Analysis of a single dose-response curve
Continuous data

Christian Ritz

Nov 3 2019

Example 1

Dose-response data were obtained from an experiment assessing the inhibitory effect of secalonic acid on plant. The response values (in the variable named `rootl`) are root lengths in cm, and the dose values (`dose`) are in mM.

```
library(drc)

library(devtools)
install_github("DoseResponse/drcData")
library(drcData)

secalonic
```

```
##    dose rootl
## 1 0.000   5.5
## 2 0.010   5.7
## 3 0.019   5.4
## 4 0.038   4.6
## 5 0.075   3.3
## 6 0.150   0.7
## 7 0.300   0.4
```

Fitting the model

We can use the model fitting function `drm()`, which is the pivotal function in the package *drc* for fitting dose-response models: the response (`rootl`) on the left hand side of the tilde ($\sim$) and the dose variable (`dose`) to the right of the tilde:

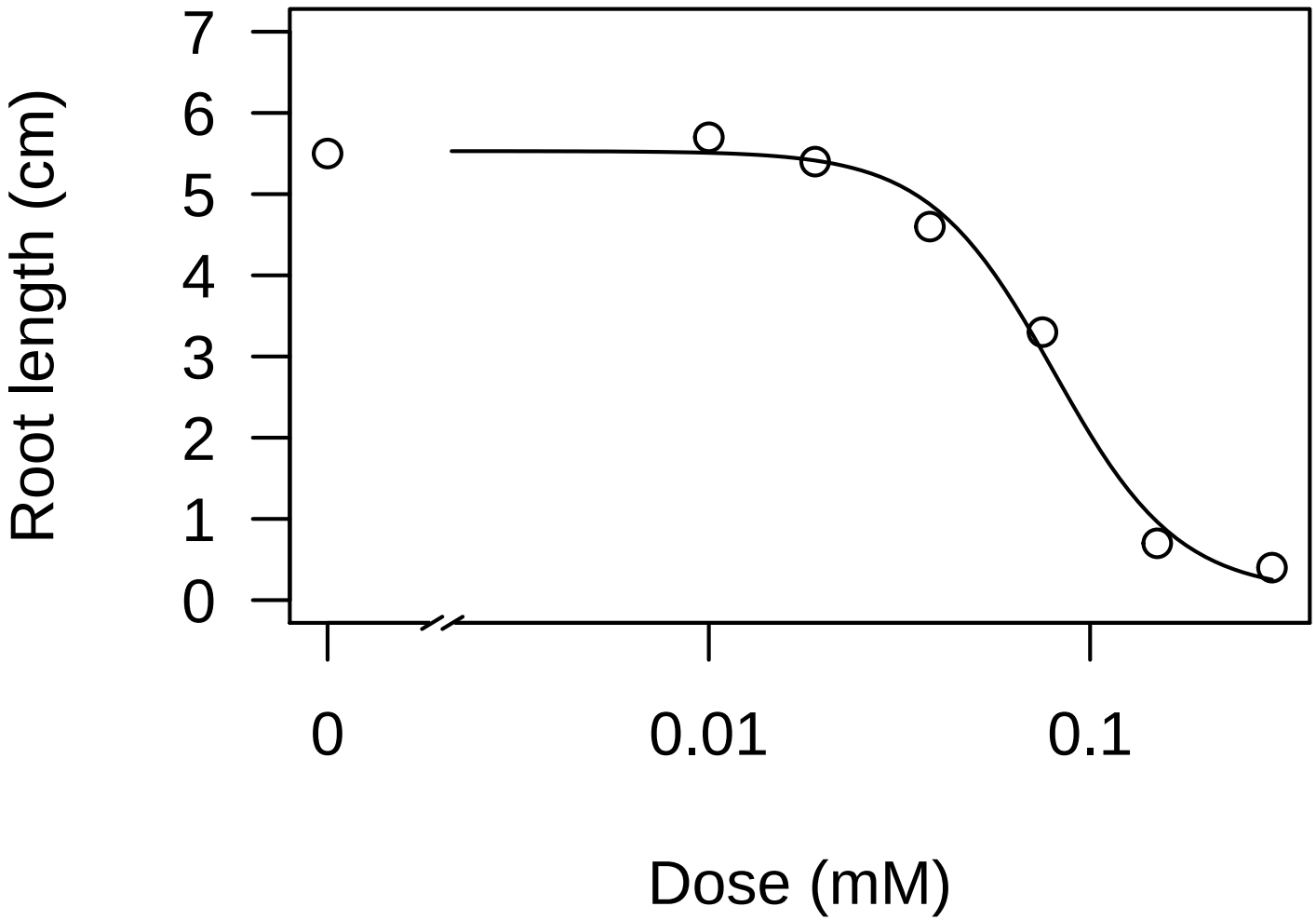
```
secalonic.LL.4 <- drm(rootl ~ dose,
                      data = secalonic,
                      fct = LL.4())
```

Fitted dose-response curves (1)

A plot of the observed response (`rootl` versus `dose`) and the corresponding fitted dose-response curve is obtained using the `plot` method:

```
plot(secalonic.LL.4,
     bp = 1e-3, broken = TRUE,
     ylim = c(0, 7),
     xlab = "Dose (mM)",
     ylab = "Root length (cm)")
```

Fitted dose-response curves (2)



Summary of the model fit

A summary of the fit is obtained using the `summary` method when applied to the model fit `secalonic.LL.4`:

```
summary(secalonic.LL.4)
```

```
##
## Model fitted: Log-logistic (ED50 as parameter) (4 parms)
##
## Parameter estimates:
##
##                 Estimate Std. Error t-value   p-value
## b:(Intercept) 2.6542086  0.6962333  3.8122 0.0317398 *
## c:(Intercept) 0.0917852  0.3747246  0.2449 0.8223012
## d:(Intercept) 5.5297495  0.2010300 27.5071 0.0001055 ***
## e:(Intercept) 0.0803547  0.0078829 10.1935 0.0020121 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error:
##
##  0.2957497 (3 degrees of freedom)
```

Estimating ED values

It is possible to estimate any ED value and also the corresponding standard error from the model fit without having to re-parametrise and re-fit the model each time a new ED value has to be estimated

For instance, ED10 and ED20 based on the above model fit are easily obtained using the following line:

```
ED(secalonic.LL.4, c(10, 20))
```

```
##
## Estimated effective doses
##
##          Estimate Std. Error
## e:1:10 0.0351149  0.0078689
## e:1:20 0.0476628  0.0074229
```

Example 2

The effect of the natural compound ferulic acid as a potential herbicide on growth of perennial ryegrass was investigated in a dose-response experiment

The dose-response data is found in the dataset `ryegrass` where the variable `conc` is the concentration of ferulic acid (mM) and `rootl` is the resulting root length (cm)

7 concentrations, 6 replicates for concentration 0 and 3 replicates for all non-zero concentrations

```
summary(ryegrass)
```

```
##      rootl             conc
##  Min.   :0.2200   Min.   : 0.000
##  1st Qu.:0.8491   1st Qu.: 0.705
##  Median :5.0778   Median : 2.815
##  Mean   :4.3272   Mean   : 7.384
##  3rd Qu.:7.4262   3rd Qu.: 9.375
##  Max.   :8.3556   Max.   :30.000
```

Fitting the model

Fitting a four-parameter log-logistic model to data:

```
ryegrass.LL.4 <- drm(rootl ~ conc,
                     data = ryegrass,
                     fct = LL.4())
```

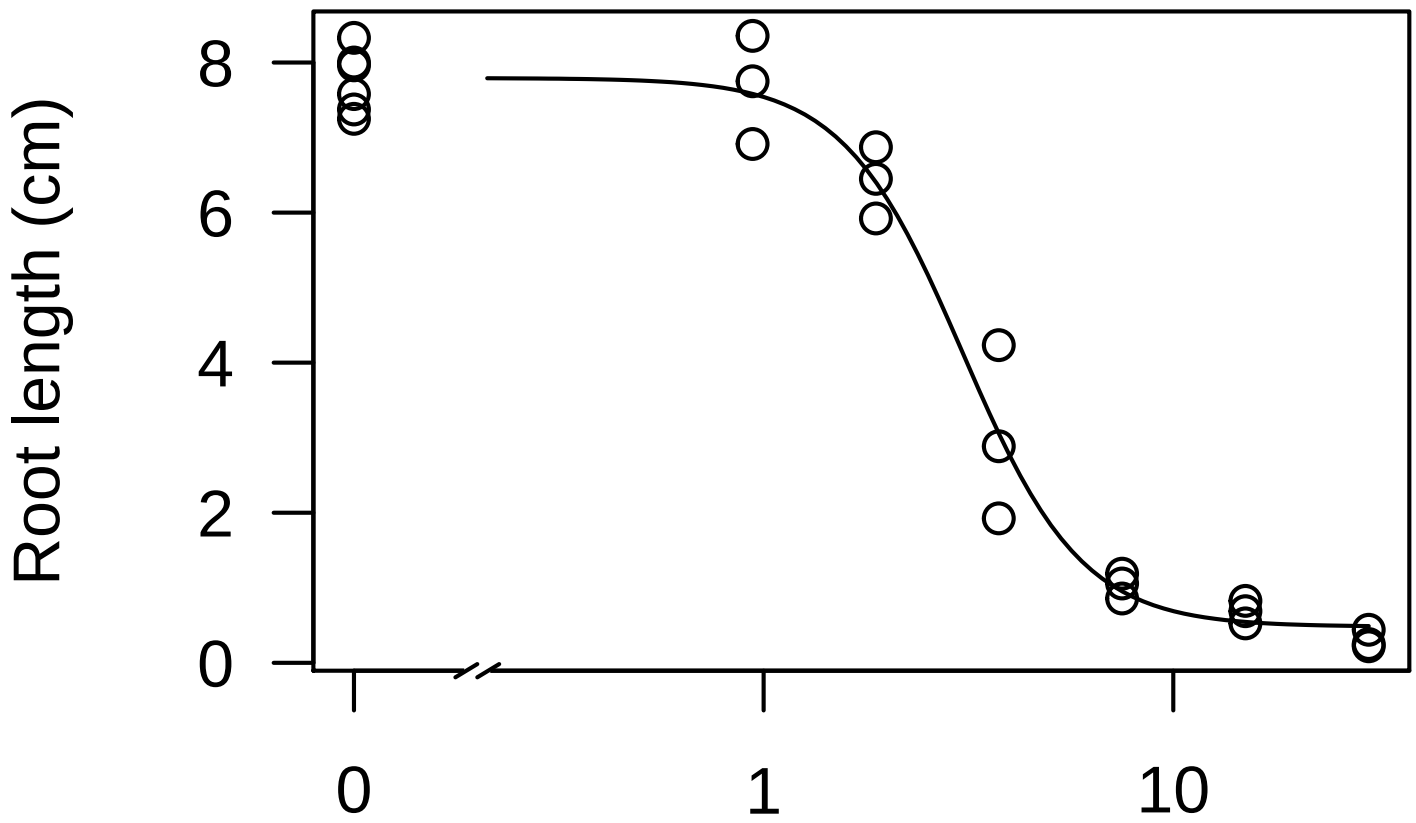
Fitted dose-response curve (1)

Showing the fitted dose-response curve together with the data:

```
plot(ryegrass.LL.4,
     broken = TRUE,
     type = "all",
     xlab = "Concentration (mM)",
     ylab = "Root length (cm)")
```

Fitted dose-response curve (2)

Showing the fitted dose-response curve together with the data:



Obtaining estimates with naive standard errors

The usual output:

```
coef(summary(ryegrass.LL.4))
```

```
##                  Estimate Std. Error   t-value      p-value
## b:(Intercept) 2.9822191  0.4650623  6.412515 2.960347e-06
## c:(Intercept) 0.4814132  0.2121924  2.268758 3.450565e-02
## d:(Intercept) 7.7929583  0.1885672 41.327218 3.821922e-21
## e:(Intercept) 3.0579550  0.1857313 16.464401 4.267922e-13
```

Obtaining estimates with robust standard errors

Standard errors that are robust against model misspecification are also available:

```
library(lmtest)
library(sandwich)

coeftest(ryegrass.LL.4, vcov = sandwich)
```

```
##
## t test of coefficients:
##
##                Estimate Std. Error t value  Pr(>|t|)
## b:(Intercept)  2.98222    0.47438  6.2865 3.882e-06 ***
## c:(Intercept)  0.48141    0.12779  3.7672  0.001212 **
## d:(Intercept)  7.79296    0.15311 50.8976 < 2.2e-16 ***
## e:(Intercept)  3.05795    0.26741 11.4355 3.170e-10 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Estimated standard errors change somewhat as compared to the model-based ones (some decrease and some increase!)