

Stat 175 problem for CWE August 2004

1. (Tobacco budworm) The data below is about the insecticide doses and the mortality rate of the tobacco budworm “*Heliothis virescens*”, from Collet, D. (1991), *Modelling Binary Data*. Twenty male and twenty female moths were exposed at each of six doses of the insecticide, pyrethroid, and the number that were killed recorded as follows.

	sex	dose	ndead	ntotal
1	male	1	1	20
2	male	2	4	20
3	male	4	9	20
4	male	8	13	20
5	male	16	18	20
6	male	32	20	20
7	female	1	0	20
8	female	2	2	20
9	female	4	6	20
10	female	8	10	20
11	female	16	12	20
12	female	32	16	20

The variables recorded are:

`sex` The gender of the budworms.
`dose` The dose of pyrethroid trans-cypermethrin (in micrograms)
`ndead` The number of budworms killed at each dose.
`ntotal` The number of budworms studied at each dose.

A generalized linear model is used to determine the relationship between the dosage and the mortality rate. This model is fitted with the following commands in S-PLUS.

```
> budworm <- read.table("/data/budworm.txt", header=T)
> attach(budworm)
> y <- cbind(ndead, ntotal-ndead)
> logdose <- log(dose)
> sex <- factor(sex)
> options(contrasts=c("contr.treatment","contr.treatment"))
> g1 <- glm(y~sex+logdose, family=binomial)
```

The output is as follows.

```
> summary(g1)
Coefficients:
                Value Std. Error  t value
(Intercept) -3.473154  0.4682939 -7.416612
          sex  1.100743  0.3557226  3.094385
        logdose  1.535336  0.1890119  8.122959
(Dispersion Parameter for Binomial family taken to be 1 )
Null Deviance: 124.8756 on 11 degrees of freedom
Residual Deviance: 6.757064 on 9 degrees of freedom
Number of Fisher Scoring Iterations: 3
Correlation of Coefficients:
      (Intercept)          sex
sex -0.5922409
logdose -0.8549127  0.2783326
```

- (a) Write down the model and explain what is the interpretation of the coefficients of the logdose and the intercept.
- (b) Construct an approximate 95% confidence interval for the odds ratio of dying as a female moth relative to a male moth.
- (c) Predict the log-odds of a female moth to die at dose 20, and give its standard error. Use these results to construct an approximate 95% prediction interval for the probability of a female moth to die at dose 20.
- (d) To compare the toxic potency or intensity of different chemicals, researchers must measure how much of a chemical is required to cause death. LD50 is the amount of a material, given all at once, which causes the death of 50% (one half) of a group of test animals. The LD50 is one way to measure the short-term poisoning potential (acute toxicity) of a material.
Assuming that the model we fitted above is correct, use the fitted model to estimate the LD50 of pyrethroid trans-cypermethrin for female moth.
- (e) Use Fieller's method to determine an approximate 95% confidence interval for the LD50.
- (f) It is suspected that linear relationships between the logit of the mortality rate and log dosage may have different slopes for male and female moths. The following model was fitted, with residual deviance 4.99.

```
> g2 <- glm(y~sex*logdose, family=binomial)
```

Perform a test to check if there is significant evidence against the hypothesis that the slopes are the same.

2. (Circular saw) An engineer wants to investigate the forces developed by a circular saw used in cutting wood. He thinks that the type of wood feed into the saw and the saw speed are the major factors determining the force generated, so he conducts the following experiment. Three pieces of wood are randomly chosen, each applied to two representative saw speeds, giving the data below.

	Wood type		
Saw speed	I	II	III
Low	2.77	2.49	2.60
High	2.86	2.84	2.84

- Write down an appropriate model to analysis this data, and explain each term in the model.
- Give the ANOVA table, including the degree of freedom, sum of squares, and mean sum of squares, and ANOVA estimates of the variance components.
- Assuming that the error has normal distribution, perform a test to check if wood type is a significant factor in determining the force generated by the saw.