

Nested_ANOVA_Anagrus.R

John

Tue Nov 27 09:50:30 2018

```
# Nested_ANOVA_Anagrus.R
# Nested ANOVA for total eggs, after Cronin and Strong (1996)

# Load necessary libraries
library(ggplot2)

## Warning: package 'ggplot2' was built under R version 3.5.1
library(lme4)

## Loading required package: Matrix
library(lmerTest)

##
## Attaching package: 'lmerTest'
## The following object is masked from 'package:lme4':
##
##      lmer
## The following object is masked from 'package:stats':
##
##      step
library(multcomp)

## Loading required package: mvtnorm
## Loading required package: survival
## Loading required package: TH.data
## Loading required package: MASS
##
## Attaching package: 'TH.data'
## The following object is masked from 'package:MASS':
##
##      geyser
# Read in data set
nestdata <- read.table(header=T,colClasses=c(rep("factor",3),"numeric"),text="
site isolate wasp eggs
1   1   1  37
1   1   2  41
1   1   3  46
1   1   4  44
1   1   5  43
1   1   6  41
1   1   7  38
1   1   8  37
```

1	2	1	37
1	2	2	28
1	2	3	34
1	2	4	37
1	2	5	35
1	2	6	39
1	2	7	36
1	2	8	29
1	3	1	35
1	3	2	37
1	3	3	40
1	3	4	39
1	3	5	37
1	3	6	44
1	3	7	35
1	3	8	38
1	4	1	28
1	4	2	36
1	4	3	31
1	4	4	27
1	4	5	36
1	4	6	33
1	4	7	31
1	4	8	35
1	5	1	34
1	5	2	35
1	5	3	30
1	5	4	39
1	5	5	42
1	5	6	39
1	5	7	38
1	5	8	32
1	6	1	30
1	6	2	32
1	6	3	35
1	6	4	35
1	6	5	32
1	6	6	31
1	6	7	34
1	6	8	30
1	7	1	30
1	7	2	36
1	7	3	37
1	7	4	30
1	7	5	41
1	7	6	35
1	7	7	34
1	7	8	37
1	8	1	25
1	8	2	31
1	8	3	24
1	8	4	26
1	8	5	30

1	8	6	31
1	8	7	25
1	8	8	24
1	9	1	34
1	9	2	35
1	9	3	29
1	9	4	34
1	9	5	34
1	9	6	40
1	9	7	37
1	9	8	37
1	10	1	38
1	10	2	30
1	10	3	33
1	10	4	32
1	10	5	33
1	10	6	34
1	10	7	35
1	10	8	41
1	11	1	36
1	11	2	33
1	11	3	36
1	11	4	34
1	11	5	37
1	11	6	41
1	11	7	37
1	11	8	31
1	12	1	35
1	12	2	36
1	12	3	35
1	12	4	37
1	12	5	40
1	12	6	34
1	12	7	29
1	12	8	42
1	13	1	33
1	13	2	39
1	13	3	33
1	13	4	37
1	13	5	28
1	13	6	35
1	13	7	34
1	13	8	38
1	14	1	35
1	14	2	33
1	14	3	25
1	14	4	29
1	14	5	29
1	14	6	35
1	14	7	33
1	14	8	29
2	1	1	26
2	1	2	39

2	1	3	36
2	1	4	27
2	1	5	25
2	1	6	31
2	1	7	30
2	1	8	25
2	2	1	42
2	2	2	46
2	2	3	46
2	2	4	42
2	2	5	43
2	2	6	36
2	2	7	36
2	2	8	41
2	3	1	38
2	3	2	36
2	3	3	35
2	3	4	31
2	3	5	36
2	3	6	32
2	3	7	29
2	3	8	34
2	4	1	28
2	4	2	36
2	4	3	33
2	4	4	32
2	4	5	27
2	4	6	31
2	4	7	30
2	4	8	32
2	5	1	30
2	5	2	35
2	5	3	32
2	5	4	31
2	5	5	36
2	5	6	34
2	5	7	29
2	5	8	36
2	6	1	28
2	6	2	34
2	6	3	34
2	6	4	35
2	6	5	32
2	6	6	31
2	6	7	24
2	6	8	31
2	7	1	35
2	7	2	34
2	7	3	44
2	7	4	34
2	7	5	35
2	7	6	36
2	7	7	32

2	7	8	30
2	8	1	37
2	8	2	32
2	8	3	33
2	8	4	39
2	8	5	30
2	8	6	31
2	8	7	32
2	8	8	34
2	9	1	41
2	9	2	41
2	9	3	43
2	9	4	36
2	9	5	43
2	9	6	42
2	9	7	42
2	9	8	37
2	10	1	34
2	10	2	30
2	10	3	35
2	10	4	27
2	10	5	30
2	10	6	22
2	10	7	31
2	10	8	31
2	11	1	34
2	11	2	36
2	11	3	38
2	11	4	36
2	11	5	34
2	11	6	33
2	11	7	35
2	11	8	29
2	12	1	28
2	12	2	29
2	12	3	27
2	12	4	36
2	12	5	33
2	12	6	32
2	12	7	34
2	12	8	32
2	13	1	40
2	13	2	39
2	13	3	39
2	13	4	34
2	13	5	32
2	13	6	42
2	13	7	36
2	13	8	39
2	14	1	38
2	14	2	42
2	14	3	37
2	14	4	37

2	14	5	34
2	14	6	33
2	14	7	43
2	14	8	34
3	1	1	30
3	1	2	35
3	1	3	36
3	1	4	37
3	1	5	29
3	1	6	27
3	1	7	39
3	1	8	38
3	2	1	30
3	2	2	37
3	2	3	30
3	2	4	31
3	2	5	27
3	2	6	31
3	2	7	36
3	2	8	40
3	3	1	27
3	3	2	33
3	3	3	31
3	3	4	32
3	3	5	34
3	3	6	31
3	3	7	31
3	3	8	31
3	4	1	26
3	4	2	27
3	4	3	37
3	4	4	30
3	4	5	29
3	4	6	35
3	4	7	34
3	4	8	31
3	5	1	36
3	5	2	32
3	5	3	34
3	5	4	37
3	5	5	32
3	5	6	34
3	5	7	33
3	5	8	32
3	6	1	33
3	6	2	40
3	6	3	34
3	6	4	38
3	6	5	36
3	6	6	35
3	6	7	41
3	6	8	34
3	7	1	31

3	7	2	33
3	7	3	31
3	7	4	34
3	7	5	29
3	7	6	33
3	7	7	28
3	7	8	33
3	8	1	22
3	8	2	25
3	8	3	29
3	8	4	24
3	8	5	24
3	8	6	26
3	8	7	25
3	8	8	21
3	9	1	32
3	9	2	31
3	9	3	28
3	9	4	28
3	9	5	35
3	9	6	34
3	9	7	33
3	9	8	31
3	10	1	31
3	10	2	32
3	10	3	29
3	10	4	30
3	10	5	28
3	10	6	31
3	10	7	28
3	10	8	36
3	11	1	32
3	11	2	31
3	11	3	34
3	11	4	35
3	11	5	35
3	11	6	31
3	11	7	41
3	11	8	34
3	12	1	28
3	12	2	27
3	12	3	27
3	12	4	27
3	12	5	27
3	12	6	30
3	12	7	28
3	12	8	28
3	13	1	36
3	13	2	39
3	13	3	36
3	13	4	30
3	13	5	37
3	13	6	32

```

3 13 7 38
3 13 8 39
3 14 1 32
3 14 2 34
3 14 3 41
3 14 4 33
3 14 5 35
3 14 6 35
3 14 7 34
3 14 8 31
")

# Apply transformations here
nestdata <- transform(nestdata,y=eggs)

# Print data set
nestdata

```

```

##      site isoline wasp eggs  y
## 1      1         1    1   37 37
## 2      1         1    2   41 41
## 3      1         1    3   46 46
## 4      1         1    4   44 44
## 5      1         1    5   43 43
## 6      1         1    6   41 41
## 7      1         1    7   38 38
## 8      1         1    8   37 37
## 9      1         2    1   37 37
## 10     1         2    2   28 28
## 11     1         2    3   34 34
## 12     1         2    4   37 37
## 13     1         2    5   35 35
## 14     1         2    6   39 39
## 15     1         2    7   36 36
## 16     1         2    8   29 29
## 17     1         3    1   35 35
## 18     1         3    2   37 37
## 19     1         3    3   40 40
## 20     1         3    4   39 39
## 21     1         3    5   37 37
## 22     1         3    6   44 44
## 23     1         3    7   35 35
## 24     1         3    8   38 38
## 25     1         4    1   28 28
## 26     1         4    2   36 36
## 27     1         4    3   31 31
## 28     1         4    4   27 27
## 29     1         4    5   36 36
## 30     1         4    6   33 33
## 31     1         4    7   31 31
## 32     1         4    8   35 35
## 33     1         5    1   34 34
## 34     1         5    2   35 35
## 35     1         5    3   30 30

```


## 36	1	5	4	39 39
## 37	1	5	5	42 42
## 38	1	5	6	39 39
## 39	1	5	7	38 38
## 40	1	5	8	32 32
## 41	1	6	1	30 30
## 42	1	6	2	32 32
## 43	1	6	3	35 35
## 44	1	6	4	35 35
## 45	1	6	5	32 32
## 46	1	6	6	31 31
## 47	1	6	7	34 34
## 48	1	6	8	30 30
## 49	1	7	1	30 30
## 50	1	7	2	36 36
## 51	1	7	3	37 37
## 52	1	7	4	30 30
## 53	1	7	5	41 41
## 54	1	7	6	35 35
## 55	1	7	7	34 34
## 56	1	7	8	37 37
## 57	1	8	1	25 25
## 58	1	8	2	31 31
## 59	1	8	3	24 24
## 60	1	8	4	26 26
## 61	1	8	5	30 30
## 62	1	8	6	31 31
## 63	1	8	7	25 25
## 64	1	8	8	24 24
## 65	1	9	1	34 34
## 66	1	9	2	35 35
## 67	1	9	3	29 29
## 68	1	9	4	34 34
## 69	1	9	5	34 34
## 70	1	9	6	40 40
## 71	1	9	7	37 37
## 72	1	9	8	37 37
## 73	1	10	1	38 38
## 74	1	10	2	30 30
## 75	1	10	3	33 33
## 76	1	10	4	32 32
## 77	1	10	5	33 33
## 78	1	10	6	34 34
## 79	1	10	7	35 35
## 80	1	10	8	41 41
## 81	1	11	1	36 36
## 82	1	11	2	33 33
## 83	1	11	3	36 36
## 84	1	11	4	34 34
## 85	1	11	5	37 37
## 86	1	11	6	41 41
## 87	1	11	7	37 37
## 88	1	11	8	31 31
## 89	1	12	1	35 35

## 90	1	12	2	36 36
## 91	1	12	3	35 35
## 92	1	12	4	37 37
## 93	1	12	5	40 40
## 94	1	12	6	34 34
## 95	1	12	7	29 29
## 96	1	12	8	42 42
## 97	1	13	1	33 33
## 98	1	13	2	39 39
## 99	1	13	3	33 33
## 100	1	13	4	37 37
## 101	1	13	5	28 28
## 102	1	13	6	35 35
## 103	1	13	7	34 34
## 104	1	13	8	38 38
## 105	1	14	1	35 35
## 106	1	14	2	33 33
## 107	1	14	3	25 25
## 108	1	14	4	29 29
## 109	1	14	5	29 29
## 110	1	14	6	35 35
## 111	1	14	7	33 33
## 112	1	14	8	29 29
## 113	2	1	1	26 26
## 114	2	1	2	39 39
## 115	2	1	3	36 36
## 116	2	1	4	27 27
## 117	2	1	5	25 25
## 118	2	1	6	31 31
## 119	2	1	7	30 30
## 120	2	1	8	25 25
## 121	2	2	1	42 42
## 122	2	2	2	46 46
## 123	2	2	3	46 46
## 124	2	2	4	42 42
## 125	2	2	5	43 43
## 126	2	2	6	36 36
## 127	2	2	7	36 36
## 128	2	2	8	41 41
## 129	2	3	1	38 38
## 130	2	3	2	36 36
## 131	2	3	3	35 35
## 132	2	3	4	31 31
## 133	2	3	5	36 36
## 134	2	3	6	32 32
## 135	2	3	7	29 29
## 136	2	3	8	34 34
## 137	2	4	1	28 28
## 138	2	4	2	36 36
## 139	2	4	3	33 33
## 140	2	4	4	32 32
## 141	2	4	5	27 27
## 142	2	4	6	31 31
## 143	2	4	7	30 30

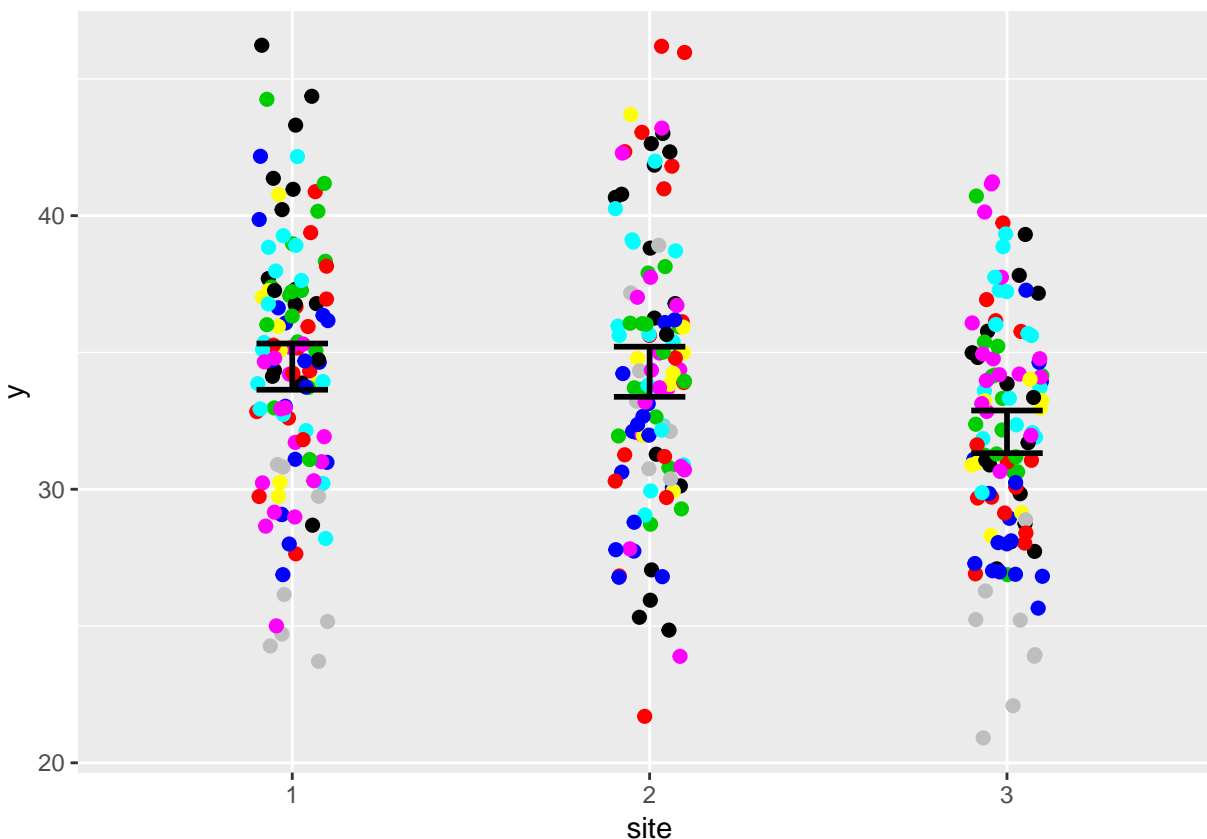
## 144	2	4	8	32 32
## 145	2	5	1	30 30
## 146	2	5	2	35 35
## 147	2	5	3	32 32
## 148	2	5	4	31 31
## 149	2	5	5	36 36
## 150	2	5	6	34 34
## 151	2	5	7	29 29
## 152	2	5	8	36 36
## 153	2	6	1	28 28
## 154	2	6	2	34 34
## 155	2	6	3	34 34
## 156	2	6	4	35 35
## 157	2	6	5	32 32
## 158	2	6	6	31 31
## 159	2	6	7	24 24
## 160	2	6	8	31 31
## 161	2	7	1	35 35
## 162	2	7	2	34 34
## 163	2	7	3	44 44
## 164	2	7	4	34 34
## 165	2	7	5	35 35
## 166	2	7	6	36 36
## 167	2	7	7	32 32
## 168	2	7	8	30 30
## 169	2	8	1	37 37
## 170	2	8	2	32 32
## 171	2	8	3	33 33
## 172	2	8	4	39 39
## 173	2	8	5	30 30
## 174	2	8	6	31 31
## 175	2	8	7	32 32
## 176	2	8	8	34 34
## 177	2	9	1	41 41
## 178	2	9	2	41 41
## 179	2	9	3	43 43
## 180	2	9	4	36 36
## 181	2	9	5	43 43
## 182	2	9	6	42 42
## 183	2	9	7	42 42
## 184	2	9	8	37 37
## 185	2	10	1	34 34
## 186	2	10	2	30 30
## 187	2	10	3	35 35
## 188	2	10	4	27 27
## 189	2	10	5	30 30
## 190	2	10	6	22 22
## 191	2	10	7	31 31
## 192	2	10	8	31 31
## 193	2	11	1	34 34
## 194	2	11	2	36 36
## 195	2	11	3	38 38
## 196	2	11	4	36 36
## 197	2	11	5	34 34

## 198	2	11	6	33 33
## 199	2	11	7	35 35
## 200	2	11	8	29 29
## 201	2	12	1	28 28
## 202	2	12	2	29 29
## 203	2	12	3	27 27
## 204	2	12	4	36 36
## 205	2	12	5	33 33
## 206	2	12	6	32 32
## 207	2	12	7	34 34
## 208	2	12	8	32 32
## 209	2	13	1	40 40
## 210	2	13	2	39 39
## 211	2	13	3	39 39
## 212	2	13	4	34 34
## 213	2	13	5	32 32
## 214	2	13	6	42 42
## 215	2	13	7	36 36
## 216	2	13	8	39 39
## 217	2	14	1	38 38
## 218	2	14	2	42 42
## 219	2	14	3	37 37
## 220	2	14	4	37 37
## 221	2	14	5	34 34
## 222	2	14	6	33 33
## 223	2	14	7	43 43
## 224	2	14	8	34 34
## 225	3	1	1	30 30
## 226	3	1	2	35 35
## 227	3	1	3	36 36
## 228	3	1	4	37 37
## 229	3	1	5	29 29
## 230	3	1	6	27 27
## 231	3	1	7	39 39
## 232	3	1	8	38 38
## 233	3	2	1	30 30
## 234	3	2	2	37 37
## 235	3	2	3	30 30
## 236	3	2	4	31 31
## 237	3	2	5	27 27
## 238	3	2	6	31 31
## 239	3	2	7	36 36
## 240	3	2	8	40 40
## 241	3	3	1	27 27
## 242	3	3	2	33 33
## 243	3	3	3	31 31
## 244	3	3	4	32 32
## 245	3	3	5	34 34
## 246	3	3	6	31 31
## 247	3	3	7	31 31
## 248	3	3	8	31 31
## 249	3	4	1	26 26
## 250	3	4	2	27 27
## 251	3	4	3	37 37

## 252	3	4	4	30	30
## 253	3	4	5	29	29
## 254	3	4	6	35	35
## 255	3	4	7	34	34
## 256	3	4	8	31	31
## 257	3	5	1	36	36
## 258	3	5	2	32	32
## 259	3	5	3	34	34
## 260	3	5	4	37	37
## 261	3	5	5	32	32
## 262	3	5	6	34	34
## 263	3	5	7	33	33
## 264	3	5	8	32	32
## 265	3	6	1	33	33
## 266	3	6	2	40	40
## 267	3	6	3	34	34
## 268	3	6	4	38	38
## 269	3	6	5	36	36
## 270	3	6	6	35	35
## 271	3	6	7	41	41
## 272	3	6	8	34	34
## 273	3	7	1	31	31
## 274	3	7	2	33	33
## 275	3	7	3	31	31
## 276	3	7	4	34	34
## 277	3	7	5	29	29
## 278	3	7	6	33	33
## 279	3	7	7	28	28
## 280	3	7	8	33	33
## 281	3	8	1	22	22
## 282	3	8	2	25	25
## 283	3	8	3	29	29
## 284	3	8	4	24	24
## 285	3	8	5	24	24
## 286	3	8	6	26	26
## 287	3	8	7	25	25
## 288	3	8	8	21	21
## 289	3	9	1	32	32
## 290	3	9	2	31	31
## 291	3	9	3	28	28
## 292	3	9	4	28	28
## 293	3	9	5	35	35
## 294	3	9	6	34	34
## 295	3	9	7	33	33
## 296	3	9	8	31	31
## 297	3	10	1	31	31
## 298	3	10	2	32	32
## 299	3	10	3	29	29
## 300	3	10	4	30	30
## 301	3	10	5	28	28
## 302	3	10	6	31	31
## 303	3	10	7	28	28
## 304	3	10	8	36	36
## 305	3	11	1	32	32

```
## 306      3      11      2    31 31
## 307      3      11      3    34 34
## 308      3      11      4    35 35
## 309      3      11      5    35 35
## 310      3      11      6    31 31
## 311      3      11      7    41 41
## 312      3      11      8    34 34
## 313      3      12      1    28 28
## 314      3      12      2    27 27
## 315      3      12      3    27 27
## 316      3      12      4    27 27
## 317      3      12      5    27 27
## 318      3      12      6    30 30
## 319      3      12      7    28 28
## 320      3      12      8    28 28
## 321      3      13      1    36 36
## 322      3      13      2    39 39
## 323      3      13      3    36 36
## 324      3      13      4    30 30
## 325      3      13      5    37 37
## 326      3      13      6    32 32
## 327      3      13      7    38 38
## 328      3      13      8    39 39
## 329      3      14      1    32 32
## 330      3      14      2    34 34
## 331      3      14      3    41 41
## 332      3      14      4    33 33
## 333      3      14      5    35 35
## 334      3      14      6    35 35
## 335      3      14      7    34 34
## 336      3      14      8    31 31
```

```
# Graphics using ggplot2
ggplot(nestdata,aes(site,y))+
  geom_jitter(size=2,position=position_jitter(width=0.1),color=nestdata$isoline)+
  stat_summary(fun.data="mean_cl_normal",geom="errorbar",width=0.2,size=1)
```



```
# Mixed model
lmerout <- lmer(y~site+(1|site:isoline),data=nestdata,na.action=na.omit)
summary(lmerout)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: y ~ site + (1 | site:isoline)
## Data: nestdata
##
## REML criterion at convergence: 1841.1
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.56441 -0.64603  0.02059  0.63656  2.73665
##
## Random effects:
## Groups      Name                Variance Std.Dev.
## site:isoline (Intercept) 10.17      3.188
## Residual              11.02      3.319
## Number of obs: 336, groups:  site:isoline, 42
##
## Fixed effects:
##              Estimate Std. Error    df t value Pr(>|t|)
## (Intercept)  34.4821    0.9081 39.0000  37.974  <2e-16 ***
## site2        -0.1875    1.2842 39.0000  -0.146   0.885
## site3        -2.3839    1.2842 39.0000  -1.856   0.071 .
```

```

## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##      (Intr) site2
## site2 -0.707
## site3 -0.707  0.500
anova(lmerout,type="II")

## Type II Analysis of Variance Table with Satterthwaite's method
##      Sum Sq Mean Sq NumDF DenDF F value Pr(>F)
## site 46.961  23.48      2    39   2.131 0.1323
# All pairwise comparisons - Tukey method
compout <- glht(lmerout,linfct=mcp(site="Tukey"))
summary(compout)

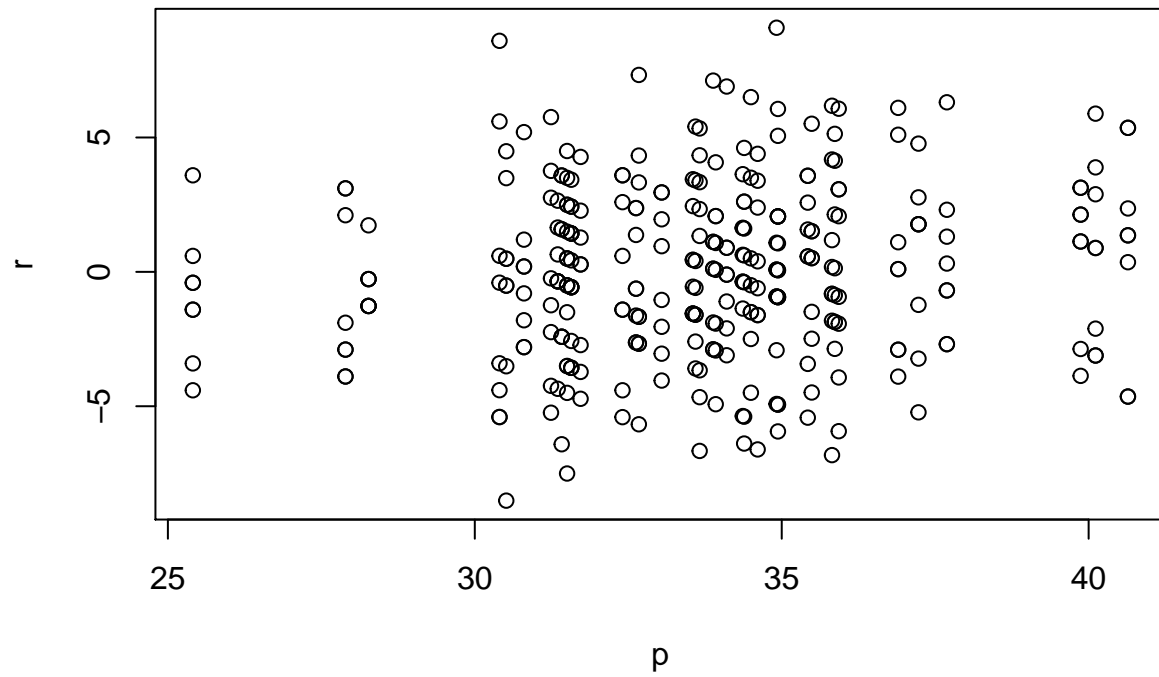
##
##      Simultaneous Tests for General Linear Hypotheses
##
## Multiple Comparisons of Means: Tukey Contrasts
##
##
## Fit: lmer(formula = y ~ site + (1 | site:isoline), data = nestdata,
##      na.action = na.omit)
##
## Linear Hypotheses:
##      Estimate Std. Error z value Pr(>|z|)
## 2 - 1 == 0   -0.1875     1.2842  -0.146   0.988
## 3 - 1 == 0   -2.3839     1.2842  -1.856   0.152
## 3 - 2 == 0   -2.1964     1.2842  -1.710   0.201
## (Adjusted p values reported -- single-step method)
confint(compout)

##
##      Simultaneous Confidence Intervals
##
## Multiple Comparisons of Means: Tukey Contrasts
##
##
## Fit: lmer(formula = y ~ site + (1 | site:isoline), data = nestdata,
##      na.action = na.omit)
##
## Quantile = 2.3439
## 95% family-wise confidence level
##
##
## Linear Hypotheses:
##      Estimate lwr      upr
## 2 - 1 == 0   -0.1875  -3.1975  2.8225
## 3 - 1 == 0   -2.3839  -5.3939  0.6261
## 3 - 2 == 0   -2.1964  -5.2064  0.8136
cld(compout)

```



```
##    1    2    3
## "a" "a" "a"
# Diagnostic plots to check ANOVA assumptions
p <- fitted(lmerout)
r <- resid(lmerout)
plot(p,r)
```



```
qqnorm(r)
```

Normal Q-Q Plot

