2: Output of hierarchical mixed-effects model of germination rate for each species. Stratification length (days), temperature (degrees Celsius), and origin were modeled as fixed effects, while local population and individual were modeled as random effects.
  + Table 3: Output of hierarchical mixed-effects model of germination date for each species. Stratification length (days), temperature (degrees Celsius), and origin were modeled as fixed effects, while local population and individual were modeled as random effects
  + Table 4: Output of hierarchical mixed-effects model of growth rate (linear fit model in cm/day—see supplementary Figure ) for each species. Stratification length (days), temperature (degrees Celsius), and origin were modeled as fixed effects, while local population and individual were modeled as random effects.
* *Germ Rate*
  + General *patterns*
    - On average, 70-100% of each species germinated, except CAPBUR which showed much lower germination rates, especially for the American origin (see Figure 5). Germination rates for most species were similar for the USA and Europe, except CAPBUR and PLAMAJ which seeds from Europe germinated better (see Figure 7a)
  + Temperature and origin did not alter the germination rate for any of the species (Table 2).
  + Stratification length did not alter the germination rate for any of the species except *Plantago major* (Table 2).
  + *Plantago major*
    - Stratification length altered the germination rate for *Plantago major* (strat, F1,16 = 6.9666, P= 0.01785) (see Table 2). All plants in the long stratification germinated, whereas germination rate was more variable in the short stratification.
* *Germ Date*
  + Temperature altered timing of germination for all species germinated, except for *Capsella bursa-pastoris* (see Table 3).
  + *Capsella bursa-pastoris* 
    - Timing of germination was not altered by stratification length, temperature, nor origin (see Table 3).
  + *Chelidonium majus* 
    - Overall, *Chelidonium majus*  germinated much later than other species (see Figure 6). *Chelidonium majus*  days to germination was dependent on origin and stratification (originUSA × strat, F1,95 =4.661, P<0.05) (Table 3). After shorter stratification , the US non-native *Chelidonium majus*  population germinated earlier than the European native population (Figure 7).
    - Days to germination was also dependent on temperature (temp, F3,95 =27.422, P<0.0001) (Table 3). *Chelidonium majus*  germinated later at lower temperature across both stratification treatments and populations (Figure 7). But response to other temperatures varied with origin (originUSA × temp, F3,95 =2.932, P<0.05) (Table 3).
  + *Dactylis glomerata*
    - *Dactylis glomerata* days to germination was dependent on temperature (temp, F3,95 =7.5346, P<0.0001), and origin and stratification (originUSA × strat, F1,92 =6.377, P<0.05) (Table 3). Overall, the US non-native population germinated earlier in the shorter stratification, but later in the longer stratification (see Figure 7). *Dactylis glomerata* germinated earlier at higher temperatures, although the long-stratified US population germinated later at the highest temperature (see Figure 7).
  + *Plantago lanceolata*
    - *Plantago lanceolata* days to germination was dependent on temperature (temp, F3,406 =41.2581, P<.0.0001) (Table 3). *Plantago lanceolata* germinated later at 11.3 degrees C (see Figure 7). But dependence on temperature also varied with origin and stratification (originUSA × temp, F3,406 =2.6468, P<.05; temp × strat, F3,406 =2.8194, P<0.05; originUSA × temp × strat, F3,406 =6.9434, P<.00001). The long-stratified European native population showed a stronger response to temperature (see Figure 7).
    - *Plantago lanceolata* days to germination was dependent on stratification (strat, F1,406 =17.8454, P<.0.0001) (see Table 3), overall exhibiting later germination after longer stratification (see Figure 7).
  + *Plantago major*
    - *Plantago major* days to germination was dependent on temperature (temp, F3,131 =30.2088, P<.0.0001) (Table 3). *Plantago major* germinated earlier at higher temperatures (see Figure 7).
    - *Plantago major* days to germination also depended on stratification and origin (originUSA × strat, F1,131 =41.2581, P<.0.01) (Table 3). The US non-native population germinated later showed more variability in the shorter stratification (see Figure 7).
  + *Rumex crispus* 
    - *Rumex crispus*  days to germination was dependent on temperature (temp, F3,130 =9.3773, P<.0.0001) and this dependence varied with origin (originUSA × temp, F3,130 =3.2384, P<.0.05) (see Table 3). US non-native population germinated at 20.7 degrees Celsius showed germinated the fastest, while the short-stratified European population showed the inverse response (see Figure 7).
    - *Rumex crispus*  days to germination was dependent on stratification and origin (originUSA × strat, F1,130 =36.344, P<.0.0001) (see Table1). European *Rumex crispus*  germinated later, but only for the short stratification (see Figure 7).
  + *Taraxacum officinale*
    - *Taraxacum officinale* germinated very quickly compared to the other species (see Figure 6). *Taraxacum officinale* days to germination was dependent on temperature (temp, F3,120 =3.647, P<.0.05) and stratification length (strat, F1,120 =9.439, P<.0.005), which depended on origin (originUSA × strat, F1,120 =36.344, P<.0.0001) (see Table).
    - The short-stratified European native population germinated later (see Figure 7)
* *Growth Rate*
  + All species had average growth rates between 0 and 0.15 cm/day, except *Dactylis glomerata*, which had a significantly higher growth rate of ~0.35 cm/day.
  + *Capsella bursa-pastoris*
    - *Capsella bursa-pastoris* growth rate depended on temp (temp F1,19 =26.4519, P<0.005)and stratification (strat, F1,19 =9.1687, P<0.01), and the temperature dependence varied with origin (origin × temp, F1,19 =6.9718, P<0.05) and stratification (origin × temp × strat, F1,19 =6.8960, P<0.05) (see Table 4).
    - Overall there was a slight decrease in growth rate with temperature, and this was much more pronounced in the US shorter stratification treatment (see Figure )
  + *Chelidonium majus* 
    - *Chelidonium majus*  growth rate was dependent on origin (origin, F1,2 =49.0239, P<0.05) temperature (temp, F2,64=42.3694, P<0.0001), and stratification (strat, F1,64=4.9397, P<0.05), and these effects were dependent on each other (temp × strat, F3,64=7.0194, P<0.005; origin × strat, F1,64=40.9529, P<0.0001; origin × temp × strat, F2,64=17.5135, P<0.0001) (Table 4).
    - US non-native *Chelidonium majus*  grew faster than European native *Chelidonium majus*  after long stratification, but the two populations were more similar, and sometimes reversed, in the short stratification (see Figure 9).
    - Overall, there is a decrease in growth rate with temperature, except in the short-stratified European native *Chelidonium majus*  (see Figure 9).
  + *Dactylis glomerata*
    - *Dactylis glomerata* growth rate was much higher than for the other species, and also showed a big response to temperature (temp, F3,89 =26.9803, P<.0.0001) (Table 4). Overall, growth rate decreased with temperature (see Figure 9). But temperature affected the growth rates of the US and European populations differently (origin × temp, F3,89 =3.0744, P<.0.05). The difference was most marked at 20.7 degrees Celsius, where the US population grew faster than the European population grew substantially (see Figure 9).
  + *Plantago lanceolata*
    - *Plantago lanceolata* growth rate depended on temperature (temp, F3,374 =62.5207, P<.0.0001) (Table 4). Overall, germination rate decreased with temperature (see Figure 9). The temperature-dependence varied with origin (originUSA × temp, F3,374 =12.7363, P<.0.0001), with the US population growing faster at mid-temperatures and slower at extreme temperatures relative to the European population (see Figure 9).
  + *Plantago major*
    - *Plantago major* growth rate was dependent on temperature (temp, F3,129=92.3502, P<0.0001), and stratification (strat, F1,129=111.8433, P<0.0001), and these effects were dependent on each other (temp × strat, F3,129=44.8222, P<0.0001) and origin (origin × temp, F3,129=3.3338, P<0.05; temp × strat, F3,129=44.8222, P<0.0001) (Table 4). Long-stratified *Plantago major* grew more slowly at higher temperatures, while the growth rate was more uniform at shorter stratification (see Figure 9). The US and European populations were tightly coupled, except at the lowest temperature (see Figure 9).
  + *Rumex crispus* 
    - *Rumex crispus*  growth rate depended on temperature (temp F3,125 =141.5037, P<0.0001)and stratification (strat, F1,125 =5.2366, P<0.05), and these dependencies varied with each other (temp × strat, F3,125 =4.7559, P<0.005) and with origin (origin × temp, F3,125 =17.38065, P<0.0001; origin × strat, F1,125 =17.38065, P<0.0001; origin × temp × strat, F3,125 =12.1615, P<0.0001) (see Table 4).
    - Overall, *Rumex crispus*  growth rate decreased with temperature and the US non-native population grew faster than the European native population (see Figure 9 & Figure 8). The US non-native population showed similar growth rate in both stratification treatments, while the European native population showed a stronger effect of temperature after longer stratification than following shorter stratification (see Figure 9).
  + *Taraxacum officinale*
    - *Taraxacum officinale* growth rate depended on temperature (temp F3,115 =11.9840, P<0.0001)and stratification (strat, F1,115 =16.4810, P<0.005), and the effects of temperature and stratification varied with each other (temp × strat, F3,115 =4. 3.2202, P<0.05) and with origin (origin × temp × strat, F1,115 =17.38065, P<0.05) (see Table 4).
    - Overall, *Taraxacum officinale* grew faster after shorter stratification, with the exception of the plants grown at 11.3 degrees Celsius (see Figure 9).
    - The American and European populations responded similarly to temperature,
    - After being stratified for 30 days, native population of *Taraxacum officinale* growth rate was unaffected by temperature, while the US growth rate decreased at mid-temperatures (see Figure 9)
    - After being stratified 60 days, both *Taraxacum officinale* populations exhibited decreases in temperature, although the European native population showed a sharper decrease at 20.7 degrees Celsius to grow more slowly than theUS native population