OIKOS ADVANCING ECOLOGY

Supplemental Information for:

Friends or Foes? Polyploidy and competition in a grassland geophyte.

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Table S1: Conviron growth chamber variable environmental parameter settings for each month, including day length (day/night hours), daily maximum and minimum temperatures (°C), and average monthly precipitation (mm/day).

Month	Abiotic/environmental factor	Parameter setting
September	Photoperiod length (day/night hours)	12h55min/11h5min
	Maximum day temperature (°C)	27.7
	Minimum night temperature (°C)	17.4
	Precipitation (mm/day)	1.3
October	Photoperiod length (day/night hours)	12h40min/11h20min
	Maximum day temperature (°C)	28.3
	Minimum night temperature (°C)	19.0
	Precipitation (mm/day)	2.7
November	Photoperiod length (day/night hours)	13h22min/10h38min
	Maximum day temperature (°C)	27.7
	Minimum night temperature (°C)	19.8
	Precipitation (mm/day)	4.8
December	Photoperiod length (day/night hours)	13h44min/10h16min
	Maximum day temperature (°C)	27.2
	Minimum night temperature (°C)	20.2
	Precipitation (mm/day)	6.3
January	Photoperiod length (day/night hours)	13h34min/10h26min
	Maximum day temperature (°C)	27.0
	Minimum night temperature (°C)	20.4
	Precipitation (mm/day)	6.5
February	Photoperiod length (day/night hours)	12h57min/11h03min
	Maximum day temperature (°C)	26.8

Table S1: Conviron growth chamber variable environmental parameter settings for each month, including day length (day/night hours), daily maximum and minimum temperatures (°C), and average monthly precipitation (mm/day).

	Minimum night temperature (°C)	20.0
	Precipitation (mm/day)	5.5
March	Photoperiod length (day/night hours)	12h14min/11h46min
	Maximum day temperature (°C)	26.1
	Minimum night temperature (°C)	18.9
	Precipitation (mm/day)	3.7

Table S2: List of traits included in the study, and classified according to trait type, as well as trait dimensionality category as described by Laughlin (2013). Shift to appendix

Trait (units)	Trait type	Trait dimensionality category (Laughlin, 2013)
Petiole length (mm)	Morphological (Size)	Plant height
Middle leaflet length (mm)	Morphological (Size)	Leaves
Middle leaflet width (mm)	Morphological (Size)	Leaves
Lateral leaflet length (mm)	Morphological (Size)	Leaves
Lateral leaflet width (mm)	Morphological (Size)	Leaves
Number of leaves	Morphological (Count)	Leaves
Flower diameter (mm; measured after midday)	Morphological (Size)	Flowers
Petal length (mm)	Morphological (Size)	Flowers
Petal width (mm)	Morphological (Size)	Flowers
Sepal length (mm)	Morphological (Size)	Flowers
Sepal width (mm)	Morphological (Size)	Flowers
Bract length (mm)	Morphological (Size)	Flowers
Peduncle length (mm)	Morphological (Size)	Flowers
Number of inflorescences	Morphological (Count)	Flowers
Number of open flowers	Morphological (Count)	Flowers
Bract position (from base of peduncle; mm)	Morphological (Shape)	Flowers
Difference between petiole length and peduncle length (Mm)	Morphological (Shape)	Flowers
Ratio middle leaflet length to width	Morphological (Shape)	Leaves
Ratio lateral leaflet length to width	Morphological (Shape)	Leaves

Table S2: List of traits included in the study, and classified according to trait type, as well as trait dimensionality category as described by Laughlin (2013). Shift to appendix

Ratio flower diameter to petal length	Morphological (Shape)	Flowers
Ratio petal length to width petal width	Morphological (Shape)	Flowers
Seed mass (g)	Morphological (Size)	Seeds
Number of bulbs after one season	Morphological (Count)	Life history
Mass of largest bulb (g)	Morphological (Size)	Roots (Bulbs)
Proportion of largest bulb mass to total bulb mass	Morphological (Shape)	Roots (Bulbs)
Change in total bulb mass (g)	Physiological	Roots (Bulbs)
Photosynthesis/CO_2 assimilation rate (A; $\mu mol \cdot m^{-2} \cdot s^{-1}$),	Physiological	Leaves
Ratio of intercellular CO_2 concentrations to ambient CO_2 (C_i/C_a).	Physiological	Leaves
Intrinsic water use efficiency (A/g_s)	Physiological	Leaves
Number of days to emergence	Phenological (Count)	Life history
Number of days to first anthesis	Phenological (Count)	Life history
Number of days to last flower	Phenological (Count)	Life history
Number of days to senescence	Phenological (Count)	Life history
Number of days from first to last flower	Phenological (Duration)	Life history
Number of days from emergence to senescence	Phenological (Duration)	Life history

Table S2: List of traits included in the study, and classified according to trait type, as well as trait dimensionality category as described by Laughlin (2013). Shift to appendix

Number of days from last flower to senescence	Phenological (Duration)	Life history

R script for statistical analyses

Import the data set

```
library(readxl)

DF1 <- read_excel("Supplementary 2_Competition Data 1.xlsx")

View(DF1)
```

Check for autocorrelation using Pearson's correlation coefficient

```
DF2 <- DF1[, 4 : 36]

round(cor(DF2), digits = 2)
```

Principal Component Analysis

```
library(FactoMineR)

#### PCA 1+2 axes ####

nb <- missMDA::estim_ncpPCA(DF1,quali.sup=c(1,2,3))$ncp

dfcompleted<- missMDA::imputePCA(DF1,ncp=nb,quali.sup=c(1,2,3))$completeObs

res.PCA<-PCA(dfcompleted,quali.sup=c(1,2,3),graph=FALSE)

plot.PCA(res.PCA,choix='var')
```

```
plotellipses(res.PCA, keepvar=2,invisible=c('quali','ind.sup'),label ='none') # Cluster based on Cytotype

plotellipses(res.PCA, keepvar=2,invisible=c('quali','ind.sup'),label ='none') # Cluster based on Competition treatment

summary(res.PCA)
```

PERMANOVA analysis

```
library(cluster)

library(vegan)

library("devtools")

DF2[, -3: -4: -5: -7: -13: -14: -17: -24] #Remove highly correlated variables, based on Pearson's correlation coefficient

Dist1 <- daisy(DF2, metric = c("gower")) #First compute a distance matrix for PCA non-correlated variables using Gower's distance

adonis2(Dist1 ~ Cytotype + CompetitionTreatment + Cytotype:CompetitionTreatment, data = DF1, by = "terms")
```

```
install_github("pmartinezarbizu/pairwiseAdonis/pairwiseAdonis")

library(pairwiseAdonis)

DF1$Treatment <- paste(DF1$Cytotype,DF1$ CompetitionTreatment)

pair.mod <- pairwise.adonis2(Dist1 ~ Treatment, data = DF1)

pair.mod
```

Univariate analyses

```
#### Perform Shapiro test for normality ####

shapiro.test(DF1$Variable) #Performed for all continuous variables

#### Use boxcox to estimate Lambda ####

library(MASS)

x <- DF1$Variable

hist(x)
```

```
boxcox(lm(x ~ 1))


#### Perform GLMs and pair-wise post-hoc tests, showing models after model simplification ####

library(MASS)

library(emmeans)


GLM1 <- glm(formula = PetioleLength ~ Cytotype, family = gaussian, data = DF1)

summary(GLM1)


GLM2 <- glm(formula = MiddleLeafletLength ~ Cytotype, family = gaussian, data = DF1)

summary(GLM2)


GLM3 <- glm.nb(formula = NumberOfLeaves ~ Cytotype * CompetitionType, data = DF1)

summary(GLM3)

emmeans(GLM3, pairwise ~ Cytotype | CompetitionType)

emmeans(GLM3, pairwise ~ CompetitionType | Cytotype)


GLM4 <- glm(formula = RatioPetioleTotal ~ Cytotype, family = binomial, data = DF1)  #Ratio of petiole length to total plant height

summary(GLM4)
```

```
GLM5 <- glm(formula = RatioMidLengthWidth ~ Cytotype, family = Gamma(link = "log"), data =
DF1) #Ratio of middle leaflet length to width
summary(GLM5)

GLM6 <- glm(formula = RatioLatLengthWidth ~ Cytotype, family = inverse.gaussian(link ="log"),
data = DF1) #Ratio of lateral leaflet length to width
summary(GLM6)

GLM7 <- glm(formula = PetalWidth ~ Cytotype, family = Gamma, data = DF1)
summary(GLM7)

DF1$SQBractLength <- 1/sqrt(DF1$BractLength)
GLM8 <- glm(formula = SQBractLength ~ Cytotype, family = gaussian, data = DF1)
summary(GLM8)

DF1$ SepalWidthTrans <- 1/(DF1$ SepalWidth)
GLM9 <- glm(formula = SepalWidthTrans ~ Cytotype, family = gaussian, data = DF1)
summary(GLM9)

GLM10 <- glm(formula = PeduncleLength ~ Cytotype, family = Gamma, data = DF1)
```

```
summary(GLM10)

GLM11<- glm(formula = RatioFlowerDiameterLength ~ Cytotype, family = inverse.gaussian(link = "log"), data = DF1) #Ratio of flower diameter to flower length

summary(GLM11)

GLM12 <- glm(formula = DifferencePendunclePetiole ~ Cytotype, family = gaussian, data = DF1) #Difference between peduncle length and petiole length

summary(GLM12)

GLM13 <- glm.nb(formula = NumberOfInflorescences ~ Cytotype + CompetitionType, data = DF1)

summary(GLM13)

emmeans(GLM13, pairwise ~ Cytotype | CompetitionType)

emmeans(GLM13, pairwise ~ CompetitionType | Cytotype)

DF3 <- read_excel("Supplementary 3_Competition Bulb Survival.xlsx")

GLM13 <- glm(formula = BulbSurvival ~ Cytotype, family = binomial, data = DF3)

summary(GLM13)
```

```
GLM14 <- glm.nb(formula = NumberOfBulbs ~ Cytotype*CompetitionType , data = DF1)
summary(GLM14)
emmeans(GLM14, pairwise ~ Cytotype | CompetitionType)
emmeans(GLM14, pairwise ~ CompetitionType| Cytotype)

DF1$SQLargestBulbMass <- sqrt(DF1$LargestBulbMass)
GLM15 <- glm(formula = SQLargestBulbMass ~ Cytotype, family = gaussian, data = DF1)
summary(GLM15)

DF1$LOGChangeInTotalMass <- log(DF1$ChangeInTotalMass + 1)
GLM16 <- glm(formula = LOGChangeInTotalMass ~ Cytotype*CompetitionType, family = gaussian, data = DF1)
summary(GLM16)
emmeans(GLM16, pairwise ~ Cytotype | CompetitionType)
emmeans(GLM16, pairwise ~ CompetitionType| Cytotype)

GLM17 <- glm(formula = ProportionBigBulbOfTotal ~ Cytotype, family = gaussian, data = DF1) #Proportion of total mass belonging to largest bulb
summary(GLM17)
```

```
DF1$SQPhotosynthesis <- sqrt(DF1$Photosynthesis)

GLM18 <- glm(formula = SQPhotosynthesis ~ Cytotype, family = gaussian, data =
DF1)

summary(GLM18)


GLM19 <- glm(formula = IntrinsicWaterUseEfficiency ~ Cytotype, family = gaussian,
data = DF1)

summary(GLM19)


GLM20 <- glm(formula = 'Ci/Ca' ~ Cytotype, family = gaussian, data = DF1)

summary(GLM20)


DF4 <- read_excel("Supplementary 4_Competition Plant Emergence.xlsx")


GLM21 <- glm(formula = Emergence ~ Cytotype, family = binomial, data = DF4)

summary(GLM21)


DF5 <- read_excel("Supplementary 5_Competition Plant Phenology.xlsx")


GLM22 <- glm.nb(formula = DaysToEmergence ~ Cytotype, data = DF5)
```

```
summary(GLM22)

GLM23 <- glm.nb(formula = DaysEmergenceToSenescence ~ Cytotype, data = DF5)
summary(GLM23)

GLM24 <- glm.nb(formula = DaysLastFlowerToSenescence ~ Cytotype, data = DF5)
summary(GLM24)

GLM25 <- glm.nb(formula = DaysToAnthesis ~ Cytotype, data = DF5)
summary(GLM25)

GLM26 <- glm.(formula = DaysEmergenceToAnthesis ~ Cytotype, family = poisson,
data = DF5)
summary(GLM26)

GLM27 <- glm.nb(formula = DaysFirstToLastFlower ~ Cytotype*CompetitionType,
data = DF5)
summary(GLM27)
emmeans(GLM27, pairwise ~ Cytotype | CompetitionType)
emmeans(GLM27, pairwise ~ CompetitionType| Cytotype)
```

Table S4: Strong ($|r| \geq 0.7$) trait correlations, indicating traits retained and removed for the univariate analysis of morphological and phenological trait variation among cytotypes of *O. obliquifolia* grown under different competition scenarios.

	Correlated trait pairs		
Retained trait	Trait 1	Trait 2	$\|r\|$
Foliar morphological traits			
Petiole length	Petiole length	Total plant height	1.00
Middle leaflet length	Middle leaflet width	Middle leaflet length	0.96
	Lateral leaflet length	Middle leaflet length	0.97
	Lateral leaflet width	Middle leaflet length	0.93
	Lateral leaflet length	Middle leaflet width	0.95
	Lateral leaflet width	Middle leaflet width	0.95
	Lateral leaflet width	Lateral leaflet length	0.95
Floral morphological traits			
Petal width	Petal length	Flower diameter	0.95
	Petal width	Flower diameter	0.87
	Petal length	Petal width	0.83
Bract length	Sepal length	Bract length	0.76
Phenological traits			
Days to emergence	Days to emergence	Days to first anthesis	0.96
Days from first to last flower	Days to last flower	Days to final senescence	0.83
	Days to last flower	Days from emergence to last flower	0.81
	Days to last flower	Days from first to last flower	0.80

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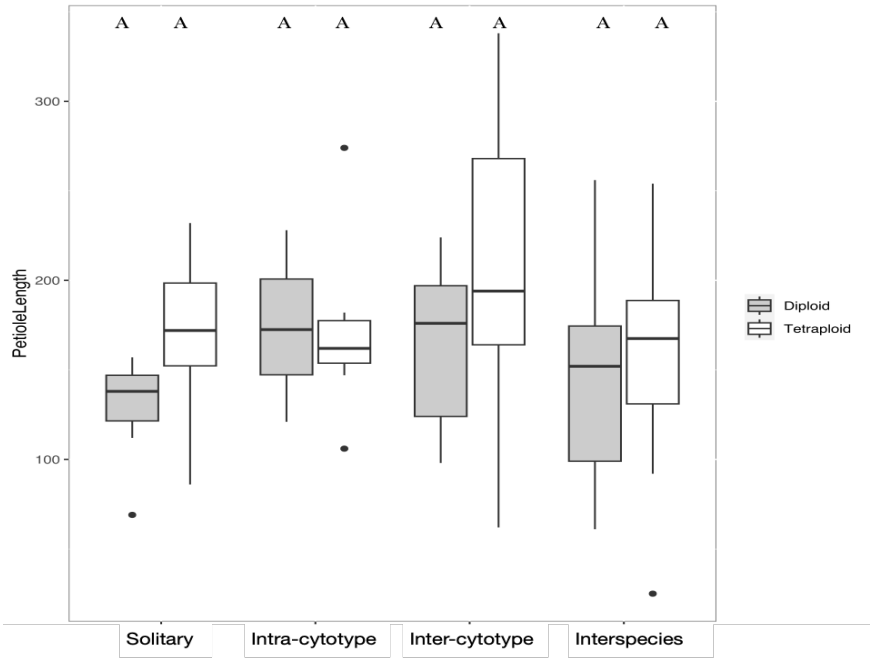
	Correlated trait pairs		
Retained trait	Trait 1	Trait 2	$\|r\|$
	Days to final senescence	Days from emergence to senescence	0.79
	Days from emergence to last flower	Days from emergence to senescence	0.86
	Days from emergence to last flower	Days from first to last flower	0.99
	Days from emergence to senescence	Days from first to last flower	0.83

Datasets available at:

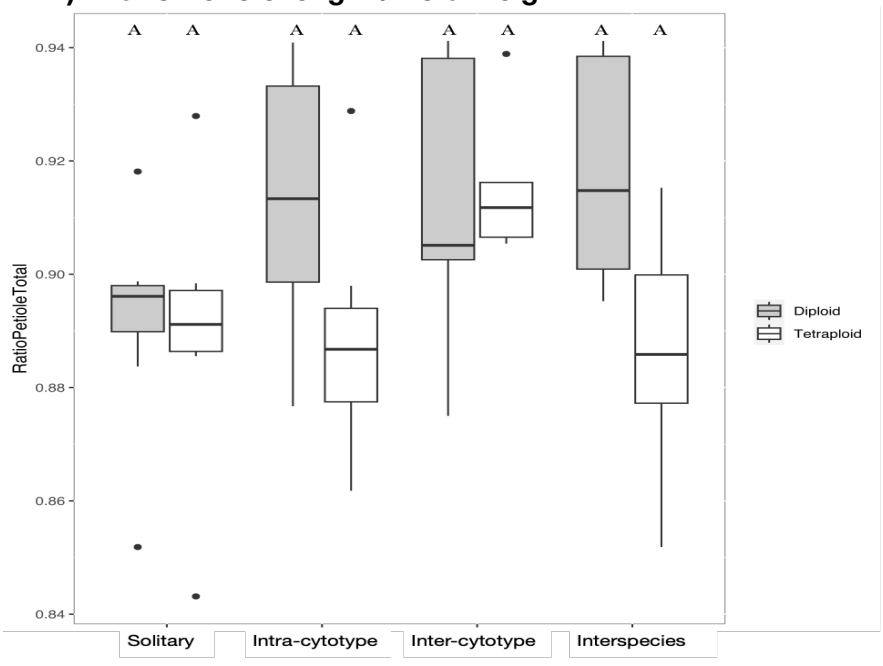
DOI: 10.25403/UPresearchdata.29164067

Additional trait graphs:

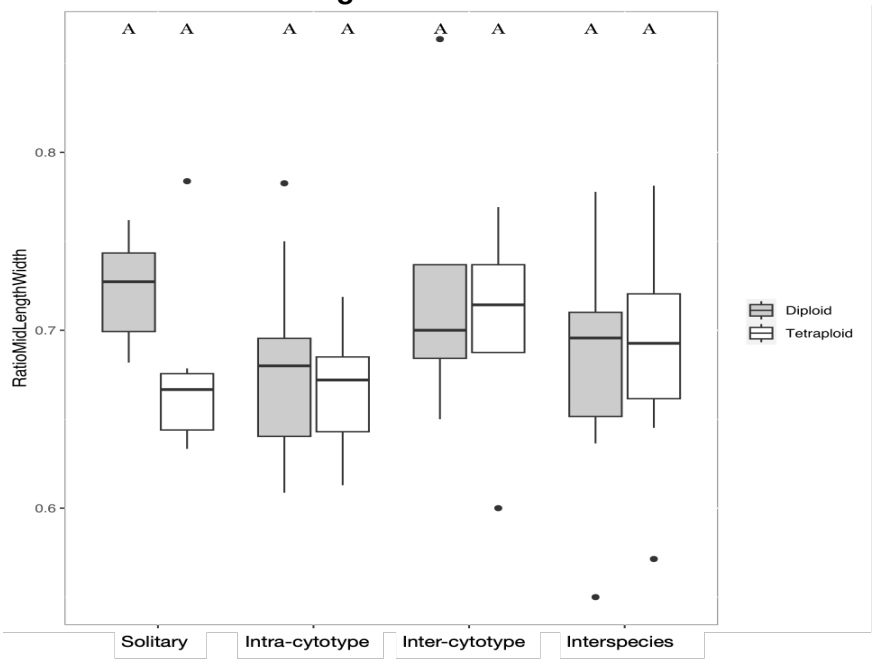
1) **Petiole Length:**



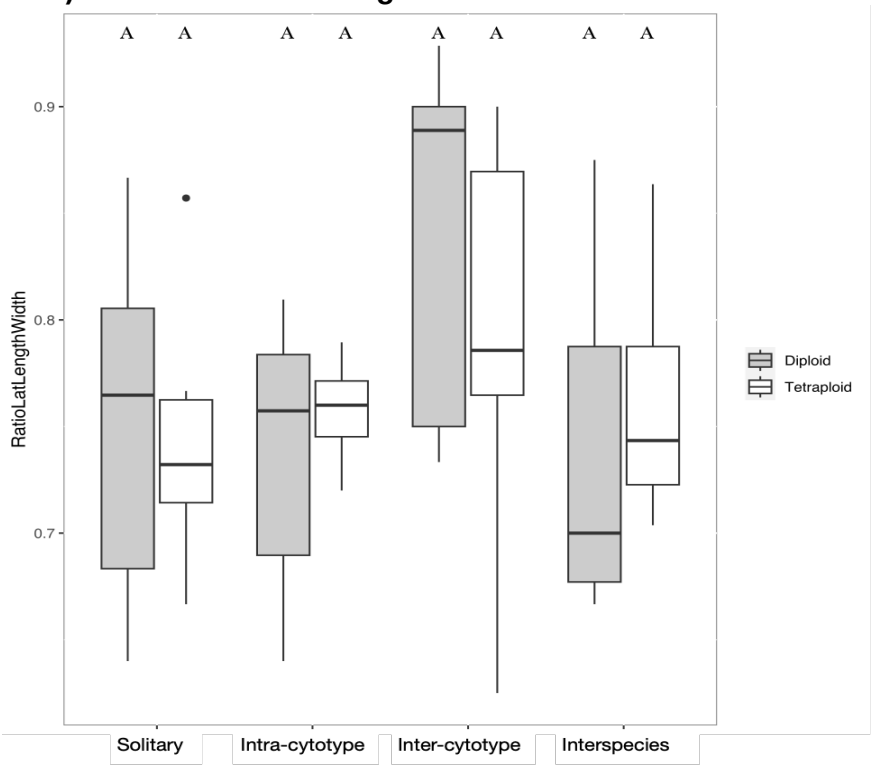
2) **Ratio Petiole length / Total height:**



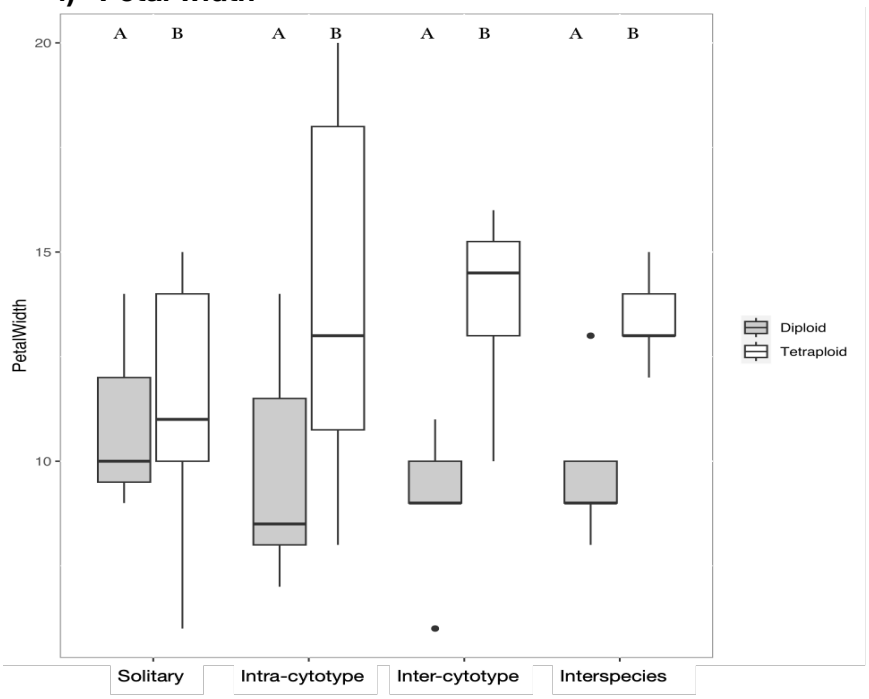
Ratio Middle leaf length to Middle leaf width



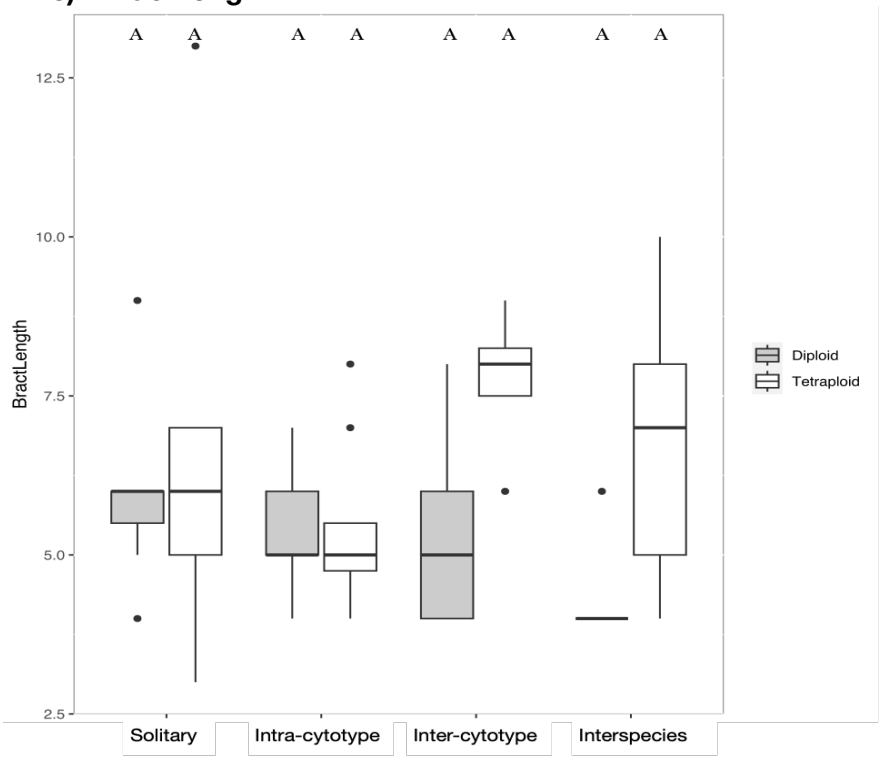
3) Ratio lateral leaf length / lateral leaf width



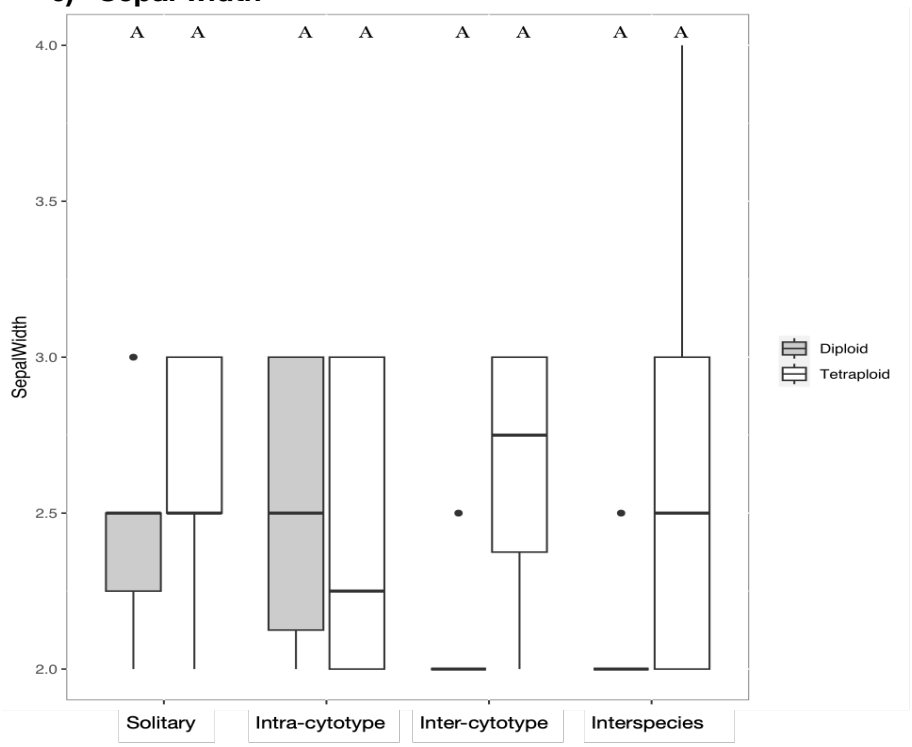
4) Petal width



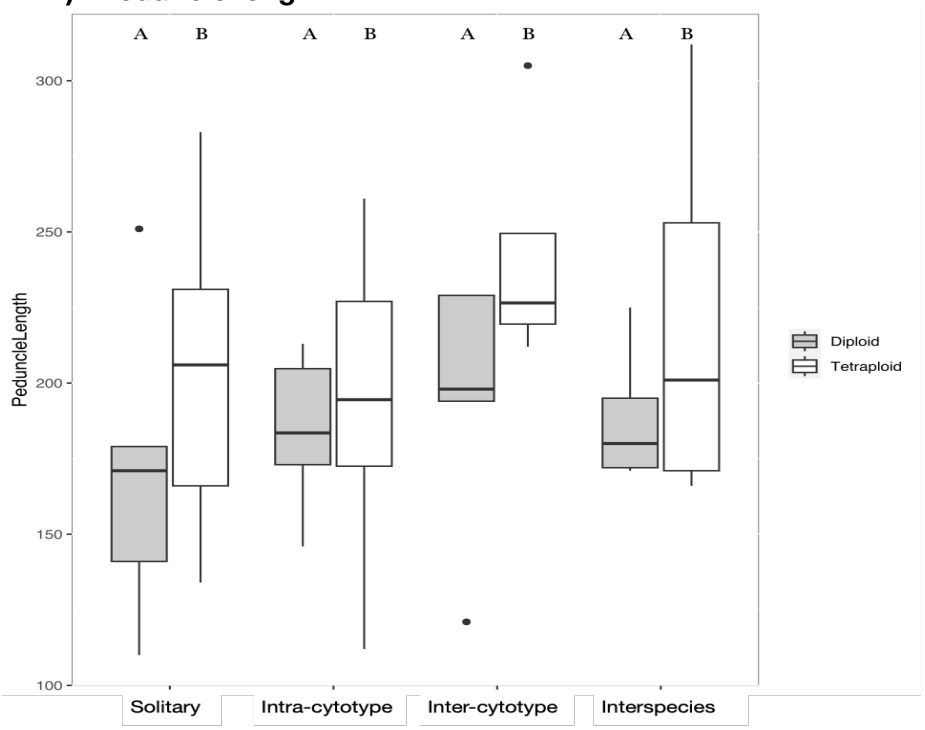
5) Bract length



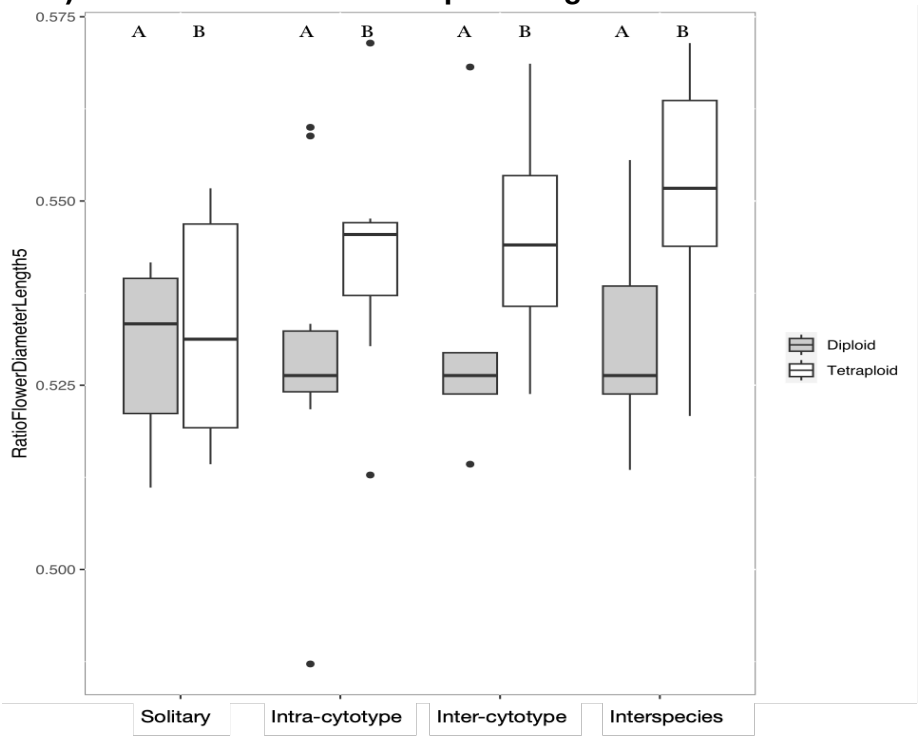
6) Sepal width



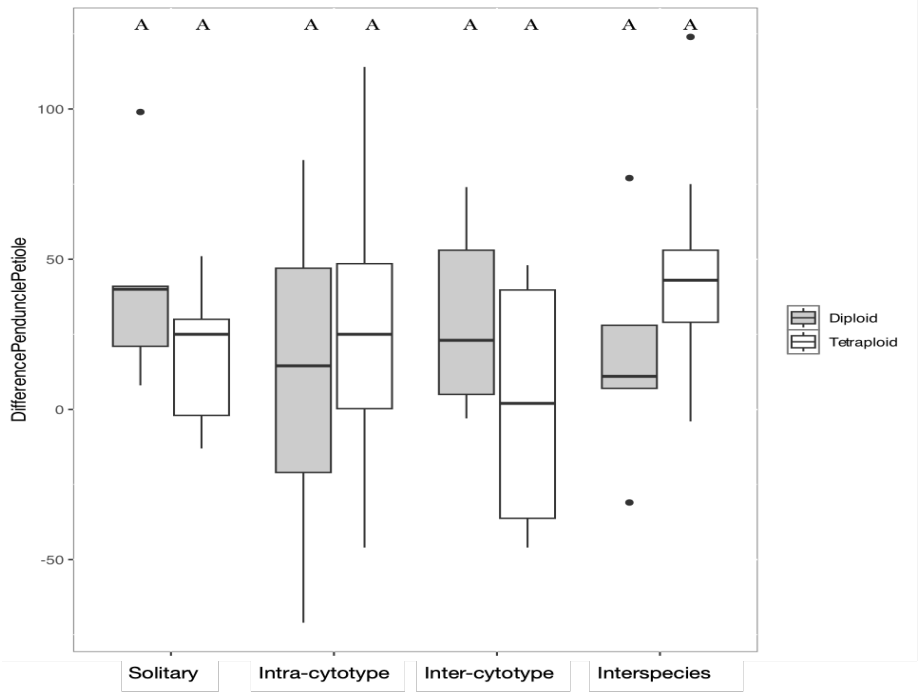
7) Peduncle length



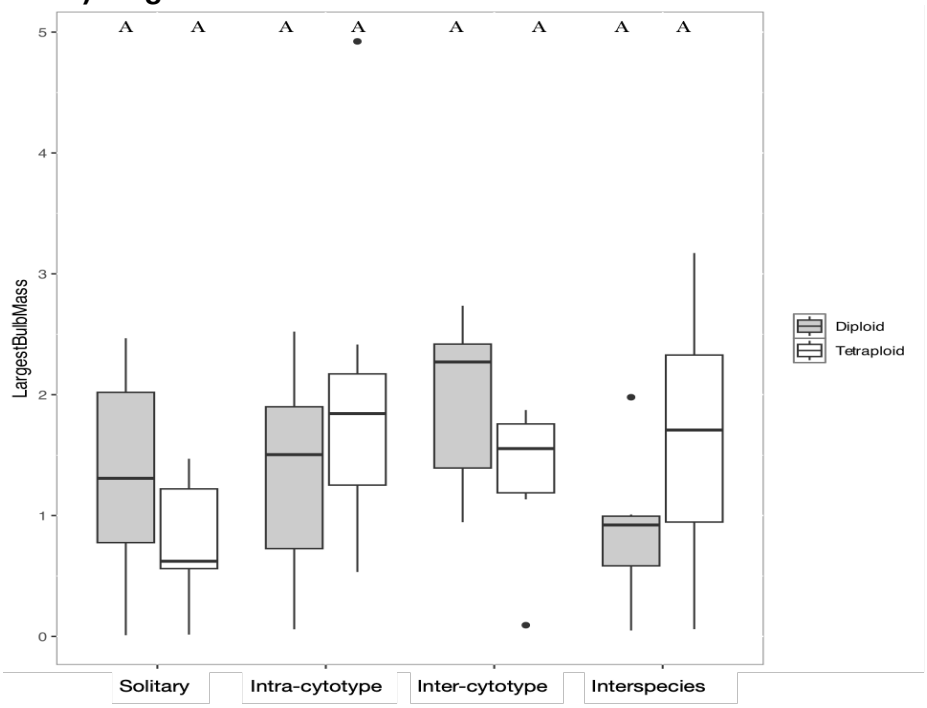
8) Ratio flower diameter to petal length



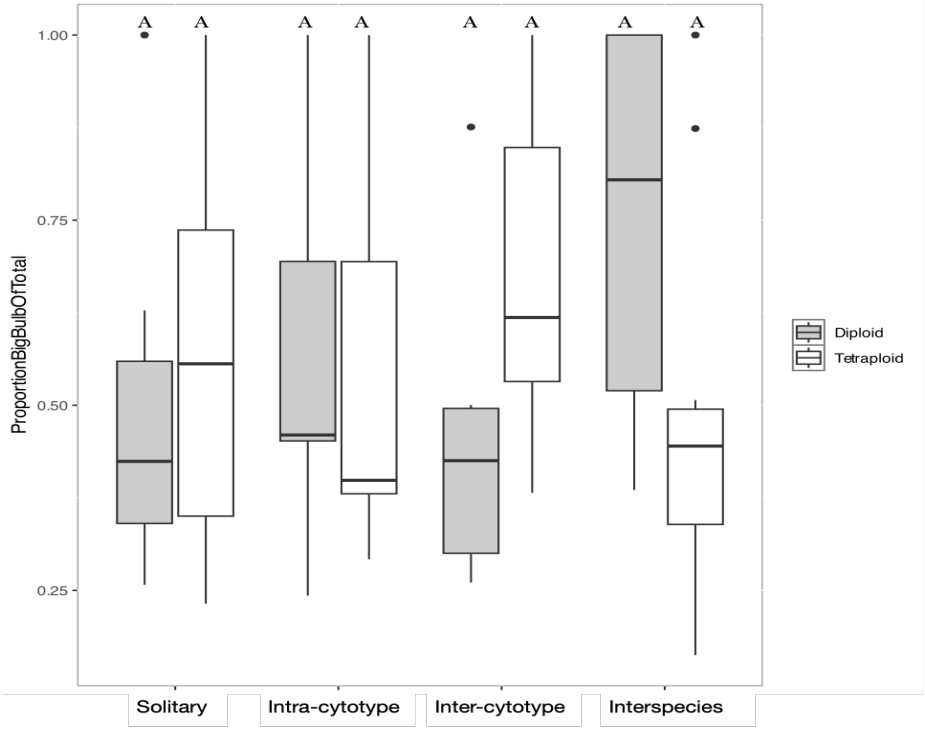
9) Difference in peduncle and petiole length



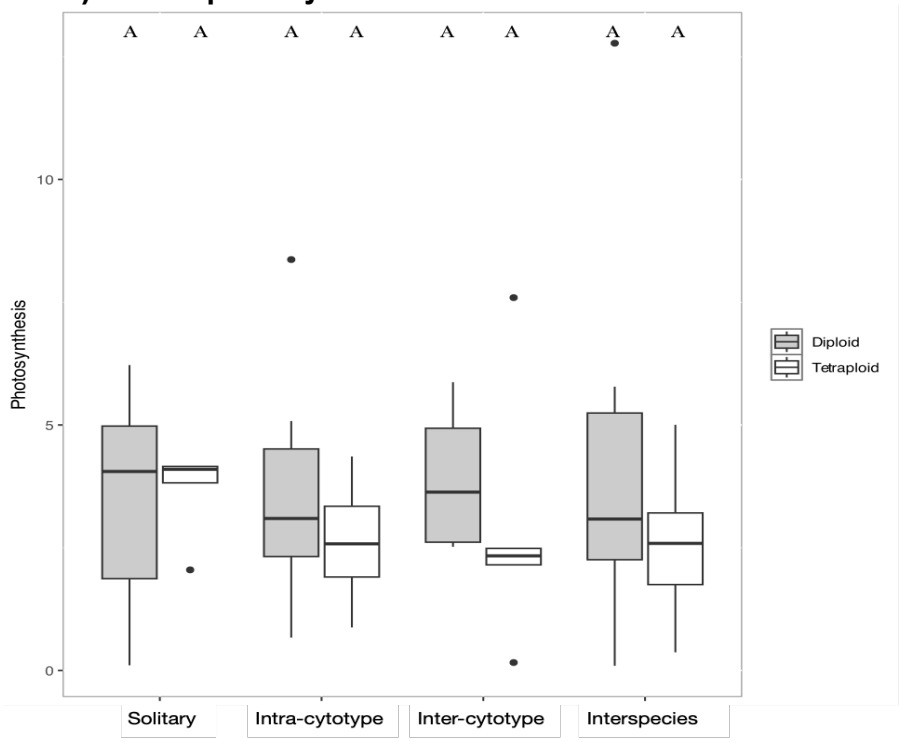
10) Largest bulb mass



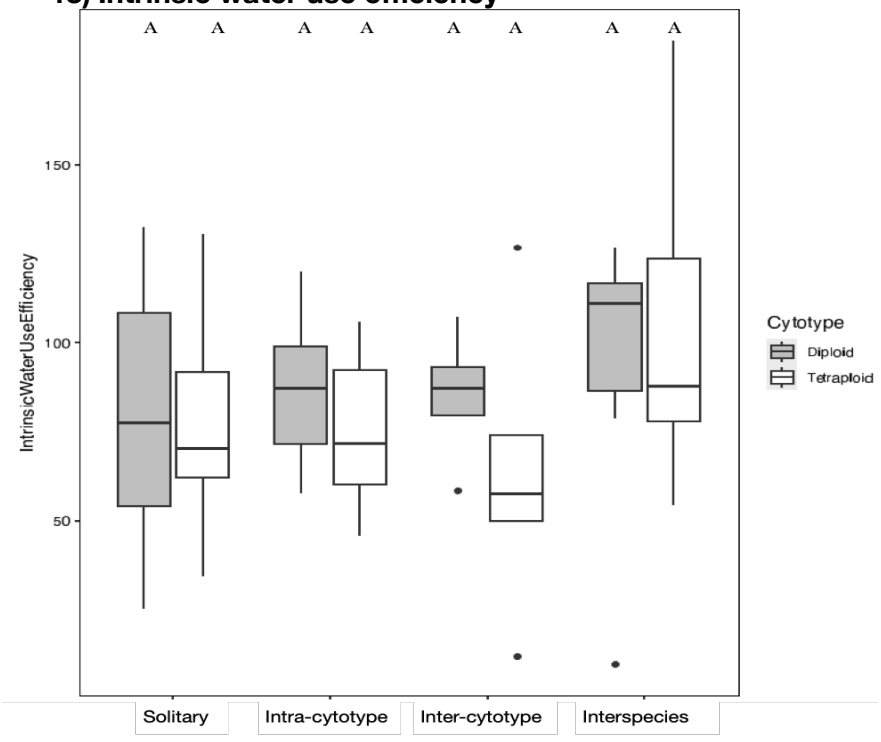
11) Proportion of largest bulb mass to total bulb mass



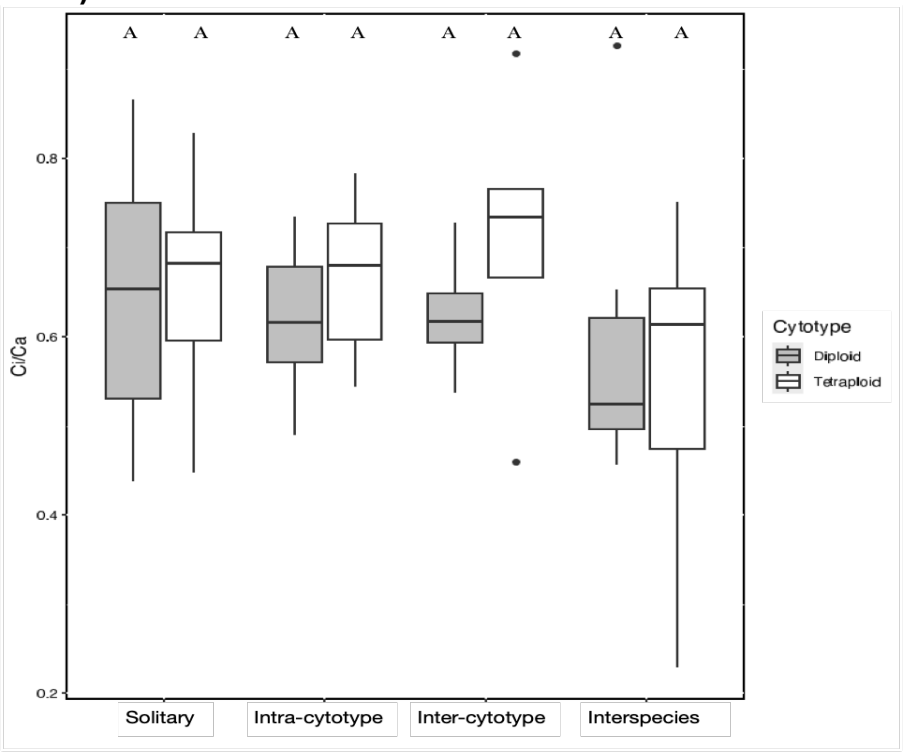
12) Rate of photosynthesis



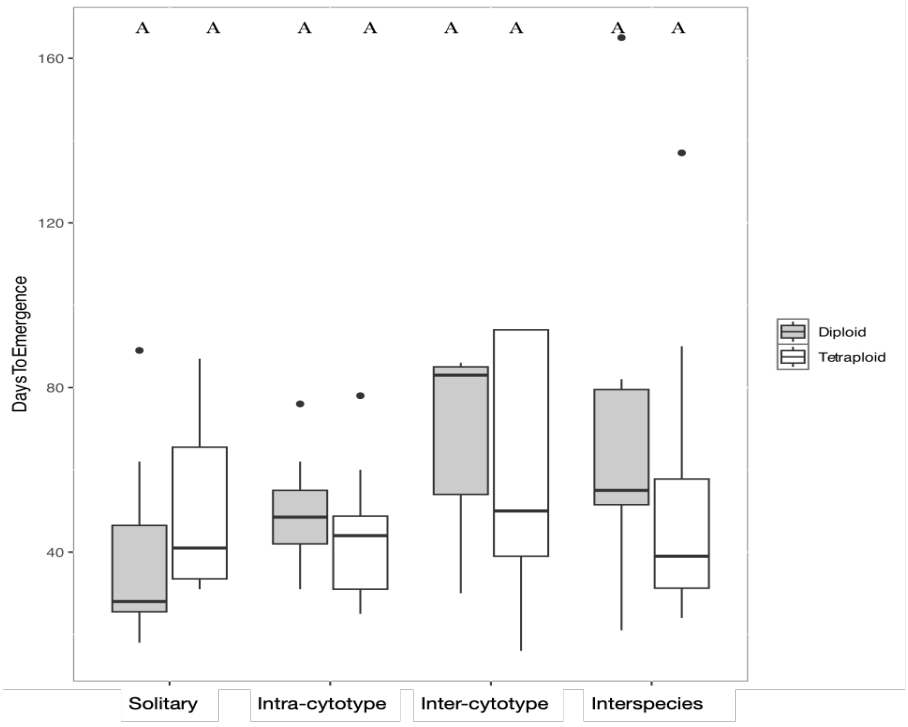
13) Intrinsic water use efficiency



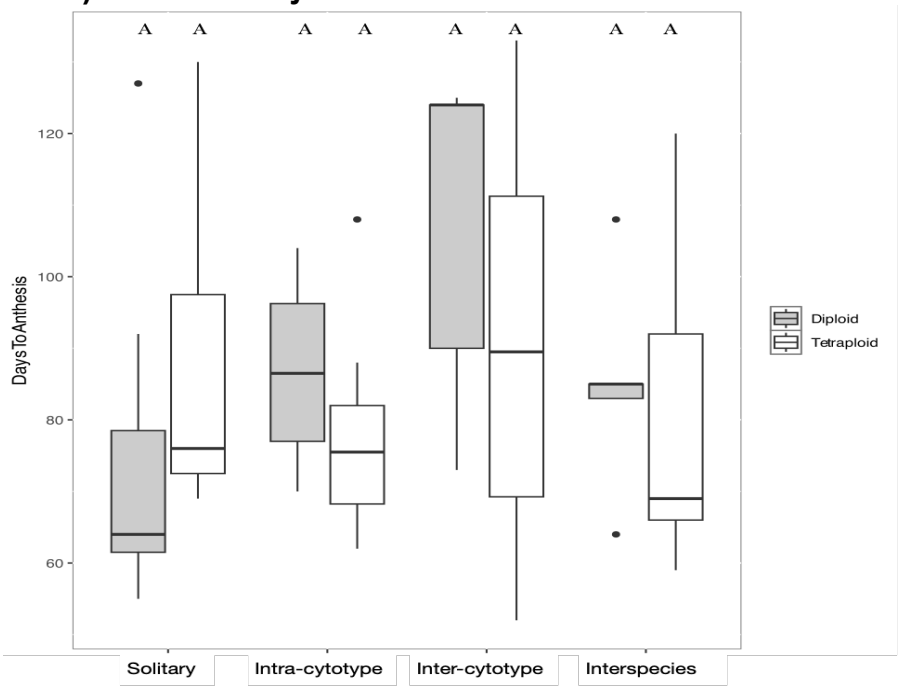
14) Ratio intercellular CO2 to ambient CO2



15) Number of days to plant emergence



16) Number of days to first anthesis



17) Number of days from last flower senescence to plant senescence