—title: “PGLS_volt_final” output: html_document —

```
library(MASS)
library(ape)
```

```
## Warning: package 'ape' was built under R version 3.5.3
```

```
library(geiger)
library(nlme)
library(phytools)
```

```
## Loading required package: maps
```

```
library(ggplot2)
```

```
## Warning: package 'ggplot2' was built under R version 3.5.3
```

PGLS + volt

```
dataVol <- read.csv("PGLS_volt.csv", row.names = 1)
treeVol <- read.tree("tree_all_species_volt.phy.phy")
name.check(treeVol, dataVol)
```

```
## [1] "OK"
```

```
sociality Vol <- dataVol[, "Sociality"]
phaseVol <- dataVol[,"Phase"]
latitudeVol <- dataVol[,"LatitudeDegress"]
voltVol <- dataVol[,"Voltinism"]
nestVol <- dataVol[,"Nest"]

names(sociality Vol) <- names(latitudeVol) <- names(phaseVol) <- names(voltVol) <- names(nestVol) <- rownames(data
```

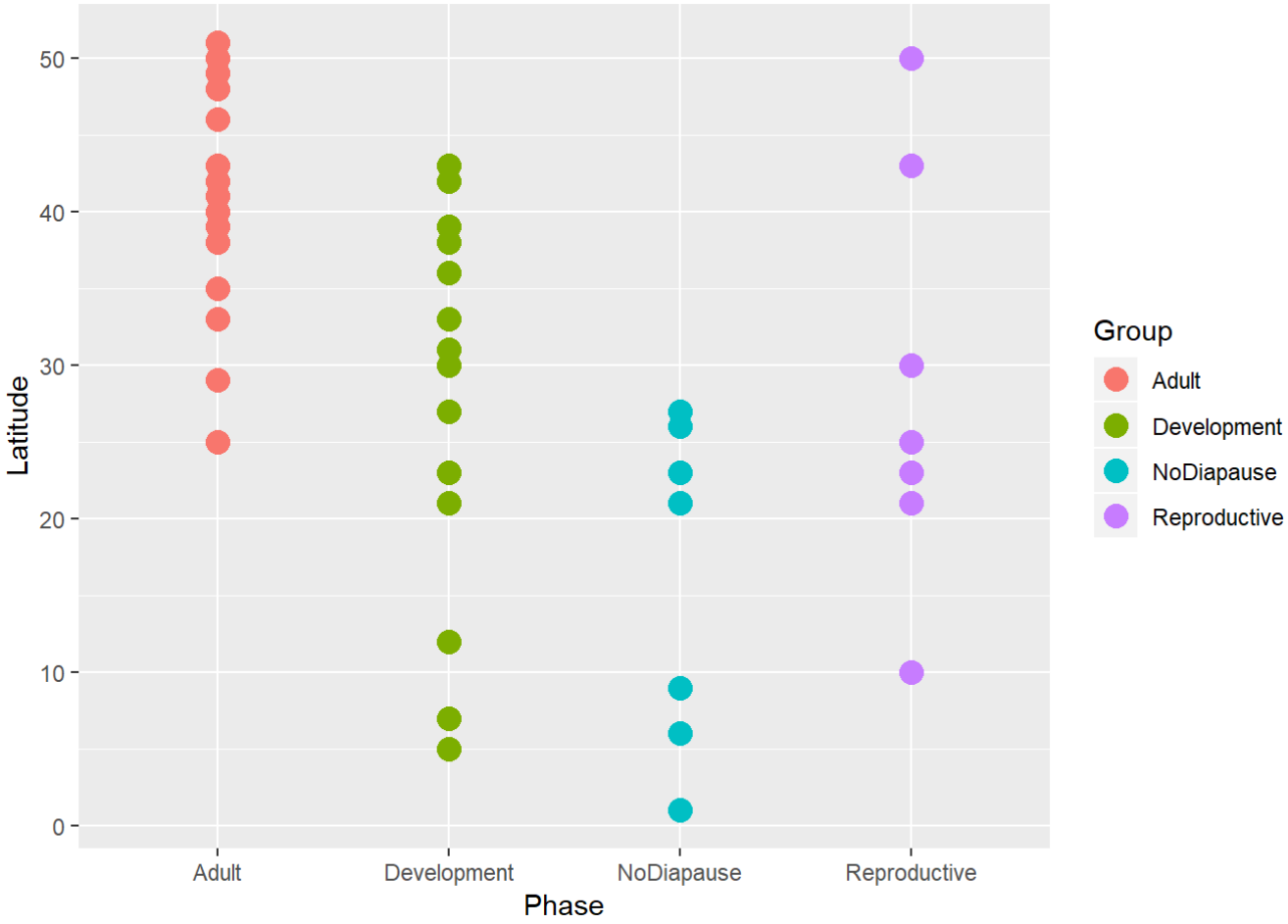
```
Vol)

datacor = dataVol[,1:5]
cor(datacor)
```

```
##                   Sociality      Phase        Nest  Voltinism
## Sociality        1.00000000  0.6357487  0.07332374  0.4985486
## Phase            0.63574866  1.0000000  0.19541598  0.4102534
## Nest             0.07332374  0.1954160  1.00000000  0.1328885
## Voltinism        0.49854862  0.4102534  0.13288850  1.0000000
## LatitudeDegress -0.06510555 -0.4223979 -0.35819830 -0.2299578
##                 LatitudeDegress
## Sociality           -0.06510555
## Phase               -0.42239793
## Nest                -0.35819830
## Voltinism           -0.22995782
## LatitudeDegress      1.00000000
```

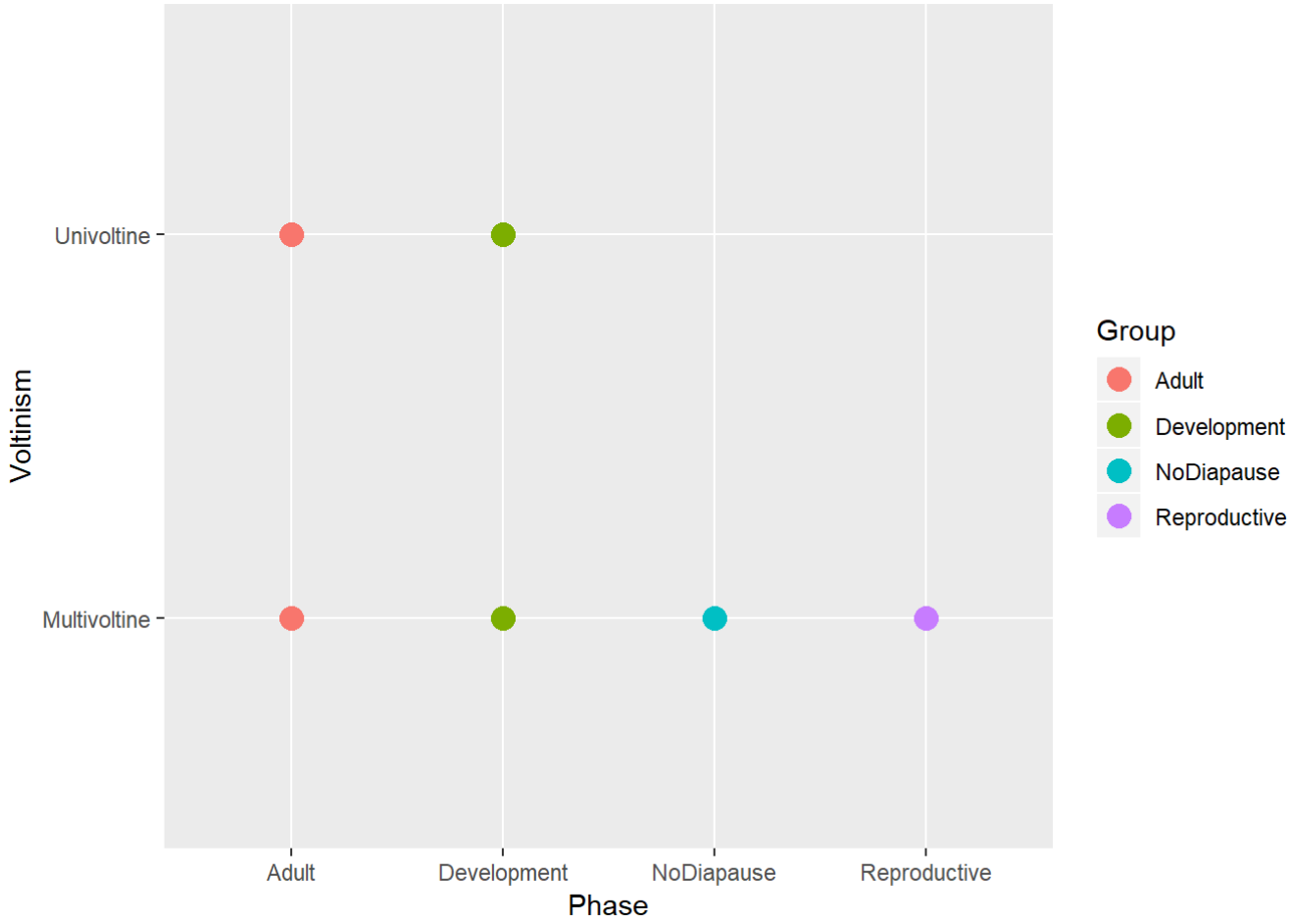
```
graph_phase_lat <- read.csv("Graphic_phase_latitude.csv")

ggplot(graph_phase_lat, aes(x=Group, y=LatitudeDegress, color=Group)) +
    geom_point(size=4) + labs(x = "Phase", y = "Latitude")
```



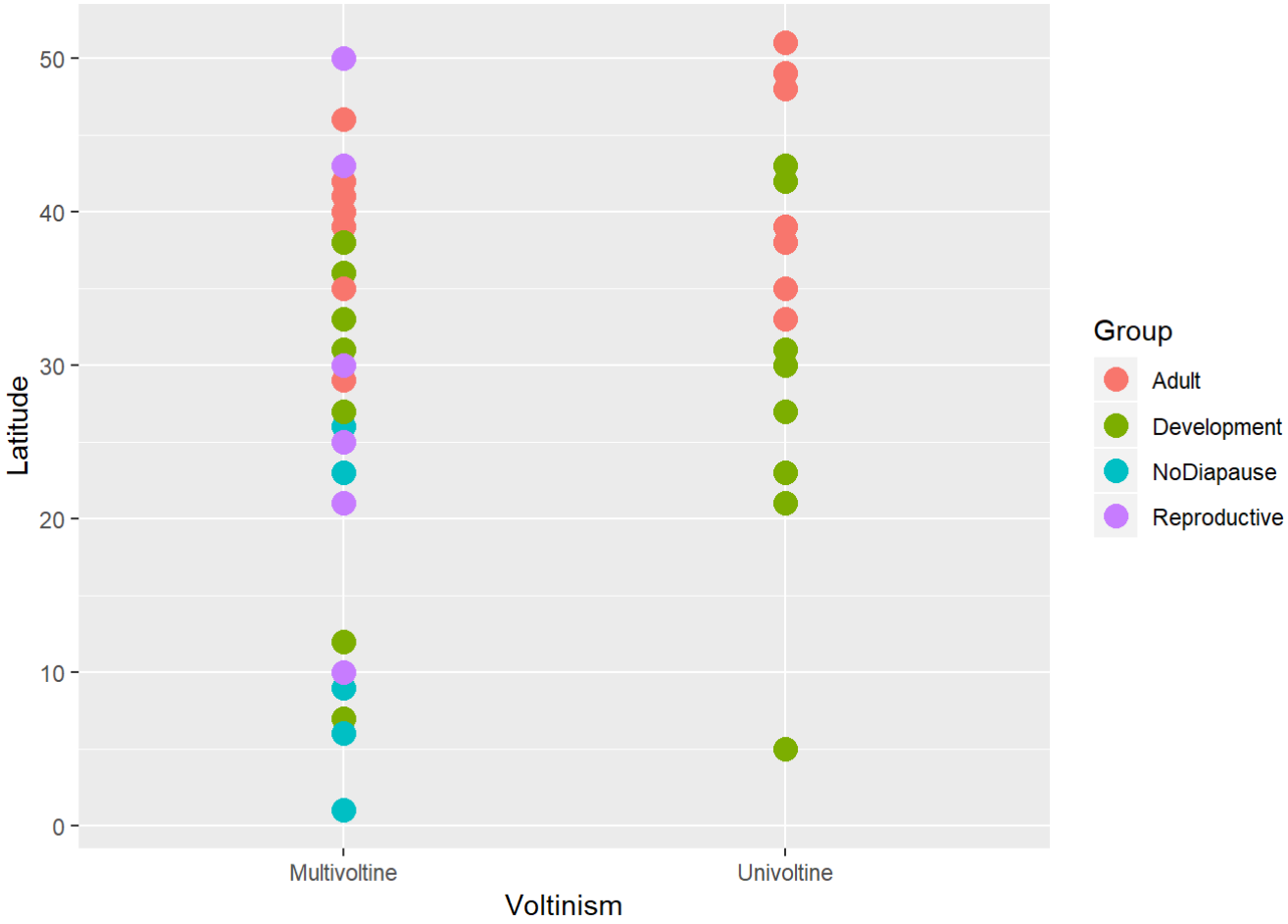

```
ggsave('/My Drive/review_diapause/updatedanalysisancestralreconstructionandpgls/Final_paper/Submitted/Phase_per_latitude.png', width = 9, height = 5, dpi = 300)

ggplot(graph_phase_lat, aes(x=Group, y=Voltinism, color=Group)) +
    geom_point(size=4) + labs(x = "Phase", y = "Voltinism")
```




```
ggsave('/My Drive/review_diapause/updatedanalysisancestralreconstructionandpgls/Final_paper/Submitted/Phase_per_Voltinism.png', width = 9, height = 5, dpi = 300)

ggplot(graph_phase_lat, aes(x=Voltinism, y=LatitudeDegress, color=Group)) +
    geom_point(size=4) + labs(x = "Voltinism", y = "Latitude")
```




```
ggsave('/My Drive/review_diapause/updatedanalysisancestralreconstructionandpgls/Final_paper/Submitted/Voltinism_per_latitude.png', width = 9, height = 5, dpi = 300)
```

```
PGLSmodel1 <- gls(phaseVol ~ sociality Vol + latitudeVol + voltVol + nestVol, correlation = corBrownian(phy = treeVol), data = dataVol, method = "ML")
anova(PGLSmodel1)
```

```
## Denom. DF: 97
##              numDF  F-value p-value
## (Intercept)      1  1.95517  0.1652
## sociality Vol     1  6.22109  0.0143
## latitudeVol      1 63.71806  <.0001
## voltVol          1  4.29665  0.0408
## nestVol          1  0.10550  0.7460
```

```
coef(PGLSmodel1)
```

```
##  (Intercept) sociality Vol  latitudeVol      voltVol      nestVol
##   1.94931455   0.31049656  -0.04089779   0.39836104   0.07968861
```

```
stepAIC(gls(phaseVol ~ sociality Vol + latitudeVol + voltVol + nestVol, correlation = corBrownian(phy = treeVol),
data = dataVol, method = "ML"), direction="both")
```

```
## Start:  AIC=228.38
## phaseVol ~ sociality Vol + latitudeVol + voltVol + nestVol
##
##                Df    AIC
## - nestVol       1 226.49
## - sociality Vol  1 228.08
## <none>            228.38
## - voltVol       1 230.47
## - latitudeVol   1 258.77
##
## Step:  AIC=226.49
## phaseVol ~ sociality Vol + latitudeVol + voltVol
##
##                Df    AIC
## - sociality Vol  1 226.16
## <none>            226.49
## + nestVol       1 228.38
## - voltVol       1 228.90
```

```
## - latitudeVol   1 256.84
##
## Step:  AIC=226.16
## phaseVol ~ latitudeVol + voltVol
##
##                Df    AIC
## <none>            226.16
## + socialityVol  1 226.49
## + nestVol       1 228.08
## - voltVol       1 232.28
## - latitudeVol   1 254.86
```

```
## Generalized least squares fit by maximum likelihood
##   Model: phaseVol ~ latitudeVol + voltVol
##   Data: dataVol
##   Log-likelihood: -109.0784
##
## Coefficients:
## (Intercept) latitudeVol     voltVol
##  2.26676229 -0.03930364  0.51290535
##
## Correlation Structure: corBrownian
##  Formula: ~1
##  Parameter estimate(s):
## numeric(0)
## Degrees of freedom: 102 total; 99 residual
## Residual standard error: 2.50509
```

Best model phase ~ latitude + voltinism

```
PGLSmodel1R <- gls(phaseVol ~ latitudeVol + voltVol, correlation = corBrownian(phy = treeVol), data = dataVol, me
thod = "ML")
anova(PGLSmodel1R)
```

```
## Denom. DF: 99
##             numDF  F-value p-value
## (Intercept)     1  1.96097  0.1645
## latitudeVol     1 64.64242  <.0001
## voltVol         1  8.20648  0.0051
```

```
coef(PGLSmodel1R)
```

```
## (Intercept) latitudeVol     voltVol
##  2.26676229 -0.03930364  0.51290535
```

```
PGLS0 <- gls(phaseVol ~ 1,correlation = corBrownian(phy = treeVol), data = dataVol, method = "ML")
anova(PGLSmodel1R,PGLS0)
```

```
##             Model df      AIC      BIC    logLik   Test  L.Ratio p-value
## PGLSmodel1R     1  4 226.1568 236.6567 -109.0784
## PGLS0           2  2 278.4093 283.6593 -137.2047 1 vs 2 56.25257  <.0001
```

Multiple predictors

```
PGLSmodel2 <- gls(phaseVol ~ sociality Vol*voltVol + latitudeVol*voltVol + sociality Vol*latitudeVol + nestVol, cor
relation = corBrownian(phy = treeVol), data = dataVol, method = "ML")
anova(PGLSmodel2)
```

```
## Denom. DF: 94
##                            numDF  F-value p-value
## (Intercept)                    1  2.36100  0.1278
## sociality Vol                  1  7.51237  0.0073
## voltVol                        1 38.36354  <.0001
## latitudeVol                    1 43.76863  <.0001
## nestVol                        1  0.12739  0.7219
```

```
## sociality:voltVol         1  0.52926  0.4687
## voltVol:latitudeVol       1 21.96040  <.0001
## sociality:latitudeVol     1  0.64414  0.4242
```

```
coef(PGLSmodel2)
```

```
##              (Intercept)             sociality                 voltVol
##              -0.78864098              -0.94165421               2.25324946
##              latitudeVol                 nestVol     sociality:voltVol
##               0.07974565              -0.03028092               0.51753502
##      voltVol:latitudeVol sociality:latitudeVol
##              -0.07646162               0.01216501
```

```
stepAIC(gls(phaseVol ~ sociality*voltVol + latitudeVol*voltVol + sociality*latitudeVol + nestVol, correlati
on = corBrownian(phy = treeVol), data = dataVol, method = "ML"), direction="both")
```

```
## Start:  AIC=211.93
## phaseVol ~ sociality * voltVol + latitudeVol * voltVol + sociality *
##     latitudeVol + nestVol
##
##                            Df    AIC
## - nestVol                   1 209.95
## - sociality:latitudeVol     1 210.63
## - sociality:voltVol         1 210.75
## <none>                        211.94
## - voltVol:latitudeVol       1 231.29
##
## Step:  AIC=209.95
## phaseVol ~ sociality + voltVol + latitudeVol + sociality:voltVol +
##     voltVol:latitudeVol + sociality:latitudeVol
##
##                            Df    AIC
## - sociality:latitudeVol     1 208.75
## - sociality:voltVol         1 208.84
```

```
## <none>                         209.95
## + nestVol                    1 211.94
## - voltVol:latitudeVol        1 229.29
##
## Step:  AIC=208.75
## phaseVol ~ sociality Vol + voltVol + latitudeVol + sociality Vol:voltVol +
##     voltVol:latitudeVol
##
##                             Df    AIC
## - sociality Vol:voltVol      1 207.06
## <none>                         208.75
## + sociality Vol:latitudeVol  1 209.95
## + nestVol                    1 210.63
## - voltVol:latitudeVol        1 227.99
##
## Step:  AIC=207.06
## phaseVol ~ sociality Vol + voltVol + latitudeVol + voltVol:latitudeVol
##
##                             Df    AIC
## <none>                         207.06
## + sociality Vol:voltVol      1 208.75
## + sociality Vol:latitudeVol  1 208.84
## + nestVol                    1 208.92
## - sociality Vol              1 209.24
## - voltVol:latitudeVol        1 226.49
```

```
## Generalized least squares fit by maximum likelihood
##   Model: phaseVol ~ sociality Vol + voltVol + latitudeVol + voltVol:latitudeVol
##   Data: dataVol
##   Log-likelihood: -97.52855
##
## Coefficients:
##         (Intercept)        sociality Vol             voltVol
##         -2.10983288          0.44415812          2.61534172
##         latitudeVol voltVol:latitudeVol
##          0.08481017         -0.06911688
##
```

```
## Correlation Structure: corBrownian
##  Formula: ~1
##  Parameter estimate(s):
## numeric(0)
## Degrees of freedom: 102 total; 97 residual
## Residual standard error: 2.2369
```

Best model phaseVol ~ sociality Vol + voltVol + latitudeVol + voltVol:latitudeVol

```
PGLSmodel2R <- gls(phaseVol ~ socialityVol + voltVol + latitudeVol + voltVol:latitudeVol, correlation = corBrowni
an(phy = treeVol), data = dataVol, method = "ML")
anova(PGLSmodel2R)
```

```
## Denom. DF: 97
##                      numDF  F-value p-value
## (Intercept)              1  2.40968  0.1238
## socialityVol             1  7.66727  0.0067
## voltVol                  1 39.15462  <.0001
## latitudeVol              1 44.67117  <.0001
## voltVol:latitudeVol      1 22.67919  <.0001
```

```
coef(PGLSmodel2R)
```

```
##         (Intercept)        socialityVol             voltVol
##         -2.10983288          0.44415812          2.61534172
##         latitudeVol voltVol:latitudeVol
##          0.08481017         -0.06911688
```

```
anova(PGLSmodel2R,PGLS0)
```

```
##             Model df      AIC      BIC     logLik   Test  L.Ratio p-value
## PGLSmodel2R     1  6 207.0571 222.8069  -97.52855
## PGLS0           2  2 278.4093 283.6593 -137.20467 1 vs 2 79.35224  <.0001
```