Aula Prática 02 - Estatística Experimental

DELINEAMENTO EM BLOCOS CASUALIZADOS

```
> rm(list = ls(all = TRUE))
> set.seed(311)
> Bloc <- c("I", "II", "III")
> Trat <- (seq(1, 9, 1))
> set.seed(13)
> Parcela <- sample(1:length(Trat))
> Bloc
```

```
[1] "I"   "II"  "III"
```

```
> Trat
```

```
[1] 1 2 3 4 5 6 7 8 9
```

```
> Parcela
```

```
[1] 7 2 3 1 5 6 8 9 4
```

```
> for (k in 2:length(Bloc)) Parcela <- c(Parcela, sample(1:length(Trat)))
> Parcela
```

```
 [1] 7 2 3 1 5 6 8 9 4 1 6 7 8 3 5 2 9 4 8 6 1 4 9 3 7 2 5
```

```
> layout <- cbind(expand.grid(Tratamento = Trat, Bloco = Bloc),
+     Parcela)
> layout
```

```
   Tratamento Bloco Parcela
1           1     I       7
2           2     I       2
3           3     I       3
4           4     I       1
5           5     I       5
6           6     I       6
7           7     I       8
8           8     I       9
9           9     I       4
10          1    II       1
11          2    II       6
12          3    II       7
13          4    II       8
14          5    II       3
15          6    II       5
16          7    II       2
17          8    II       9
18          9    II       4
```

```
19          1   III       8
20          2   III       6
21          3   III       1
22          4   III       4
23          5   III       9
24          6   III       3
25          7   III       7
26          8   III       2
27          9   III       5
```

```
> bloco <- c(1, 1, 1, 1, 1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 2, 2, 2,
+     2, 3, 3, 3, 3, 3, 3, 3, 3, 3)
> trat <- c(1, 2, 3, 4, 5, 6, 7, 8, 9, 1, 2, 3, 4, 5, 6, 7, 8,
+     9, 1, 2, 3, 4, 5, 6, 7, 8, 9)
> prod <- c(145, 200, 183, 190, 180, 130, 206, 250, 164, 155, 190,
+     186, 175, 160, 160, 165, 271, 190, 166, 190, 208, 186, 156,
+     130, 170, 230, 193)
> dados <- as.data.frame(cbind(bloco, trat, prod))
> dados
```

```
   bloco trat prod
1      1    1  145
2      1    2  200
3      1    3  183
4      1    4  190
5      1    5  180
6      1    6  130
7      1    7  206
8      1    8  250
9      1    9  164
10     2    1  155
11     2    2  190
12     2    3  186
13     2    4  175
14     2    5  160
15     2    6  160
16     2    7  165
17     2    8  271
18     2    9  190
19     3    1  166
20     3    2  190
21     3    3  208
22     3    4  186
23     3    5  156
24     3    6  130
25     3    7  170
26     3    8  230
27     3    9  193
```

```
> names(dados)
```

```
[1] "bloco" "trat"  "prod"
```

```
> is.factor(dados$bloco)
```

```
[1] FALSE

> dados$bloco <- as.factor(dados$bloco)
> is.factor(dados$trat)

[1] FALSE

> dados$trat <- as.factor(dados$trat)

> sb <- with(dados, tapply(prod, bloco, sum))
> sb

   1    2    3
1648 1652 1629

> st <- with(dados, tapply(prod, trat, sum))
> st

  1   2   3   4   5   6   7   8   9
466 580 577 551 496 420 541 751 547

> media.por.trat <- with(dados, tapply(prod, trat, mean))
> media.por.trat

       1        2        3        4        5        6        7        8
155.3333 193.3333 192.3333 183.6667 165.3333 140.0000 180.3333 250.3333
       9
182.3333

> variancia.por.trat <- with(dados, tapply(prod, trat, var))
> variancia.por.trat

        1         2         3         4         5         6         7         8
110.33333  33.33333 186.33333  60.33333 165.33333 300.00000 500.33333 420.33333
        9
254.33333

> mod1 <- with(dados, aov(prod ~ bloco + trat))
> names(mod1)

 [1] "coefficients"  "residuals"     "effects"       "rank"
 [5] "fitted.values" "assign"        "qr"            "df.residual"
 [9] "contrasts"     "xlevels"       "call"          "terms"
[13] "model"

> anova(mod1)
```

```
Analysis of Variance Table

Response: prod
          Df  Sum Sq Mean Sq F value    Pr(>F)
bloco      2    33.6   16.78  0.0666    0.9358
trat       8 22981.3 2872.67 11.4114 2.637e-05 ***
Residuals 16  4027.8  251.74
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

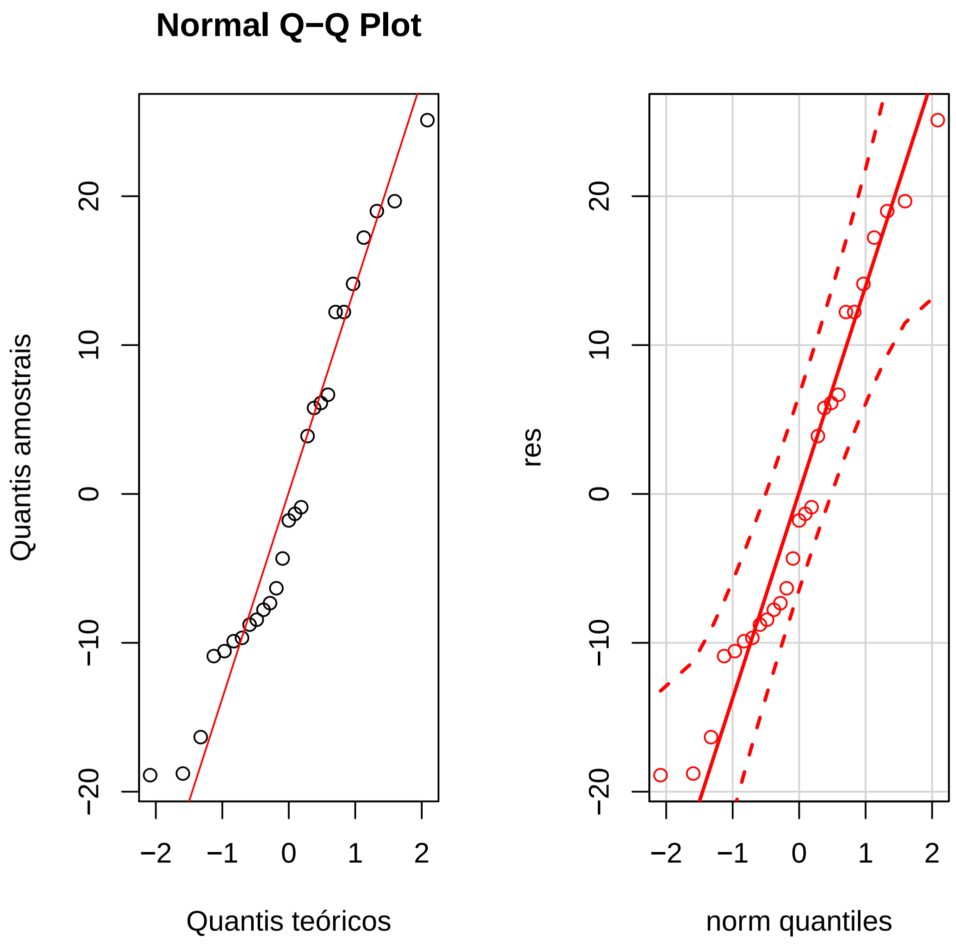
```
> res <- mod1$residuals
> var.por.trat <- with(dados, tapply(res, trat, var))
> F <- max(variancia.por.trat)/min(variancia.por.trat)
> F
```

```
[1] 15.01
```

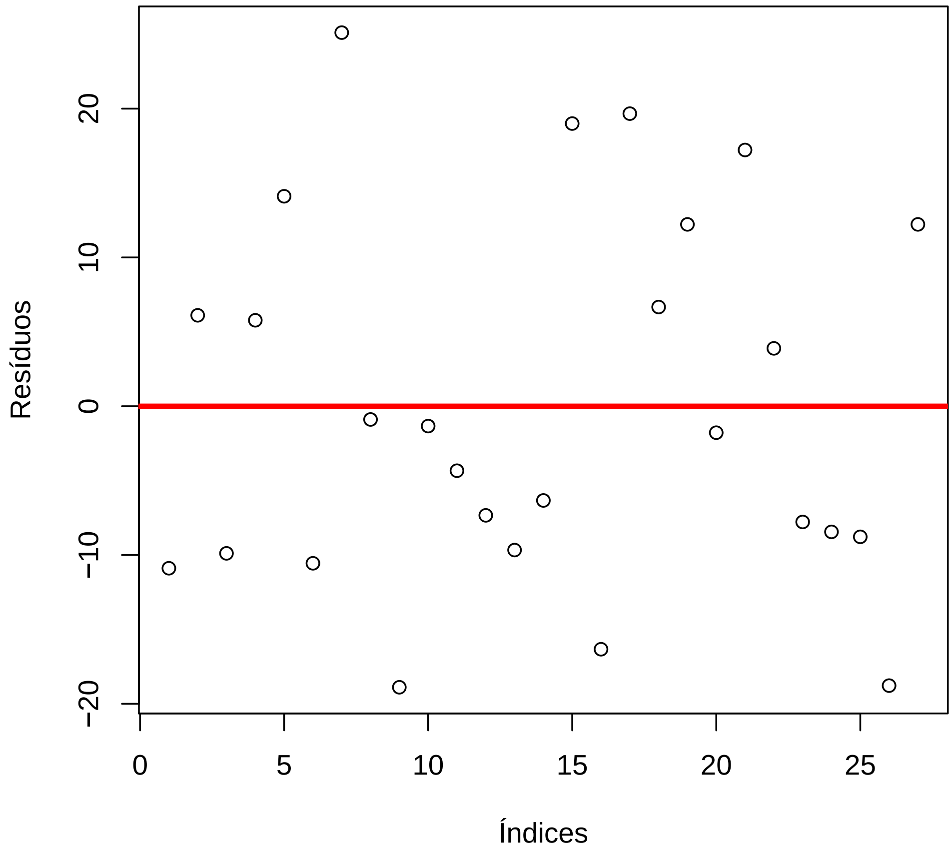
```
> with(dados, bartlett.test(prod ~ bloco + trat))
```

```
        Bartlett test of homogeneity of variances

data:  prod by bloco by trat
Bartlett's K-squared = 0.3244, df = 2, p-value = 0.8503
```

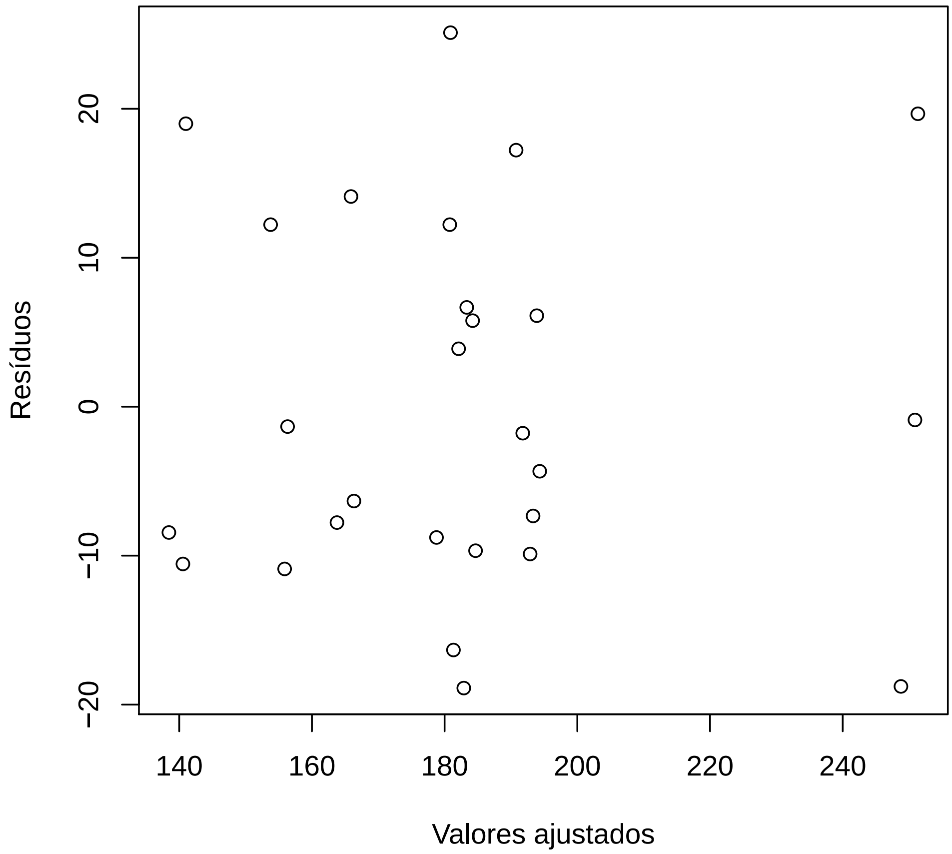
```
> require(car)
> par(mfrow = c(1, 2))
> qqnorm(res, xlab = "Quantis teóricos", ylab = "Quantis amostrais")
> qqline(res, col = "red")
> qqPlot(res)
```



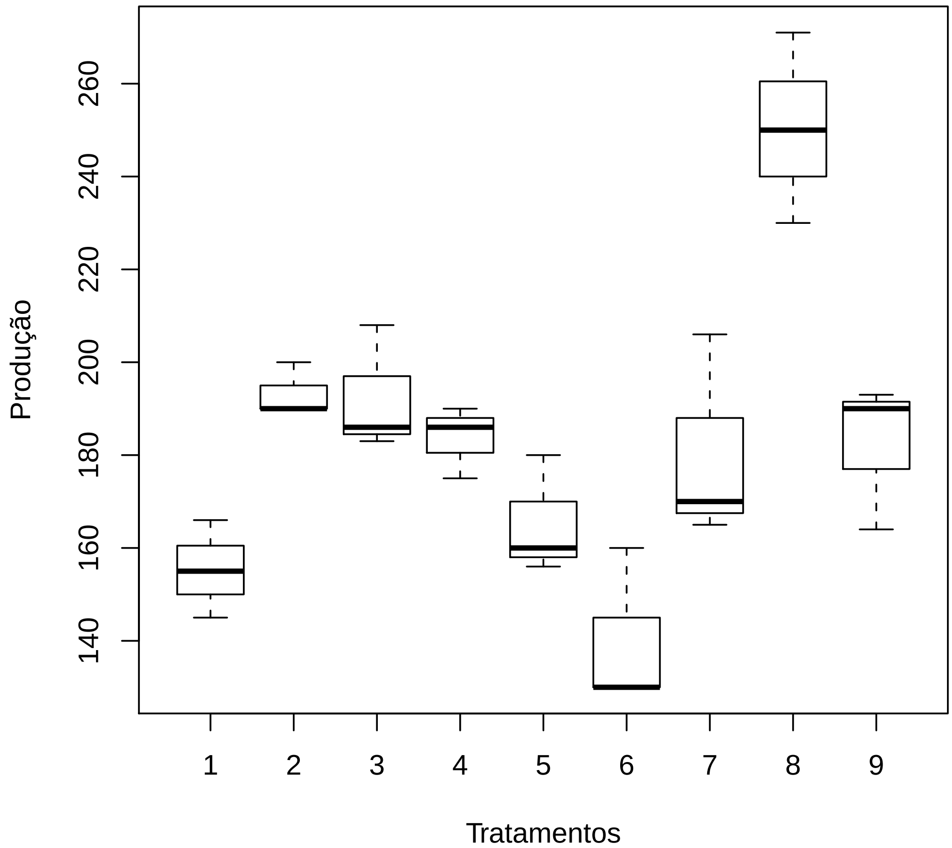

```
> shapiro.test(res)

        Shapiro-Wilk normality test

data:  res
W = 0.9476, p-value = 0.1873

> par(mfrow = c(1, 1))
> plot(mod1$res, xlab = "Índices", ylab = "Resíduos")
> abline(h = 0, col = "red", lwd = 3)
```




```
> plot(fitted(mod1), res, xlab = "Valores ajustados", ylab = "Resíduos")
```




```
> boxplot(prod ~ trat, xlab = "Tratamentos", ylab = "Produção",
+     data = dados)
```

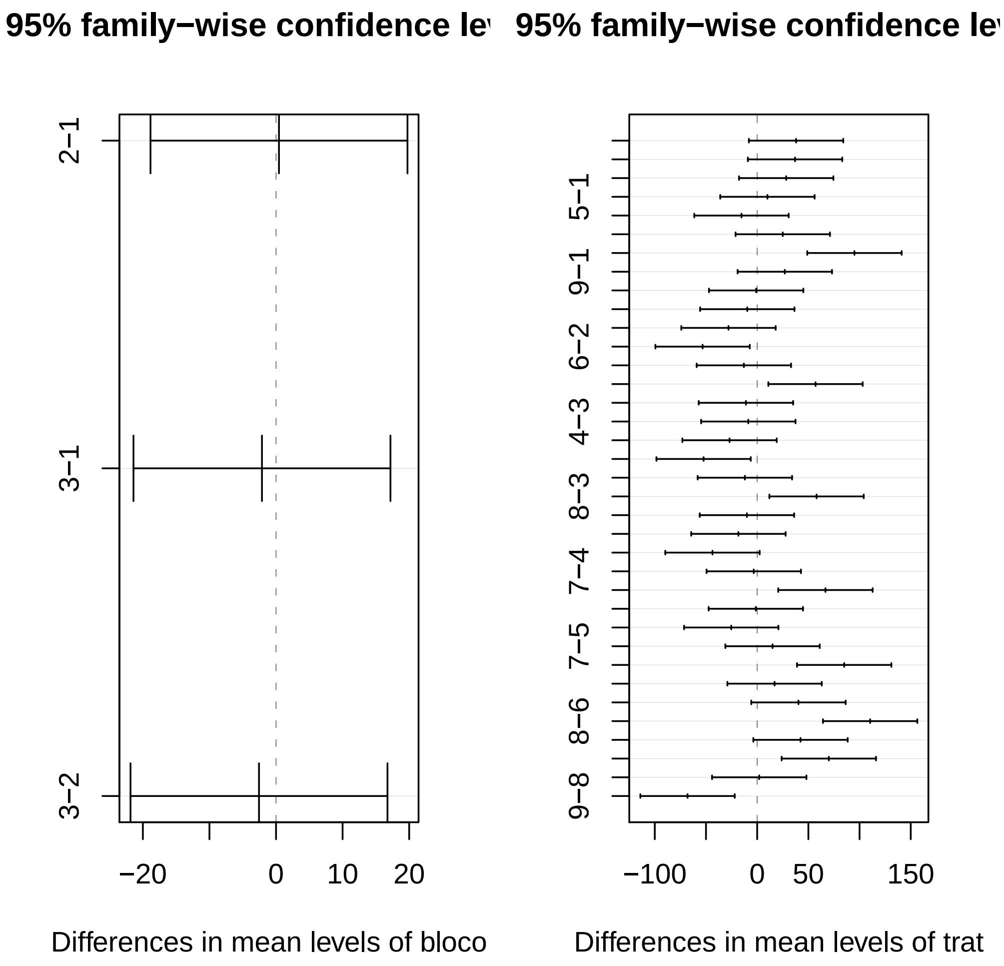



```
> mod1$coeff

(Intercept)      bloco2      bloco3       trat2       trat3       trat4
155.8888889   0.4444444  -2.1111111  38.0000000  37.0000000  28.3333333
      trat5       trat6       trat7       trat8       trat9
 10.0000000 -15.3333333  25.0000000  95.0000000  27.0000000

> bl <- c(0, mod1$coeff[2:3])
> tr <- c(0, mod1$coeff[4:11])
> bl

               bloco2     bloco3
 0.0000000  0.4444444 -2.1111111

> tr

              trat2     trat3     trat4     trat5     trat6     trat7     trat8
  0.00000  38.00000  37.00000  28.33333  10.00000 -15.33333  25.00000  95.00000
    trat9
 27.00000
```

```
> bltr <- rep(bl, 3) * rep(tr, rep(3, 9))
> ttna <- update(mod1, . ~ . + bltr)
> anova(ttna)

Analysis of Variance Table

Response: prod
          Df  Sum Sq Mean Sq F value    Pr(>F)
bloco      2    33.6   16.78  0.0654    0.9370
trat       8 22981.3 2872.67 11.1974 4.458e-05 ***
bltr       1   179.6  179.56  0.6999    0.4159
Residuals 15  3848.2  256.55
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

> q <- qtukey(0.95, 9, 16)
> delta <- q * sqrt(251.7/sqrt(3))
> tcm.tu <- TukeyHSD(mod1)
> tcm.tu

  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = prod ~ bloco + trat)

$bloco
          diff       lwr      upr     p adj
2-1  0.4444444 -18.85487 19.74376 0.9980554
3-1 -2.1111111 -21.41043 17.18820 0.9571497
3-2 -2.5555556 -21.85487 16.74376 0.9379209

$trat
          diff         lwr        upr     p adj
2-1  38.000000   -8.085796  84.085796 0.1520249
3-1  37.000000   -9.085796  83.085796 0.1728150
4-1  28.333333  -17.752463  74.419129 0.4559717
5-1  10.000000  -36.085796  56.085796 0.9962223
6-1 -15.333333  -61.419129  30.752463 0.9489958
7-1  25.000000  -21.085796  71.085796 0.6053536
8-1  95.000000   48.914204 141.085796 0.0000460
9-1  27.000000  -19.085796  73.085796 0.5143733
3-2  -1.000000  -47.085796  45.085796 1.0000000
4-2  -9.666667  -55.752463  36.419129 0.9969942
5-2 -28.000000  -74.085796  18.085796 0.4703201
6-2 -53.333333  -99.419129  -7.247537 0.0172692
7-2 -13.000000  -59.085796  33.085796 0.9799785
8-2  57.000000   10.914204 103.085796 0.0099947
9-2 -11.000000  -57.085796  35.085796 0.9929220
4-3  -8.666667  -54.752463  37.419129 0.9985839
5-3 -27.000000  -73.085796  19.085796 0.5143733
6-3 -52.333333  -98.419129  -6.247537 0.0200347
7-3 -12.000000  -58.085796  34.085796 0.9877062
8-3  58.000000   11.914204 104.085796 0.0086074
9-3 -10.000000  -56.085796  36.085796 0.9962223
```

```
5-4 -18.333333  -64.419129  27.752463 0.8763516
6-4 -43.666667  -89.752463   2.419129 0.0705323
7-4  -3.333333  -49.419129  42.752463 0.9999989
8-4  66.666667   20.580871 112.752463 0.0023716
9-4  -1.333333  -47.419129  44.752463 1.0000000
6-5 -25.333333  -71.419129  20.752463 0.5900630
7-5  15.000000  -31.085796  61.085796 0.9546944
8-5  85.000000   38.914204 131.085796 0.0001740
9-5  17.000000  -29.085796  63.085796 0.9134401
7-6  40.333333   -5.752463  86.419129 0.1116698
8-6 110.333333   64.247537 156.419129 0.0000069
9-6  42.333333   -3.752463  88.419129 0.0849582
8-7  70.000000   23.914204 116.085796 0.0014541
9-7   2.000000  -44.085796  48.085796 1.0000000
9-8 -68.000000 -114.085796 -21.914204 0.0019490
```

```
> par(mfrow = c(1, 2))
> plot(tcm.tu)
```




```
> require(laercio)
> LTukey(mod1, "trat", conf.level = 0.95)
```

```
 TUKEY TEST TO COMPARE MEANS

 Confidence level:  0.95
 Dependent variable:  prod
 Variation Coefficient:  8.69116 %

Independent variable:  trat
  Factors Means
  8       250.333333333333 a
  2       193.333333333333  b
  3       192.333333333333  b
  4       183.666666666667  bc
  9       182.333333333333  bc
  7       180.333333333333  bc
  5       165.333333333333  bc
  1       155.333333333333  bc
  6       140                c
```

```
> LTukey(mod1, "trat", conf.level = 0.99)
```

```
 TUKEY TEST TO COMPARE MEANS

 Confidence level:  0.99
 Dependent variable:  prod
 Variation Coefficient:  8.69116 %

Independent variable:  trat
  Factors Means
  8       250.333333333333 a
  2       193.333333333333  b
  3       192.333333333333  b
  4       183.666666666667  b
  9       182.333333333333  b
  7       180.333333333333  b
  5       165.333333333333  b
  1       155.333333333333  b
  6       140               b
```