SI Carpentries Brown Bags - rmarkdown tutorial

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# This is how we create titles

## And subtitles

### And so on…

#### An index is created based on our headings

# Setup

First, we load some libraries we need, and create a subset of the *penguins* dataset that will be used for some examples. You can find more information about this dataset [here](https://allisonhorst.github.io/palmerpenguins/articles/intro.html).

library(knitr)  
library(dplyr)  
library(palmerpenguins)  
  
# subset the penguins dataset for some rmarkdown examples  
  
minipenguins <- penguins %>%   
 dplyr::select(species, island, flipper\_length\_mm, body\_mass\_g) %>%   
 dplyr::distinct(species, island, .keep\_all = T)

# Resources consulted for this tutorial

This is just my own summary to give you a little taste of the wonders of rmarkdown. Most of this information has been compiled from available tutorials or thanks to awesome people that share their knowledge on *stackoverflow.com* to solve specific problems.

Note how you can wrap word or sentences with one *asterisk* or a *dash* to make them *italics*. And when you use **two** asterisks or **two** dashes, you will make the words or sentence **bold**.

Some of the sources I have consulted:

* <https://bookdown.org/yihui/rmarkdown-cookbook/how-to-read-this-book.html>
* <https://bookdown.org/yihui/rmarkdown/basics.html>
* <https://r4ds.had.co.nz/r-markdown.html>
* <https://rstudio.com/wp-content/uploads/2015/03/rmarkdown-reference.pdf>
* Slides showing other uses of rmarkdown: <https://slides.yihui.org/2019-rmarkdown-RaukR-Yihui-Xie.html#18>
* Interactive tutorial with markdown basics: <https://commonmark.org/help/>

# Why do we want to learn rmarkdown?

Because it can combine text, citations, data, plots, code, and render into a professional looking document. For that, it uses:

*markdown* for the plain text formatting syntax and *R* for the code chunks to analyze and visualize data.

Below I used a chunk of text, so that the text will appear different when we render the document. Chunks of text start and end with three backticks.

code + narrative + plots + citations = nice and reproducible report

And you can also do slides, and more with rmarkdown, but today I will focus on the HTML, Word, and PDF outputs.

To me, the most important thing is that **everything is dynamic**, which gives clear advantages for reproducibility:

\* your tables and plots will change when your data changes  
\* even the text can have inline dynamic variables that will change as well

# Introduction

## Getting started: what do you need

You need the latest version of R studio and R for the rmarkdown to work. The first time you try to open an “R markdown” file, it may ask you to download more packages, to help you set up with everything you need. From rmarkdown you can transform (“knit”) your documents into different formats (e.g., Word, PDF, HTML). And then the first time you try to knit a document, it may prompt you to install a few more packages. After following the suggestions, knitting in the three formats should work.

## Basic markdown functionality

The good thing of rmarkdown, is that if we want to write text…we just write! And a recent addition with the new R studio is the spell check functionality.

Using the R Studio tabs, if you go to “Help” you will find *Markdown Quick Reference*, if you go to “Help/Cheatsheets” you will also find *R markdown Cheat Sheet* and *R markdown Reference Guide*.

I showed earlier how to do a bulleted list, if you want to do numbered list, you directly put the numbers, and you can nest items using 2 TAB or 4 spaces:

1. Easy enumerated lists
2. Simple syntax
   * nested lists
     + super nested!
3. You can add chunks of code by:
   * manually typing the chunk delimiters (three back ticks)
   * Using the “Insert” button icon in the editor toolbar.
   * The keyboard shortcut Cmd/Ctrl + Alt + I

The argument after {r} in the first line will indicate the chunk options, for example look at the same script with and without a trick to make it look nicer. The first word after the **r** is the label, and that is going to be very helpful to navigate between chunks.

After the chunk label {r mylabel,…}, you can add other chunk options, for example, if you want to evaluate the code or not, if you want to show your results or not, or some edition tricks as *comment* that is useful to avoid the *#* signs in the output.

Here the basic look if we want to show the minipenguins object:

minipenguins

## # A tibble: 5 x 4  
## species island flipper\_length\_mm body\_mass\_g  
## <fct> <fct> <int> <int>  
## 1 Adelie Torgersen 181 3750  
## 2 Adelie Biscoe 174 3400  
## 3 Adelie Dream 178 3250  
## 4 Gentoo Biscoe 211 4500  
## 5 Chinstrap Dream 192 3500

Here a nicer look:

minipenguins

# A tibble: 5 x 4  
 species island flipper\_length\_mm body\_mass\_g  
 <fct> <fct> <int> <int>  
1 Adelie Torgersen 181 3750  
2 Adelie Biscoe 174 3400  
3 Adelie Dream 178 3250  
4 Gentoo Biscoe 211 4500  
5 Chinstrap Dream 192 3500

Here a way to not display this chunk in the final report (*echo = FALSE*, you will not see the commands in the output, only the table):

## # A tibble: 5 x 4  
## species island flipper\_length\_mm body\_mass\_g  
## <fct> <fct> <int> <int>  
## 1 Adelie Torgersen 181 3750  
## 2 Adelie Biscoe 174 3400  
## 3 Adelie Dream 178 3250  
## 4 Gentoo Biscoe 211 4500  
## 5 Chinstrap Dream 192 3500

Here a way of displaying the chunk but hiding the results (*results = ‘hide’*)

minipenguins

You can also choose to show it in the final document without running it (*eval = FALSE*).

minipenguins

And you can write inline code that is visible such as x <- 1:10. Or calculate something directly from your dataset, such as there were 3 penguin species studied. This is how if your data changes, you can rerun your document and the text with your calculations will change automatically.

So, there are many ways to personalize your output, depending who is your audience. If there is someone that doesn’t use R, you can hide your code and only show your results. You can also set up your preferred chunk options at the beginning of the document using **opts\_chunk**:

knitr::opts\_chunk$set(echo = F, warning = F, message = F, comment = "")

And if you need one chunk to be different, setting the option in that particular chunk will be counted over the global setup made at the begginng of the document.

Have in mind that if you have duplicated chunk labels, you will have an error when trying to knitt your document. The error will tell you which one is duplicated so you can find it. It happens **very** frequently because we tend to copy-paste chunks when we only want to tweak something. I just added this paragraph after my third time getting this error :)

# Citations

Bibliography management can be also done with rmarkdown.

## Set up to insert bibliography

You need two things:

1. A **.bib** file with your reference library

For example, I am now using Zotero, that is a free reference manager software. In Zotero, you can do *Edit/Select All* (or select the specific references you want), and then go to *File/Export Library*, selecting BibTeX from the dropdown menu. If you use Endnote, [this link](http://www.reed.edu/cis/help/LaTeX/EndNote.html) can help you to export a library in the bib.tex format. This is how a reference will look in the **.bib** file, in the first line, after { and before the comma, you can see the label for that particular reference, that you will use to cite it:

@article{fortin\_species\_2005,  
 title = {Species’ geographic ranges and distributional limits: pattern analysis and statistical issues},  
 volume = {108},  
 issn = {00301299, 16000706},  
 shorttitle = {Species’ geographic ranges and distributional limits},  
 url = {http://doi.wiley.com/10.1111/j.0030-1299.2005.13146.x},  
 doi = {10.1111/j.0030-1299.2005.13146.x},  
 language = {en},  
 number = {1},  
 urldate = {2018-06-01},  
 journal = {Oikos},  
 author = {Fortin, M.-J. and Keitt, T. H. and Maurer, B. A. and Taper, M. L. and Kaufman, Dawn M. and Blackburn, T. M.},  
 month = jan,  
 year = {2005},  
 pages = {7--17},  
 file = {Fortin et al. - 2005 - Species’ geographic ranges and distributional limi.pdf:C\:\\Users\\Paula\\Zotero\\storage\\2CE3UZ94\\Fortin et al. - 2005 - Species’ geographic ranges and distributional limi.pdf:application/pdf}  
}

1. A **.cls** file that will indicate the journal style for the references. In this [zotero link](https://www.zotero.org/styles) you can find hundreds of styles in *cls* format.

In the first lines of the markdown document (the YAML code), there is a section called *Bibliography* that allows you to indicate your **.bib** and **.cls** files. In this case I downloaded the **.csl** file for the ICES Journal of Marine Sciences style (*ices-journal-of-marine-science.csl*), and saved my references in a file called *References.bib*.

## How to cite?

To add one citation, you use [@mycitation].  
  
To separate multiple citations you use `;`: [@burgman\_bias\_2003; @fortin\_species\_2005].

This will look like this (Burgman and Fox, 2003; Fortin *et al.*, 2005). To know which code corresponds to each of your citations, you will have to check your **.bib** file and look at the label for the reference you want to cite. You can also open the **.bib** file in R studio and have it on hand.

When you need to add comments within your citation, you can do so inside the square brackets:   
   
Multiple citations with comments [see @cote\_meta-analysis\_2012, pp. 1-3; also see @pappalardo\_comparing\_2020].

Comments within citations will look like this (see Côté and Reynolds, 2012, pp. 1–3; also see Pappalardo *et al.*, 2020).

Sometimes we need to cite authors within the text, we can do that removing the square brackets:  
   
 @gurevitch\_meta\_2001 said this

Which will look like Gurevitch *et al.* (2001) said this.

When you knit the document, the references will appear in the correct format, at the end of your document. This is why I ended my rmarkdown file with the header *# References*.

To get a **.bib** file for all the R packages you are using, you can use:

knitr::write\_bib(c(.packages()), "packages.bib")

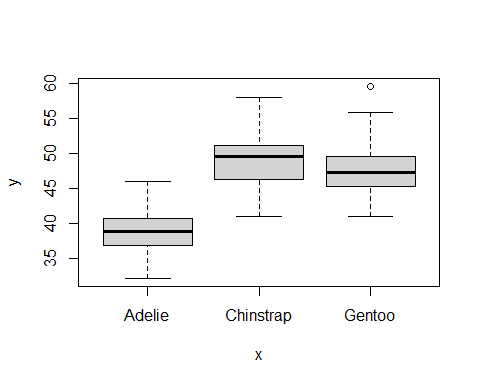
This will compile the citations for all the packages that are loaded into the file *packages.bib*. Note that many packages are loaded in the background, as dependencies of packages you called directly, so it may return a much bigger list than you thought, but they will be handy for you to cite them. You can have more than one **.bib** file in your YAML header, separated by commas.

# Plots

Images generated by knitr are saved in a figures folder. However, they also appear to be represented in the HTML output using a [data URI scheme](http://en.wikipedia.org/wiki/Data_URI_scheme). This means that you can paste the HTML into a blog post or discussion forum and you don’t have to worry about finding a place to store the images; they’re embedded in the HTML.

Here is a basic plot using base graphics:

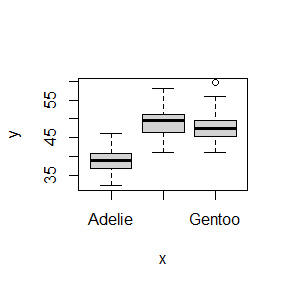
plot(penguins$species, penguins$bill\_length\_mm)



You can set up the plot size using the chunk options, for this example I added:

fig.width= 3, fig.height= 3

plot(penguins$species, penguins$bill\_length\_mm)



# Equations

Equations are included by using LaTeX notation and including them either between single dollar signs (inline equations) or double dollar signs (displayed equations).

There are inline equations such as $y\_i = \alpha + \beta x\_i + e\_i$.  
   
And displayed formulas:  
   
$$\frac{1}{1+\exp(-x)}$$

There are inline equations such as .

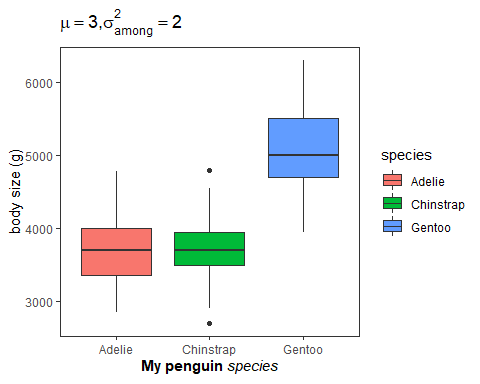
And displayed formulas:

[Here](https://www.math.uci.edu/~xiangwen/pdf/LaTeX-Math-Symbols.pdf) you can find information on how to write the symbols you may need.

There are packages that can provide additional help for other types of scientific notation. For example the R package *latex2exp* helps to write mathematical expressions in plots, using the function *TeX()*. Using the function *expression()* from the base package we can add **bold** or *italics* to our plots as well.

Here for an example, I made up a title that include symbols:

library(ggplot2)  
library(latex2exp)  
  
ggplot(penguins, aes(x = species, y = body\_mass\_g, fill = species)) +  
 theme\_bw() +  
 theme(panel.grid.major = element\_blank(),  
 panel.grid.minor = element\_blank()) +  
 geom\_boxplot() +  
 xlab(expression(bold(paste("My penguin ", italic("species"))))) +  
 ylab("body size (g)") + ggtitle(TeX("$\\mu = 3, \\sigma^2\_{among} = 2$"))



# Tables

Tables can be included using the following notation

A | B | C  
--- | --- | ---  
1 | Dog | German Sheperd  
2 | Cat | Siamese

|  |  |  |
| --- | --- | --- |
| A | B | C |
| 1 | Dog | German Sheperd |
| 2 | Cat | Siamese |

Which is not very practical! Luckily we can directly use dataframes we have in the environment and display them as nice tables using functions from different packages.

For example, we can use **kable()** from the *knitr* package:

kable(minipenguins)

|  |  |  |  |
| --- | --- | --- | --- |
| species | island | flipper\_length\_mm | body\_mass\_g |
| Adelie | Torgersen | 181 | 3750 |
| Adelie | Biscoe | 174 | 3400 |
| Adelie | Dream | 178 | 3250 |
| Gentoo | Biscoe | 211 | 4500 |
| Chinstrap | Dream | 192 | 3500 |

Or we can use **flextable()** from the *flextable* package, you can find more information [here](#X1f469be6222205b402b3acdde9765a7cb4ca01a):

library(flextable)  
  
flextable(minipenguins)

| species | island | flipper\_length\_mm | body\_mass\_g |
| --- | --- | --- | --- |
| Adelie | Torgersen | 181 | 3,750 |
| Adelie | Biscoe | 174 | 3,400 |
| Adelie | Dream | 178 | 3,250 |
| Gentoo | Biscoe | 211 | 4,500 |
| Chinstrap | Dream | 192 | 3,500 |

For HTML outputs, we can use **kable\_styling()** from the *kableExtra* to create an “interactive” table where you can scroll up and down. Not that useful if the table is small:

library(kableExtra)  
  
knitr::kable(minipenguins) %>%   
 kable\_styling(bootstrap\_options =   
 c("striped", "hover",  
 "condensed", "responsive"),  
 stripe\_color = "blue") %>%   
 scroll\_box(height = "250px")

species

island

flipper\_length\_mm

body\_mass\_g

Adelie

Torgersen

181

3750

Adelie

Biscoe

174

3400

Adelie

Dream

178

3250

Gentoo

Biscoe

211

4500

Chinstrap

Dream

192

3500

Tweaking some options we can make it look different:

knitr::kable(minipenguins) %>%   
 kable\_styling(font\_size = 7,  
 html\_font = "Arial Narrow",  
 bootstrap\_options =   
 c("bordered"))

species

island

flipper\_length\_mm

body\_mass\_g

Adelie

Torgersen

181

3750

Adelie

Biscoe

174

3400

Adelie

Dream

178

3250

Gentoo

Biscoe

211

4500

Chinstrap

Dream

192

3500

Adding a scroll box (avaiable in HTML) is very useful for a big table:

library(kableExtra)  
  
knitr::kable(penguins) %>%   
 kable\_styling(bootstrap\_options =   
 c("striped", "hover",  
 "condensed", "responsive")) %>%   
 scroll\_box(height = "300px")

species

island

bill\_length\_mm

bill\_depth\_mm

flipper\_length\_mm

body\_mass\_g

sex

year

Adelie

Torgersen

39.1

18.7

181

3750

male

2007

Adelie

Torgersen

39.5

17.4

186

3800

female

2007

Adelie

Torgersen

40.3

18.0

195

3250

female

2007

Adelie

Torgersen

NA

NA

NA

NA

NA

2007

Adelie

Torgersen

36.7

19.3

193

3450

female

2007

Adelie

Torgersen

39.3

20.6

190

3650

male

2007

Adelie

Torgersen

38.9

17.8

181

3625

female

2007

Adelie

Torgersen

39.2

19.6

195

4675

male

2007

Adelie

Torgersen

34.1

18.1

193

3475

NA

2007

Adelie

Torgersen

42.0

20.2

190

4250

NA

2007

Adelie

Torgersen

37.8

17.1

186

3300

NA

2007

Adelie

Torgersen

37.8

17.3

180

3700

NA

2007

Adelie

Torgersen

41.1

17.6

182

3200

female

2007

Adelie

Torgersen

38.6

21.2

191

3800

male

2007

Adelie

Torgersen

34.6

21.1

198

4400

male

2007

Adelie

Torgersen

36.6

17.8

185

3700

female

2007

Adelie

Torgersen

38.7

19.0

195

3450

female

2007

Adelie

Torgersen

42.5

20.7

197

4500

male

2007

Adelie

Torgersen

34.4

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184

3325

female

2007

Adelie

Torgersen

46.0

21.5

194

4200

male

2007

Adelie

Biscoe

37.8

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174

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Adelie

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male

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180

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Adelie

Biscoe

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Adelie

Biscoe

40.6

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male

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Adelie

Biscoe

40.5

17.9

187

3200

female

2007

Adelie

Biscoe

37.9

18.6

172

3150

female

2007

Adelie

Biscoe

40.5

18.9

180

3950

male

2007

Adelie

Dream

39.5

16.7

178

3250

female

2007

Adelie

Dream

37.2

18.1

178

3900

male

2007

Adelie

Dream

39.5

17.8

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Adelie

Dream

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3100

female

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Adelie

Dream

44.1

19.7

196

4400

male

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Adelie

Dream

37.0

16.9

185

3000

female

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Adelie

Dream

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Dream

36.0

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3450

female

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Adelie

Dream

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191

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male

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Adelie

Biscoe

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3500

female

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Adelie

Biscoe

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Adelie

Biscoe

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Biscoe

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Biscoe

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Adelie

Biscoe

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Adelie

Biscoe

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Adelie

Biscoe

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19.1

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Adelie

Torgersen

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3050

female

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Adelie

Torgersen

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Adelie

Torgersen

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Adelie

Torgersen

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Adelie

Torgersen

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Adelie

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Torgersen

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Adelie

Torgersen

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Adelie

Torgersen

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Torgersen

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3900

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Adelie

Torgersen

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Adelie

Torgersen

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Dream

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Adelie

Dream

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2008

Adelie

Dream

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female

2008

Adelie

Dream

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Adelie

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female

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Adelie

Dream

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Adelie

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female

2008

Adelie

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4300

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Adelie

Dream

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18.6

190

3700

female

2008

Adelie

Dream

40.3

18.5

196

4350

male

2008

Adelie

Dream

33.1

16.1

178

2900

female

2008

Adelie

Dream

43.2

18.5

192

4100

male

2008

Adelie

Biscoe

35.0

17.9

192

3725

female

2009

Adelie

Biscoe

41.0

20.0

203

4725

male

2009

Adelie

Biscoe

37.7

16.0

183

3075

female

2009

Adelie

Biscoe

37.8

20.0

190

4250

male

2009

Adelie

Biscoe

37.9

18.6

193

2925

female

2009

Adelie

Biscoe

39.7

18.9

184

3550

male

2009

Adelie

Biscoe

38.6

17.2

199

3750

female

2009

Adelie

Biscoe

38.2

20.0

190

3900

male

2009

Adelie

Biscoe

38.1

17.0

181

3175

female

2009

Adelie

Biscoe

43.2

19.0

197

4775

male

2009

Adelie

Biscoe

38.1

16.5

198

3825

female

2009

Adelie

Biscoe

45.6

20.3

191

4600

male

2009

Adelie

Biscoe

39.7

17.7

193

3200

female

2009

Adelie

Biscoe

42.2

19.5

197

4275

male

2009

Adelie

Biscoe

39.6

20.7

191

3900

female

2009

Adelie

Biscoe

42.7

18.3

196

4075

male

2009

Adelie

Torgersen

38.6

17.0

188

2900

female

2009

Adelie

Torgersen

37.3

20.5

199

3775

male

2009

Adelie

Torgersen

35.7

17.0

189

3350

female

2009

Adelie

Torgersen

41.1

18.6

189

3325

male

2009

Adelie

Torgersen

36.2

17.2

187

3150

female

2009

Adelie

Torgersen

37.7

19.8

198

3500

male

2009

Adelie

Torgersen

40.2

17.0

176

3450

female

2009

Adelie

Torgersen

41.4

18.5

202

3875

male

2009

Adelie

Torgersen

35.2

15.9

186

3050

female

2009

Adelie

Torgersen

40.6

19.0

199

4000

male

2009

Adelie

Torgersen

38.8

17.6

191

3275

female

2009

Adelie

Torgersen

41.5

18.3

195

4300

male

2009

Adelie

Torgersen

39.0

17.1

191

3050

female

2009

Adelie

Torgersen

44.1

18.0

210

4000

male

2009

Adelie

Torgersen

38.5

17.9

190

3325

female

2009

Adelie

Torgersen

43.1

19.2

197

3500

male

2009

Adelie

Dream

36.8

18.5

193

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Adelie

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37.5

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Adelie

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38.1

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187

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Adelie

Dream

41.1

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190

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male

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Adelie

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35.6

17.5

191

3175

female

2009

Adelie

Dream

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Adelie

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37.0

16.5

185

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Adelie

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Adelie

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187

3475

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41.5

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2009

Gentoo

Biscoe

46.1

13.2

211

4500

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Biscoe

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16.3

230

5700

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2007

Gentoo

Biscoe

48.7

14.1

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4450

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46.5

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4550

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45.4

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4800

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46.7

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5200

male

2007

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Biscoe

43.3

13.4

209

4400

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2007

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215

5150

male

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45.1

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215

5000

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Gentoo

Biscoe

46.5

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46.3

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215

5050

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Biscoe

42.9

13.1

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5000

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Gentoo

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46.1

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5100

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44.5

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47.8

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3525

female

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Chinstrap

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52.7

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3725

male

2007

Chinstrap

Dream

45.2

17.8

198

3950

female

2007

Chinstrap

Dream

46.1

18.2

178

3250

female

2007

Chinstrap

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51.3

18.2

197

3750

male

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Please note that for us to be able to knit this document with the HTML specific commands into Word or PDF, we need to add this to the YAML metadata:

always\_allow\_html: true

Also note that for the previous example that focused on the HTML output, this table will look aweful in the Word file, and will be incomplete in the PDF file.

# Other useful things to add to a document

## Hyperlinks

Create simple links by wrapping square brackets around the link text and round brackets around the URL. Example:

To find species occurrence data, you can check [GBIF](http://www.gbif.org/).

To find species occurrence data, you can check [GBIF](http://www.gbif.org/).

Or another example:

Penguin artwork provided by @allison\_horst. You can get it [here](https://allisonhorst.github.io/palmerpenguins/articles/art.html)

Penguin artwork provided by @allison\_horst. You can get it [here](https://allisonhorst.github.io/palmerpenguins/articles/art.html).

Notice that in the sentence above we had to use “" to avoid the at symbol to be interpreted as a reference. We can also use”" before an asterisk or lower dash to stop it from considering as in use for bold or italics.

## Images

Here are @allison\_horst cute penguins. You can put your Figure legend between the square brackets:

![your figure legend](pictures/penguins.png)

## Quotes

With the “>” symbol at the beginning of your sentences, they will appear as a quote. You can also use bold and italics within a quote. For example:

> "It is not the strongest or the most intelligent who  
> will survive but those who can best manage change".  
> \_Charles Darwin\_

“It is not the strongest or the most intelligent who will survive but those who can best manage change”. *Charles Darwin*

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