# Statistical Modelling: Understanding Mean Structure

Chapter 3

Timothée Bonnet and Terry Neeman

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# Key components of a statistical model of an experiment

- Outcome measure
  - Response variable
  - Measure of interest
- Experimental factors
  - Conditions that can be manipulated
  - Conditions of interest (e.g. genotype, gender)
  - Main questions: do the conditions impact upon the outcome measure?
- Blocking factors
  - Conditions (not of interest) that may impact upon the outcome measure
  - Sources of variation in the experiment that need to be controlled for
  - Clustering of experimental units

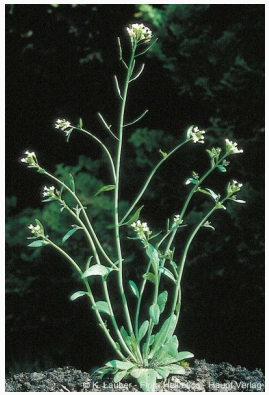
ALWAYS BEGIN WITH A RESEARCH QUESTION

# Simple linear models

$$\textit{response} = \underbrace{A + D \times \textit{predictor}}_{\substack{\text{Mean Structure} \\ \text{Experimental factors}}} + \underbrace{\epsilon, \text{ with } \epsilon \sim N(0, \sigma)}_{\substack{\text{Variance Structure} \\ \text{Unrelated to experiment factors} \\ \text{Unexplained ``noise''}}}$$

# Example 1: Can drought tolerance in Arabidopsis be improved through genetic modification?

## Context



Outcome measure: Leaf water retention LWR (%)
Experimental factors:

- Gene A, genotypes (`AA/aa`)
- Gene B, genotypes (`BB/bb`)

How many parameters to describe the different genotypes combinations?

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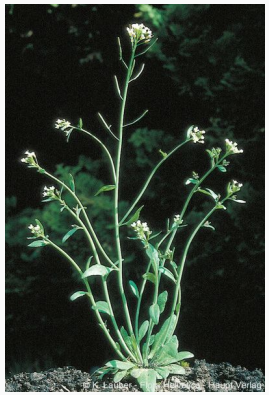

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How many parameters to describe the different genotypes combinations?

| 4 treatments | | Gene A | |
|---|---|---|---|
| | | AA | aa |
| Gene B | BB | $C$ | $C + A$ |
| | bb | $C + B$ | $C + A + B + D$ |

# Two different models

**Additive model - 3 parameters**

| 4 treatments | | Gene A | |
|---|---|---|---|
| | | AA | aa |
| Gene B | BB | $C$ | $C + A$ |
| | bb | $C + B$ | $C + A + B$ |

**Full factorial model / Interactive model - 4 parameters**

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**What is different? What does the additive model assume?**

# Which model to use?

**Additive model - 3 parameters**

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# Analysis in R

1. Import data "Prac3mockLWR.csv"
2. Visualize data
3. Model data
4. Assess model assumptions

# Analysis in R

1. Import data "Prac3mockLWR.csv"

```
LWR <- read.csv("Prac3mockLWR.csv")
```

# Analysis in R

2. Visualise the data

```
ggplot(LWR, aes(GeneB,LWR,colour=GeneA)) +
  geom_boxplot() + geom_point()
```

Full factorial or additive?

# Analysis in R

3. Model data

```
lmadditive <- lm(LWR ~ GeneA + GeneB, data = LWR)
summary(lmadditive)
anova(lmadditive)
```

```
lminteraction <- lm(LWR ~ GeneA * GeneB, data = LWR)
summary(lminteraction)
anova(lminteraction)
emmeans(lminteraction, pairwise ~ GeneA|GeneB)
emmeans(lminteraction, pairwise ~ GeneB|GeneA)
```

What are the estimates for $A, B, C, D$ under each models?

# Analysis in R

4. Model assumptions

```
plot(lminteraction)
```

# Which cabbage cultivar has the higher Vitamin C content on average?

## Research context

- 60 cabbage heads
- 2 cultivars: c39 and c52
- 3 planting dates: Days 16, 20, 21

How many parameters to describe our scientific question?

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| | | Cultivar | |
|---|---|---|---|
| | | c39 | c52 |
| Planting date | Day 16 | $A$ | $A + B$ |
| | Day 20 | $A + C$ | $A + B + C$ |
| | Day 21 | $A + D$ | $A + B + D$ |
| Marginal means | | | |

# Which cabbage cultivar has the higher Vitamin C content on average?

**Fit additive and interactive models in R**

Dataset "Prac3cabbagedata.csv"

# Are temperature mechanisms modified in a genetically modified tomato plant?

## Research context

- 2 tomato plants
- 2 Genotypes: WT/mutant
- Watering condition: Normal/Drought
- Leaf temperature measured

How many parameters to describe our scientific question?

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| | | Water condition | | |
|---|---|---|---|---|
| | | Normal | Drought | Marginal means |
| Genotype | WT | | | |
| | mutant | | | |
| Marginal means | | | | |

# Are temperature mechanisms modified in a genetically modified tomato plant?

Dataset "Prac3droughtdata.csv"

Fit the appropriate model in R.

Compare genotypes and water conditions with emmeans

# Relationship diameter/density differ between tree species?

## Research context

- *Nothofagus* in the Andes
- 41 plots with 3 species (StandTypes)
- Outcome: Plot density
- Factors: StandType, QuadDiam

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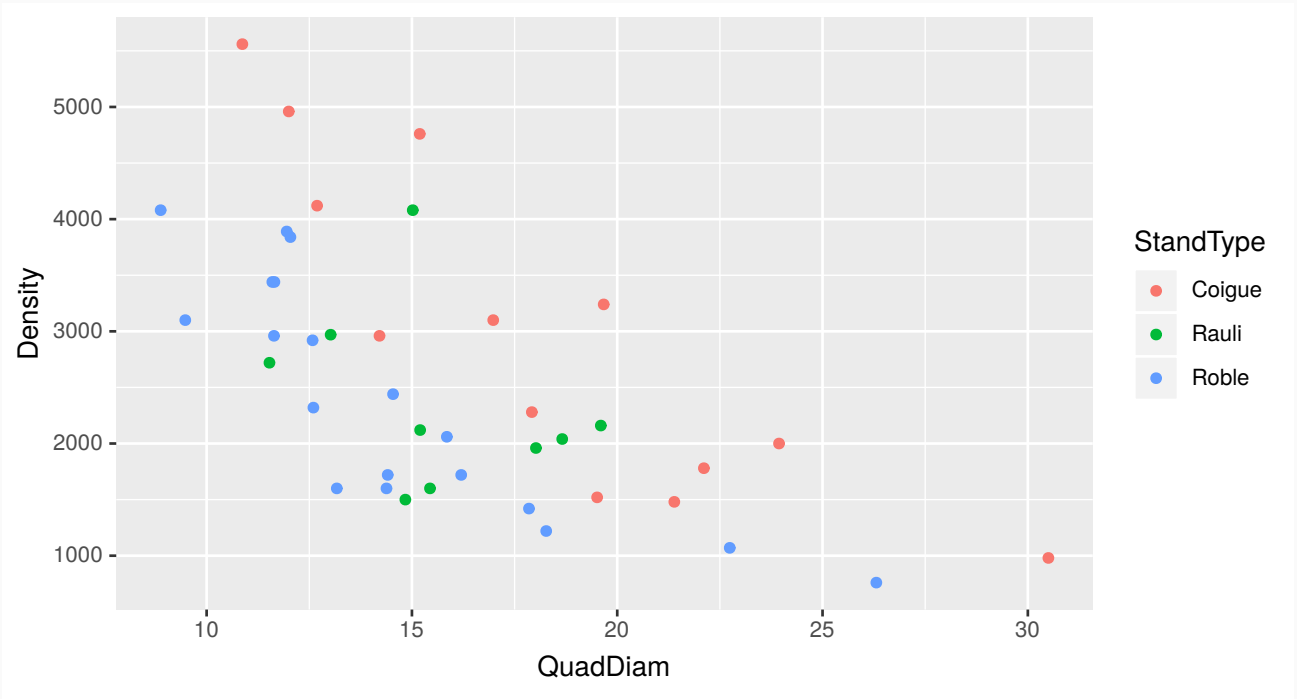
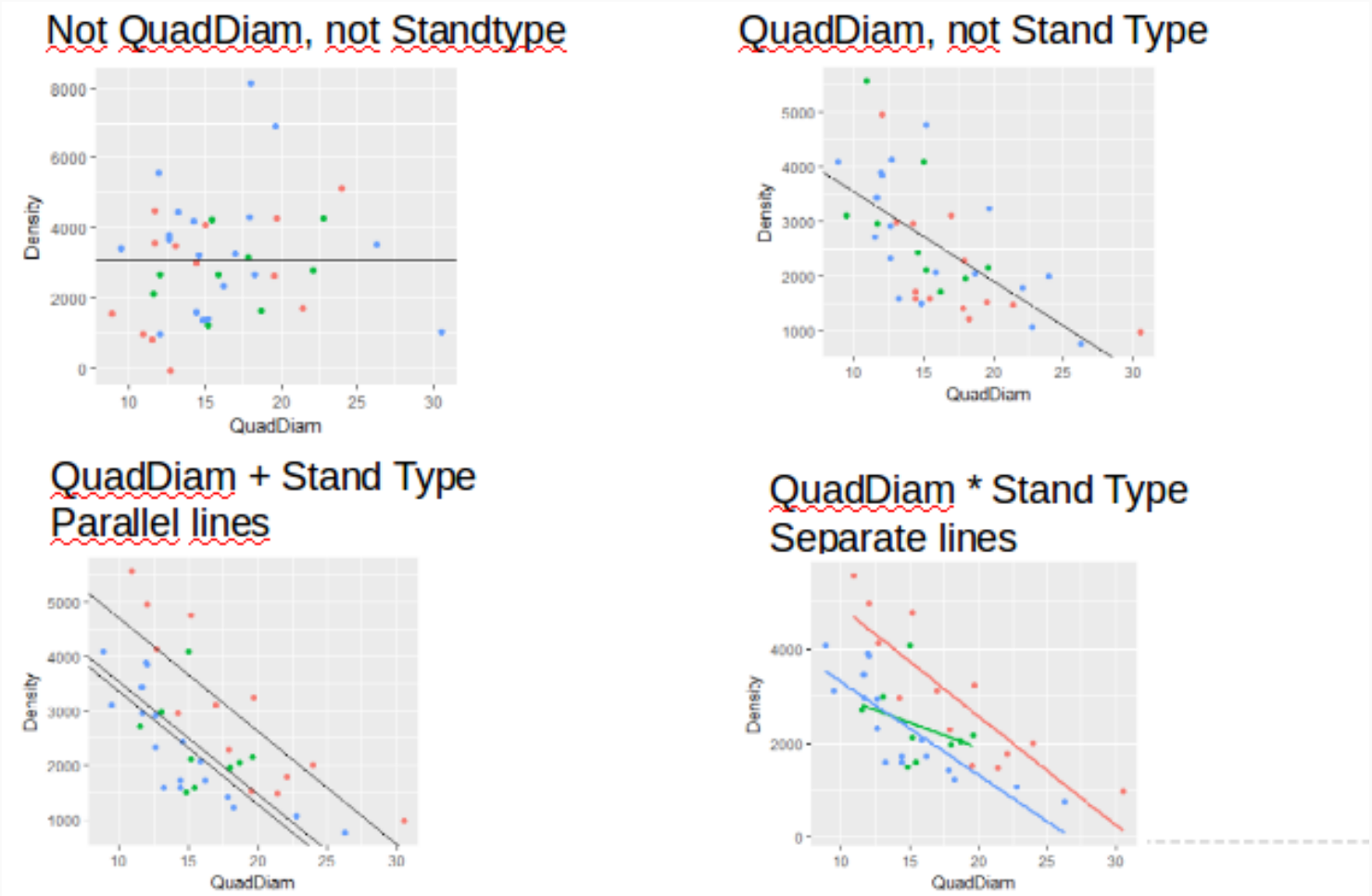


# Which model to use

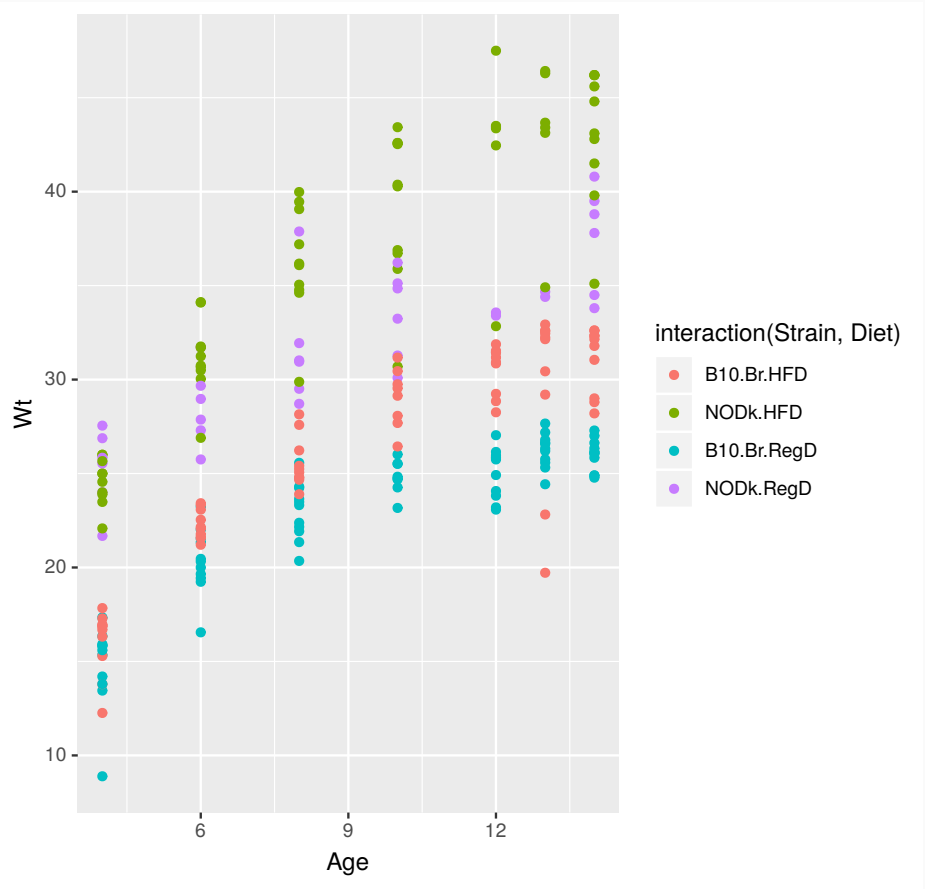



Fit the models with "Prac3forest.csv" and answer the scientific question

# Are NODk mice more susceptible to obesity when exposed to a high fat diet?

## Research context

- 37 mice: 16 NODk /21 WT
- Randomised to either regular or high fat diet
- Monitored for 14 weeks
- Outcome measure: Body weight (g)
- Experimental factors: Diet (2), Strain (2), Age (7)




Data "Prac3diabeticmice.csv"