```
# Enter data -- Note use of rep command!

> V <- c(26,38,50,76,108,157,17,26,37,53,83,124,13,20,27,37,57,87,NA,15,22,27,41,63)
> f <- rep(c(0,12,24,36,48,60),4)
> p <- rep(c(0,10,20,30),rep(6,4))
> visc <- data.frame(V, f=f, p = p)
> plot(visc)
```

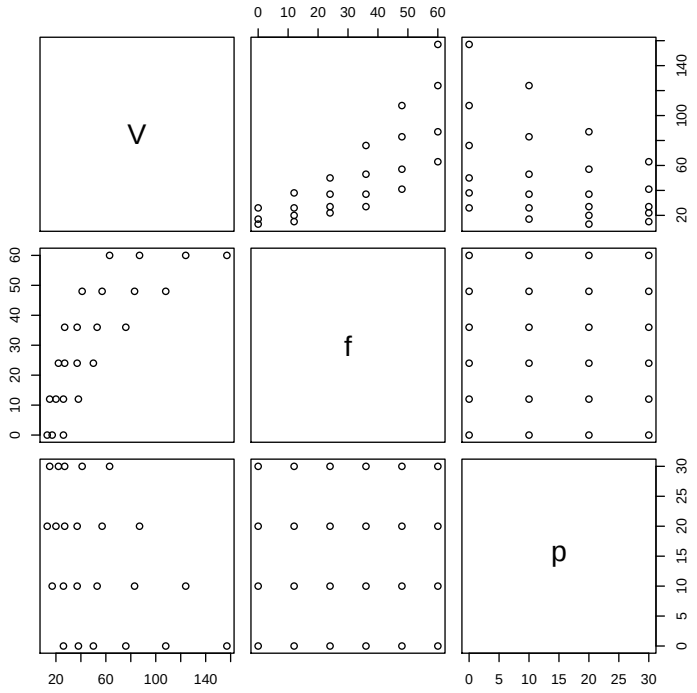

Figure 1: Scatter plot matrix of raw data

```
par(mfrow=c(2,2))
plot(lm(V ~ f + p), ask=F)


par(mfrow=c(2,2))
plot(lm(V ~ p + f + I(p*f) + I(p^2) + I(f^2)),ask=F)
```

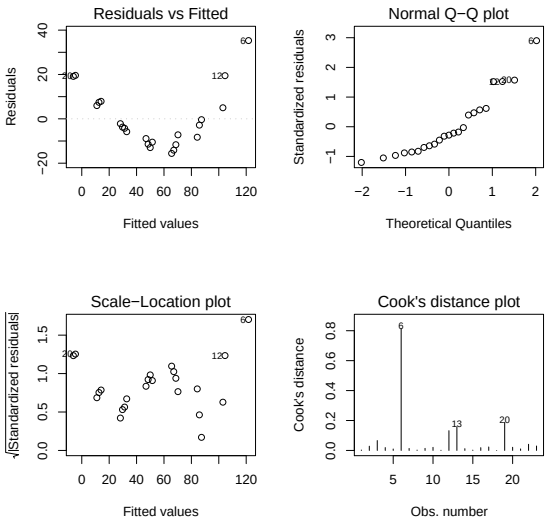

Figure 2: Scatter plots of diagnostics for model $V = \beta_0 + \beta_1 f + \beta_2 p + e$

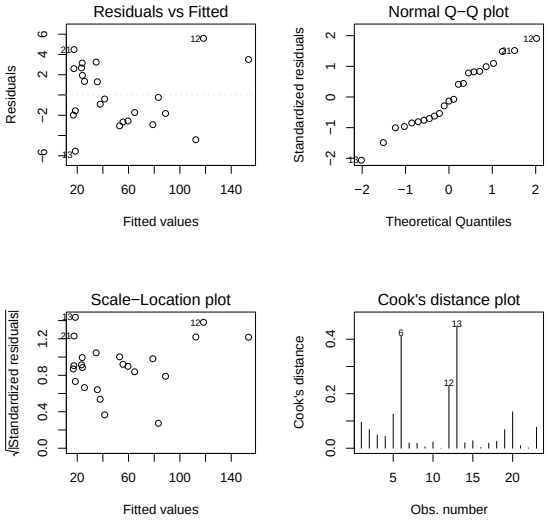

Figure 3: Scatter plots of diagnostics for model $V = \beta_0 + \beta_1 f + \beta_2 p + +\beta_{12} p * f + \beta_{11} f^2 + \beta_{22} p^2 + e$

```
library(MASS)  # load the MASS library from Venables and Ripley
pdf("boxcox.pdf")
boxcox(lm(V ~ f + p), plotit=T)
dev.off()
```

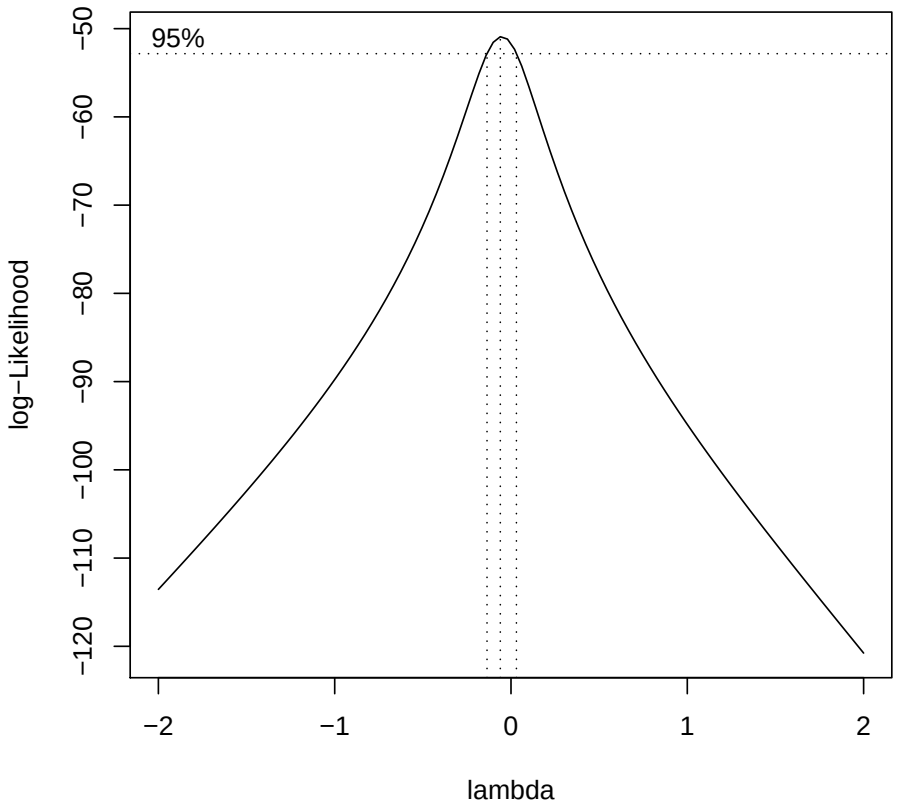

Figure 4: Plot of profile log-likelihood for Box-Cox transformation

```
# Suggests log transformation
> lmlog1 <- lm(log(V) ~ f + p)
> plot(lmlog1)  # check diagnostics once again
```

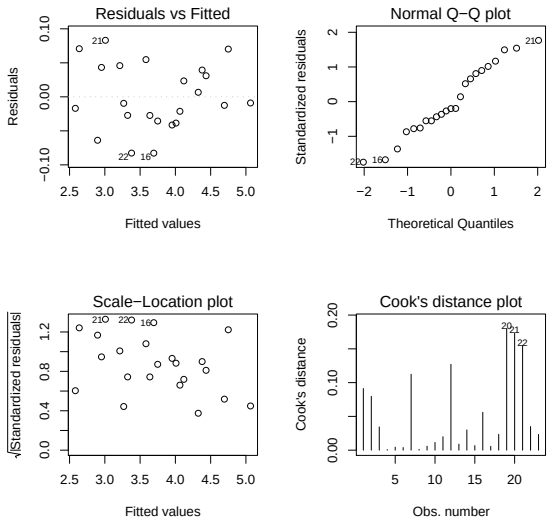

Figure 5: Scatter plots of diagnostics for model $\log(V) = \alpha_0 + \alpha_1 f + \alpha_2 p + e$

```
> summary(lmlog1)

Call:
lm(formula = log(V) ~ f + p)

Residuals:
      Min        1Q    Median        3Q       Max
-0.082763 -0.031436 -0.009541  0.041322  0.083153

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  3.2122065  0.0232951  137.89   <2e-16 ***
f            0.0308843  0.0005342   57.82   <2e-16 ***
p           -0.0315180  0.0009712  -32.45   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.05085 on 20 degrees of freedom
Multiple R-Squared: 0.9951,     Adjusted R-squared: 0.9946
F-statistic:  2041 on 2 and 20 DF,  p-value: < 2.2e-16
```

```
> lmlog2 <- lm(log(V) ~ f + p + I(f*p)  + I(f^2) + I(p^2), data=visc)
> summary(lmlog2)

Call:
lm(formula = log(V) ~ f + p + I(f * p) + I(f^2) + I(p^2), data = visc)

Residuals:
       Min         1Q     Median         3Q        Max
-0.0796815 -0.0338626 -0.0001883  0.0356121  0.0772335

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  3.231e+00  3.534e-02  91.441  < 2e-16 ***
f            2.861e-02  1.991e-03  14.370 6.10e-11 ***
p           -3.346e-02  3.529e-03  -9.479 3.37e-08 ***
I(f * p)    -3.718e-05  5.186e-05  -0.717    0.483
I(f^2)       4.416e-05  3.090e-05   1.429    0.171
I(p^2)       1.121e-04  1.079e-04   1.039    0.314
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.05085 on 17 degrees of freedom
Multiple R-Squared: 0.9959,     Adjusted R-squared: 0.9946
F-statistic: 816.8 on 5 and 17 DF,  p-value: < 2.2e-16

> anova(lmlog1,lmlog2)
Analysis of Variance Table

Model 1: log(V) ~ f + p
Model 2: log(V) ~ f + p + I(f * p) + I(f^2) + I(p^2)
  Res.Df      RSS Df Sum of Sq      F Pr(>F)
1     20 0.051708
2     17 0.043954  3  0.007754 0.9997 0.4169
> anova(lmlog2)
Analysis of Variance Table

Response: log(V)
          Df Sum Sq Mean Sq   F value Pr(>F)
f          1 7.8287  7.8287 3027.9066 <2e-16 ***
p          1 2.7230  2.7230 1053.1566 <2e-16 ***
I(f * p)   1 0.0004  0.0004    0.1389 0.7140
I(f^2)     1 0.0046  0.0046    1.7812 0.1996
I(p^2)     1 0.0028  0.0028    1.0789 0.3135
Residuals 17 0.0440  0.0026
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```