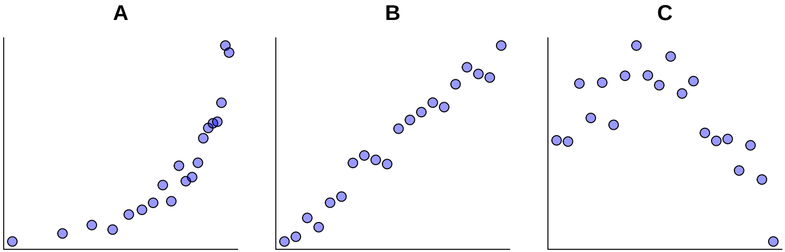
# Correlations

Introduction to Quantitative Ecology
Fall 2018

Chris Sutherland
csutherland@umass.edu

# Group evaluations

1. We would *not* use the Spearman's rank test to calculate a correlation coefficient - which one?




iclicker®

# Group evaluations

2. For her PhD, Eugene is studying the effects of annual temperature on American robin reproductive success (number of eggs hatched). What is the *dependent* variable?

A) American robin

B) Eugene

C) Temperature

D) Number of eggs

# Group evaluations

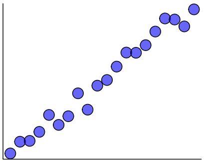
3. What is the most likely Pearson's correlation coefficient ($r$) for this relationship?

A) 0.90

B) 0.09

C) -0.9

D) -0.09



# Group evaluations

4. What is the slope in this equation of a straight line?

$$y = mx + c$$

A) $y$
B) $m$
C) $x$
D) $c$

# Group evaluations

5. Which of the following is *polynomial* relationship?

A) $y = ax + c$

B) $y = ax + bx^2 + c$

C) $y = log(ax) + c$

D) $y = c$

# Correlations

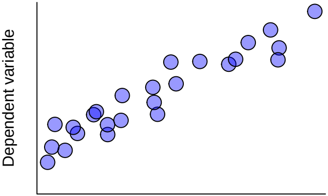
- What are examples of correlations?
- Why would we be interested in correlations?

?

# Correlations

Interested in the relationship between two samples

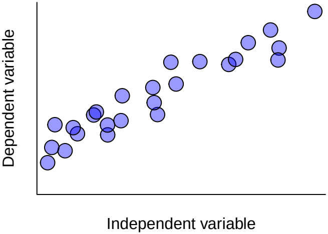
- Dependent variable:
  - data we are interested in explaining
  - Y-axis
  - *response* variable



# Correlations

Interested in the relationship between two samples

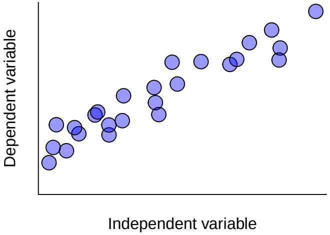
- Dependent variable:
  - data we are interested in explaining
  - Y-axis
  - *response* variable
- Independent variable:
  - data used to describe variation in dependent variable
  - X-axis
  - *explanatory* variable



# Correlations

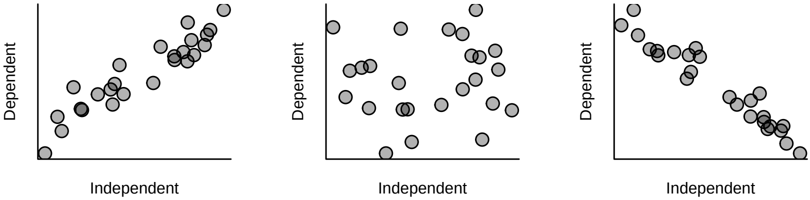
Interested in the relationship between two samples

- Dependent variable:
  - data we are interested in explaining
  - Y-axis
  - *response* variable
- Independent variable:
  - data used to describe variation in dependent variable
  - X-axis
  - *explanatory* variable
- Dealing with *pairs* of values!



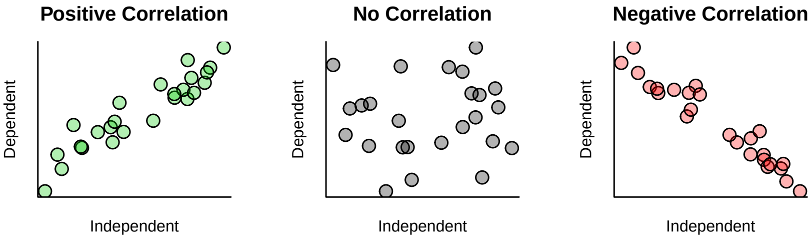
# Correlations

What is the sign of the correlation?



# Correlations

What is the sign of the correlation?



# Correlations

Lets play a game!

http://www.istics.net/Correlations/

# Correlations

We need a way to

- quantify correlations/relationships
- assess whether correlations/relationships are *significant*

# Correlations

We need a *test*!

1. Spearman's rank test ($r_s$)
    - determine the strength of the link between 2 samples
    - data are *not* normally distributed
    - realtionship not linear
        - but still exhibits a positive of negative trend
        - is not u-shaped or n-shaped
    - use the *ranks* of values
    - correlation strenght ranges from -1 to 1
        - -1: perfect *negative* correlation
        - 1: perfect *positive* correlation
        - 0: no correlation

# Correlations

We need a *test*!

2. Pearson's product moment ($r$)
   - determine the strength of the link between 2 samples
   - data *are* normally distributed
   - relationship assumed to be linear
     - positive of negative trend
     - not u- or n-shaped
   - use actual values
   - correlation strenght ranges from -1 to 1
     - -1: perfect *negative* correlation
     - 1: perfect *positive* correlation
     - 0: no correlation

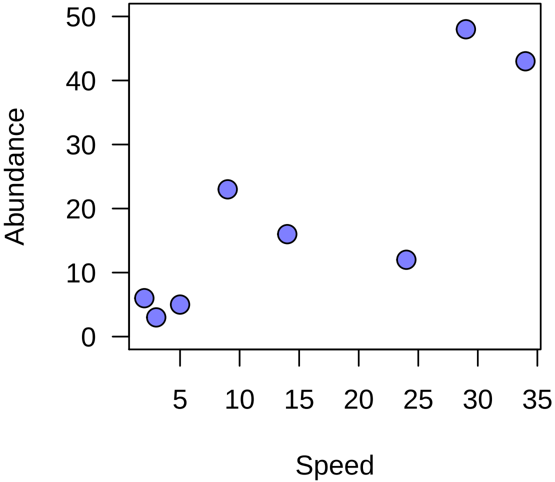
# Correlations

1. Spearman's rank test ($r_s$)
   - determine the strength of the link between 2 samples
   - data are *not* normally distributed
   - not neccesarily linear
   - use the *ranks* of values
2. Pearson's product moment ($r$)
   - determine the strength of the link between 2 samples
   - data *are* normally distributed
   - assumed to be linear linear
   - use actual values

- For both, the *correlation coefficient* ranges from -1 to 1
  - -1: perfect *negative* correlation
  - 1: perfect *positive* correlation
  - 0: no correlation

# Example: the Mayfly data

```
head(mayfly)
  Speed Abundance
1     2         6
2     3         3
3     5         5
4     9        23
5    14        16
6    24        12
```



# Spearman's rank test ($r_s$) - the hypothesis

Before conducting any statistical test, we need to state the hypotheses!

- $H_0$ (the *null* hypothesis):

# Spearman's rank test ($r_s$) - the hypothesis

Before conducting any statistical test, we need to state the hypotheses!

- $H_0$ (the *null* hypothesis):

*There is no correlation between stream speed and mayfly abundance*

# Spearman's rank test ($r_s$) - the hypothesis

Before conducting any statistical test, we need to state the hypotheses!

- $H_0$ (the *null* hypothesis):

*There is no correlation between stream speed and mayfly abundance*

- $H_1$ (the *alternative* hypothesis):

# Spearman's rank test ($r_s$) - the hypothesis

Before conducting any statistical test, we need to state the hypotheses!

- $H_0$ (the *null* hypothesis):

*There is no correlation between stream speed and mayfly abundance*

- $H_1$ (the *alternative* hypothesis):

*There is a positive correlation between stream speed and mayfly abundance*

# Spearman's rank test ($r_s$) - the statistical test

$$r_s = 1 - \frac{6 \times \sum D^2}{n(n^2 - 1)}$$

- programs (`Excel` and `R`) will do the math for us
- <u>BUT</u> we should be aware of what's going on!

# Spearman's rank test ($r_s$) - the statistical test

$$r_s = 1 - \frac{6 \times \sum D^2}{n(n^2 - 1)}$$

- programs (`Excel` and `R`) will do the math for us
- <u>BUT</u> we should be aware of what's going on!

```
mayfly
  Speed Abundance
1     2         6
2     3         3
3     5         5
4     9        23
5    14        16
6    24        12
7    29        48
8    34        43
```

# Spearman's rank test ($r_s$) - the statistical test

$$r_s = 1 - \frac{6 \times \sum D^2}{n(n^2 - 1)}$$

- first, calculate the *ranks* of the values: speed

```
mayfly
  Speed Abundance Speed.rank
1     2         6          1
2     3         3          2
3     5         5          3
4     9        23          4
5    14        16          5
6    24        12          6
7    29        48          7
8    34        43          8
```

# Spearman's rank test ($r_s$) - the statistical test

$$r_s = 1 - \frac{6 \times \sum D^2}{n(n^2 - 1)}$$

- first, calculate the *ranks* of the values: abundance

```
mayfly
  Speed Abundance Speed.rank Abundance.rank
1     2         6          1              3
2     3         3          2              1
3     5         5          3              2
4     9        23          4              6
5    14        16          5              5
6    24        12          6              4
7    29        48          7              8
8    34        43          8              7
```

# Spearman's rank test ($r_s$) - the statistical test

$$r_s = 1 - \frac{6 \times \sum D^2}{n(n^2 - 1)}$$

- then, calculate the difference in the *ranks*: $D$

```
mayfly
  Speed Abundance Speed.rank Abundance.rank Diff
1     2         6          1              3    2
2     3         3          2              1   -1
3     5         5          3              2   -1
4     9        23          4              6    2
5    14        16          5              5    0
6    24        12          6              4   -2
7    29        48          7              8    1
8    34        43          8              7   -1
```

# Spearman's rank test ($r_s$) - the statistical test

$$r_s = 1 - \frac{6 \times \sum D^2}{n(n^2 - 1)}$$

- then, square the difference in the *ranks*: $D^2$

```
mayfly
  Speed Abundance Speed.rank Abundance.rank Diff Diff.sq
1     2         6          1              3    2       4
2     3         3          2              1   -1       1
3     5         5          3              2   -1       1
4     9        23          4              6    2       4
5    14        16          5              5    0       0
6    24        12          6              4   -2       4
7    29        48          7              8    1       1
8    34        43          8              7   -1       1
```

# Spearman's rank test ($r_s$) - the statistical test

$$r_s = 1 - \frac{6 \times \sum D^2}{n(n^2 - 1)}$$

- so now we have all the pieces!
  - $n$: number of pairs of observations (each has an $x$ and a $y$)
  - $D$: difference in ranks between variables
  - $D^2$: the difference squared

# Spearman's rank test ($r_s$) - in practice

$$r_s = 1 - \frac{6 \times \sum D^2}{n(n^2 - 1)}$$

```
mayfly
  Speed Abundance Speed.rank Abundance.rank Diff Diff.sq
1     2         6          1              3    2       4
2     3         3          2              1   -1       1
3     5         5          3              2   -1       1
4     9        23          4              6    2       4
5    14        16          5              5    0       0
6    24        12          6              4   -2       4
7    29        48          7              8    1       1
8    34        43          8              7   -1       1
```

# Spearman's rank test ($r_s$) - in practice

$$r_s = 1 - \frac{6 \times \sum D^2}{n(n^2 - 1)}$$

$$r_s = 0.81$$

What does this tell us?

# Spearman's rank test ($r_s$) - in practice

$$r_s = 1 - \frac{6 \times \sum D^2}{n(n^2 - 1)}$$

$$r_s = 0.81$$

Two useful pieces of information:

1. Sign of the correlation
   - positive value means *positive* correlation

# Spearman's rank test ($r_s$) - in practice

$$r_s = 1 - \frac{6 \times \sum D^2}{n(n^2 - 1)}$$

$$r_s = 0.81$$

Two useful pieces of information:

1. Sign of the correlation
   - positive value means *positive* correlation
2. Strength of the correlation
   - $r$ ranges from -1 to 1
   - $r_s = 0.81$ is *strongly* positive
   - but is this *significant*?

# Spearman's rank test ($r_s$) - conclusions

As with many statistical tests, determine significance based on:

- *significance level*
- *sample size*
- *critical value*

# Spearman's rank test ($r_s$) - conclusions

As with many statistical tests, determine significance based on:

- *significance level*
- *sample size*
- *critical value*

If the test statistic is <u>greater than</u> the critical value:

- *reject* the null hypothesis
- there *is* a statistically significant positive correlation

# Spearman's rank test ($r_s$) - conclusions

As with many statistical tests, determine significance based on:

- *significance level*
- *sample size*
- *critical value*

If the test statistic is greater than the critical value:

- *reject* the null hypothesis
- there *is* a statistically significant positive correlation

If the test statistic is less than the critical value:

- *fail to reject* the null hypothesis
- there is no evidence of a statistically significant positive correlation

# Spearman's rank test ($r_s$) - mayfly conclusions

- *significance level* (typically 5%)
- *sample size* (number of pairs = 8)
- *critical value* (0.738)
- *test stasistic* ($r_s = 0.81$)
- the *test stasistic* is ?? than the *critical value*

| | Significance level | | |
|---|---|---|---|
| No. of pairs, *n* | 5% | 2% | 1% |
| 5 | 1.000 | 1.000 | - |
| 6 | 0.886 | 0.943 | 1.000 |
| 7 | 0.786 | 0.893 | 0.929 |
| 8 | 0.738 | 0.833 | 0.881 |
| 9 | 0.683 | 0.783 | 0.833 |
| 10 | 0.648 | 0.746 | 0.794 |
| 12 | 0.591 | 0.712 | 0.777 |
| 14 | 0.544 | 0.645 | 0.715 |
| 16 | 0.506 | 0.601 | 0.665 |
| 18 | 0.475 | 0.564 | 0.625 |
| 20 | 0.450 | 0.534 | 0.591 |
| 22 | 0.428 | 0.508 | 0.562 |
| 24 | 0.409 | 0.485 | 0.537 |
| 26 | 0.392 | 0.465 | 0.515 |
| 28 | 0.377 | 0.448 | 0.496 |
| 30 | 0.364 | 0.432 | 0.478 |

# Spearman's rank test ($r_s$) - mayfly conclusions

So, $r_s > 0.738$:

- reject the null hypothesis
- accept the alternative hypothesis

There *is* a statistically significant positive correlation between stream flow and mayfly abundance!

# Pearson's product moment ($r$)

2. Pearson's product moment ($r$)

# Pearson's product moment ($r$)

2. Pearson's product moment ($r$)
   - determine the strength of the link between 2 samples
   - data *are* normally distributed
   - relationship assumed to be linear
   - use actual values

# Pearson's product moment ($r$)

2. Pearson's product moment ($r$)
    - determine the strength of the link between 2 samples
    - data *are* normally distributed
    - relationship assumed to be linear
    - use actual values
    - -1: perfect *negative* correlation
    - 1: perfect *positive* correlation
    - 0: no correlation

# Pearson's product moment ($r$)

2. Pearson's product moment ($r$)
    - determine the strength of the link between 2 samples
    - data *are* normally distributed
    - relationship assumed to be linear
    - use actual values
    - -1: perfect *negative* correlation
    - 1: perfect *positive* correlation
    - 0: no correlation

# Pearson's product moment ($r$)

The linear assumption:

- relationship between two variables can be described by the equation of a straight line:

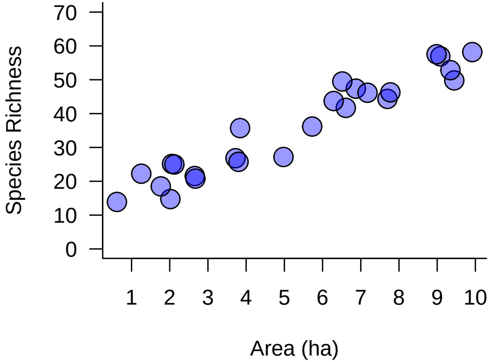
$$y = mx + c$$

- $y$: the dependent/response variable
- $x$: the independent/explanatory variable
- $m$: the *slope* of the relationship
- $c$: the *intercept*

# Pearson's product moment ($r$) - an example

Relationship between area & species richness (by hand/eye):

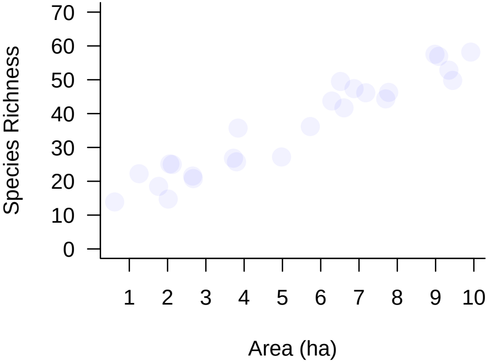
$$species = m \times area + c$$



# Pearson's product moment ($r$) - an example

Relationship between area & species richness (by hand/eye):

$$species = m \times area + c$$



# Pearson's product moment ($r$)

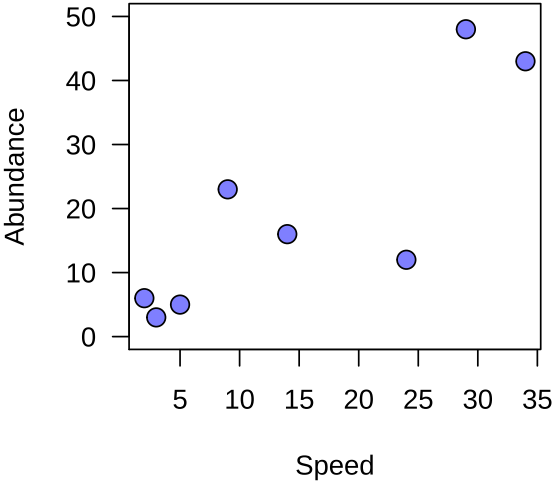
2. Pearson's product moment ($r$)

- calculates the strength of the correlation
  - similar to Spearman's coefficient
- *also* the equation of the best fit line
  - calculates the slope
  - calculates the intercepts

Pearson's product moment calculates strength of correlation & parameters of linear relationship between two variables.

# Example: the Mayfly data

```
head(mayfly)
  Speed Abundance Speed.ran
1     2         6
2     3         3
3     5         5
4     9        23
5    14        16
6    24        12
```



# Pearson's product moment ($r$) - the hypothesis

Before conducting any statistical test, we need to state the hypotheses!

- $H_0$ (the *null* hypothesis):

# Pearson's product moment ($r$) - the hypothesis

Before conducting any statistical test, we need to state the hypotheses!

- $H_0$ (the *null* hypothesis):

*There is no correlation between stream speed and mayfly abundance*

# Pearson's product moment ($r$) - the hypothesis

Before conducting any statistical test, we need to state the hypotheses!

- $H_0$ (the *null* hypothesis):

*There is no correlation between stream speed and mayfly abundance*

- $H_1$ (the *alternative* hypothesis):

# Pearson's product moment ($r$) - the hypothesis

Before conducting any statistical test, we need to state the hypotheses!

- $H_0$ (the *null* hypothesis):

*There is no correlation between stream speed and mayfly abundance*

- $H_1$ (the *alternative* hypothesis):

*There is a positive correlation between stream speed and mayfly abundance*

# Pearson's product moment ($r$) - the hypothesis

Before conducting any statistical test, we need to state the hypotheses!

- $H_0$ (the *null* hypothesis):

*There is no correlation between stream speed and mayfly abundance*

- $H_1$ (the *alternative* hypothesis):

*There is a positive correlation between stream speed and mayfly abundance*

NOTE: the hypotheses remain the same, but the assumption about the data are different. The assumptions determine the appropriate model!

# Pearson's product moment ($r$) - the straight line

Equation of a straight line:

$$y = mx + c$$

# Pearson's product moment ($r$) - the slope

Equation of a straight line:

$$y = mx + c$$

Calculating the slope:

$$m = \frac{\sum(x - \bar{x})(y - \bar{y})}{\sum(x - \bar{x})^2}$$

# Pearson's product moment ($r$) - the intercept

Equation of a straight line:

$$y = mx + c$$

Calculating the slope:

$$m = \frac{\sum(x - \bar{x})(y - \bar{y})}{\sum(x - \bar{x})^2}$$

Calculating the intercept:

$$c = \bar{y} - m\bar{x}$$

# Pearson's product moment ($r$) - the linear equation

Equation of a straight line:

$$y = mx + c$$

- programs (`Excel` and `R`) will do the math for us
- BUT we should be aware of what's going on!
  - calculating the *slope* from the data
  - calculating the *intercept* from the data

# Pearson's product moment ($r$) - the statistical test

Equation of a straight line: $y = mx + c$

- but, is the linear relationship *significant*?
- we can calculate Pearson's correlation coefficient

$$r = \frac{\sum(x - \bar{x})(y - \bar{y})}{\sqrt{\sum(x - \bar{x})^2 \sum(y - \bar{y})^2}}$$

# Pearson's product moment ($r$) - the statistical test

Equation of a straight line: $y = mx + c$

- but, is the linear relationship *significant*?
- we can calculate Pearson's correlation coefficient

$$r = \frac{\sum(x - \bar{x})(y - \bar{y})}{\sqrt{\sum(x - \bar{x})^2 \sum(y - \bar{y})^2}}$$

```
mayfly
  Speed Abundance
1     2         6
2     3         3
3     5         5
4     9        23
5    14        16
6    24        12
7    29        48
8    34        43
```

# Pearson's product moment ($r$) - the statistical test

Equation of a straight line: $y = mx + c$

- but, is the linear relationship *significant*?
- we can calculate Pearson's correlation coefficient

$$r = \frac{\sum(x-\bar{x})(y-\bar{y})}{\sqrt{\sum(x-\bar{x})^2 \sum(y-\bar{y})^2}}$$

$$r = 0.84$$

# Pearson's product moment ($r$) - in practice

$$r = \frac{\sum(x-\bar{x})(y-\bar{y})}{\sqrt{\sum(x-\bar{x})^2 \sum(y-\bar{y})^2}}$$

$$r = 0.84$$

Again we have two useful pieces of information:

1. Sign of the correlation
   - positive value means *positive* correlation
2. Strength of the correlation
   - $r$ ranges from -1 to 1
   - $r_s = 0.84$ is *strongly* positive
   - but is this *significant*?

# Pearson's product moment ($r$) - conclusions

As with many statistical tests, determine significance based on:

- *significance level*
- *sample size*
- *critical value*

# Pearson's product moment ($r$) - conclusions

As with many statistical tests, determine significance based on:

- *significance level*
- *sample size*
- *critical value*

If the test statistic is <u>greater than</u> the critical value:

- *reject* the null hypothesis
- there *is* a statistically significant positive correlation

# Pearson's product moment ($r$) - conclusions

As with many statistical tests, determine significance based on:

- *significance level*
- *sample size*
- *critical value*

If the test statistic is greater than the critical value:

- *reject* the null hypothesis
- there *is* a statistically significant positive correlation

If the test statistic is less than the critical value:

- *fail to reject* the null hypothesis
- there is no evidence of a statistically significant positive correlation

# Pearson's product moment ($r$) - mayfly conclusions

- *significance level* (typically 5%)
- *sample size* (df = number of pairs - 2 = 8 - 2 = 6)
- *critical value* (0.707)
- *test stasistic* ($r = 0.84$)
- the *test stasistic* is ?? than the *critical value*

| | Significance | |
|---|---|---|
| Degrees of freedom | 5% | 1% |
| 1 | 0.997 | 1 |
| 2 | 0.95 | 0.99 |
| 3 | 0.878 | 0.959 |
| 4 | 0.811 | 0.917 |
| 5 | 0.754 | 0.874 |
| 6 | 0.707 | 0.834 |
| 7 | 0.666 | 0.798 |
| 8 | 0.632 | 0.765 |
| 9 | 0.602 | 0.735 |
| 10 | 0.576 | 0.708 |
| 12 | 0.532 | 0.661 |
| 14 | 0.497 | 0.623 |
| 16 | 0.468 | 0.59 |
| 18 | 0.444 | 0.561 |
| 20 | 0.423 | 0.537 |
| 22 | 0.404 | 0.515 |
| 24 | 0.388 | 0.496 |
| 26 | 0.374 | 0.478 |
| 28 | 0.361 | 0.463 |
| [illegible] | 0.349 | 0.449 |

# Pearson's product moment ($r$) - mayfly conclusions

So, $r > 0.707$:

- reject the null hypothesis
- accept the alternative hypothesis

There *is* a statistically significant positive correlation between stream flow and mayfly abundance!

# Mayfly conclusions

Spearman's rank correlation coefficient:

- $r_s > 0.738$:
- reject the null hypothesis
- accept the alternative hypothesis

Pearson's correlation coefficient:

- $r > 0.707$:
- reject the null hypothesis
- accept the alternative hypothesis

Conclusion:

- same regardless of assumptions!
- there *is* a statistically significant positive correlation between stream flow and mayfly abundance!

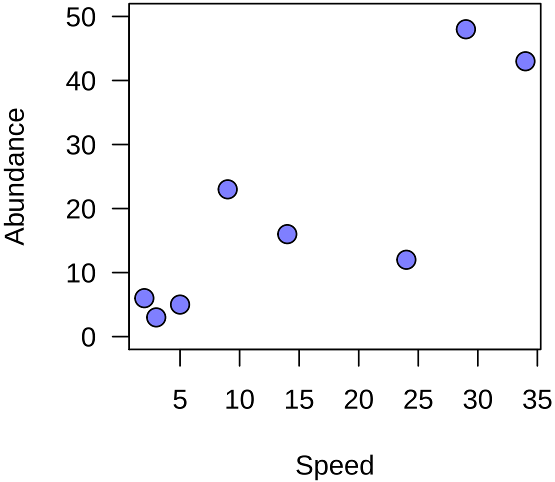
# Correlations in practice

- we *could* do it by hand (UGH!)
- we *prefer* to use built in functions
  - in `Excel`
  - in `R`

# Example: the Mayfly data

```
head(mayfly)
  Speed Abundance
1     2         6
2     3         3
3     5         5
4     9        23
5    14        16
6    24        12
```

Spearman: $r_s = 0.81$ Pe



# Spearman's rank test in `Excel`

$$r_s = 1 - \frac{6 \times \sum D^2}{n(n^2 - 1)}$$

In `Excel`

- an automated routine doe snot exist
- have to do it by hand
- :(

# Pearson's product moment in Excel

Pearson's correlation coefficient:

- $r = \frac{\sum(x-\bar{x})(y-\bar{y})}{\sqrt{\sum(x-\bar{x})^2 \sum(y-\bar{y})^2}}$
- `CORREL(response, predictor)`

Slope of the best fit line:

- $m = \frac{\sum(x-\bar{x})(y-\bar{y})}{\sum(x-\bar{x})^2}$
- `SLOPE(response, predictor)`

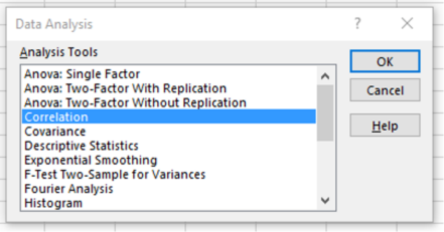
Intercept of the best fit line:

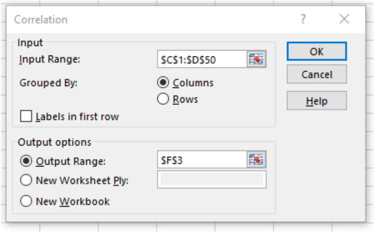
- $c = \bar{y} - m\bar{x}$
- `INTERCEPT(response, predictor)`

# Pearson's product moment in Excel

Pearson's correlation coefficient:

- $r = \frac{\sum(x-\bar{x})(y-\bar{y})}{\sqrt{\sum(x-\bar{x})^2\sum(y-\bar{y})^2}}$
- Analysis toolpack - `Correlation`



# Spearman's rank test in R

```r
#make the mayfly 'data.frame' by hand:
mayfly <- data.frame(Speed = c(2,3,5,9,14,24,29,34),
                     Abundance = c(6,3,5,23,16,12,48,43))
```

# Spearman's rank test in R

```
#make the mayfly 'data.frame' by hand:
mayfly <- data.frame(Speed = c(2,3,5,9,14,24,29,34),
                     Abundance = c(6,3,5,23,16,12,48,43))
mayfly
  Speed Abundance
1     2         6
2     3         3
3     5         5
4     9        23
5    14        16
6    24        12
7    29        48
8    34        43
```

# Spearman's rank test in R

$$r_s = 1 - \frac{6 \times \sum D^2}{n(n^2 - 1)}$$

- Spearman correlation coefficient $(r_s)$

```
cor(var1, var2, method='spearman')
```

- Spearman correlation coefficient *and* significance test

```
cor.test(var1, var2, method='spearman')
```

# Spearman's rank test in R

- Spearman correlation coefficient ($r_s$)

```
cor(mayfly$Speed, mayfly$Abundance, method='spearman')
[1] 0.8095238
```

# Spearman's rank test in R

- Spearman correlation coefficient ($r_s$)

```
cor(mayfly$Speed, mayfly$Abundance, method='spearman')
[1] 0.8095238
```

- Spearman correlation coefficient *and* significance test

```
cor.test(mayfly$Speed, mayfly$Abundance, method='spearman')

    Spearman's rank correlation rho

data:  mayfly$Speed and mayfly$Abundance
S = 16, p-value = 0.02178
alternative hypothesis: true rho is not equal to 0
sample estimates:
      rho
0.8095238
```

# Pearson's product moment in R

- $r = \frac{\sum(x-\bar{x})(y-\bar{y})}{\sqrt{\sum(x-\bar{x})^2 \sum(y-\bar{y})^2}}$
- Pearson's correlation coefficient ($r$)

```r
cor(var1, var2, method='pearson')
```

- Pearson's correlation coefficient *and* significance test

```r
cor.test(var1, var2, method='pearson')
```

# Pearson's product moment in R

- Pearson's correlation coefficient ($r$)

```r
cor(mayfly$Speed, mayfly$Abundance, method='pearson')
```

# Pearson's product moment in R

- Pearson's correlation coefficient ($r$)

```
cor(mayfly$Speed, mayfly$Abundance, method='pearson')
[1] 0.8441408
```

# Pearson's product moment in R

- Pearson's correlation coefficient ($r$)

```
cor(mayfly$Speed, mayfly$Abundance, method='pearson')
[1] 0.8441408
```

- Pearson's correlation coefficient *and* significance test

```
cor.test(mayfly$Speed, mayfly$Abundance, method='pearson')
```

# Pearson's product moment in R

- Pearson's correlation coefficient ($r$)

```
cor(mayfly$Speed, mayfly$Abundance, method='pearson')
[1] 0.8441408
```

- Pearson's correlation coefficient *and* significance test

```
cor.test(mayfly$Speed, mayfly$Abundance, method='pearson')

    Pearson's product-moment correlation

data:  mayfly$Speed and mayfly$Abundance
t = 3.8568, df = 6, p-value = 0.008393
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 0.3442317 0.9711386
sample estimates:
      cor
0.8441408
```

# Linear equation in `R`

To calculate the slope and the intercept of the best fit line:

- use a *linear model*
- in `R` use the function `lm(respnse ~ predictor)`

# Linear equation in R

To calculate the slope and the intercept of the best fit line:

- use a *linear model*
- in R use the function `lm(respnse ~ predictor)`

```
lm(mayfly$Abundance ~ mayfly$Speed)

Call:
lm(formula = mayfly$Abundance ~ mayfly$Speed)

Coefficients:
 (Intercept)  mayfly$Speed
       1.867         1.176
```

# Linear equation in R

To calculate the slope and the intercept of the best fit line:

- use a *linear model*
- in R use the function `lm(respnse ~ predictor)`

```
summary(lm(mayfly$Abundance ~ mayfly$Speed))

Call:
lm(formula = mayfly$Abundance ~ mayfly$Speed)

Residuals:
    Min      1Q  Median      3Q     Max
-18.080  -2.481  -0.580   3.975  12.042

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)    1.8667     5.7912   0.322  0.75813
mayfly$Speed   1.1756     0.3048   3.857  0.00839 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 10.05 on 6 degrees of freedom
Multiple R-squared:  0.7126,    Adjusted R-squared:  0.6647
F-statistic: 14.87 on 1 and 6 DF,  p-value: 0.008393
```

# Its all related!

```
cor.test(mayfly$Speed, mayfly$Abundance, method='pearson')

    Pearson's product-moment correlation

data:  mayfly$Speed and mayfly$Abundance
t = 3.8568, df = 6, p-value = 0.008393
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 0.3442317 0.9711386
sample estimates:
      cor
0.8441408
```

```
summary(lm(mayfly$Abundance ~ mayfly$Speed))

Call:
lm(formula = mayfly$Abundance ~ mayfly$Speed)

Residuals:
    Min      1Q  Median      3Q     Max
-18.080  -2.481  -0.580   3.975  12.042

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)    1.8667     5.7912   0.322  0.75813
mayfly$Speed   1.1756     0.3048   3.857  0.00839 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 10.05 on 6 degrees of freedom
Multiple R-squared:  0.7126,    Adjusted R-squared:  0.6647
F-statistic: 14.87 on 1 and 6 DF,  p-value: 0.008393
```

# Its all related!

```
cor.test(mayfly$Speed, mayfly$Abundance, method='spearman')

    Spearman's rank correlation rho

data:  mayfly$Speed and mayfly$Abundance
S = 16, p-value = 0.02178
alternative hypothesis: true rho is not equal to 0
sample estimates:
      rho
0.8095238
```

```
summary(lm(mayfly$Abundance ~ mayfly$Speed))

Call:
lm(formula = mayfly$Abundance ~ mayfly$Speed)

Residuals:
    Min      1Q  Median      3Q     Max
-18.080  -2.481  -0.580   3.975  12.042

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)    1.8667     5.7912   0.322  0.75813
mayfly$Speed   1.1756     0.3048   3.857  0.00839 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 10.05 on 6 degrees of freedom
Multiple R-squared:  0.7126,    Adjusted R-squared:  0.6647
F-statistic: 14.87 on 1 and 6 DF,  p-value: 0.008393
```

# Group exercise: salamander length correlations

Correlations in `R`:

1. Read in the data
2. Make a plot of ‘total length’ in response to ‘SVL’ length
3. Decide whether to use the Pearson or Spearman test

# Group exercise: salamander length correlations

Correlations in `R`:

- Read in the data
- Make a plot of 'total length' in response to 'SVL' length
- Decide whether to use the Pearson or Spearman test
- Conduct the analysis:
  - what is the correlation coefficient?
  - what is the intercept of the relationship?
  - what is the slope of the relationship?
  - is the relationship significant?

# Group exercise: salamander length correlations

Correlations in `Excel`:

- Create an Excel worksheet that show the same values you got in `R`:
  - the correlation coefficient
  - the intercept of the relationship
  - the slope of the relationship
  - the $p$-value

# Group exercise: salamander length correlations

Correlations in `Excel`:

- Create an Excel worksheet that show the same values you got in `R`:
  - the correlation coefficient
  - the intercept of the relationship
  - the slope of the relationship
  - the $p$-value (see below)
- **Submit the workbook**

To compute the $p$-value, you need to use `T.DIST.2T()` in Excel. This needs $t$, *test statistic*, which you can calculate that using $r$ (the correlation coefficient):

$$t = \frac{r \times \sqrt{n-2}}{\sqrt{1-r^2}}$$