Graphics in R

Christophe Lalanne

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Les différents systèmes graphiques

Le package ggplot2

Paramètres avancés

Graphiques interactifs

The greatest value of a picture is when it forces us to notice what we never expected to see.
–John Tukey

Les différents systèmes graphiques

Systèmes graphiques

R dispose de deux principaux système graphiques, `base` et `grid` (P. Murrell 2005), et de trois interfaces/packages : `graphics` (Becker, Chambers, and Wilks 1988), `lattice` (Sarkar 2008) et `ggplot2` (Wickham 2009) ; voir aussi Chang (2013).

Graphiques de base

```
> plot(density(ToothGrowth$len[ToothGrowth$supp == "OJ"]),
       main = "", xlab = "len", las = 1, lwd = 2, col = "coral")
> lines(density(ToothGrowth$len[ToothGrowth$supp == "VC"]),
        lwd = 2, col = "cornflowerblue")
> ## rug() does not allow to use a grouping factor
> points(x = ToothGrowth$len[ToothGrowth$supp == "OJ"],
         y = runif(n = length(ToothGrowth$len[ToothGrowth$supp == "OJ"]),
                   min = -0.001, max = 0.001),
         col = "coral")
> points(x = ToothGrowth$len[ToothGrowth$supp == "VC"],
         y = runif(n = length(ToothGrowth$len[ToothGrowth$supp == "VC"]),
                   min = -0.001, max = 0.001),
         col = "cornflowerblue")
> legend("top", levels(ToothGrowth$supp),
         col = c("coral", "cornflowerblue"),
         lty = 1, bty = "n")
```

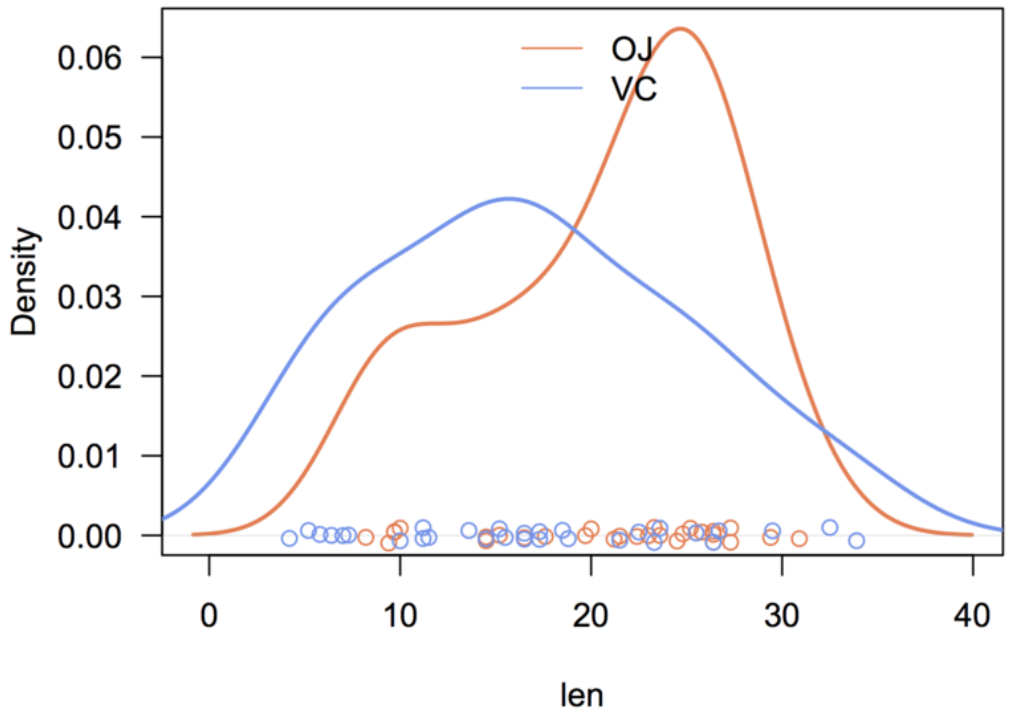


Figure 1: Graphique de type base

Graphiques lattice

```
library(lattice)
densityplot(~ len, data = ToothGrowth, group = supp,
            auto.key = TRUE)
```

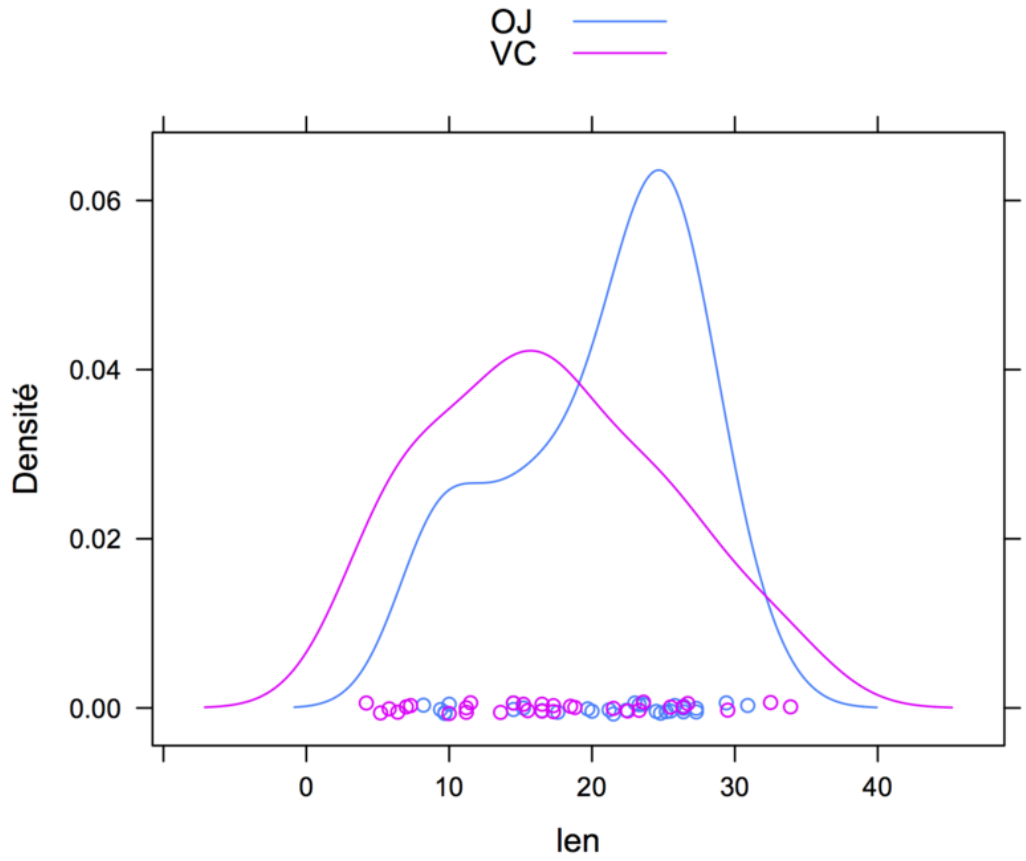


Figure 2: Graphique de type lattice

Graphiques ggplot

```
library(ggplot2)
ggplot(data = ToothGrowth, aes(x = len, color = supp)) +
  geom_line(stat = "density") + geom_rug()
```

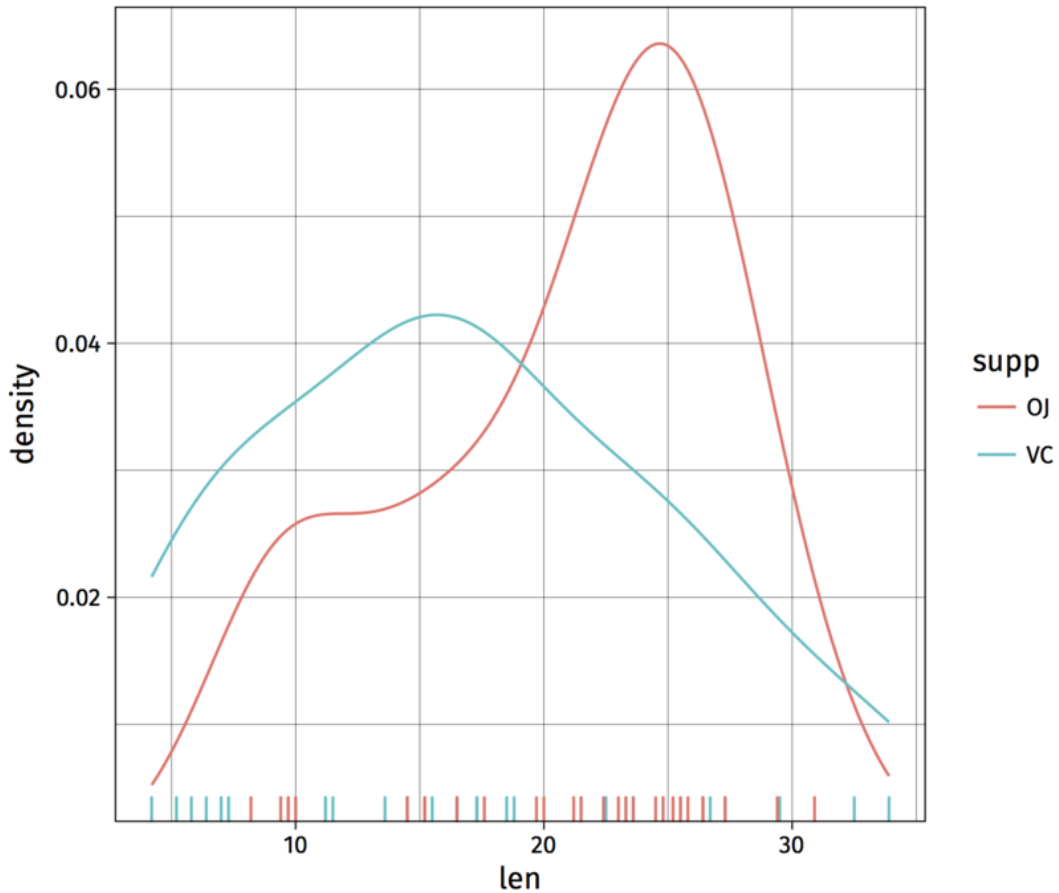
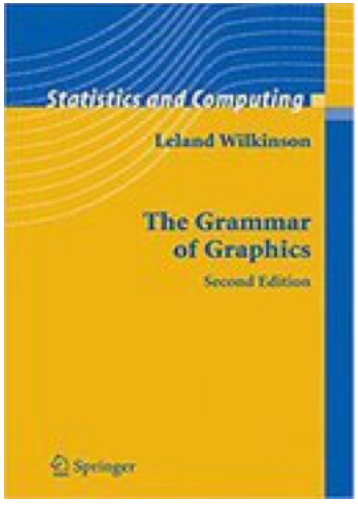
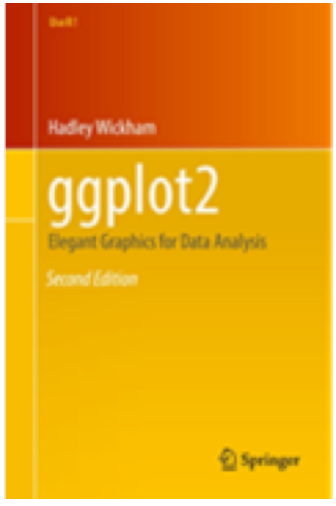


Figure 3: Graphique de type ggplot

Le package ggplot2

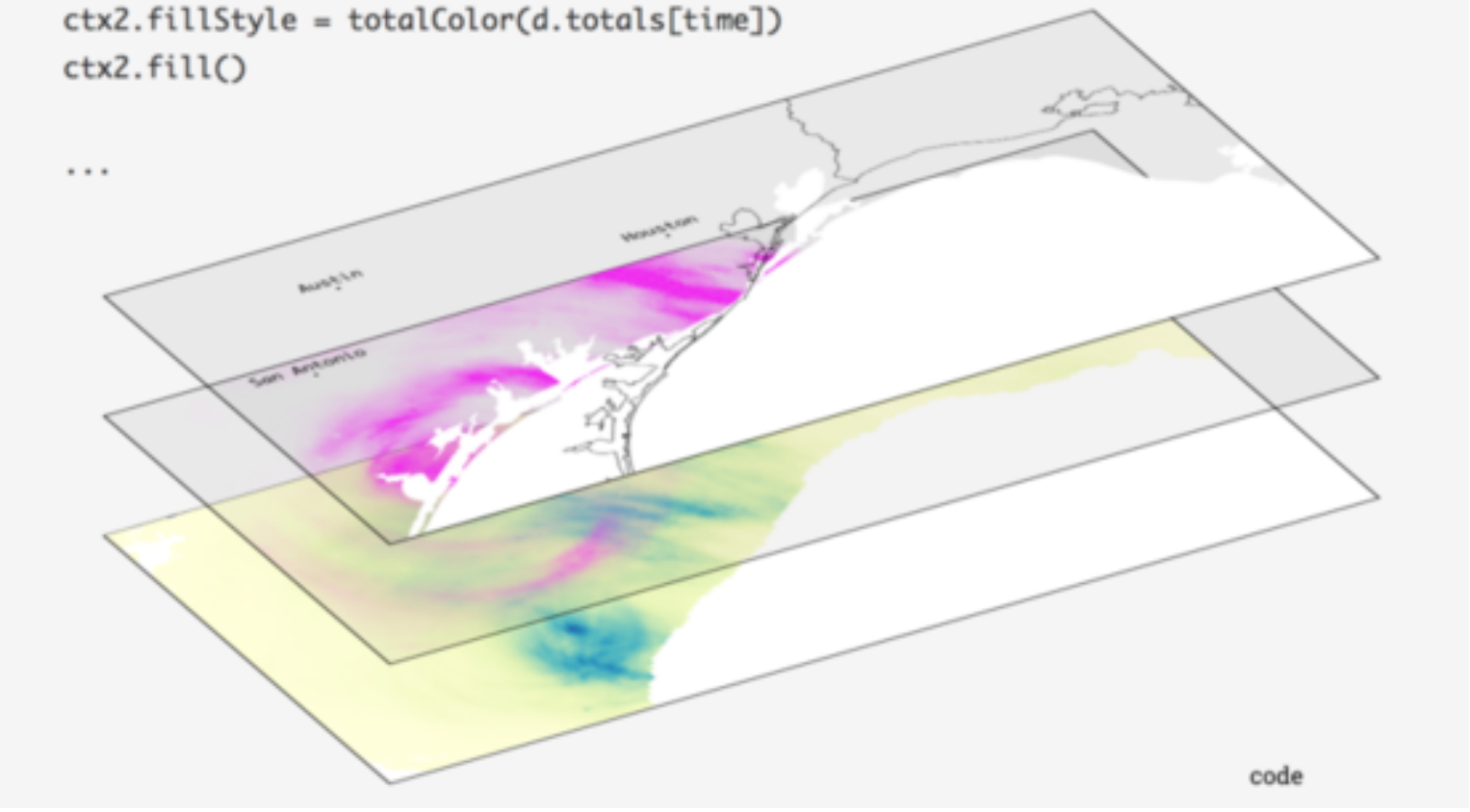
“The Grammar of Graphics”





- Wilkinson (2005) fournit un cadre de réflexion et des idées d’application d’une grammaire des graphiques
- Wickham (2009) offre une implémentation en langage R : https://github.com/hadley/ggplot2-book

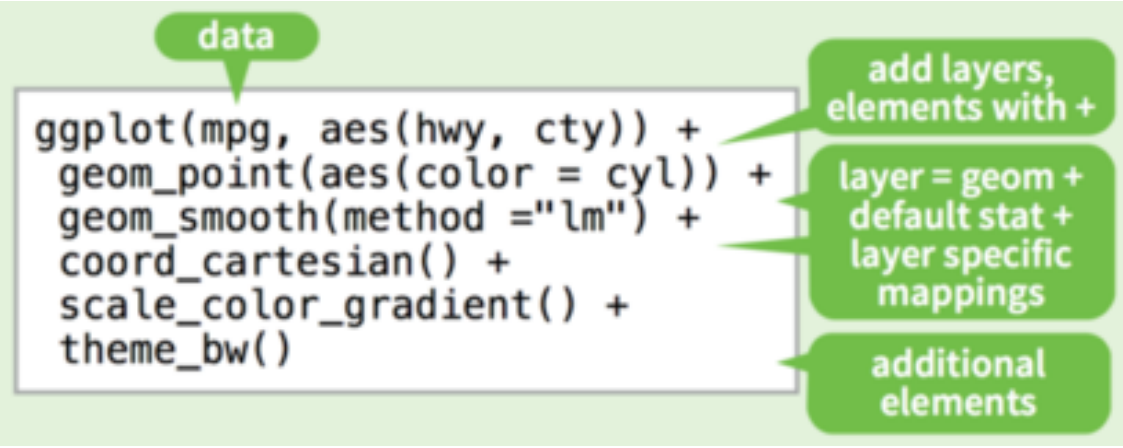
Un concept de couches



https://roadtolarissa.com/hurricane/

Les bases d'un graphique ggplot

- `ggplot()` : un data frame (`data =`) et un mapping (`aes()`)
- `geom_*()` : un ou plusieurs objets géométriques
- `facet_wrap()` : un système de facettes (conditionnement)
- `scale_*_*()` : une échelle pour les axes ou les palettes de couleurs
- `coord_*()` : un système de coordonnées
- `labs()` : des annotations pour les axes et le graphique
- `theme_*()` : un thème personnalisé

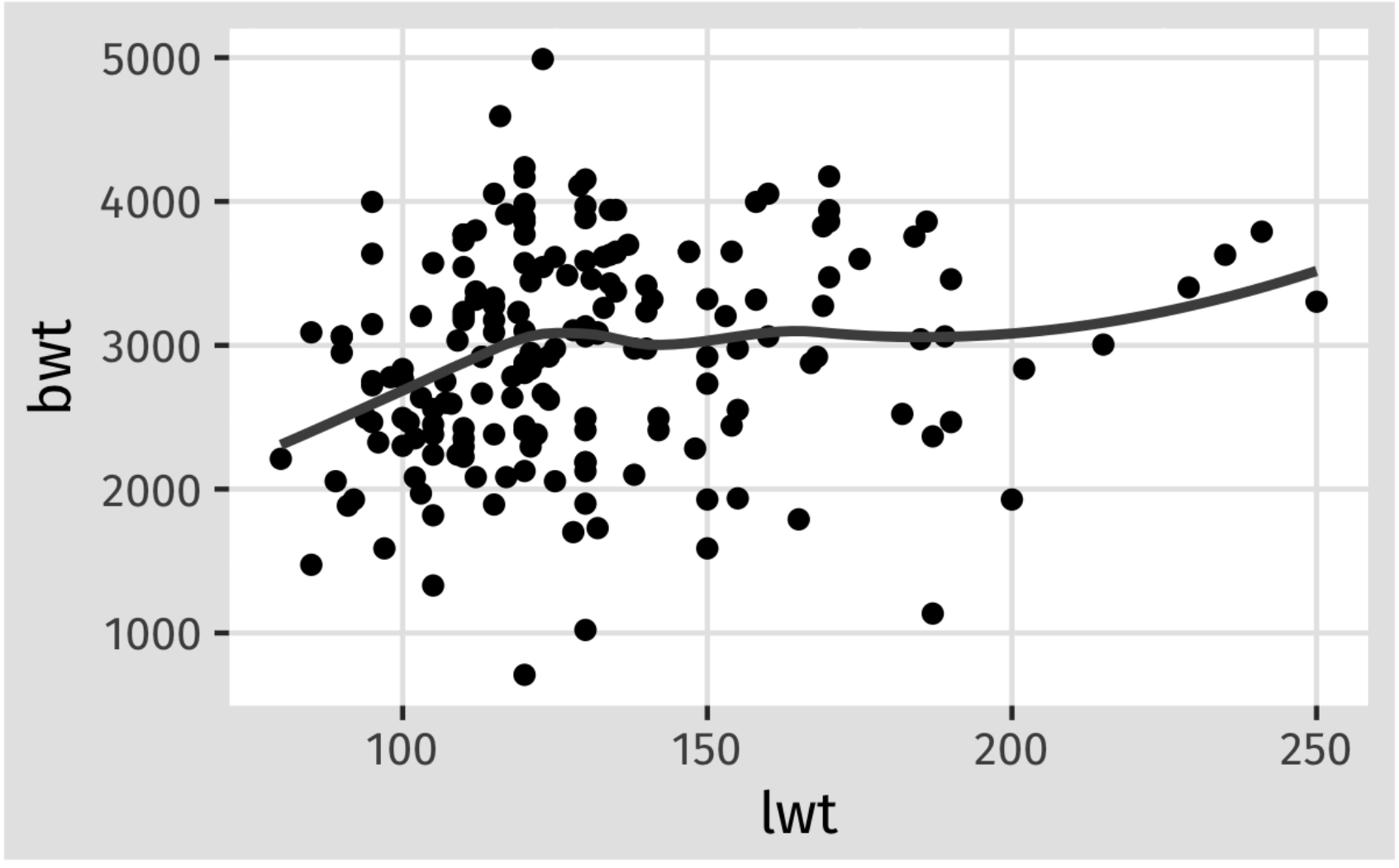


ggplot2-cheatsheet.pdf[1]

[1] version plus récente disponible sur le site de RStudio.

Mise en œuvre

```
p = ggplot() +
    layer(data = MASS::birthwt,
          stat = "identity",
          geom = "point",
          mapping = aes(x = lwt, y = bwt),
          position = "identity") +
    layer(data = MASS::birthwt,
          stat = "smooth",
          geom = "line",
          mapping = aes(x = lwt, y = bwt),
          position = "identity",
          params = list(method = "auto"))
```


5000
4000
3000
2000
1000
bwt
100
150
200
250
lwt

Syntaxe ggplot

Formulation équivalente et simplifiée :

```
library(MASS)
p = ggplot(data = birthwt, aes(x = lwt, y = bwt))
p + geom_point() + geom_smooth(method = "auto")
```

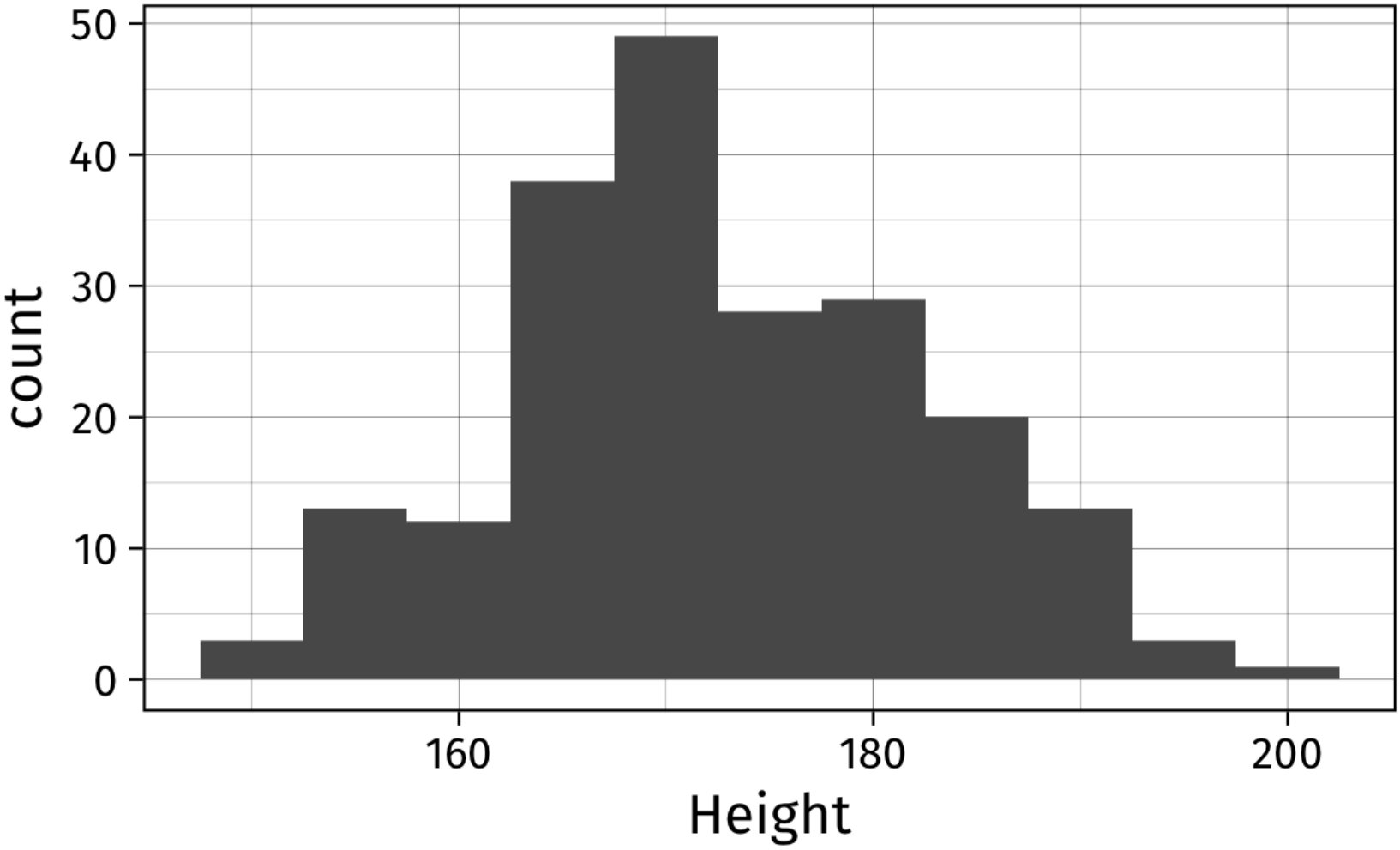
→ structure graphique (`ggplot`) et objets géométriques (`geom_*`).

Histogramme d'effectifs

`MASS::survey` = "responses of 237 Statistics I students at the University of Adelaide to a number of questions." (Venables and Ripley 2002)

12 variables : `Sex` `Wr.Hnd` `NW.Hnd` `W.Hnd` `Fold` `Pulse` `Clap` `Exer` `Smoke` `Height` `M.I` `Age`

```
p = ggplot(data = survey, aes(x = Height))
p + geom_histogram(binwidth = 5)  ## bins = 11
```

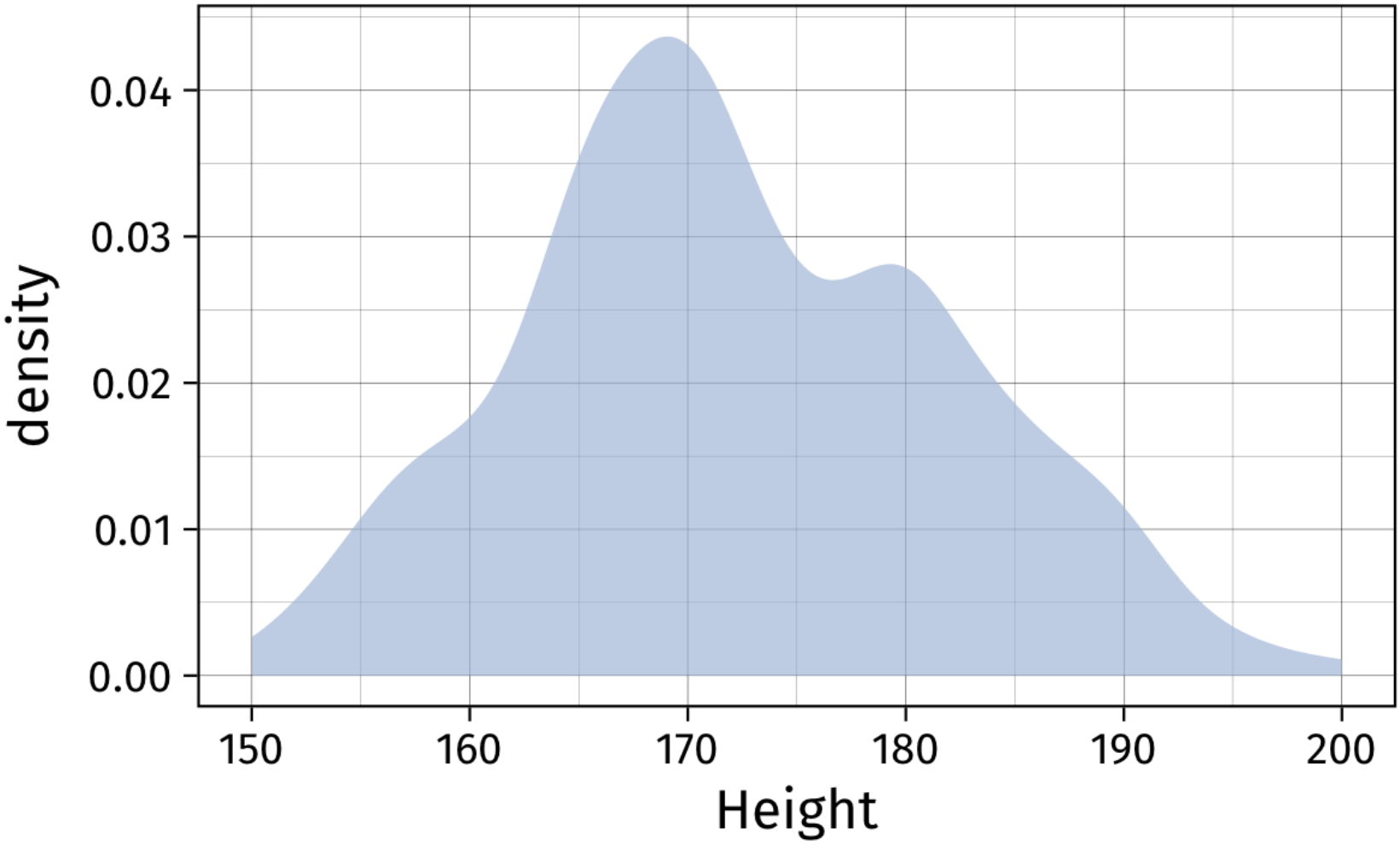

50
40
30
20
10
0
count
160
180
200
Height

Courbe de densité

```
p = ggplot(data = survey, aes(x = Height))
p + geom_density(adjust = 0.8)          ## (1)
```

On peut également construire une courbe de densité explicitement à l'aide de `geom_line()`

```
p + geom_line(stat = "density", ...)  ## (1)
```


density
0.04
0.03
0.02
0.01
0.00
150
160
170
180
190
200
Height

Estimateur

Venables and Ripley (2002), *§5.6 – Density Estimation* (pp. 126–130)

$$\hat{f}(x) = \frac{1}{nb} \sum_{j=1}^{n} K\left(\frac{x - x_j}{b}\right)$$

$x_1, \ldots, x_n$ un échantillon de taille n
$K()$ une fonction noyau fixée, par défaut gaussienne
$\hat{b} = 1.06 \min(\hat{\sigma}, \mathrm{IQR}/1.34)\, n^{-1/5}$ la largeur de la fenêtre de lissage.

Histogramme d'effectifs revisité

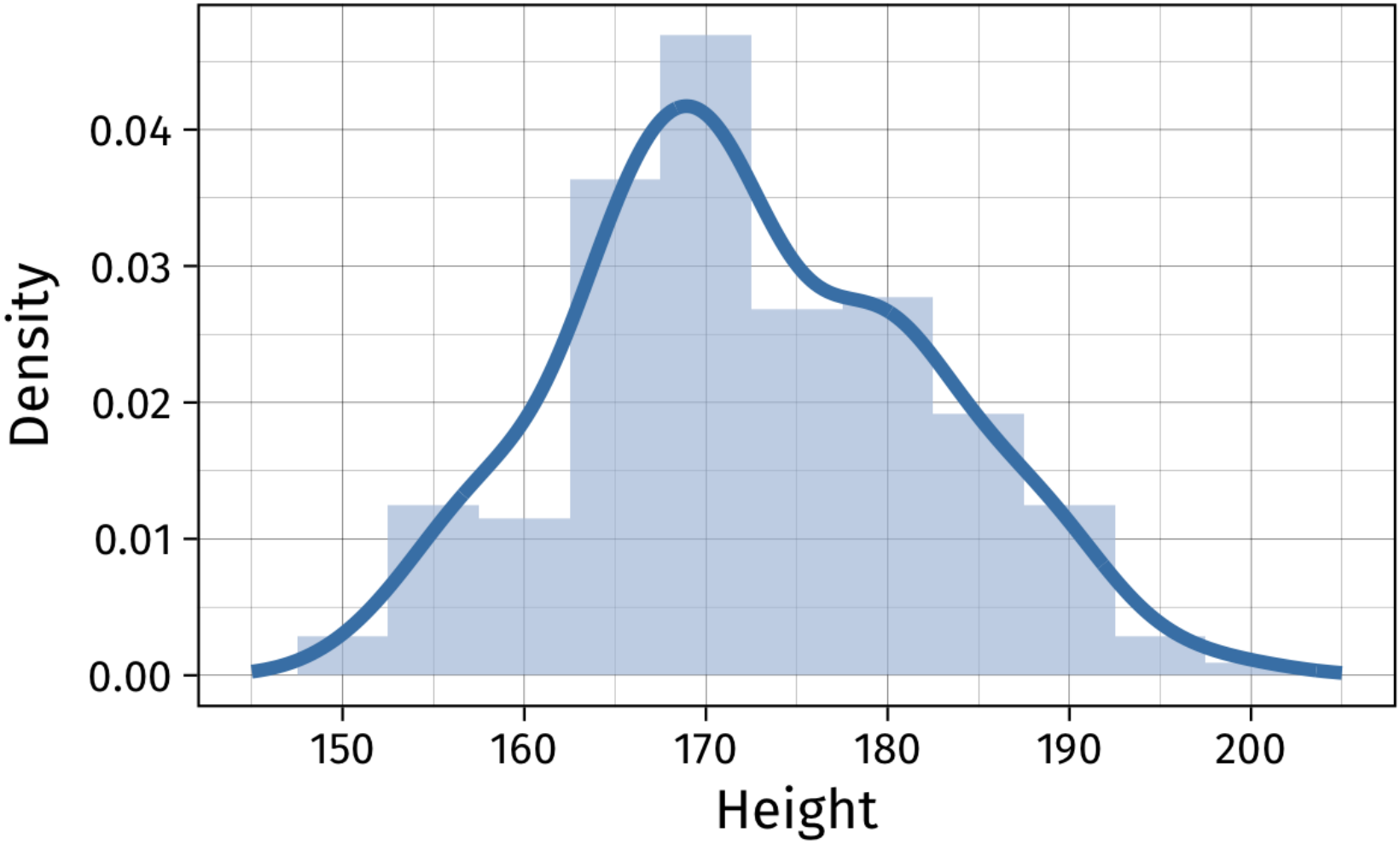


Figure 4: Distribution de la taille des répondants

- `03-graphics-figs.R`

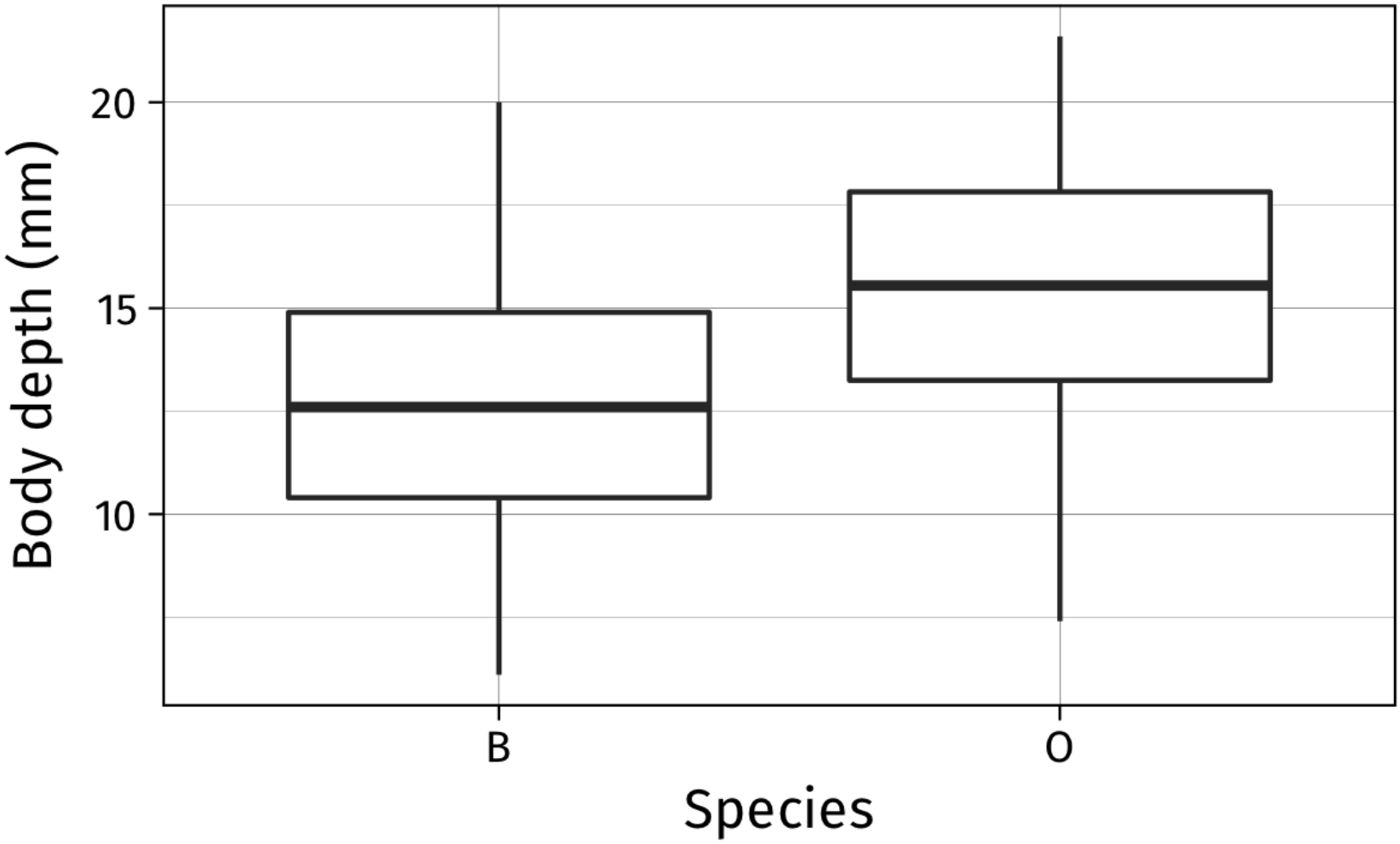
Boîte à moustaches (“boxplot”)

Un diagramme de type boîte à moustaches (Tukey 1977) fournit une représentation graphique (ou schématique) du résumé numérique renvoyé par `summary()`.

`MASS::crabs` = “morphological measurements on 50 crabs each of two colour forms and both sexes, of the species Leptograpsus variegatus collected at Fremantle, W. Australia.”

8 variables : sp sex index FL RW CL CW BD

```
> summary(crabs[["BD"]])
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
   6.10   11.40   13.90   14.03   16.60   21.60
```




```
p = ggplot(data = crabs, aes(x = sp, y = BD))
p + geom_boxplot()
```

Changement de format (large → long)

Le package `reshape2` fournit deux commandes qui permettent d'alterner entre le format large (`dcast`) et long (`melt`). Cela permet, entre autres, de travailler avec des séries de mesure multivariées.

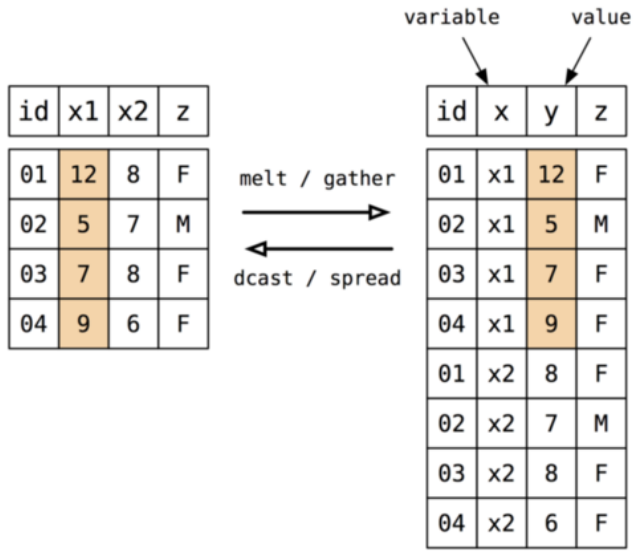
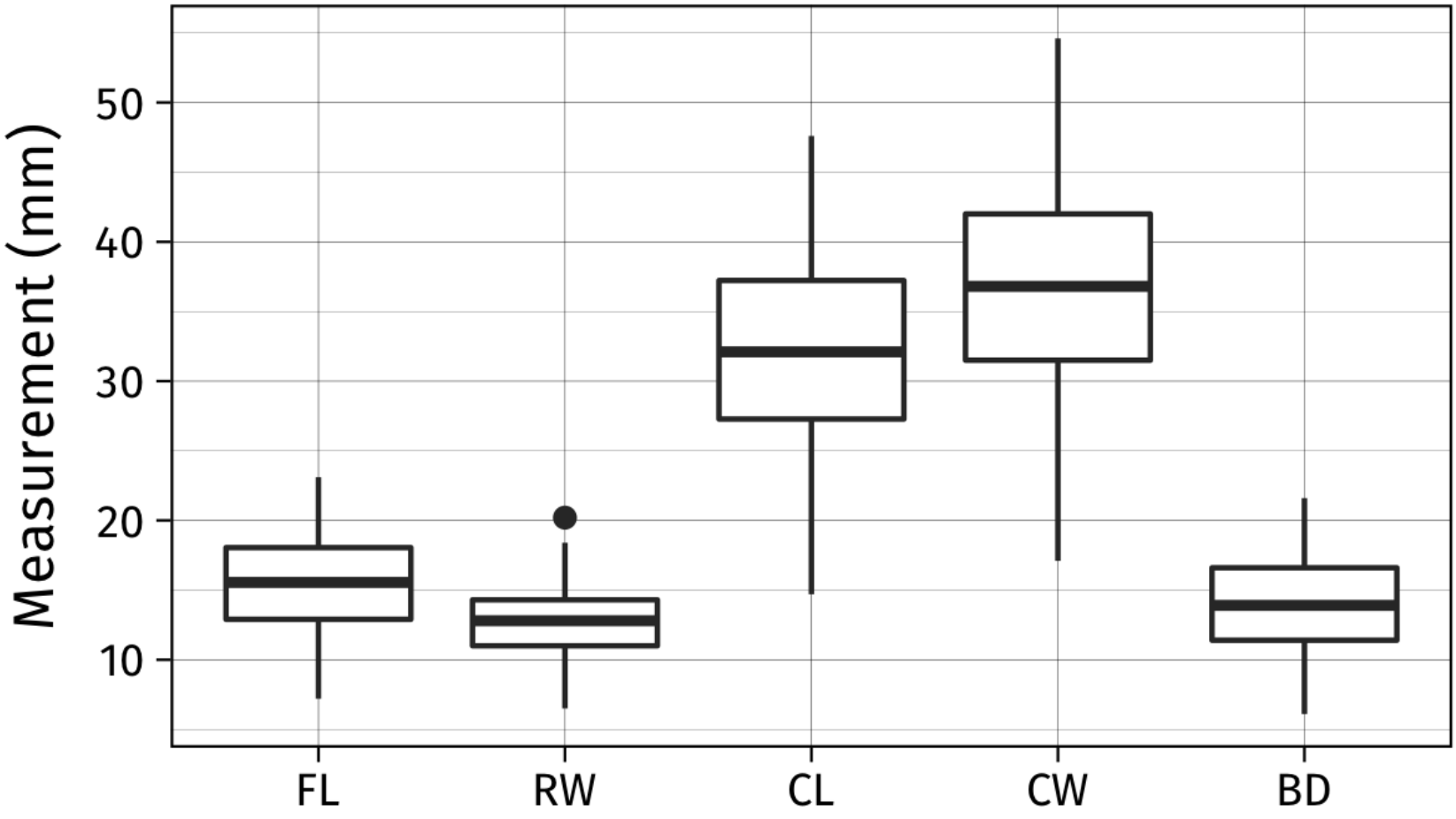


Figure 5: Représentation au format wide/long

Illustration

```
crabs.df = reshape2::melt(crabs, measure.vars = 4:8)
p = ggplot(data = crabs.df, aes(x=variable, y=value))
p = p + geom_boxplot()
```

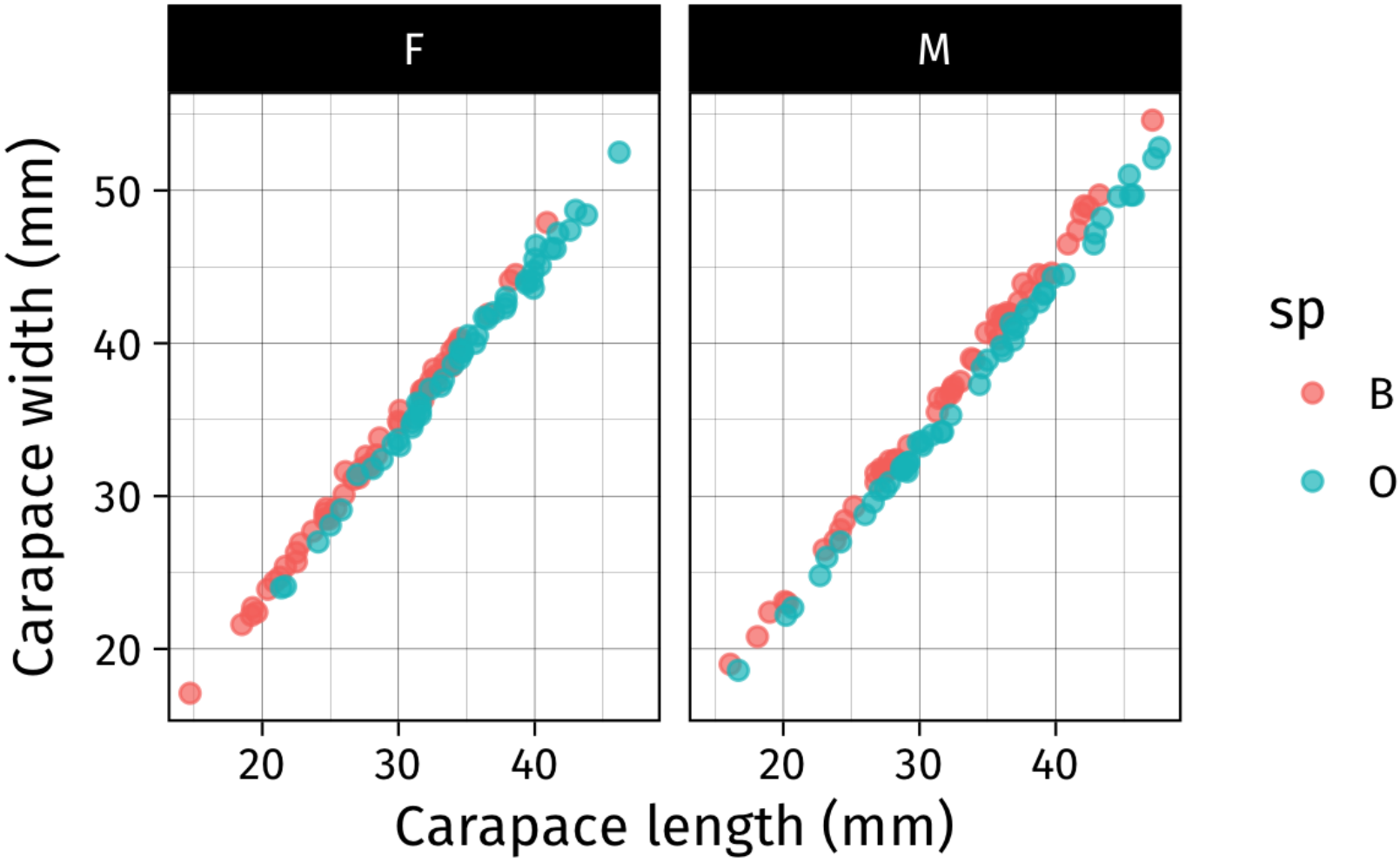


Utilisation de facettes

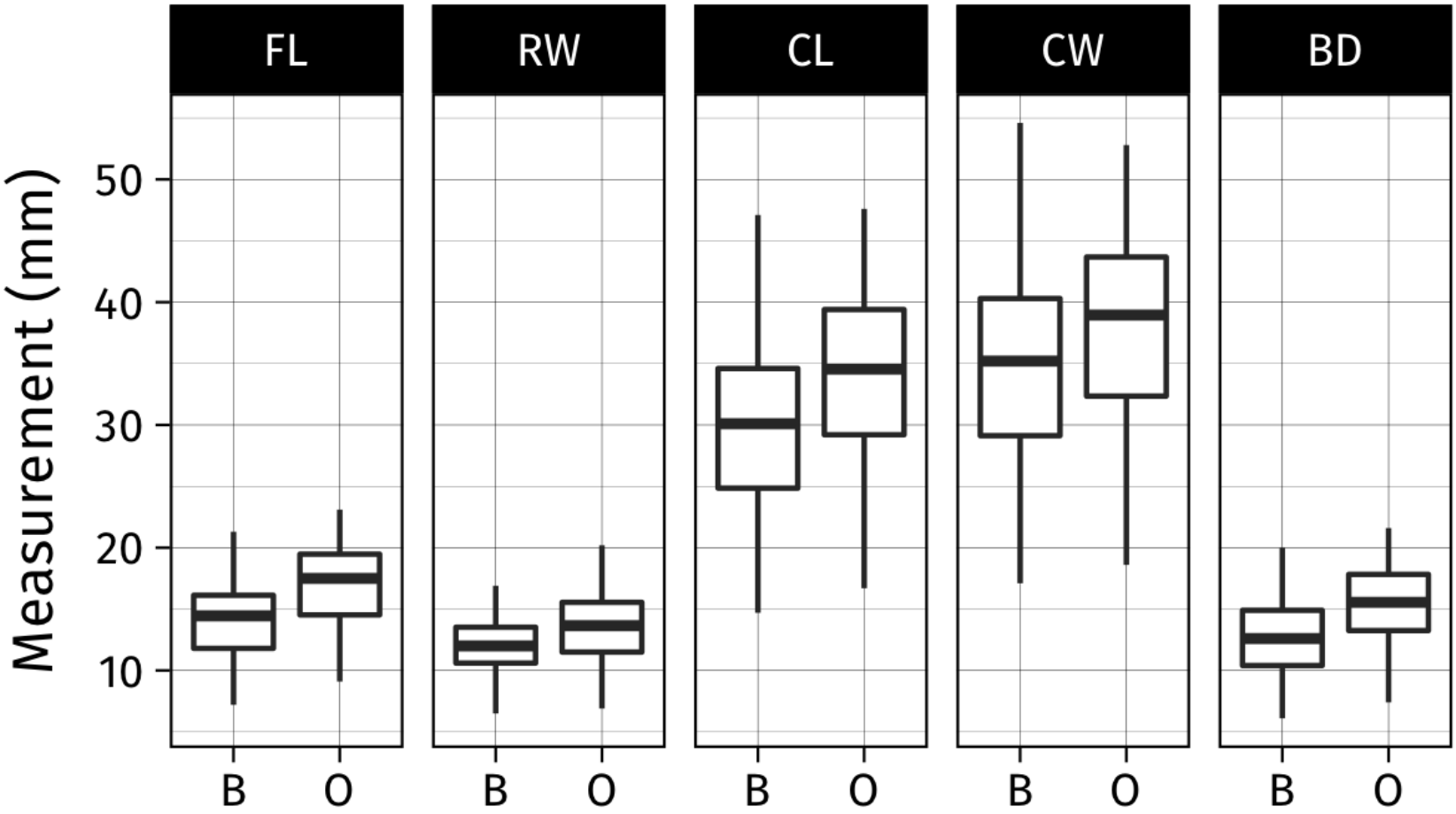
Les “facettes” permettent de prendre en considération une ou plusieurs variables de conditionnement, e.g. une relation de type `Y ~ X | Z1` ou `Y ~ X | Z1 + Z2` (Becker, Cleveland, and Shyu 1996).

Ici, `Z1` et `Z2` peuvent être de type numérique ou discret (avec niveaux ordonnés ou non). Le conditionnement peut être rendu apparent *via* des attributs propres aux objets géométriques (couleur, forme, etc.) et/ou *via* des facettes.

```
p = ggplot(data = crabs,
           aes(x = CL, y = CW, color = sp))
p = p + geom_point(alpha = .7)
p + facet_wrap(~ sex)
```


F
M
Carapace width (mm)
50
40
30
20
20
30
40
20
30
40
Carapace length (mm)
sp
B
O

```
p = ggplot(data = crabs.df, aes(x = sp, y = value))
p = p + geom_boxplot()
p + facet_grid(~ variable)
```

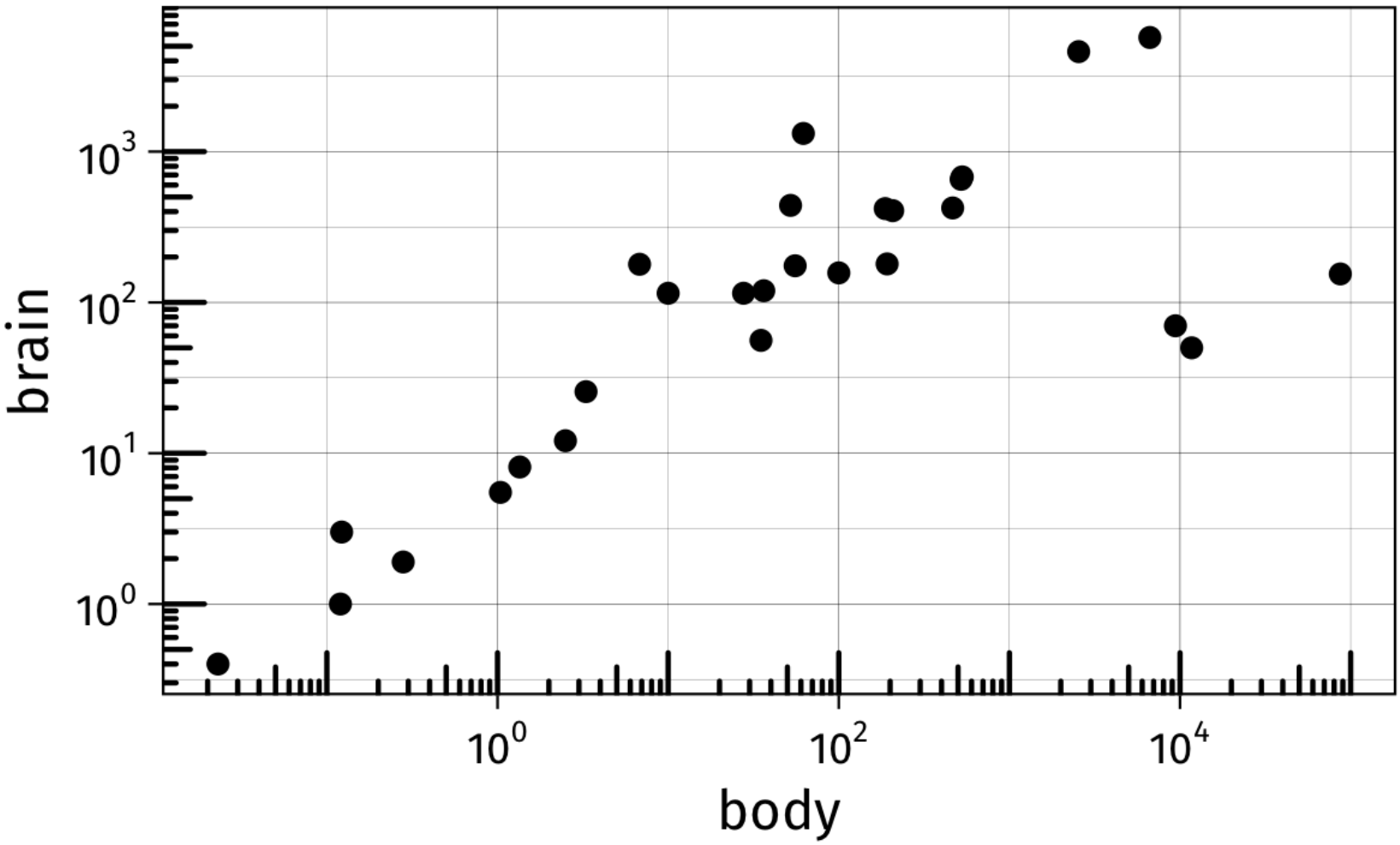


Paramètres avancés

Echelles et repères

- **type** : `scale_x_continuous(name, breaks, labels, limits =, trans =)`
- **limites** : `xlim()`, `ylim()`, `expand_limits()`, `limits =`
- **transformation** : `trans =`, `scale_y_log10()`, `coord_trans(y = "log10")`
- **format** {`scales`} : `scale_x_date(labels = date_format("%m/%d"))`, `annotation_logticks()`
- **propriétés** : `coord_flip()`, `coord_equal()`, `coord_polar()`

Illustration



http://www.sthda.com/french/wiki/ggplot2-echelle-et-transformation-des-axes-logiciel-r-et-visualisation-de-donnees

Changement de repère

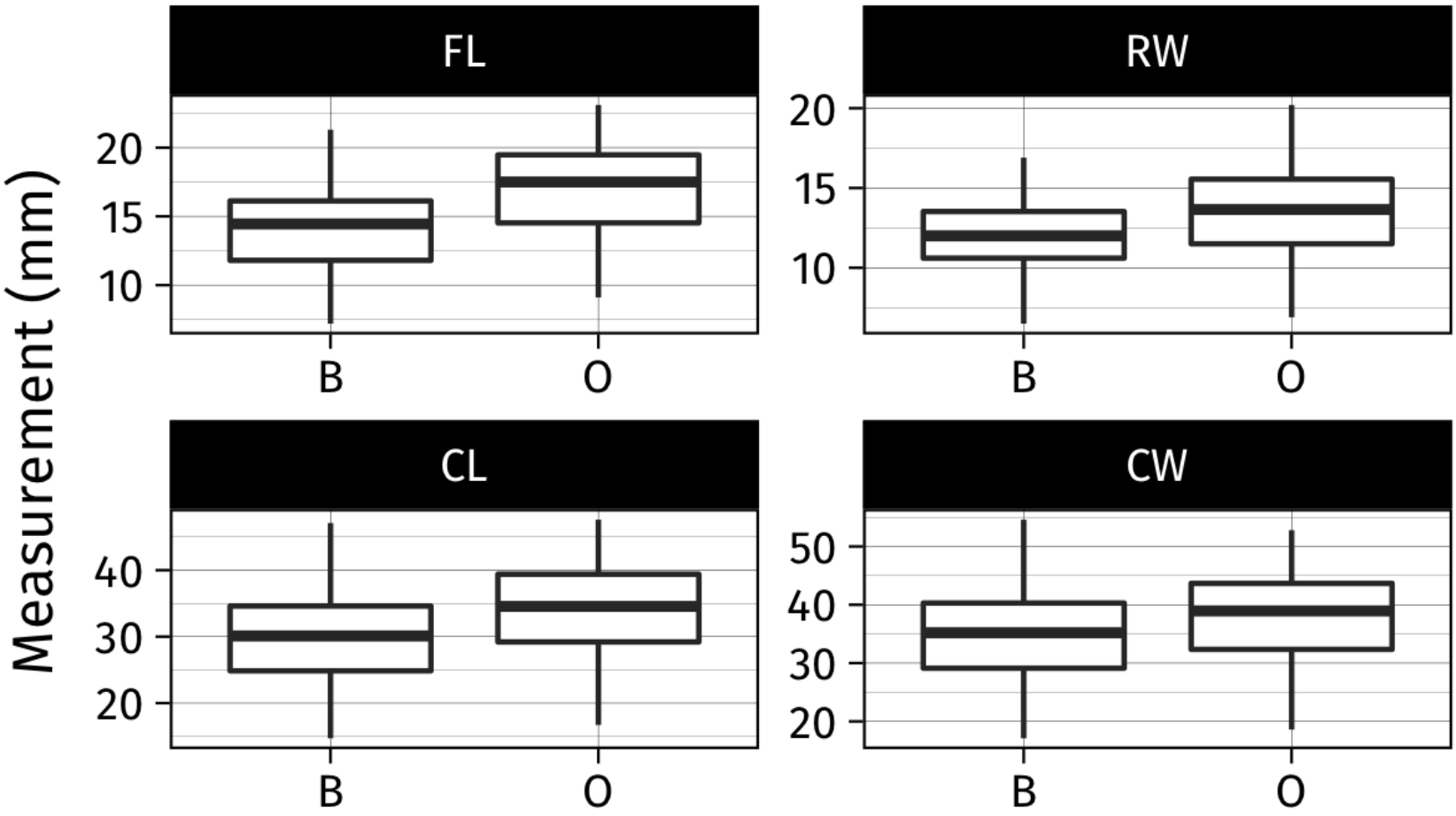
Sans toucher au mapping (`aes()`) définissant le rôle joué par les variables, il est possible d'échanger les axes du repère cartésien :

```
p = ggplot(data = crabs.df,
           aes(x = variable, y = value))
p + geom_boxplot()
```

```
p = ggplot(data = crabs.df,
           aes(x = variable, y = value))
p = p + geom_boxplot()
p + coord_flip()
```

Cas des facettes “libres”

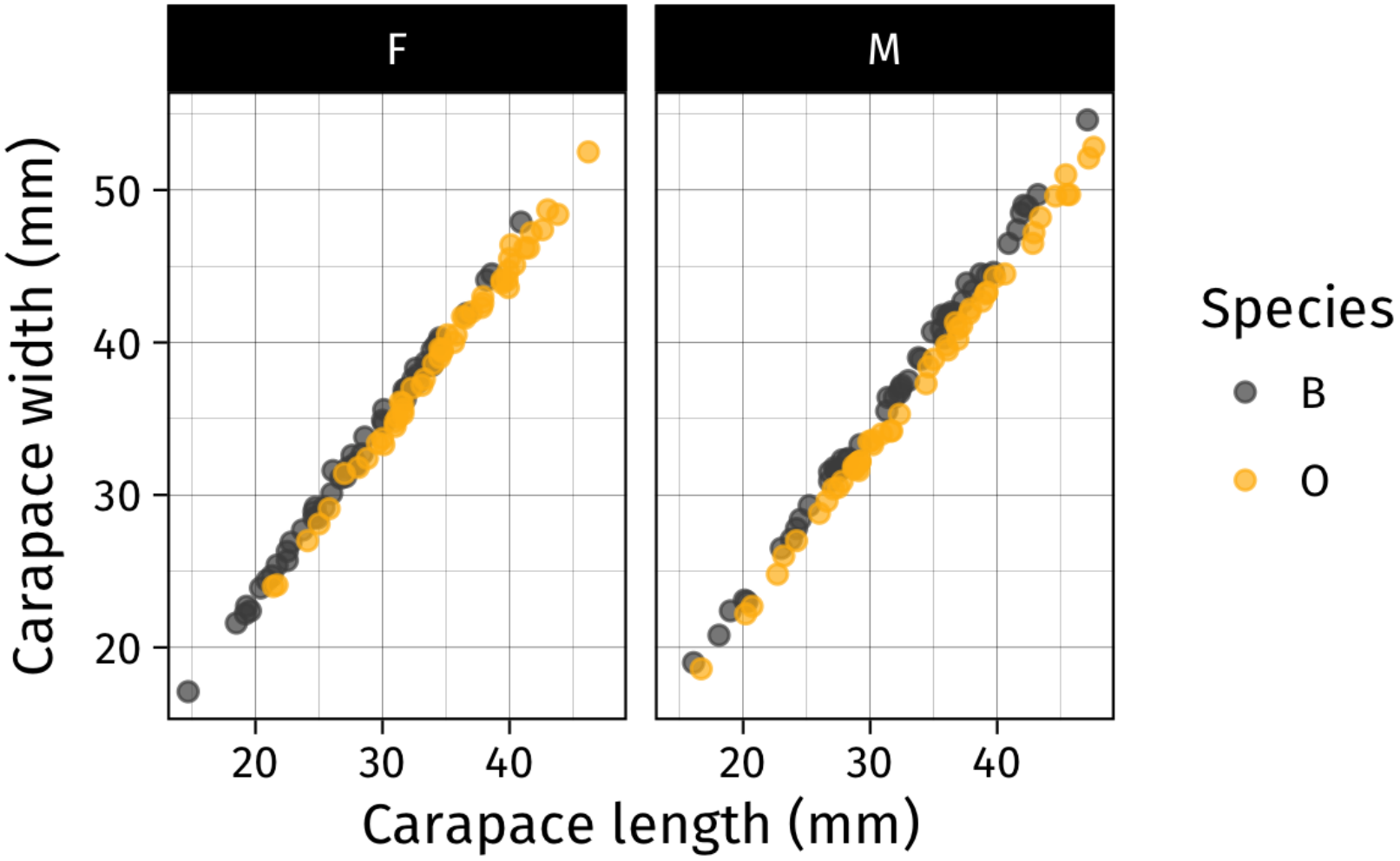
```
p = ggplot(data = subset(crabs.df, variable != "BD"),
           aes(x = sp, y = value))
p = p + geom_boxplot()
p + facet_wrap(~ variable, nrow = 2, scales = "free")
```



Palettes “divergente” de couleurs

```
p = ggplot(data = crabs,
           aes(x = CL, y = CW, color = sp))
p = p + geom_point(alpha = .7)
p = p + scale_color_manual("Species",
          values = c(grey(.3),
                     "darkgoldenrod1"))      ## (1)
p = p + facet_wrap(~ sex)
```

```
p + scale_color_brewer(palette = "Pastel1")  ## (1)
```

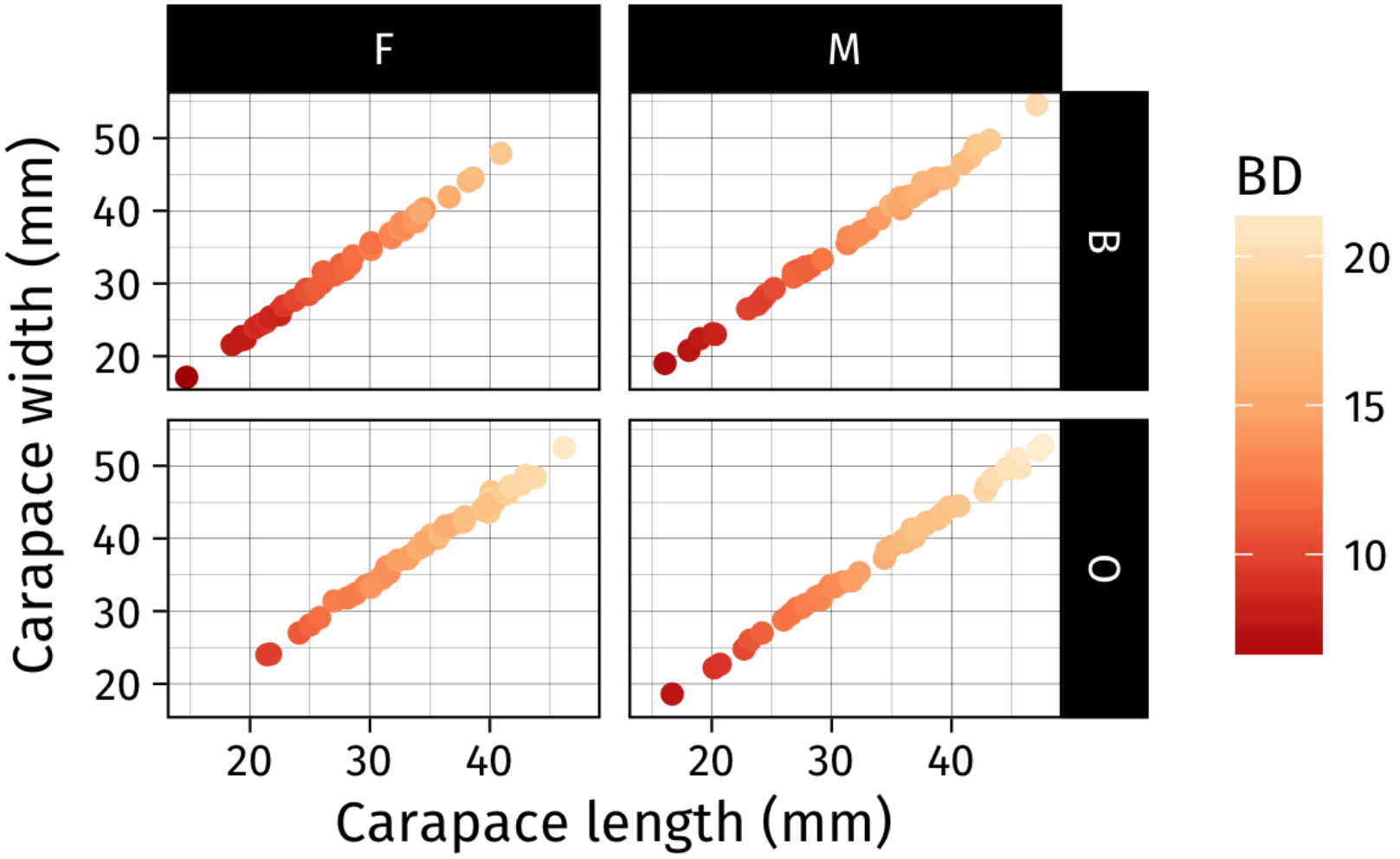

F
M
Carapace width (mm)
50
40
30
20
20
30
40
20
30
40
Carapace length (mm)
Species
B
O

Palette séquentielle (cas continu)

- http://colorbrewer2.org
- http://hclwizard.org
- pour une discussion, voir Zeileis, Hornik, and Murrell (2009)

```
p = ggplot(data = crabs,
           aes(x = CL, y = CW, color = BD))
p = p + geom_point()
p = p + scale_color_distiller(palette = "OrRd") ## (1)
p = p + facet_grid(sp ~ sex)
```

```
p <- p + scale_color_gradient()                  ## (1)
```


F
M
B
O
Carapace width (mm)
Carapace length (mm)
20
30
40
50
BD
20
15
10

Thèmes graphiques

- 8 thèmes de base, `ggplot2::theme_*`
- ggthemes, ggthemr, hrbrthemes

À partir d'un thème de base, il est toujours possible de redéfinir soi-même certains éléments du thème.

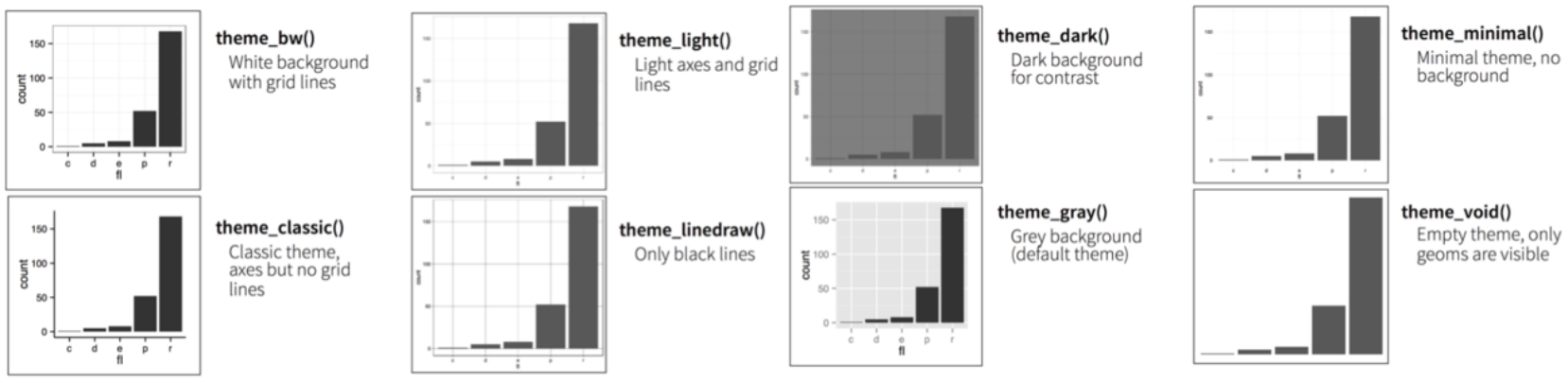


Figure 6: Thèmes de base ggplot. Adapté de Wickham and Grolemund (2017), *§3 – Data visualisation*

Graphiques interactifs

Le package ggvis

http://ggvis.rstudio.com

- basé sur Vega (projets connexes @ UW Interactive Data Lab, e.g. Wongsuphasawat et al. (2016))
- intégration à RStudio (“Viewer”)
- fonctionnalités plus limitées que `ggplot2`, mais dans l’esprit de l’approche Shiny

Similarité avec ggplot

chaînage des couches (`layer`) avec + *versus* {dplyr} %>% :

```
ggplot(data = birthwt, aes(x = lwt, y = bwt)) +
  geom_point() +
  geom_smooth(method = "auto")
```

```
ggvis(data = birthwt, ~ lwt, ~ bwt) %>%
  layer_points() %>%
  layer_smooths()
```

Interactivité

```
ggvis(data = birthwt, ~ lwt, ~ bwt) %>%
  layer_points(fill := "cornflowerblue") %>%
  layer_smooths(span = input_slider(0.5, 1.5,
                                    value = 1))
```

```
ggvis(data = survey, x = ~ Height) %>%
  layer_densities(adjust = input_slider(0.1, 2,
                                        value = 1,
                                        step = 0.1))
```

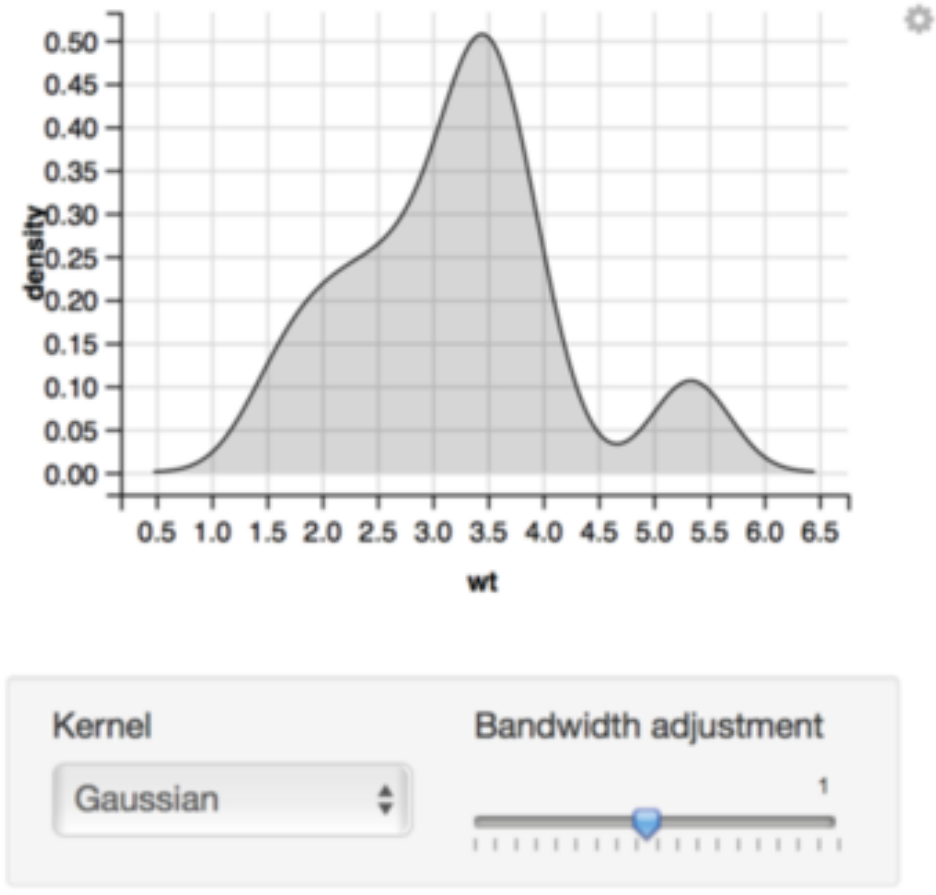


Figure 7: Exemple de graphique interactif avec ggvis

plotly

Basé sur plotly.js, le package `plotly` permet de construire des graphiques interactifs ou d'embarquer directement des graphiques ggplot, publiables sur https://plot.ly.

```
library(plotly)
p = ggplot(data = birthwt, aes(x = lwt, y = bwt)) +
      geom_point() +
      geom_smooth(method = "auto")
ggplotly(p)
```

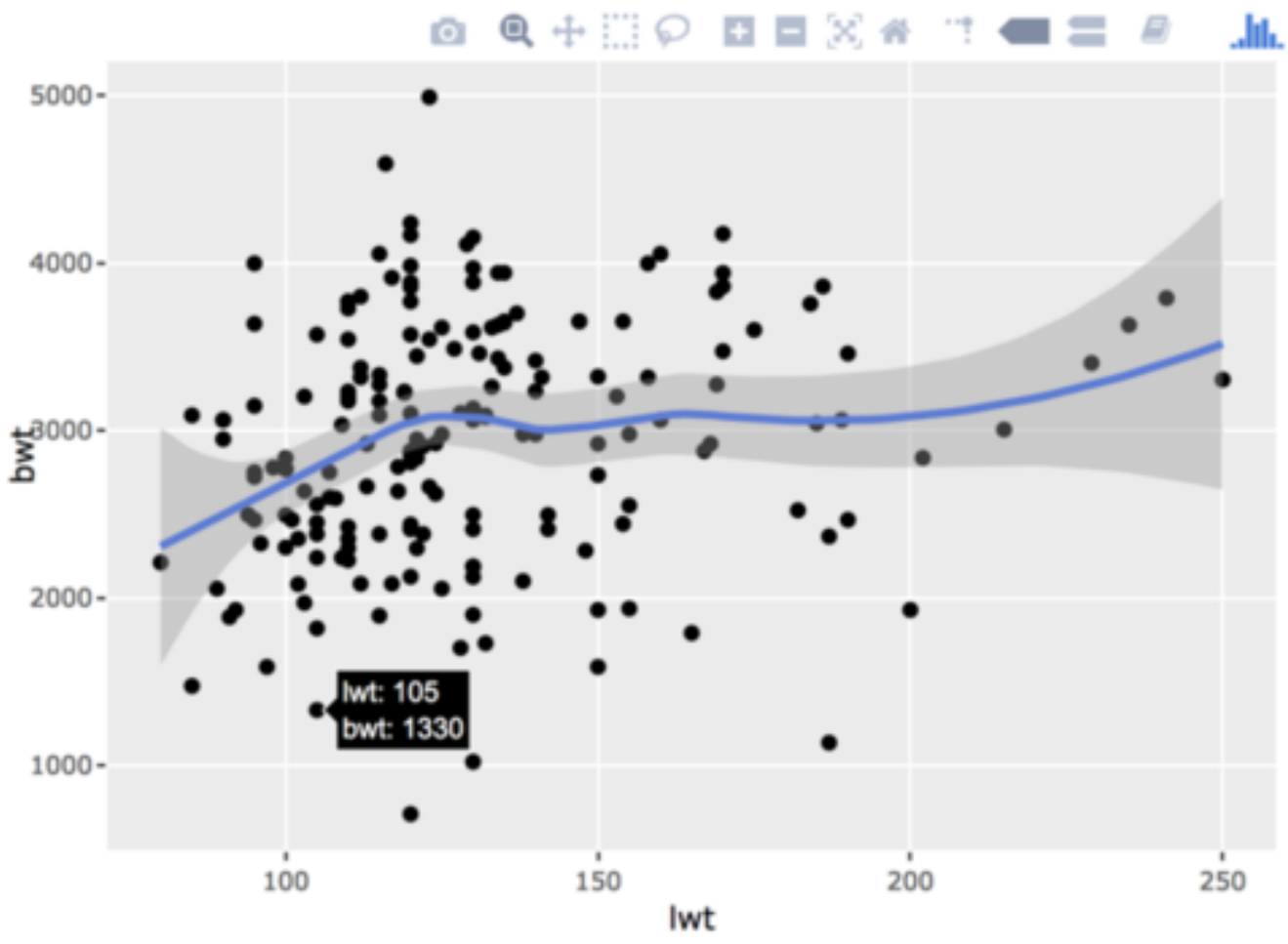


Figure 8: Exemple de graphique interactif avec ggplotly

Visual vocabulary

Designing with data

There are so many ways to visualise data - how do we know which one to pick? Use the categories across the top to decide which data relationship is most important in your story, then look at the different types of chart within the category to form some initial ideas about what might work best. This list is not meant to be exhaustive, nor a wizard, but is a useful starting point for making informative and meaningful data visualisations.

ft.com/vocabulary

FT

http://ft.com/vocabulary

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Tukey, J. W. 1977. *Exploratory Data Analysis*. Addison-Wesley.

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Wilkinson, Leland. 2005. *The Grammar of Graphics*. Springer.

Wongsuphasawat, K., D. Moritz, A. Anand, J. Mackinlay, B. Howe, and J. Heer. 2016. "Voyager: Exploratory Analysis via Faceted Browsing of Visualization Recommendations." *IEEE Trans. Visualization & Comp. Graphics (Proc. InfoVis)*. http://idl.cs.washington.edu/papers/voyager.

Zeileis, A., K. Hornik, and P. Murrell. 2009. "Escaping RGBland: Selecting Colors for Statistical Graphics." *Computational Statistics & Data Analysis* 53 (9):3259–70. https://doi.org/10.1016/j.csda.2008.11.033.