NTNU – Trondheim
Norwegian University of
Science and Technology

Department of Biology

Examination paper for BI 3051 Evolutionary Analyses

Academic contact during examination: C. Pelabon

Phone: 90824159

Examination date: 3/06

Examination time (from-to): 09:00 / 13:00

Permitted examination support material: authorized calculator

Other information:

Language: English

Number of pages (front page excluded): 3

Number of pages enclosed: 0

Informasjon om trykking av eksamensoppgave

Originalen er:

1-sidig X 2-sidig □

sort/hvit X farger □

Checked by:

Date Signature

(20%) Question 1 – Mixed effect models

Mixed-effect models include both fixed and random factors.

A) Explain the differences between these two types of factors by providing a concrete example of a study where these are present.
B) Explain what is pseudoreplication, and why mixed-effect models can take care of this problem.
C) Explain the statistical differences between the parameters obtained for the fixed and random factors.

(20%) Question 2 – GLM

A) What are generalized linear models (GLM)?
B) Give some examples of different types of GLM and explain what type of data can be fitted with these models (provide concrete examples).
C) Provide the link function for these different models and explain the importance of this link function.

(20%) Question 3 – We study the effect of seed mass on germination time under different drought levels (from really dry level 1 to wet level 5). The output of the model is presented below. Explain this output and make a graphical representation of the results. Give a rapid interpretation of the results in biological terms.

```
> model1<-lm(Timegerm~log(Seedmass)*factor(Drought))
> anova(model1)
Analysis of Variance Table

Response: Timegerm
                              Df      Sum Sq  Mean    Sq F value    Pr(>F)
log(Seedmass)                 1       343.44  343.44 26.9823         4.144e-06
factor(Drought)               4       195.31  48.83  3.8361          0.008753
log(Seedmass):factor(Drought) 4       59.96   14.99  1.1776          0.332535
Residuals                     48      610.96  12.73

> model2<-lm(Timegerm~log(Seedmass)+factor(Drought))
> anova(model2)
Analysis of Variance Table

Response: Timegerm
                Df     Sum     Sq Mean          Sq F value     Pr(>F)
log(Seedmass)   1      343.44  343.44           26.6186         3.935e-06
factor(Drought) 4      195.31  48.83            3.7844          0.008942
Residuals       52     670.92  12.90


> summary(model2)
Call:
lm(formula = Timegerm ~ log(Seedmass) + factor(Drought))
Residuals:
    Min      1Q  Median      3Q     Max
-6.9453 -2.3021 -0.1252  2.2788  7.8689
Coefficients:
                  Estimate    Std. Error      t value         Pr(>|t|)
(Intercept)       13.3031     0.9951          13.369          < 2e-16 ***
log(Seedmass)     -0.7503     0.1569          -4.783          1.47e-05 ***
factor(Drought)2  -0.4507     1.3552          -0.333          0.74078
factor(Drought)3  -3.3990     1.4904          -2.281          0.02670 *
factor(Drought)4  -2.0439     1.6634          -1.229          0.22470
factor(Drought)5  -4.6637     1.4131          -3.300          0.00175 **

Residual standard error: 3.592 on 52 degrees of freedom
Multiple R-squared: 0.4454,    Adjusted R-squared: 0.392
F-statistic: 8.351 on 5 and 52 DF,  p-value: 7.52e-06
```

(15%) Question 4 – Statistical power

A) What is the power of a statistical test?

B) When you are conducting an experiment, for example to test the effect of a chemical on the metabolic rate of birds, how can you increase the power of your statistical test?

C) Is it always desirable?

(25%) Question 5 – In a recent paper published in *Journal of Evolutionary Biology*, Pilakouta et al. (2016) present an experiment aiming at testing whether larval density increases the expression of inbreeding depression. They perform their experiment on the burying beetle *Nicrophorus vespilloides*, a species where parents feed their larvae from carcasses of small mammals. In this species, larvae are begging for food and the number of larvae in the brood increases the competition for parental care.

The authors used virgin beetles from an outbred laboratory population. To test for a causal effect of sibling competition on the severity of inbreeding depression, they used a 2 x 3 factorial design with offspring inbreeding status (outbred or inbred) and brood size (5, 20 or 40 larvae) as the two factors. Inbred larvae were produced by pairing males and females that were full siblings (n = 186 pairs), whereas outbred larvae were produced by pairing unrelated males and females that shared no common ancestors for at least two generations (n = 187 pairs). These breeding pairs (n = 373) were transferred to transparent plastic containers (17 x 12 x 6 cm) where they can lay eggs on a mouse carcass of a standardized size (22–25 g). In each container the female was left to provide care for the eggs because sibling competition only starts when larvae compete by begging for food after hatching. When the eggs started hatching, the authors used the newly hatched larvae to generate inbred and outbred broods comprising of 5, 20 or 40 larvae. All experimental broods included larvae of mixed maternity. This brood size manipulation is within the natural variation of brood size in *N. vespilloides* (mean ±SD: 21 ±10 larvae, range: 2–47 larvae) and corresponds to small, average and large broods (i.e. low, medium and high level of sibling competition), respectively. Each experimental brood (outbred or inbred) was randomly assigned to an unrelated female who had been mated either to her full-sib brother or to an unrelated male (in this species, parents cannot distinguish between unrelated foster broods and their own broods, as long as the larvae are at the same developmental stage). To account for potential effects of relatedness between the female and her male partner on the maternal care, this factor was included in all of models. Females were left to care for their brood until the larvae dispersed from the carcass about 5 days later. When the larvae dispersed, the authors recorded the number of larvae still alive and the mass of each larva. The total sample size in the experiment was n = 166 broods. The sample sizes for the different treatments were as follows: n = 31 for outbred broods with 5 larvae, n = 32 for outbred broods with 20 larvae, n = 22 for outbred broods with 40 larvae, n = 31 for inbred broods with 5 larvae, n = 30 for inbred broods with 20 larvae and n = 20 for inbred brood with 40 larvae.

A) What are the predictor and response variables in this study?

B) What is the unit of each response variable and on which scale it is?

C) Is the number of observational units different from the number of statistical units for each response variable?

D) What is the advantage of using 3 levels of competition (low, intermediate and high)?

E) How would you analyze these data? Explain the type of model used and the structure of the model (predictor and response variable(s)).

Results of the analyses performed by the authors are summarized below.

F) What can you conclude from these?

Table 1 - Effects of offspring inbreeding status (inbred or outbred) and sibling competition (small, medium-sized or large brood) on offspring fitness traits: average larval mass at dispersal (mg) and survival to dispersal.

	Larval mass (mg)		Survival to dispersal	
	F-value	*P*-value	LR χ^2	*P*-value
Inbreeding status	2.27	0.13	4.54	**0.03**
Brood size	4.93	**< 0.01**	6.72	**0.03**
Interaction	0.09	0.91	0.31	0.86