

Bachelor's / Master's Thesis

## **Thesis title**

submitted by

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Matriculation number: 1234567

Degree program: Biology

submitted on 1. April 2000

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2. Advisor: Prof. Dr.

# **Abstract**

The abstract comes always first and should raise the readers interest in reading further.

The abstract summarizes, usually in one or two paragraph (here max. 1 page), the major aspects of the entire thesis in a prescribed sequence. This should include:

- the overall purpose of the study and the research problem(s) you investigated
- the basic design of the study
- the major findings or trends found as a result of your analysis
- a brief summary of your interpretations and conclusions.

## **Zusammenfassung**

The thesis should always provide a German summary after the abstract, independent of the language of the main sections. Its content should not deviate from the abstract.

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## List of Abbreviations

You can provide a table of abbreviations in R Markdown syntax or  $\text{\LaTeX}$  syntax. But if you do the former, R will count this table and, consequently, the next actual table will start with the counter 2:

ATP	Adenosine Triphosphate
CoA	Coenzyme A
DNA	Deoxyribonucleic Acid
mtDNA	Mitochondrial DNA

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## Settings in the YAML Header

This section provides an overview of the options and settings in the YAML (*YAML Ain't Markup Language*) header. You can delete this section later.

- This .Rmd file is the actual R Markdown file, which needs to be knitted to render the entire thesis. It is important that you name this file `index.Rmd`, otherwise you'll run into an error. All other .Rmd file in this thesis folder (i.e. all the prelim and chapter files) **should not** be knitted!
- In the above YAML header (which none of the other .Rmd file have) all necessary settings are made including some dummy text for the title page, which you need to adjust to your thesis. Please note that if you run into knitting problems, spacing in the YAML header might be the cause.
- The list of references you cite in your thesis can either be copied into the “bib/references.bib” file, which is provided above as default bibliography or you replace this file name with your own file(s). The reference style can be defined by providing a .csl file. This template uses the **SAGE Harvard** reference style, provided by the “bib/sage-harvard.csl” file. But you can replace this style file with any other .csl file. For more information see also [Citation and reference list].
- Hyperlinks: you can change the default colors for internal links (incl. ToC), external links, citation links, and linked URLs by adding the YAML fields `linkcolor`, `filecolor`, `citecolor`, or `urlcolor` and providing the name of a LaTeX color, e.g. `linkcolor: red`.
- The actual function to create this thesis is `UHHformats::pdf_thesis_en` and should be provided at the end:

output:

```
UHHformats::pdf_thesis_en:
  toc: true
  toc_depth: 5
  highlight: default
  citation_package: natbib
```

The default settings of `toc`, `toc_depth`, `highlight` and `citation_package` are shown here but don't have to be set in the YAML header unless you want to change them. As `UHHformats::pdf_thesis_en` is based on the `bookdown::pdf_book` function, see its help page for more options.

The content of the section *Abstract*, *Zusammenfassung*, and *List of Abbreviations* has to be provided in individual .Rmd files located in the folder `prelim/`, i.e.

- `00-abstract.Rmd`

- 00-zusammenfassung.Rmd
- 00-abbreviations.Rmd

All other chapters have their own .Rmd file within the `chapter/` folder:

- 01-intro.Rmd
- 02-methods.Rmd
- 03-results.Rmd
- 04-discussion.Rmd
- 96-references.Rmd
- 97-appendix.Rmd
- 98-acknowledge.Rmd
- 99-declaration.Rmd

The order of all sections and chapters is determined in the `_bookdown.yml` file. If you want to add more chapters, simply create a new .Rmd file in the `chapter/` folder following the same naming convention as the other files and add its filename to the `_bookdown.yml` file.

If you want to learn more on how to modify this template or about PDF books made with `bookdown` (which is the basis for this template) in general, I highly recommend the online book [bookdown: Authoring Books and Technical Documents with R Markdown!](#)

# 1 Introduction

The Bachelor and Master thesis can be written in German or English. The number of pages should correspond to the workload of the Bachelor (12LP) or Master (30LP) thesis (if necessary, consult your supervisor). The thesis is to be submitted in triplicate (bound; no spiral binding) and as a PDF file on two CD-ROMs (flexible CD cover) to the Academic Office (in time!)

## 1.1 Thesis structure and format

The thesis should consist of the following sections, which have already been outlined in this template:

1. **Title page** [is created automatically via the YAML header]
2. **Summary** in English (i.e., the **Abstract**) and German [see files in the `prelim/` folder].
3. **Table of Contents** [is created automatically here]
4. **List of Abbreviations** (optional) [see file in `prelim/` folder].
5. **List of Tables** and **List of Figures** (optional) [will be created automatically if YAML header `lot: true` and `lof: true` stops]
6. **Introduction** [see file in the `chapter/` folder].
7. **Material and Methods** [see file in the `chapter/` folder].

8. **Results** [see file in the `chapter/ folder`].
9. **Discussion** [see file in the `chapter/ folder`]
10. **References** [the corresponding `.bib` file with the individual references must be specified in the YAML header].
11. **Appendix** (optional) [see file in the `chapter/ folder`].
12. **Acknowledgement** (optional) [see file in `chapter/ folder`].
13. **Declaration of Authorship** (obligatory) - don't forget date and signature here [see file in `chapter/ folder`]

The following format should be followed: Font size 12 Times New Roman, line spacing 1.5, page margins each 2.5cm, upper margin 2.5cm, lower margin 2.0cm. This is already defined in this template so you don't have to bother with!

## 1.2 Content of the introduction

The introduction consists of the problem definition, its relevance as well as the objectives and structure of the work. The introduction should start more broadly and then move to the more specific topics of your study. The following questions should be answered in brief form:

- What is the general topic?
- What is the specific question of the work, what is the goal? Why is the question important?
- How was the question dealt with in the literature so far?
- Which hypothesis is tested in the present work?
- How is the following text structured? (chain of argumentation, subproblems)

## 1.3 Literature

The selection and use of relevant academic literature is an important part of any thesis and scientific publication.

### 1.3.1 Literature research

When searching for literature, it is recommended to start with the given introductory literature and the references cited therein. Many titles can be easily searched and found via **Web of Science** or **Google Scholar**. The number of citations can provide a useful indication of the relevance of a certain publication. Note, that the Web of Science database can only be accessed from the university or from home via a **VPN** client.

Important literature sources are

1. reference books, standards
2. scientific articles

3. conference proceedings
4. university theses
5. technical reports, grey literature
6. online material

Further important literature databases in biology are among others

- the **Electronic Journals Library of the University of Hamburg** (ECB)
- the **Digital Library** of the Departmental Library of the UHH Biology
- the **Virtual Library of Biology** (vifabio) of the **University Library Johann Christian Senckenberg**
- the catalogues and databases listed in vifabio: <http://www.vifabio.de/howto/info/icatalogs.html>
- **ScienceDirect**

### 1.3.2 Citation and bibliography

The following applies to all scientific work: Wherever possible, reference should be made to other relevant publications instead of reproducing their content. A references must be given for all statements and representations that originate from publications. Whenever content from external sources is paraphrased or literally interpreted, the source must be indicated at the text passage. It is not sufficient to include the source in the bibliography. Literal interpretations are to be put in quotation marks.

The program BibTeX is used here to create the bibliography. The advantage of BibTeX or any other literature database is that all citations and source references in the entire document are automatically detected and assigned to the corresponding reference in the literature database. The .bib file referred to in the YAML header represents this literature database. The file is a so-called plain-text file, which contains bibliographic entries in the following form

```
@article{May1976,
  author = {May, R. M.},
  title = {Simple mathematical models with very
    complicated dynamics},
  journal = {Nature},
  volume = {261},
  number = {5560},
  pages = {459-467},
  ISSN = {0028-0836},
  DOI = {10.1038/261459a0},
  url = {<Go to ISI>://WOS:A1976BT72500018},
  year = {1976},
```

```
type = {Journal Article}
}
```

A single entry always starts with `@type{`, where the `type` can be an `article`, `book`, `manual`, `techreport`, `inproceedings`, `phdthesis` or `misc` (for e.g. multimedia types, computer programs). More information about the possible types as well as the individual fields such as `author`, `title`, etc. can be found at <https://de.wikipedia.org/wiki/BibTeX>. After the type and the curly opening bracket comes the “citation key”. To cite one of these entries or references the `@` character is followed by this key, e.g.

- `@May1976` → becomes May (1976)
- `[@May1976]` → becomes (May, 1976)

Note, when placing the citation key inside of square brackets, the name of the author appears in the round brackets together with the year.

In the R Markdown file, for example, you would write “`@May1976` could show that simple population models can trigger complex chaotic dynamics”, which is translated in the PDF/LaTeX document to “May (1976) could show ...”. All references automatically get a hyperlink to the bibliography. If this is not desired, add `link-citation: false` to the YAML header.

Multiple cited references are separated with a semicolon, e.g. (Kamm, 2000; May, 1976; Post and Forchhammer, 2002).

The formatting of the bibliography is variable. The BibTeX style set in the document determines which information is displayed in which format. The style is defined in the YAML header via the `.csl` file. CSL stands for *Citation Style Language* and is an open XML-based language to describe the formatting of citations and bibliographies. Instead of the current **SAGE Harvard** style any other style can be used by replacing the `.csl` file in the YAML header. There is a repository on GitHub that provides a variety of `.csl` files for the different styles: <https://github.com/citation-style-language/styles>.

To facilitate the organization, sharing, and citation of scientific articles and PDF documents in this thesis as well as future research projects, it is recommended to use a literature management program or reference manager such as **Mendeley** or **Zotero** from the beginning. These programs easily create the needed `.bib` file for this thesis or other publications.

There is also the package `[citr]` (<https://github.com/crsh/citr>) which I highly recommend: `citr` provides functions and an RStudio add-in to search a BibTeX-file to create and insert formatted Markdown citations into the current document. If you are using Zotero the add-in can access your reference database directly.

## 2 Material and Methods

The structure of this chapter depends very much on the type of research study, whether it is a field, laboratory or modelling study or a literature review. For field studies, the typical subsections are the

- study site
- experimental set-up
- sampling design
- statistical analysis with information on the used computer program<sup>1</sup>

### 2.1 Study site

If you want to add external images here, e.g. to show the sampling site as in Fig. 1, use the `knitr::include_graphics()` function:



**Figure 1:** Location of sampling site....

### 2.2 Cross-references

External images and R figures can be referenced with `\@ref(fig:<label>)`, where `<label>` is the name of the code chunk (in the above example its *location*). These label names should **not contain underscores** to separate words, use hyphens here instead. Note that figures need to have a caption to be numbered and for cross-referencing, The caption is also set in the chunk option with `fig.cap='Your caption'`.

Cross-references to individual sections can simply be made by placing the name of the section into squared brackets, e.g. a link to the [Discussion](#) is made via `[Discussion]`.

Tables require also a label and table caption for cross-referencing as figures. But here, the cross-reference contains a `tab:` in `\@ref(tab:<name>)` instead of a `fig:`. Also, captions of

---

<sup>1</sup> such as **R** - this is an example of a footnote

tables produced with R cannot be set in the chunk options as for figures but in the R functions directly (see examples in the [Results](#)).

This is for example a cross-reference to table 2 in the [Using the knitr and kableExtra packages](#) chapter.

**Important note:** Labels for tables produced with R Markdown syntax have to be set with  $\LaTeX$  notation, hence, the cross-reference has to be also in  $\LaTeX$  (see for an example [R Markdown table](#)).

## 2.3 Formulas

Use mathematics in R Markdown as usual using the dollar sign  $\$$ ; either in **inline mode** with one dollar sign  $E = mc^2$  or in **display mode** with two  $\$$ :

$$E = mc^2$$

Important to note: do not leave a space between the  $\$$  and your mathematical notation.

Alternatively, you can use  $\LaTeX$  for more control and when equations are more complicated.  $\LaTeX$  equations are also automatically numbered, which is useful if you have many equations and want to cross-reference them (note: if you set a star after the `\{equation*`, as in the last equation, the number is suppressed). The equation label needs to be written in  $\LaTeX$  with `\label{eq:label}`, which follows the `\begin{equation}` element (see eq. (1)):

$$\bar{X} = \frac{\sum_{i=1}^n X_i}{n} \tag{1}$$

Formulas and corresponding explanations should be integrated into the sentence and, thus, end with a comma or period. Here comes an example:

If the random variable  $Y$  follows a standard normal distribution, i.e.  $Y \sim N(0, 1)$ , it's density function can be described with

$$f_Y(y) = \varphi(y) \stackrel{\text{def}}{=} \frac{1}{\sqrt{2\pi}} \exp\left\{-\frac{y^2}{2}\right\}, y \in \mathbb{R}. \tag{2}$$

$\pi$  represents the circle number or Ludolph's number. The function

$$F_Y(y) = \Phi(y) \stackrel{\text{def}}{=} \int_{-\infty}^y \varphi(x) \, dx, \quad y \in \mathbb{R},$$

represents then the distribution function of (2).

## 3 Results

The result chapter is of great importance in an empirical study and should comprise a good mix of text, tables and figures. Use your research questions and hypothesis for structuring this chapter to provide the reader some structure and to not lose the thread.

Figures and tables should be continuously numbered and referred to in the main text.  $\text{\LaTeX}$  places figures and tables automatically where they fit best, which is sometimes on the next page. This is fine since they are cross-referenced anyway.

Tables have generally a caption at the top, while figures have a caption at the bottom. This has to be considered in some of the R functions (see below).

## 3.1 Tables

### 3.1.1 R Markdown table

Table 1 is a R Markdown table including a caption and label for cross-referencing. The caption is set with `Table: . . .` and can come before or after the table. You do not need to set a number as  $\text{\LaTeX}$  will care of the numbering as well as the placing. Also note that the caption requires no quotation marks.

The label is set **right after** the table caption with `\label{tab:name}`. **Note here** that this is  $\text{\LaTeX}$  notation, where brackets are **curly**, not round! Also when cross-referencing R Markdown tables use the  $\text{\LaTeX}$  notation `\ref{tab:name}` (i.e., no @ and curly brackets).

**Table 1:** This is a table written in R Markdown.

A	New	Table
left-aligned	center-aligned	right-aligned
\$123	\$456	\$789
<i>italics</i>	normal	<b>boldface</b>

### 3.1.2 Tables generated with R

#### 3.1.2.1 Using the `knitr` and `kableExtra` packages

Table 2 is an example when using `knitr::kable` to generate the table and `kableExtra` to modify it. `knitr::kable()` has an explicit argument named `caption` where you can place your caption text.



**Table 2:** This is a table produced with knitr and modified with kableextra.

	Group 5				Group 6	
	Group 1		Group 2		Group 3	Group 4
	mpg	cyl	disp	hp	drat	wt
Mazda RX4	21.0	6	160	110	3.90	2.620
Mazda RX4 Wag	21.0	6	160	110	3.90	2.875
Datsun 710	22.8	4	108	93	3.85	2.320
Hornet 4 Drive	21.4	6	258	110	3.08	3.215
Hornet Sportabout	18.7	8	360	175	3.15	3.440

*Note:*

Your comments go here.

### 3.1.2.2 The `xtable` package

`xtable` has become increasingly popular but is not as easy to use as `knitr::kable`. For instance, when using the default settings the table caption is placed *below* the table (see Table 3). Also, the label for cross-referencing has to be set inside the `xtable::xtable` function instead of the code chunk. And if you don't write `results='asis'` inside the chunk options, you get the  $\text{\LaTeX}$ code for the table instead of the actual table in your PDF output file! The

	speed	dist
1	4.00	2.00
2	4.00	10.00
3	7.00	4.00
4	7.00	22.00
5	8.00	16.00
6	9.00	10.00

**Table 3:** This is a table made with 'xtable'.

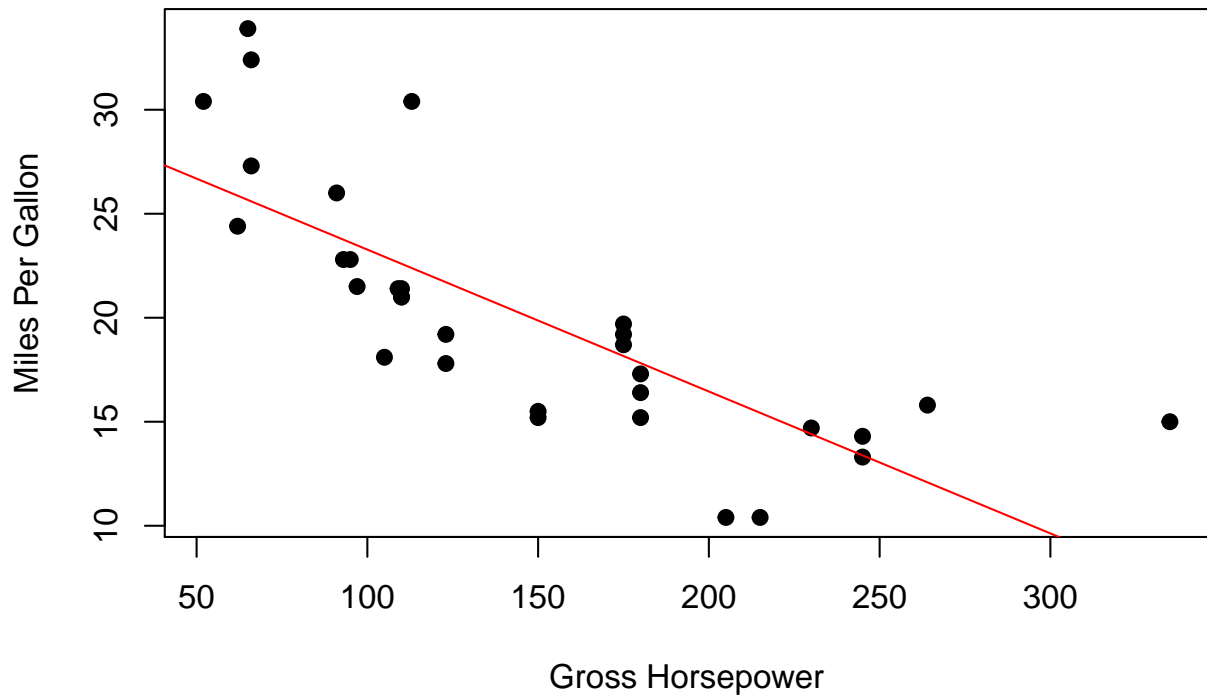
advantage of the `xtable` package for the advanced  $\text{\LaTeX}$ user is that  $\text{\LaTeX}$ code can directly be incorporated (see Table 4), and also the `xtable::print.xtable` function allows various additional settings.

## 3.2 Figures

Figures can directly be produced with R and displayed here. Similar to external images, figure captions and labels are placed inside the chunk options for cross-referencing (see Figure 2).

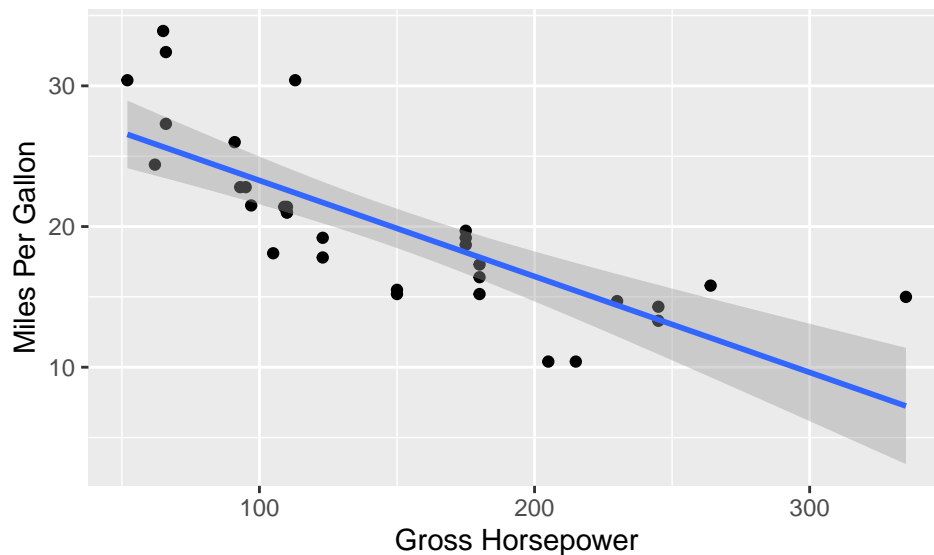
**Table 4:** This is a table made with 'xtable' and modified with LaTeX Code and the print.xtable function.

	mpg	cyl	disp	hp	drat	wt
<i>Mazda RX4</i>	21.00	6.00	160.00	110.00	3.90	2.62
<i>Mazda RX4 Wag</i>	21.00	6.00	160.00	110.00	3.90	2.88
<i>Datsun 710</i>	22.80	4.00	108.00	93.00	3.85	2.32



**Figure 2:** Relationship between horsepower and fuel economy

Purely for demonstration purposes, figure 3 shows the same relationship but with `ggplot2` (automatically loaded with `tidyverse`) and in a different figure size.



**Figure 3:** Relationship between horsepower and fuel economy - displayed with ggplot2.

## 4 Discussion

Providing strict guidelines and rules for a good discussion is difficult. But the following recommendations might be helpful:

- The discussion follows the opposite structure than the introduction and should move from the specific to the more general topics.
- Summary/recapitulation: You should start the discussion with a short summary of your main results and whether they support your hypothesis/hypotheses or not. Avoid here any statistical language as in the result section. You should again sketch out your line of argumentation in this section.
- Continue with the main messages of your empirical or theoretical study or your literature review: What are new insights from your results?
- Discussion of individual findings: expose results concisely and evaluate them critically. Potential questions that could be addressed here:
  - Are the findings convincing?
  - In empirical studies: which conclusions about the problem studied can be drawn? What are the implications of your findings? Which theories and previous studies support your results, which are contradicting?
  - In literature reviews: how many of the publications included in your analyses were high-quality and most recent? How many were outdated or had methodological flaws? Is there consensus across studies? Or are there group of studies that found different results?
  - Which questions remain still unanswered? Which come out as important due to your findings?

- Point out the limitations of your study (assist reader in judging validity of findings). Are there any results that contradict your hypothesis and how can they be explained? Discuss to which extent your results can be generalized.

## **4.1 Conclusion**

- Which *take home messages* do you like to give the reader? What is the relevance of your study for future research and potential applications? Suggest issues for future research.
- One *final sentence* to complete the thesis.

## References

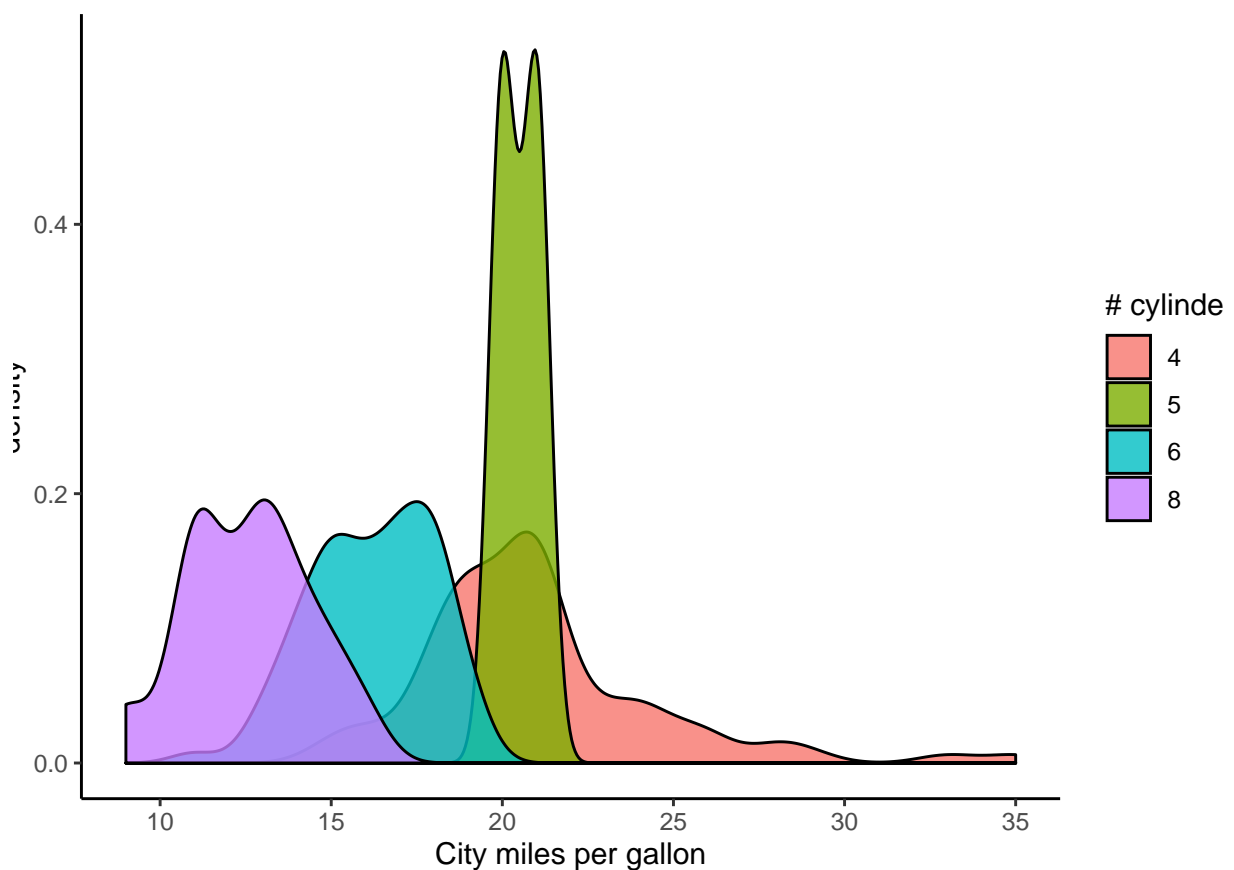
- Kamm J (2000) *Evaluation of the Sedov-von Neumann-Taylor blast wave solution*. Technical Report LA-UR-00-6055. Los Alamos National Laboratory.
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- Post E and Forchhammer MC (2002) Synchronization of animal population dynamics by large-scale climate. *Nature* 420(6912). Journal Article: 168–171. DOI: [10.1038/nature01064](https://doi.org/10.1038/nature01064).

## A Appendix

All relevant information has to be included in the main text. Irrelevant information as to be completely left out. Content that is related to the topic but not essential can be included in the appendix. Such could be the derivation of equations, additional information on statistical or laboratory analyses, source code of computer programs or any other comprehensive (data) material.

The appendix has to be similar to figures and tables cross-referenced and should **not** stand by itself. All figures and tables in the appendix should also have captions.

### A.1 Figures



**Figure 4:** Fuel economy in cities, grouped by the number of cylinders

### A.2 Tables

**Table 5:** Descriptive statistics of ....

	3m	6m	1yr	2yr	3yr	5yr	7yr	10yr	12yr	15yr
Mean	3.138	3.191	3.307	3.544	3.756	4.093	4.354	4.621	4.741	4.878
Median	3.013	3.109	3.228	3.490	3.680	3.906	4.117	4.420	4.575	4.759
Min	1.984	1.950	1.956	2.010	2.240	2.615	2.850	3.120	3.250	3.395
Max	5.211	5.274	5.415	5.583	5.698	5.805	5.900	6.031	6.150	6.295
StD	0.915	0.919	0.935	0.910	0.876	0.825	0.803	0.776	0.768	0.762

## **B Acknowledgements**

I want to thank the following people ...

## **C Declaration of Authorship**

*I hereby declare in lieu of an oath that I have authored the present Bachelor's / Master's Thesis independently and without use of others than the indicated sources - in particular of internet sources other than the one mentioned in the list of sources. The Bachelor's / Master's Thesis has not been submitted by me to any other examination procedure before. The submitted written version corresponds to the version on the electronic storage medium. I agree that the Bachelor's / Master's Thesis may be published.*

*[Hiermit erkläre ich an Eides statt, dass die vorliegende Bachelor's / Master's Thesis von mir selbständig verfasst wurde und ich keine anderen als die angegebenen Hilfsmittel – insbesondere keine im Quellenverzeichnis nicht benannten Internet-Quellen – benutzt habe und die Arbeit von mir vorher nicht einem anderen Prüfungsverfahren eingereicht wurde. Die eingereichte schriftliche Fassung entspricht der auf dem elektronischen Speichermedium. Ich bin damit einverstanden, dass die Bachelor's / Master's Thesis veröffentlicht wird.]*

Hamburg,

.....

Mandy Mustermann