Slow-feeding and horses:

investigating consequences on horse health and behaviour

Oct. 15 - PhD Defense, Marie Roig-Pons

Overview of the defense

Background

Chapter 1: Population of slow-feeder users

Chapter 2: Feeding behaviour with hay net

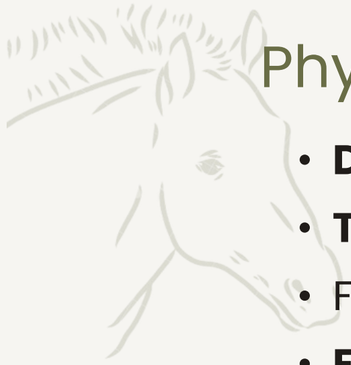
Chapter 3: Associations with long-term use

Chapter 4: slow- vs portioned feeding

General Discussion

1 Background

The feeding dilemma

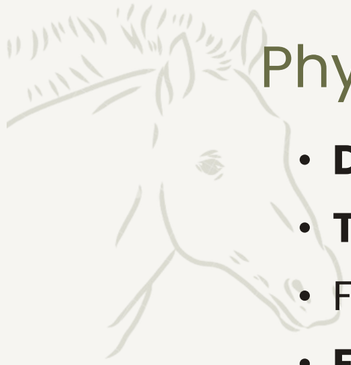


Physiological & behavioural needs

- **Diet high in fiber**
- **Total time spent feeding: 10 to 15 hour**
- Feeding bouts during the day and the night
- **Feeding breaks < 4 hours**
- **Sufficiant number of mastication**

Van Dierendonck et al., 1996; Ralston, 1984; Vulink et al., 2001; Souris et al., 2007; Davidson and Harris, 2007

The feeding dilemma



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- Abnormal & stereotypic behaviour
- Digestive problems
- Increased agressiveness in group

Nicol, 1999; Bachmann et al., 2003; Davidson and Harris, 2007; Durham and Thiemann, 2015; Burla et al., 2016; Lesimple et al., 2016

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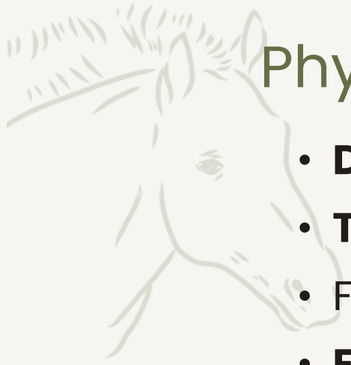

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Similar to wild/feral counterparts

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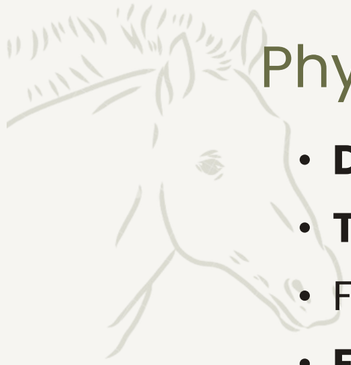

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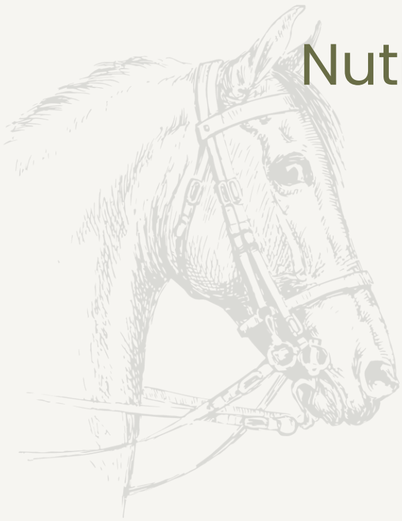

Nutritional needs

Similar to wild/feral counterparts

Different from wild/feral counterparts

Arnold et al., 2006; Giles et al., 2014; Schubert et al., 2014; Raudsepp et al., 2019; Norton et al., 2019; Moore et al., 2019 Gregić et al., 2022

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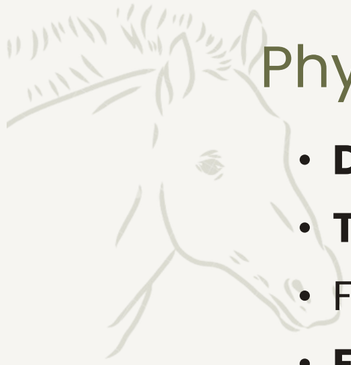

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Similar to wild/feral counterparts

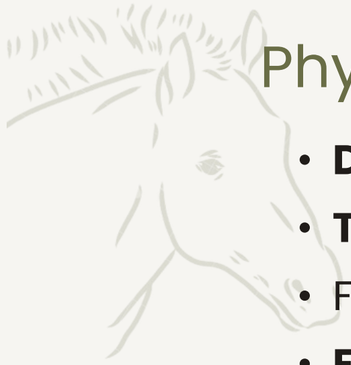
Nutritional needs

- **Captivity**: environment, food supply, no or low reproductive status
- **Modern use of horses**: recreational purpose only
- **Metabolic predisposition** for overweight

Different from wild/feral counterparts

Arnold et al., 2006; Giles et al., 2014; Schubert et al., 2014; Raudsepp et al., 2019; Norton et al., 2019; Moore et al., 2019 Gregić et al., 2022

The feeding dilemma



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Nutritional needs

- **Captivity**
- **Modern use of horses**
- **Metabolic predisposition**

- Overweight
- Metabolic disease

Johnson et al., 2004; Dugdale et al., 2010; Moore et al., 2019 Dosi et al., 2020

The feeding dilemma

Overweight

- **30% to 70% of equine population**
- **Adverse health outcomes** (laminitis, orthopaedic problems, metabolic diseases, fertility loss and reduced immune system ...)
- **Reduced lifespan**
- **Compromised quality of life**

Vick et al., 2007; Wyse et al., 2008; Stephenson et al., 2011; Morgan et al., 2016

The feeding dilemma

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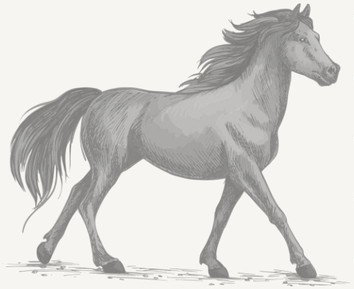
Possible solutions



- Increase energy expenditure
- Decrease energy intake
- Promote non-feeding behaviours
- **Better portioning**
- **Slow down hay ingestion**

King and Mansmann, 2004; Giles et al., 2014; Dosi et al., 2020

Slow-feeders (SFs)

Dispenser that mechanically slow-down hay ingestion

Glunk et al., 2014; Rochais et al., 2018

Slow-feeders (SFs)

in 2018-2019 *(surveys)*

70% of horse owners using a hay net

33% of care-takers using a slow-feeders

Siegel et al., 2018; Jaqueth et al., 2019

Existing & missing knowledge

What we knew when I started this PhD

- Increase intake time (1.5kg/h --> 1kg/h)
- Enhance welfare for stabled horses
- Modify feeding behaviour and posture while feeding compared to loose hay
- May lead to muscular tensions
- Hints for horses' preference

Webster and Ellis, 2010; Glunk et al., 2014; Benz et al., 2014; Ellis et al., 2015a; Speaight et al., 2016; Rochais et al., 2018; Correa et al., 2020

Existing & missing knowledge

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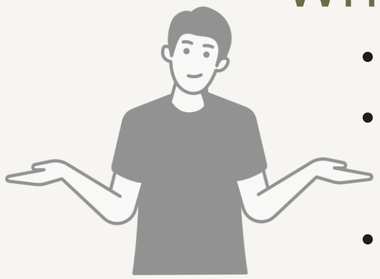
What was still unknown



- Basic knowledge about SF users
- Extent of feeding behaviour modification compared to natural feeding behaviour (pasture)
- Long-term effect on muscular tensions and articular impairments
- Studies on stabled horses / suspended nets only
- Horses' preference

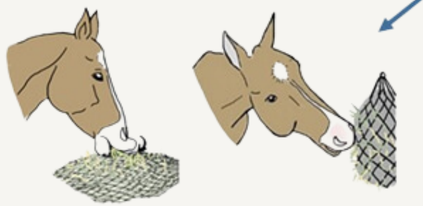
Thesis aims

SLOW-FEEDER USERS

Horse keepers & horses

Population of slow-feeders users

→ **Chapter 1**



Horses

Do hay nets encourage natural feeding patterns?

→ **Chapter 2**

Horses

Long-term effect of hay net on health and welfare of horses

→ **Chapter 3**

Horses

Comparing slow- and portioned-feeding for horses housed in groups

→ **Chapter 4**

Descriptive study

Observational study

Experimental study

Hypotheses

(from existing literature)

- Slow-feeders can **improve human-horse relationship**
- Slow-feeders can **promote a more natural feeding behaviour** compared to loose hay
- Slow-feeders are **associated with health impairments**: oral cavity (teeth, gums) and musculoskeletal health
- Slow-feeding promote a **more natural time-budget compared to multiple portioning** but **may also be frustrating** to horses

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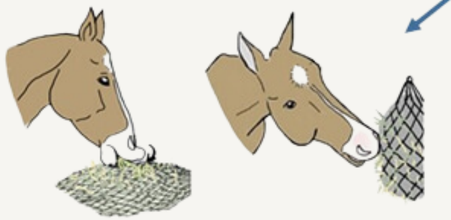

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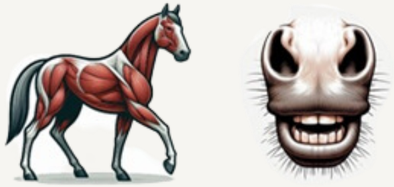

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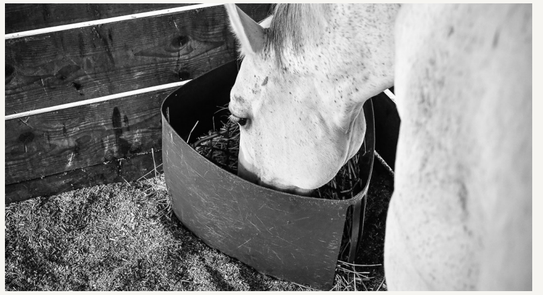
Manuscript 1: Slow-feeders for horses: who, how and why?

M. Roig-Pons, I. Bachmann, S. Briefer-Freymond



This manuscript is currently under review in *Journal of Veterinary Behavior*

Chap.1 - Aims

- **Better knowledge of target population**
  - Describe the population of slow-feeder users (both humans and horses)

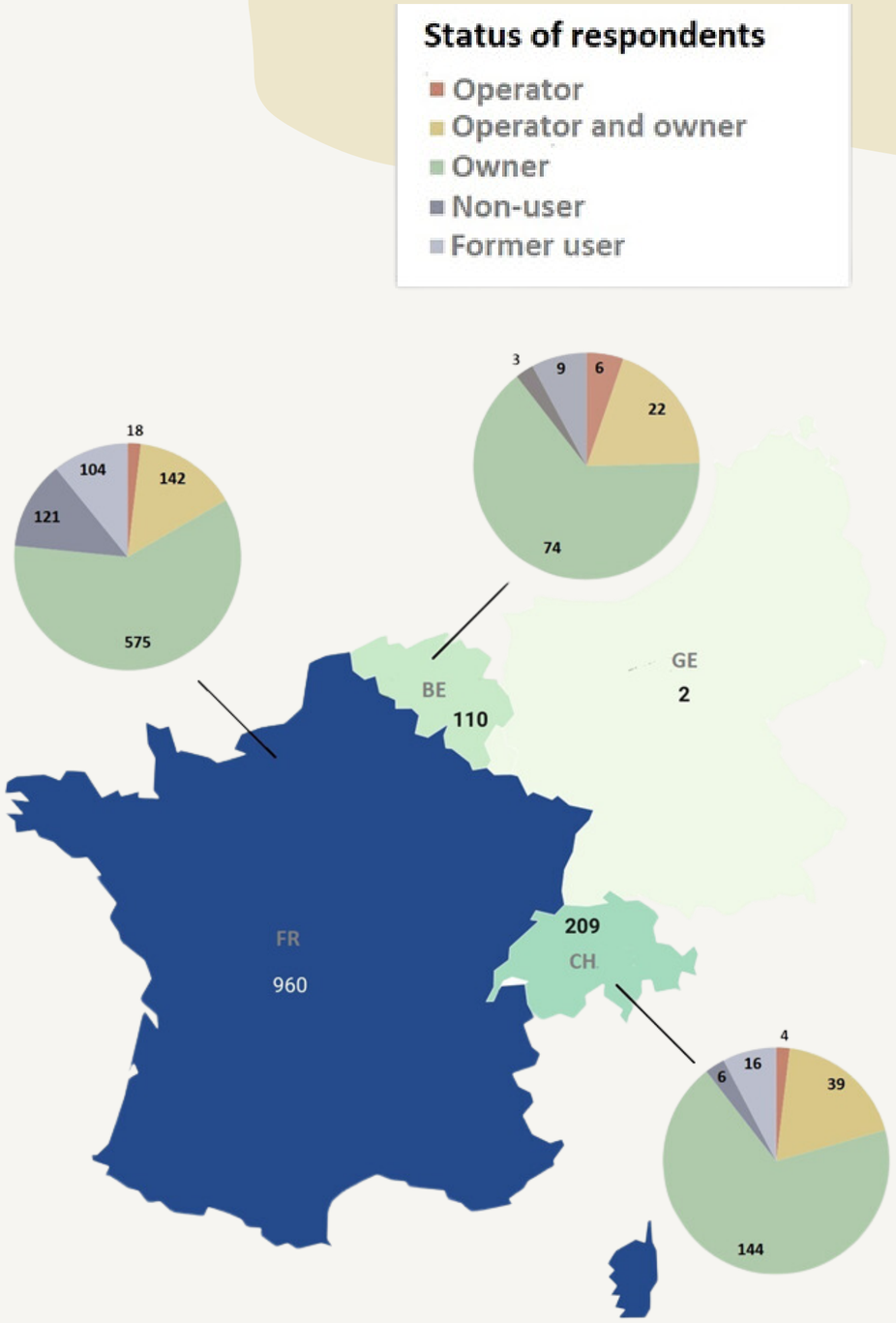
- **Identify key areas for research**
  - Understand motivations to use slow-feeders
  - Collect information about feeding practices & feedback
  - Survey former and non-users to investigate their fears and criticism

Chap.1 - Methods

- Online questionnaire with 4 sections
  - **Former SF-user** (SF practices, reasons to stop)
  - **Non SF-user** (reasons not to use any SF)
  - **Current SF user** (status, SF practices, feedback)
  - **Horses** (general info, housing, feeding, training and health)

- **Distributed on social media**, news letter, magazines ….

- **1'283 answers in total**



Chap.1 - Key findings

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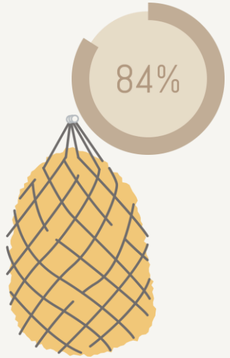

Slow-feeding practices
n = 1192

Horses feeding from slow-feeder(s)
n = 1430

Chap.1 - Key findings

- Focus PhD on hay **nets**
- Need to investigate **not only suspended nets**

Type of net may influence
- **workload**
- frequency of **issue reporting**
- **adverse effect** on horse health

Slow-feeding practices
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Slow-feeding practices
n = 1192

Horses feeding from slow-feeder(s)
n = 1430

- Slow-feeding: **relatively new practice**

- Most horses are fed using **only a SF**

Horses feeding from nets differ from the general equine population
- age
- training
- housing
- feeding

Chap.1 - Conclusion

- **Need for further research**
  - **Horses feeding 10 to 15h from slow-feeders**
  - **Lack of long-term insights**
  - Investigate **different types of net**
  - **No major drawbacks reported** but **sample likely to be biased**

- **Be careful when sampling for observational study**

(target population ≠ equine population)

SLOW-FEEDER USERS

Horse keepers & horses

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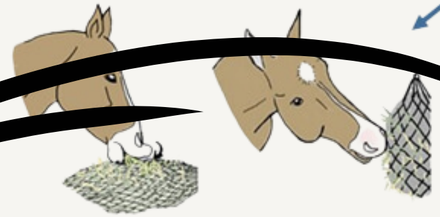

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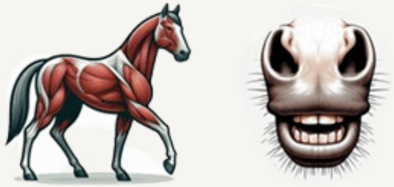

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Descriptive study

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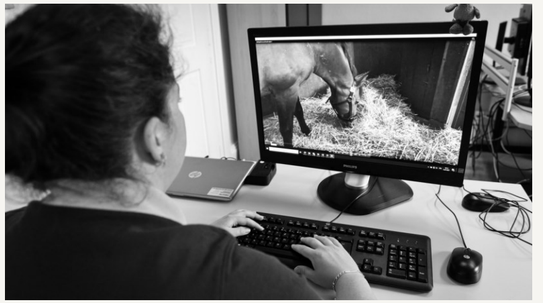
Experimental study

Manuscript 2: Investigating feeding methods and their consequences on horse behaviour and posture

M. Roig-Pons, S. Tomozyk, L. Gardès, S. Briefer Freymond



This manuscript will be submitted to *Animal*

Chap.2 - Brief background

Feeding behaviour & equine health

- Forage collection and mastication are linked to dental wear
- Correct dental wear is essential for dental health
- Mastication promotes saliva production
- Posture while feeding may affect horse's musculoskeletal health on the long-term perspective
- Importance of choice for animal welfare

Until now:

- **feeding behaviour: mainly forage mastication**
- **only comparison with loose hay**

McGreevy et al., 2001; Dixon and Dacre, 2005; Staszyk et al., 2015; Bochnia et al., 2019; Hodgson et al., 2022; McAteer et al., 2023; Speaight et al., 2016

Chap.2 - Aims & Hypotheses

Aims

- Compare feeding behaviour and posture while feeding hay in net vs. loose hay
- Compare it to natural grazing behaviour
- Evaluate the preference of horses regarding hay presentation

Hypotheses

- Prehension and mastication rates differs between hay in net and loose hay
- Feeding from net promote more natural prehension and mastication
- Feeding from net may increase the frequency of neck torsions
- When given the choice, horses will preferentially feed from loose hay, but not exclusively

Ellis et al., 2015; Burla et al., 2016; Correa et al., 2020; Speaight et al,, 2019; Webster and Ellis, 2010

Chap.2 - Methods

Pilot-sudy

- Optimise ethogram
- Define video analysis strategy
- Sample size calculations

- 4 stallions
- 4 treatments
- 8 videos (15min)

per horse per treatment

Loose hay on the floor (FL)

Porta Grazer (PG)

Hay Bag (HB)

Heu Toy (HT)

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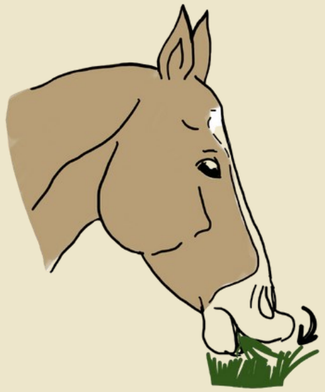
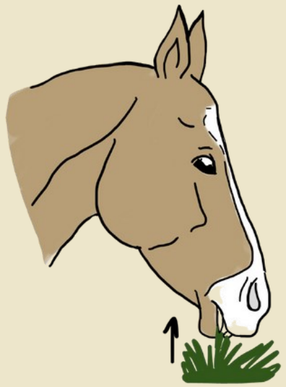
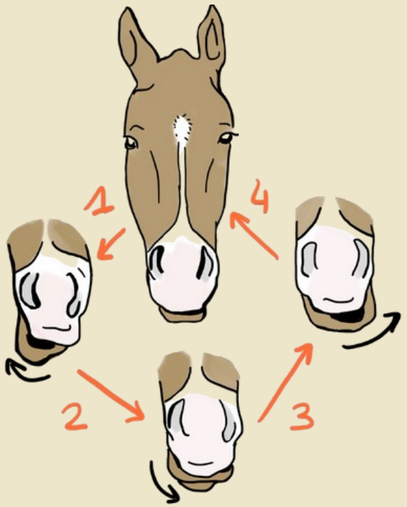


"Gathering" (upper lip)

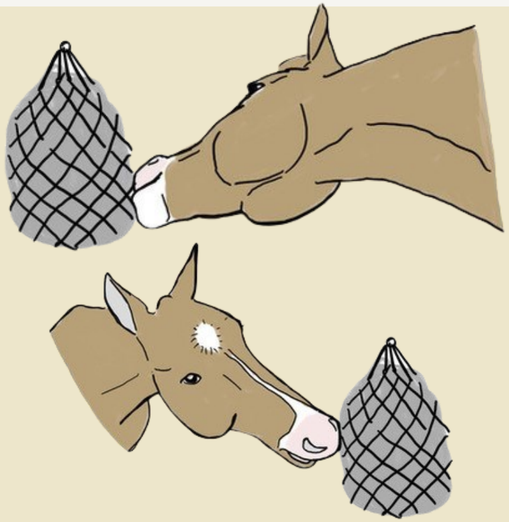


"Biting" (incisors)

Prehension



"Chewing"



"Torsion"

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- **Very different forage prehension between loose hay / all SFs**

➡ **Compare to prehension in natural conditions: pasture**

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Main study

- 12 horses (in 2 groups)

A. Hay rack | B. Hay stalls | C. Hay bell | D. Hay rack

G1 | G2

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Main study

- 12 horses (in 2 groups)
- 5 treatments (Loose hay & hay in net = same dispenser)

Loose hay

Hay in net

Short grass

Medium grass

Long grass

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} Feeding behaviour & posture

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→ Feeding behaviour & posture

- 5 horses of G1
- 2 forage presentation: hay loose or in net
- 3 tests

→ Preference test

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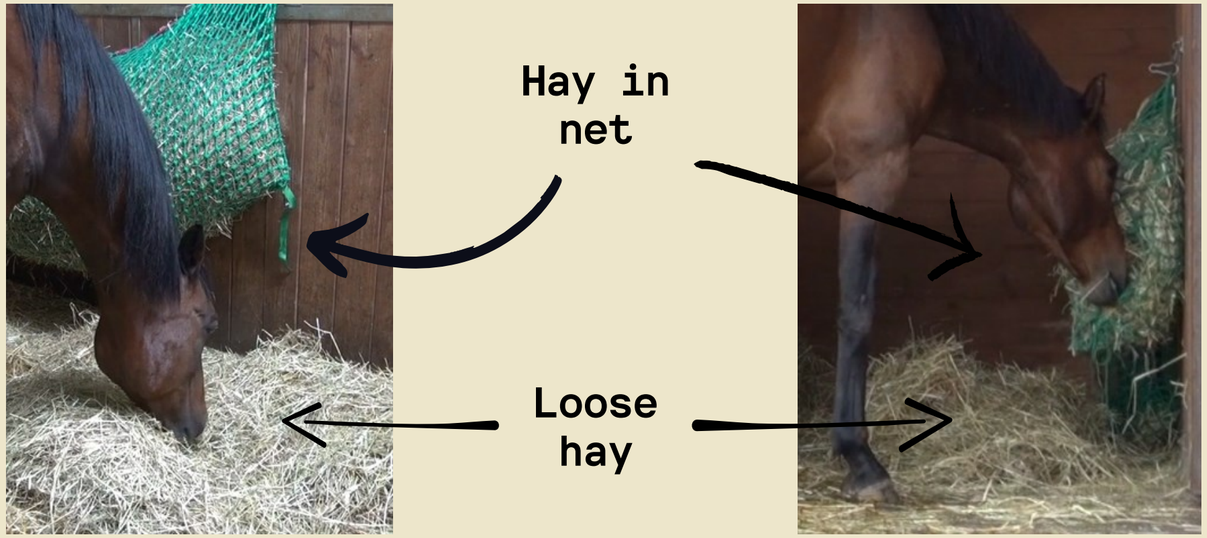

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- (Generalized) Linear mixed-model
- Tukeys' post-hoc test

- 5 horses of G1
- 2 forage presentation: hay loose or in net
- 3 tests

- Time spent feeding from net, loose hay or not feeding

Descriptive statistics

Chap.2 - Key findings

Feeding behaviour & posture

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- Despite same forage being used, **significant differences between loose hay and hay in net** (all 3 $p < 0.05$)

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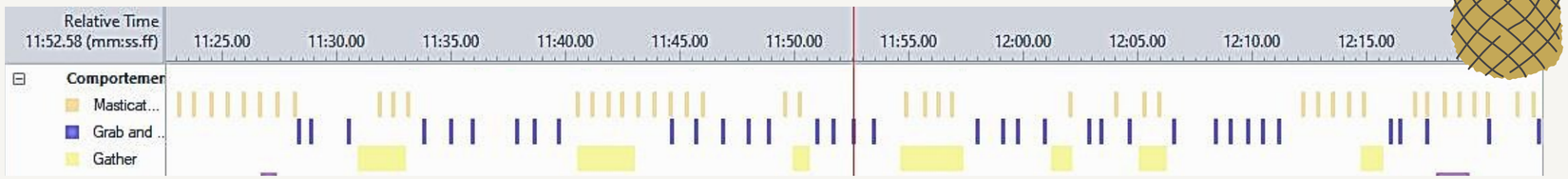
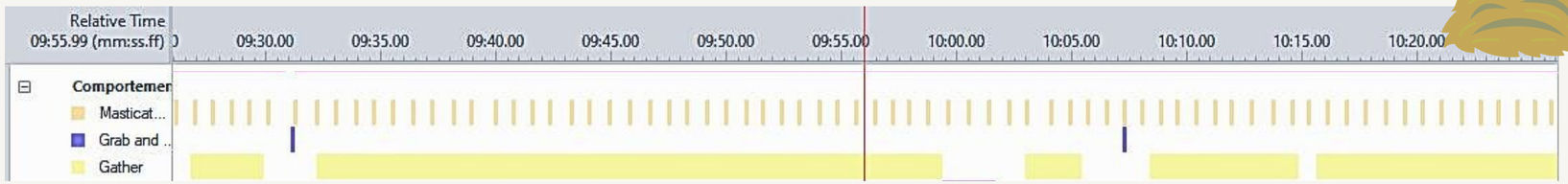
Hay in net



Loose hay



Bite (*incisors*)

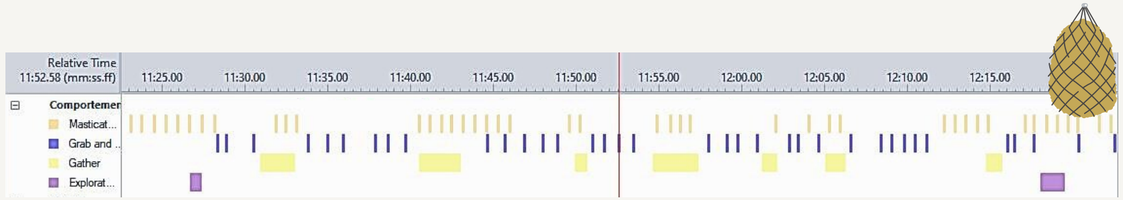
Gather *(upper lip)*

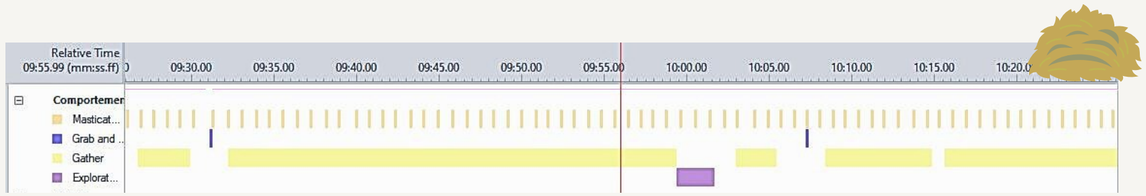
Chew

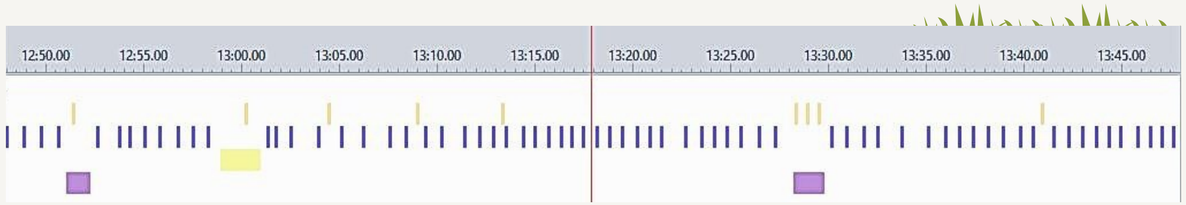
Chap.2 - Key findings

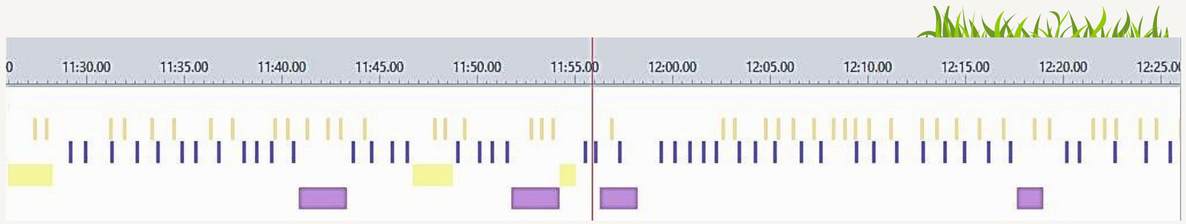
Feeding behaviour & posture

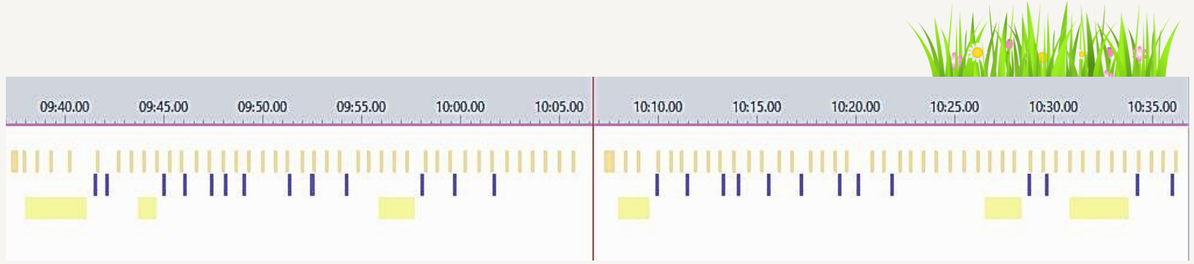
- Despite same forage being used, significant differences between loose hay and hay in net (all 3 $p < 0.05$)
- **Forage collection with net not significantly different from pasture** *($p > 0.05$)* **but loose hay was** *($p < 0.05$)*
- **Chewing rates all differed significantly** *(all $p > 0.05$)*







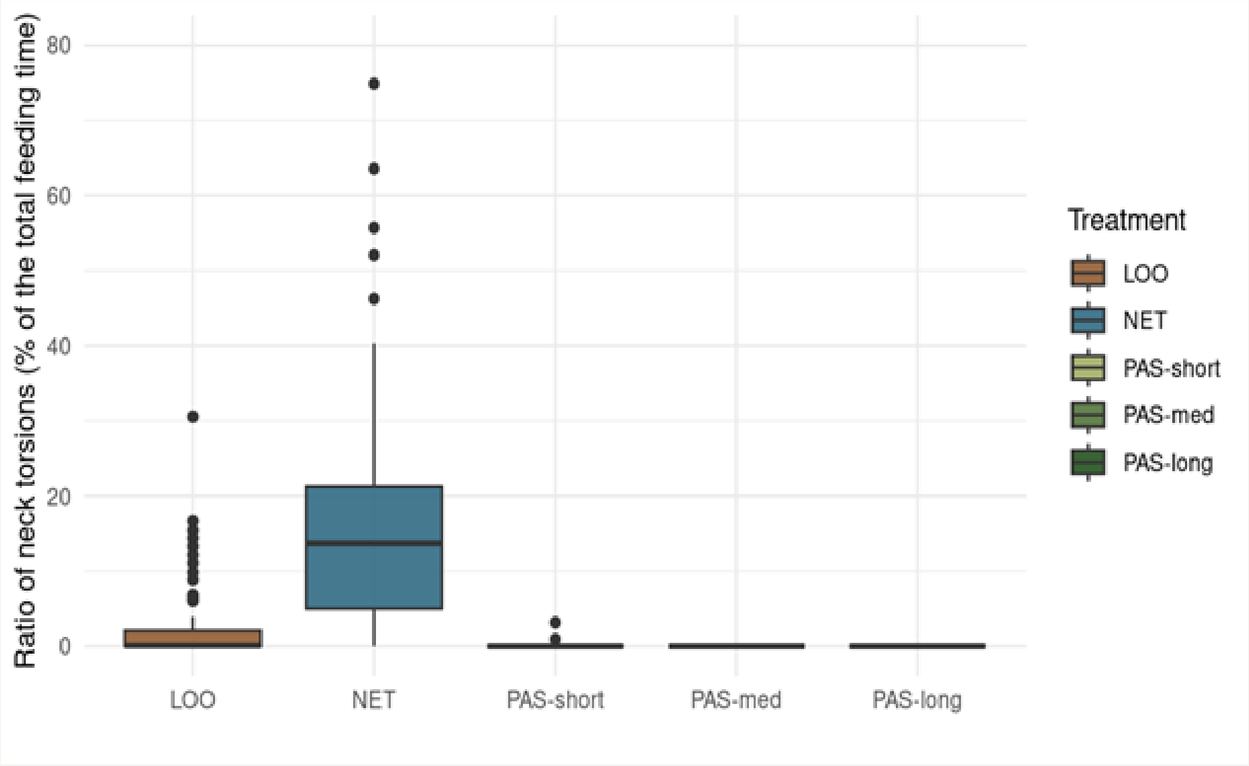




Chap.2 - Key findings

Feeding behaviour & posture

- Despite same forage being used, significant differences between loose hay and hay in net (all 3 $p < 0.05$)
- Forage collection with net not significantly different from pasture *($p > 0.05$)* but loose hay was (*$p < 0.05$*)
- Chewing rates all differed significantly *(all $p > 0.05$)*
- **Neck torsions only observed with hay** (e.g. with a dispenser) and **significantly more with the net** *($p < 0.01$)*



Chap.2 - Key findings

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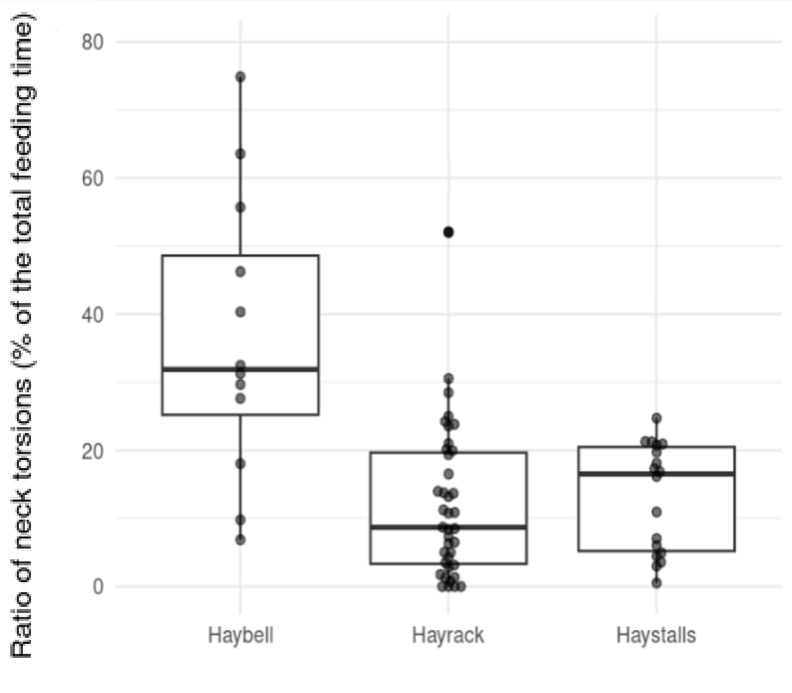
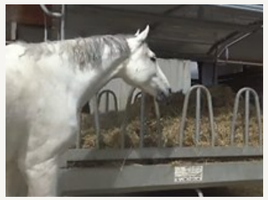
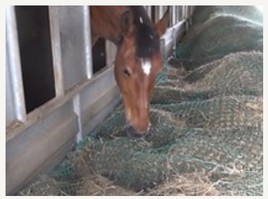
- **Frequency and duration of neck torsions** influenced by the **inclination of the net**



`Hay bell` → **8 to 70%** of feeding bouts
Average duration **> 10 sec**





`Hay rack`
`Hay stall`

0 to 40% of feeding bouts
Average duration ~ **2-5 sec**

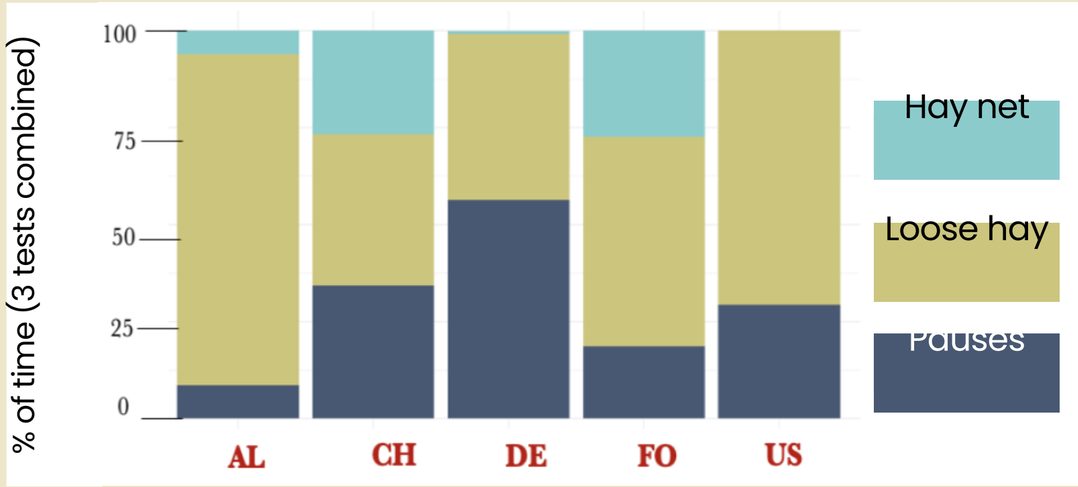
Chap.2 - Key findings

Feeding behaviour & posture

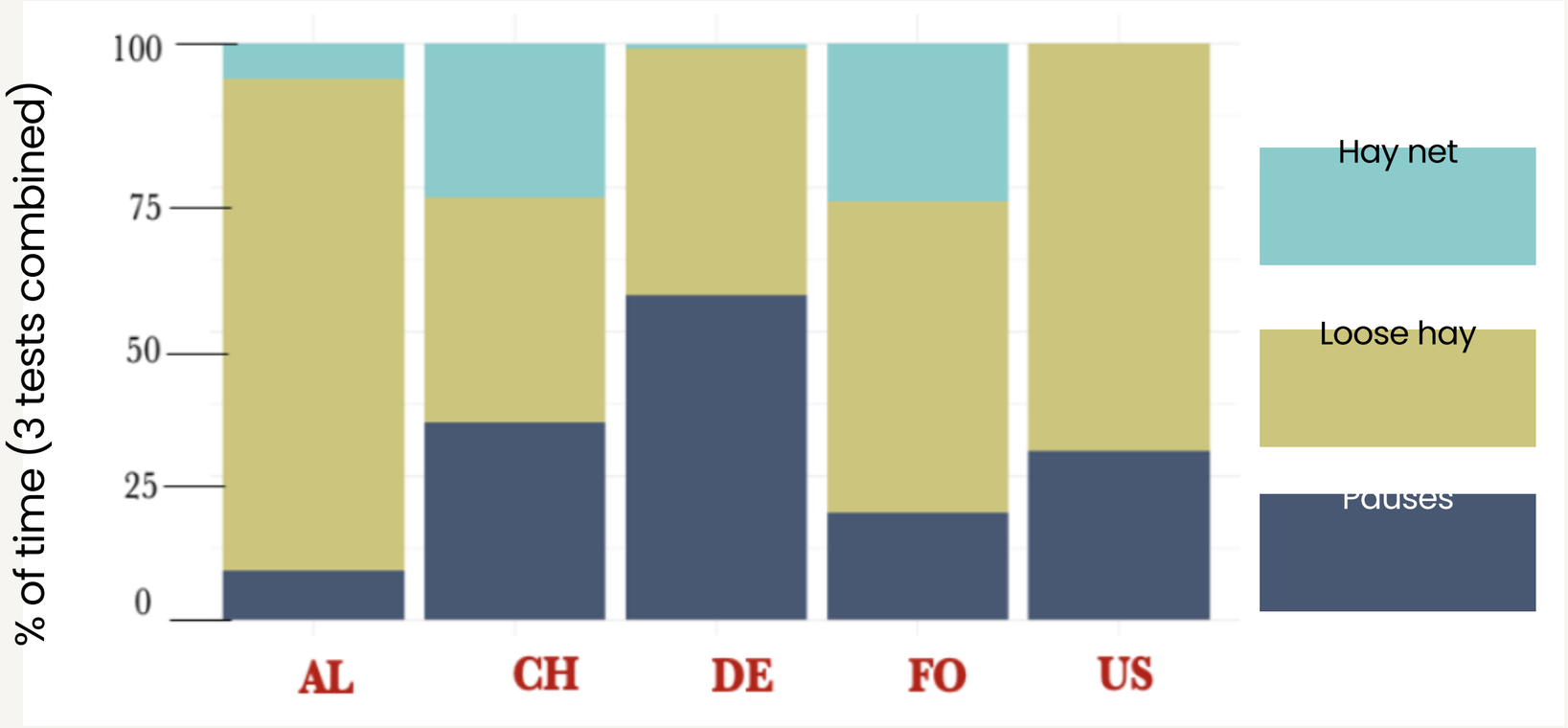
- Despite same forage being used, significant differences between loose hay and hay in net (all 3 $p < 0.05$)
- Forage collection with net not significantly different from pasture *($p > 0.05$)* but loose hay was ($p < 0.05$)
- Chewing rates all differed significantly *(all $p > 0.05$)*
- Neck torsions only observed with hay (e.g. with a dispenser) and significantly more with the net *($p < 0.01$)*
- Frequency and duration of neck torsions influenced by the inclination of the net

Preference test

- Horses fed predominantly from loose hay, <u>but not exclusively</u>



Chap.2 - Key findings

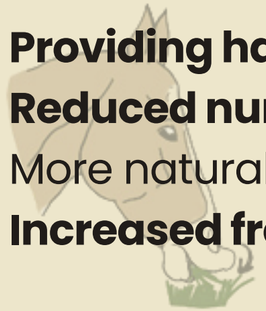


Chap.2 - Conclusion

Hypotheses

- Prehension, mastication and exploration rate differs between hay in net and loose hay ✓
- Feeding from net promote more natural collection and mastication of the forage ≈
- Feeding from net may increase the frequency of pauses and neck torsions ≈
- When given the choice between loose hay and hay in net, horses will preferentially feed from loose hay, but not exclusively ✓

Take-away



- **Providing hay in net** instead of loose **promoted a more natural collection of forage**
- **Reduced number of chews with net compensated** by increased time spent feeding
- More natural collection of forage --> **improved dental health ?**
- **Increased frequency of neck torsions** with (vertical) nets --> **muscular impairments ?**

"Contrafreeloading occurs when animals work for food even though identical food is freely available" (Inglis et al., 1977)

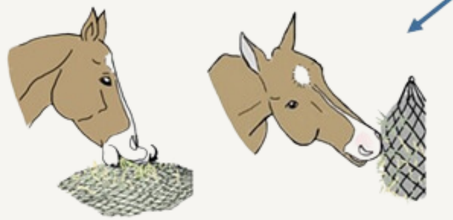
- **Limited sample size**, but **in line with the literature** *Ellis & Webster, 2010*
- **Contrafreeloading** observed in other herbivores *Van Os et al., 2018; Sasson-Yenor and Powell, 2019*

SLOW-FEEDER USERS

Horse keepers & horses

Population of slow-feeders users

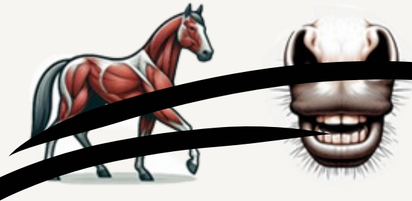
→ **Chapter 1**



Horses

Do hay nets encourage natural feeding patterns?

→ **Chapter 2**



Horses

Long-term effect of hay net on health and welfare of horses

→ **Chapter 3**

Horses

Comparing slow- and portioned-feeding for horses housed in groups

→ **Chapter 4**

Descriptive study

Observational study

Experimental study

Chap. 3 - Brief background

Positive effects of slow-feeding

- Increased time spent feeding (reduced intake rate)

Glunk et al., 2014; Ellis et al., 2015; Rochais et al., 2018

- Decreased frequency of repetitive & abnormal behaviour

Raspa et al., 2018; Correa et al., 2020

- More natural feeding behaviour

Chap. 3 - Brief background

Positive effects of slow-feeding

- Increased time spent feeding (reduced intake rate)

Glunk et al., 2014; Ellis et al., 2015; Rochais et al., 2018

- Decreased frequency of repetitive & abnormal behaviour

Raspa et al., 2018; Correa et al., 2020

- More natural feeding behaviour

But still many unanswered questions

- Unnatural posture while feeding

Ellis et al., 2015; Rochais et al., 2018; Raspa et al., 2021

- Potential muscular tensions associated (conflictory results)

Mac Ateer et al., 2023; DeBoer et al., 2024;

- Effect of net on oral cavity (gums & teeth) and vibrissae ?

Hodgson et al., 2021; De boer et al., 2024

- Effect on horse-human relationship

Rochais et al., 2018

Figure 1: Points of measurement for the pressure algometer on the *m. brachiocephalicus*. Origin: distally to the deltoid tuberosity. Insertion: caudal to the wing of atlas. Muscle Belly: proximal to C5.

from Mc Ateer et al., 2023

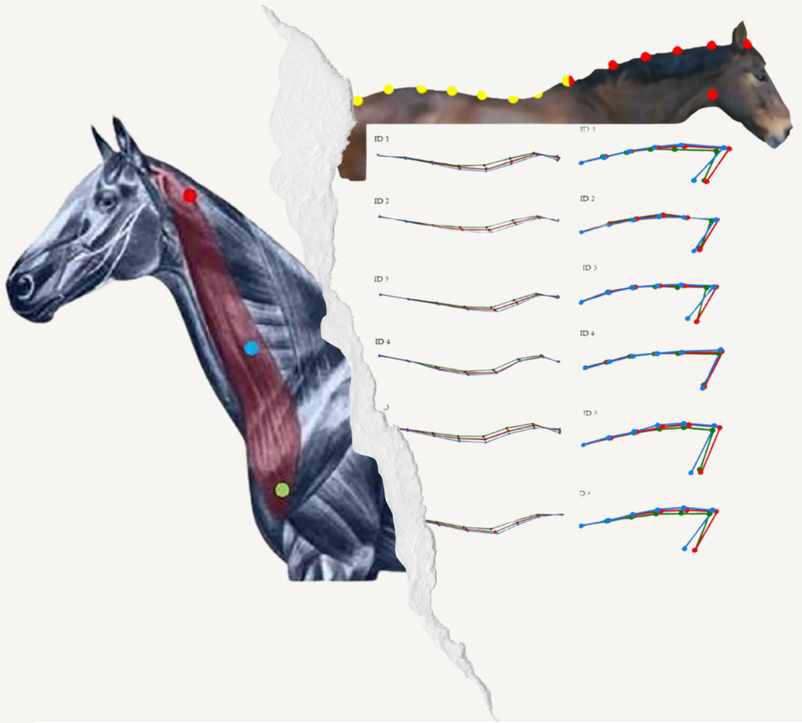


Figure 9. Mean individual shape variations in back and neck postures according to the three different feeding positions: red, on the ground—control position (CP); green, neck held 15 ± 3° below withers height with low hay net position (LP); and blue, neck held 15 ± 3° above withers height with high hay net position (HP).

from Raspa et al., 2021

Chap. 3 - Aims & Hypotheses

Aims: Associations between hay net usage and ...

- Horse reactivity to humans
- Horse oral health (gums & teeth)
- Horse vibrissae condition
- Horse musculoskeletal health

→ **Mid- and long-term perspectives**

Hypotheses

- Use of hay net associated with improved horse-human relationship
- Use of hay net associated with gingiva impairments and increased vibrissae wear
- Use of hay net not associated with specific dental wear
- Use of hay net associated with musculoskeletal impairments (especially in the neck)

Chap. 3 - Methodological issues

Reactivity to humans

- Already several tests described and validated

Søndergaard and Halekoh, 2003; Lansade et al., 2008; Burn et al., 2010; Popescu et al., 2014

Chap. 3 - Methodological issues

Reactivity to humans

- Already several tests described and validated

Oral cavity (teeth and gingiva)

- Protocol well described but not validated yet

Cross, 2023; De Boer et al., 2023

Chap. 3 - Methodological issues

Reactivity to humans

- Already several tests described and validated

Oral cavity (teeth and gingiva)

- Protocol well described but not validated yet

Musculoskeletal health

- Different methodologies
- Lack of information regarding protocol used

Speaight et al., 2016; Chen et al., 2017; Raspa et al., 2020

Chap. 3 - Methodological issues

Reactivity to humans

- Already several tests described and validated

Oral cavity (teeth and gingiva)

- Protocol well described but not validated yet

→ **Test the protocol**

Musculoskeletal health

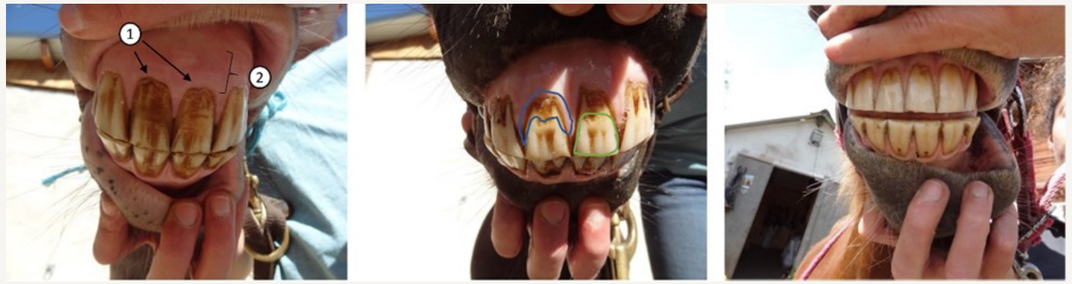
- Different methodologies
- Lack of information regarding protocol used

→ **Design a new protocol and test it**

Chap. 3 - Assessing horse health

Chap. 3 - Assessing horse health

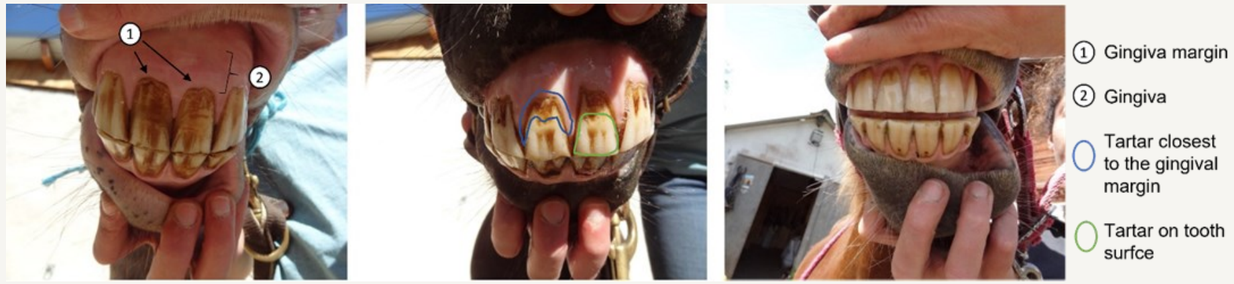
Rostral Oral Cavity Score *(from Cross, 2023)*



- **Photographs**
- **6 items**
  - *gingiva margin*
  - *tartar closest to gingiva*
  - *tartar closest on the tooth*
  - *cementum cracks*
  - *level of incisors abrasion*
  - *type of abrasion*
- **scores from 1 to 3**

Chap. 3 - Assessing horse health

Rostral Oral Cavity Score *(from Cross, 2023)*



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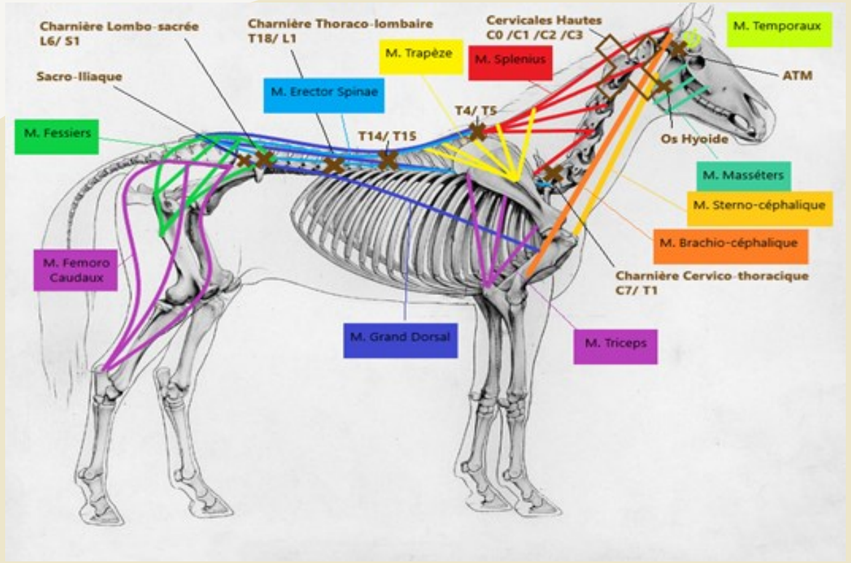
Musculoskeletal health



- **Live evaluation (manual palpation)**
- **4 types of structures**
  - *muscles (11)*
  - *peri-articular tissues (11)*
  - *joints (11)*
  - *viscera (3)*
- **scores from 0 to 3**

Chap. 3 - Assessing horse health

Criteria for a “good protocol”

Chap. 3 - Assessing horse health

Criteria for a “good protocol”

Gives accurate measure (**validity**)

Gives same results when performed by different assessors (**observer independence**)

Gives same results when repeated by the same assessor (**consistency over time**)

(inter- and intra-rater **reliability**)

+ **feasibility**, especially for on-site assessment

Gwet, 2014; Vieira et al., 2018

Chap. 3 - Assessing horse health

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ELSEVIER

Journal of Clinical Epidemiology 64 (2011) 96–106

Journal of Clinical Epidemiology

Guidelines for Reporting Reliability and Agreement Studies (GRRAS) were proposed

Jan Kottner[a,*], Laurent Audigé[b], Stig Brorson[c], Allan Donner[d], Byron J. Gajewski[e], Asbjørn Hróbjartsson[f], Chris Roberts[g], Mohamed Shoukri[h], David L. Streiner[i]

Chap. 3 - Assessing horse health

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Manuscript 4: Agreement, reliability and feasibility of two protocols assessing horses' musculoskeletal and rostral oral health

M. Roig-Pons, C. Pérot, S. Briefer-Freymond

This manuscript has been published as a pre-print on *Research Square* and will be submitted to *Animal Open Space*

Chap. 3 - Assessing horse health

- **Moderate to high inter- and intra- rater reliability**
- **Quick and easy** to perform
- **Importance of training** (more than background)

Non- (or minimally-) invasive and reliable ways to assess horse health

Manuscript 3: Hay net feeding in horses: potential impacts on welfare, health, and human interaction

M. Roig-Pons, S. Briefer-Freymond

This manuscript will be submitted to Scientific Report

Chap. 3 - Methods

Experimental design

- Cross-sectional study

--> Compare **horses feeding from nets** and **horses not feeding from nets**

Chap. 3 - Methods

Pilot-study

- Test protocols
- Sample size calculations

- 25 horses in a commercial stable
- 12 with nets
- 13 control

- Feeding management
- MSH, oral cavity & vibrissae
- Reactivity to human

Chap. 3 - Methods

Pilot-study

- Test protocols
- Sample size calculations

- 25 horses in a commercial stable
- 12 with nets
- 13 control

Largest sample size
MSH --> N = 670

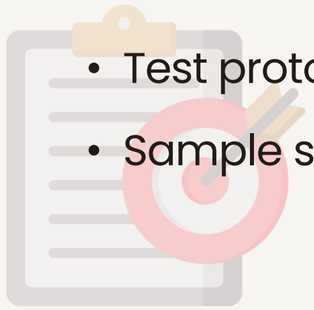
Important source of bias for response variables:

- Age
- Housing
- Training frequency
- Shoes

Stratified sampling

Chap. 3 - Methods

Pilot-study



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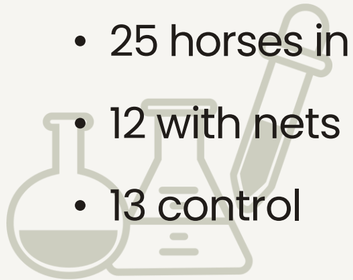

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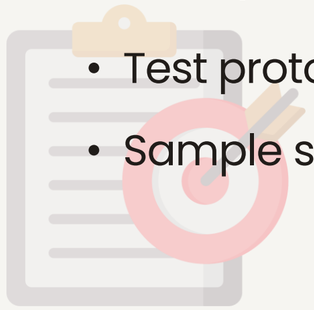
Stratified sampling

+ inclusion criteria

Chap. 3 - Methods

Pilot-study



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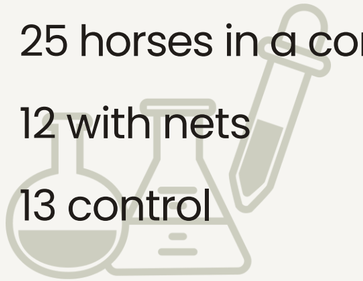

- 25 horses in a commercial stable
- 12 with nets
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Main study

- 702 horses: “Hay net” / “Control”

Chap. 3 - Methods

Pilot-study

- Test protocols
- Sample size calculations
- 25 horses in a commercial stable
- 12 with nets
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Main study

- 702 horses: “Hay net” / “Control”

Horses feeding from a net (sole or main dispenser) - NH





Chap. 3 - Methods

Pilot-study

- Test protocols
- Sample size calculations
- 25 horses in a commercial stable
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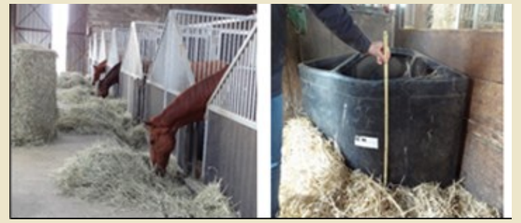
- 13 control

Main study

- 702 horses: “Hay net” / “Control”

Horses not feeding from a net (loose hay, other dispenser) - CH

Horses feeding from a net (sole or main dispenser) - NH





Chap. 3 - Methods

- 2 Reactivity to Human-test (free and tied)
- Evaluation of musculoskeletal health (MSH)
- Evaluation Body Condition Score
- Photo for Rostral oral cavity (ROC) score
- Live evaluation vibrissae & gum coloration

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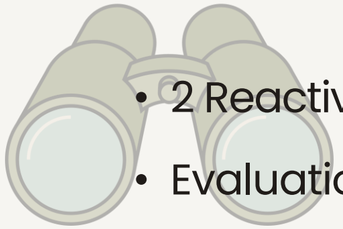
+ **Feeding management**
(dispenser features, opening size, feeding frequency ...)

+ **General information**
(Housing, health, training ...)

Chap. 3 - Methods



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Ordinal logistic regression

Linear model + (wilcoxon / orl for subgroups)

Ordinal logistic regression

+ **Feeding management**
(dispenser features, opening size, feeding frequency ...)

+ **General information**
(Housing, health, training ...)

Chap. 3 - Key findings

Reactivity to human

- **No clear differences between the two groups**

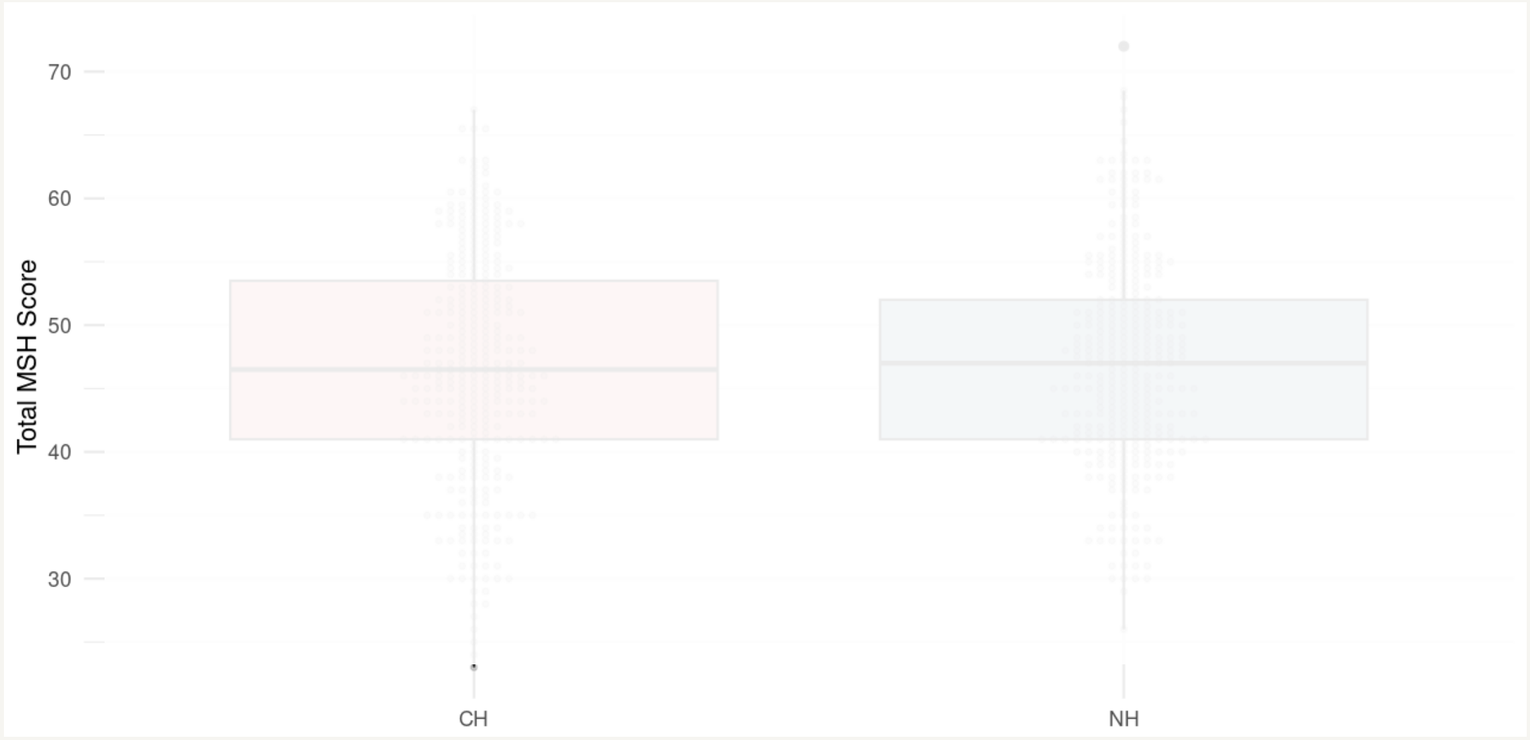
Chap. 3 - Key findings

Reactivity to human

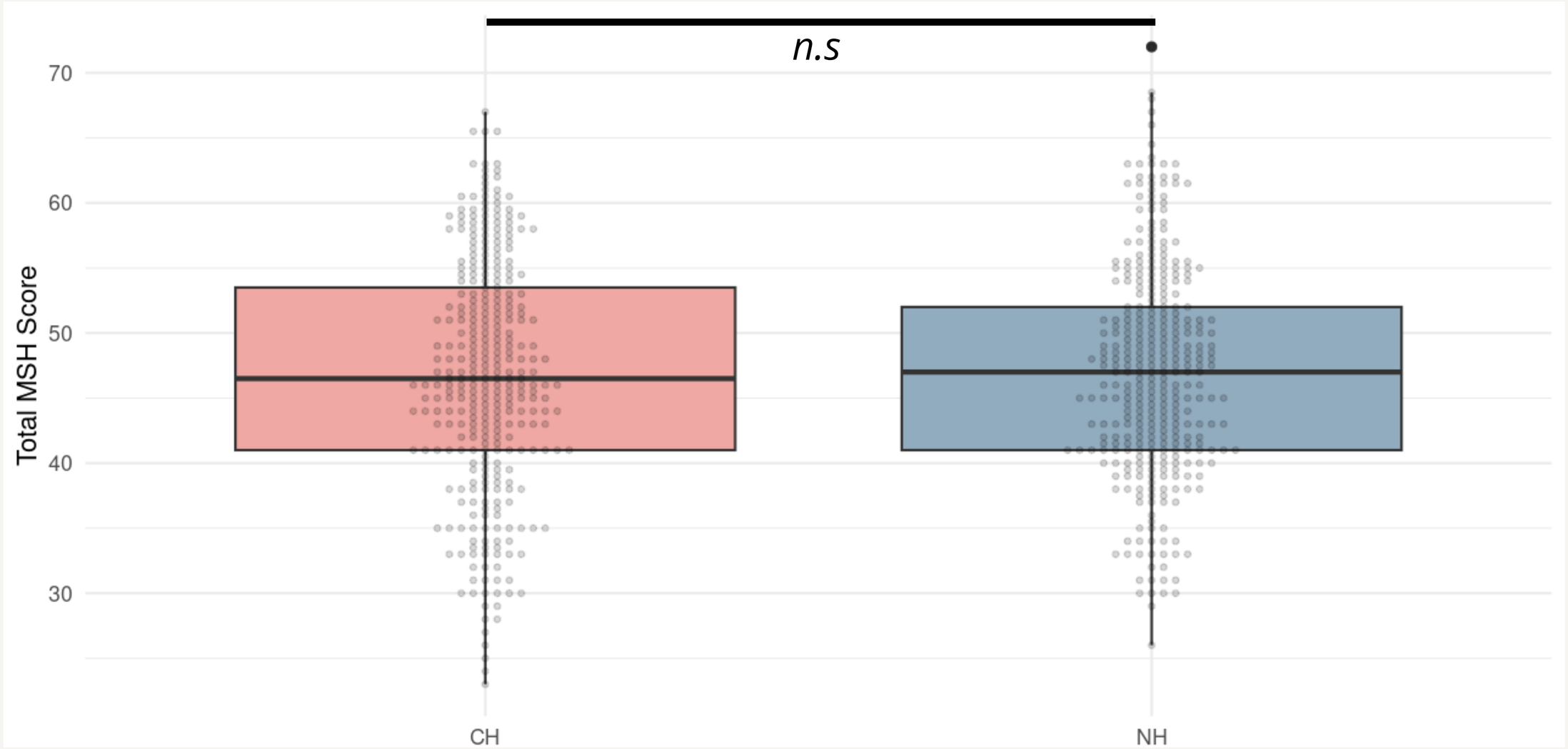
- No clear differences between the two groups

Musculoskeletal health (MSH)

- **No significant differences for overall MSH**



Chap. 3 - Key findings



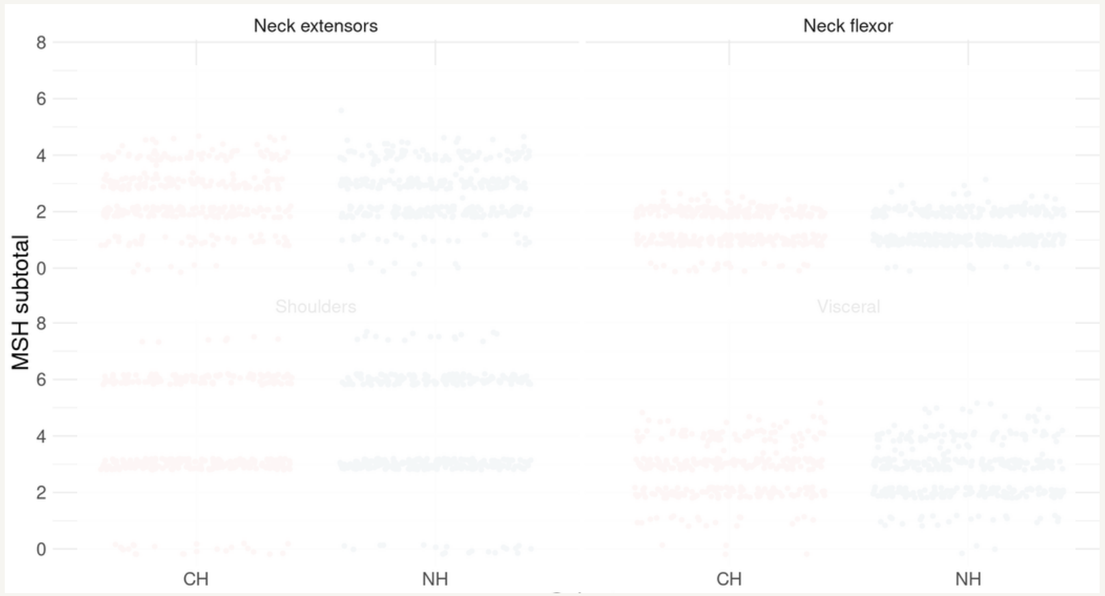
Chap. 3 - Key findings

Reactivity to human

- No clear differences between the two groups

Musculoskeletal health (MSH)

- No significant differences for overall MSH
- **No significant differences for specific areas** (back line, neck, hindquarters …)



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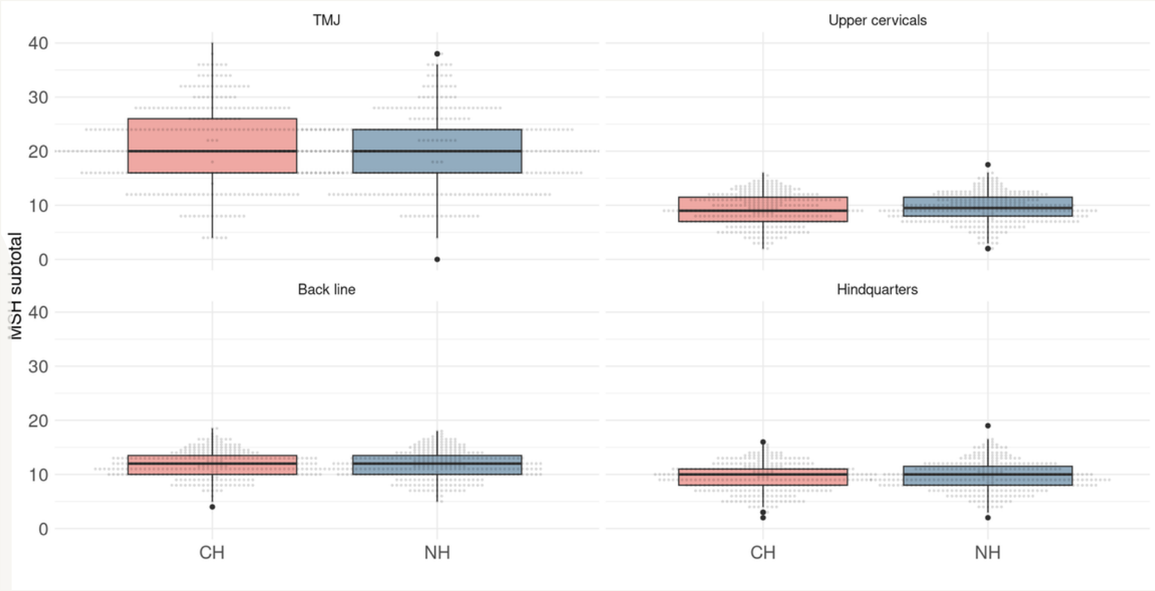

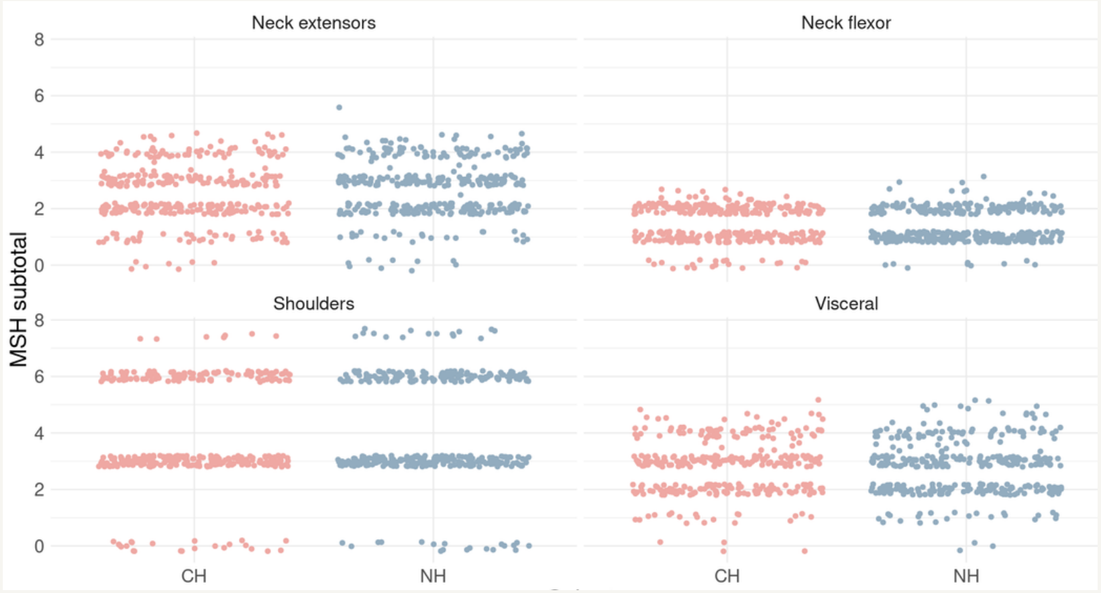

Chap. 3 - Key findings

Reactivity to human

- No clear differences between the two groups

Musculoskeletal health (MSH)

- No significant differences for overall MSH
- No significant differences for specific areas (back line, neck, hindquarters ...)

Rostral oral cavity (ROC) and vibrissae

- **No association** between **hay net usage** (and openings size) **and vibrissae length**
- **No association** between **hay net usage** and most of the ROC parameters (**cracks, abrasion**)
- **Increased risk of redden** (**OR = 3.45** [1.67; 7.54]) **and raised gingiva margins** (**OR = 3.38** [2.23; 5.18]) **with nets** --> oedema ?

Chap. 3 - Key findings

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Chap. 3 - Conclusions

- Overall **reassuring results** for horse health

- **Contradiction of some findings with existing literature** (reactivity to humans/MSH)

--> experimental design ? methodology ?

- **Importance of overall living conditions**
  - Importance of **stratified sampling**
  - **Be careful with generalization** to different population

- Only observational study: **results need to be validated** with experimental study

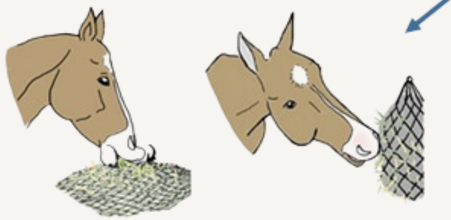
1 Effect of hay nets on subluxations, pain-pressure thresholds, and cervical range of motion in the
2 axial skeleton of adult horses
3 M. DeBoer[a], T. Rieck[b], L. Johnson[a], H. Redenius[a], and K. Martinson[e]

SLOW-FEEDER USERS

Horse keepers & horses

Population of slow-feeders users

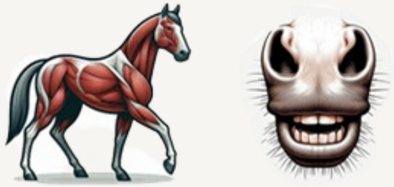
→ **Chapter 1**



Horses

Do hay nets encourage natural feeding patterns?

→ **Chapter 2**



Horses

Long-term effect of hay net on health and welfare of horses

→ **Chapter 3**

Horses

Comparing slow- and portioned-feeding for horses housed in groups

→ **Chapter 4**

Descriptive study

Observational study

Experimental study

Manuscript 5: Impact of feeding strategies on the welfare and behaviour of horses in groups: an experimental study

M. Roig-Pons, S. Briefer-Freymond, I. Bachmann

This manuscript will be submitted to *Plos One*

Chap. 4 - Brief background

Keeping horses in groups

- **Importance of conspecifics**
- **Detrimental effects single-housing**
- **Group housing highly recommended** by many authorities
- **Individual housing still very prevalent** (practicality, space limitation, tradition & … **fear of injuries**)

Tyler 1972; Boyd and Bandit, 2002; Feh, 2005; Hartmann et al., 2012; Marliani et al., 2021; Henderson, 2007

Chap. 4 - Brief background

Keeping horses in groups

- **Importance of conspecifics**
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- **Group housing highly recommended** by many authorities
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SF as an alternative to ensure both limited aggression and optimal body condition ?

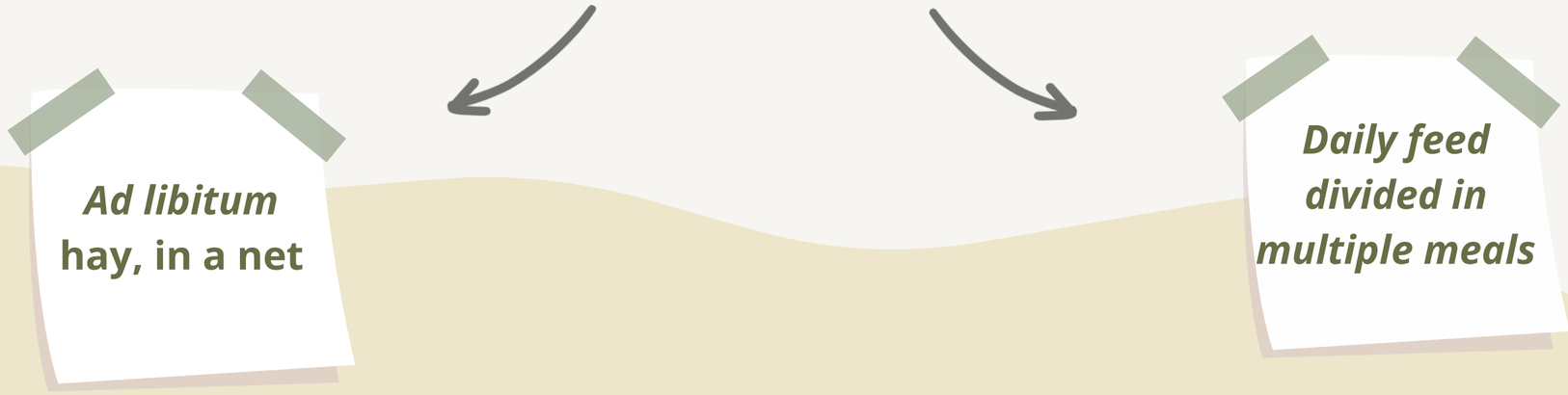
- **Hay availability closely linked to agressiveness**
- **Ad libitum hay: not always feasible** (overweight, waste)
- Two potential feeding strategies: **multiple portioning** or **slow-feeding**

Benhajali et al., 2009; Burla et al., 2016; Seabra et al., 2023; Ellis et al., 2015; Rochais et al., 2018

Chap. 4 - Aims & Hypotheses

Aims

- Compare two feeding strategies with same goal (slow-feeding / multiple portioning)



Chap. 4 - Aims & Hypotheses

Aims

- Compare two feeding strategies with same goal (slow-feeding / portioning)
- Test importance of hay availability vs. duration feeding breaks

Chap. 4 - Aims & Hypotheses

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- Test importance of hay availability vs. duration feeding breaks

Hypotheses

- Slow-feeding (ad libitum with a net) enhances welfare by promoting a natural time budget and reduce aggression compared to portioned feeding
- Slow-feeding may cause frustration
- Dividing daily feed into smaller and more regular meals may improve horse welfare

Chap. 4 - Methods

- Social interactions
- Injuries
- Time-budget
- Lying behaviour

- 4 groups of 4-5 mares
- Identical housing

Chap. 4 - Methods

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- Injuries
- Time-budget
- Lying behaviour

- 4 groups of 4-5 mares
- Identical housing
- 3 treatments

Traditional (TD)
3 feeding slots of **2 hours each**
(7-9 am, 1-3 pm, 7-9 pm)

Portioned (PO)
6 feeding slots of **1 hour each**
(3-4 am, 7-8 am, 11-12 pm, 3-4 pm, 7-8 pm, 11-12 pm)

Slow-feeding (SF)
Ad libitum hay, covered by a **net**

Total = 6h
Loose hay

Chap. 4 - Methods

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- 3 weeks of habituation,
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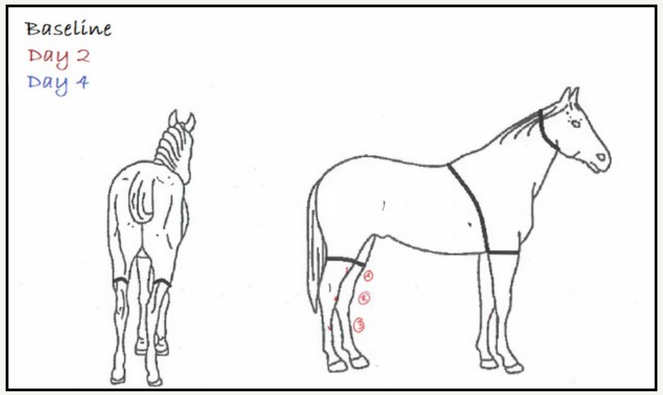
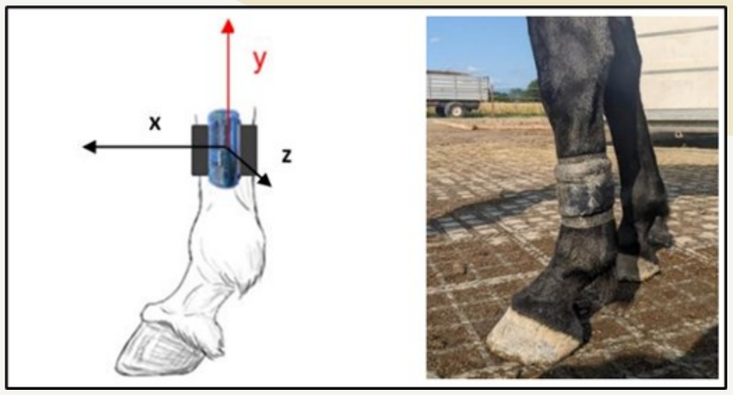
Activity & spatial positioning

Social interactions

- Number of new injuries
- Time spent lying





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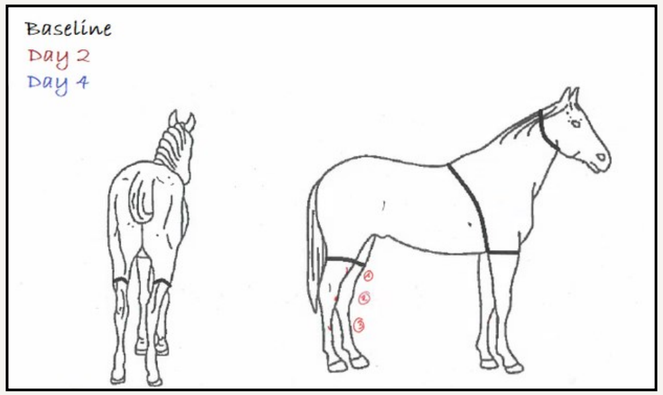
Social interactions

- Number of new injuries
- Time spent lying

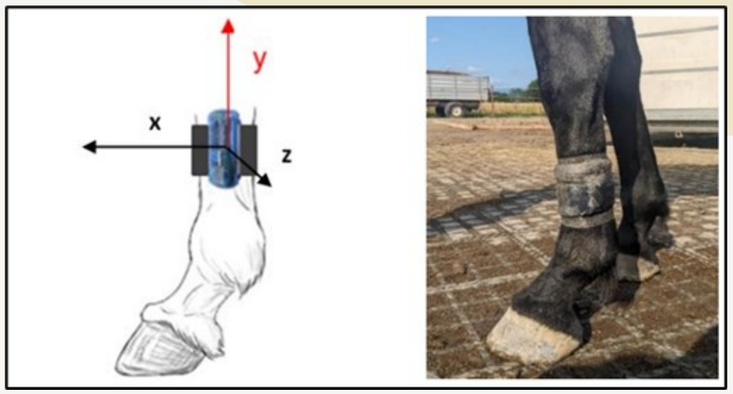
Diurnal activity distribution (descriptive stat.)

Social int: Linear mixed-models

Generalized linear mixed-models



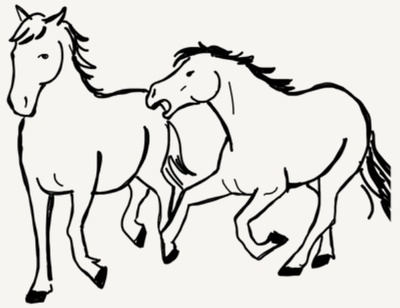
Linear mixed-models



- Transformation (1+ log(response variable)) when needed
- Tukey's post-hoc tests

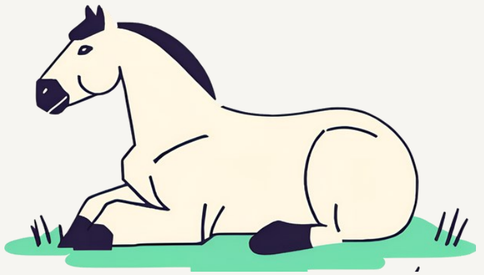
Chap. 4 - Key findings

Diurnal time-budget



Social interactions

Injuries



Lying behaviour

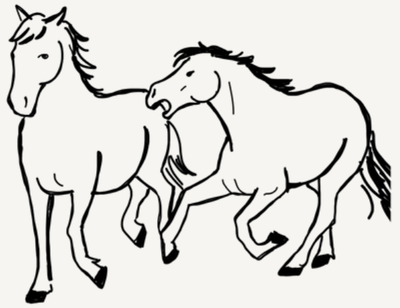
Chap. 4 - Key findings

- **With SF :**
  - **increased feeding time**
  - **more social interactions & less “standing”**

- **TD & PO: very similar**

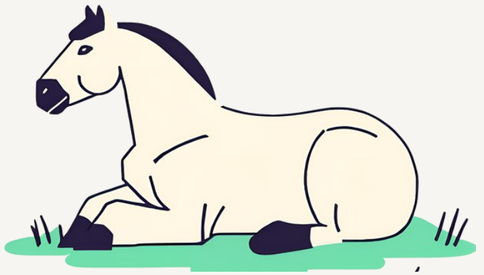
Chap. 4 - Key findings

Diurnal time-budget



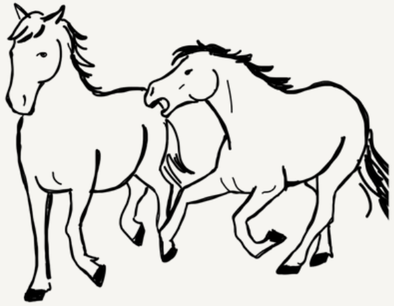
Social interactions

Injuries



Lying behaviour

Chap. 4 - Key findings

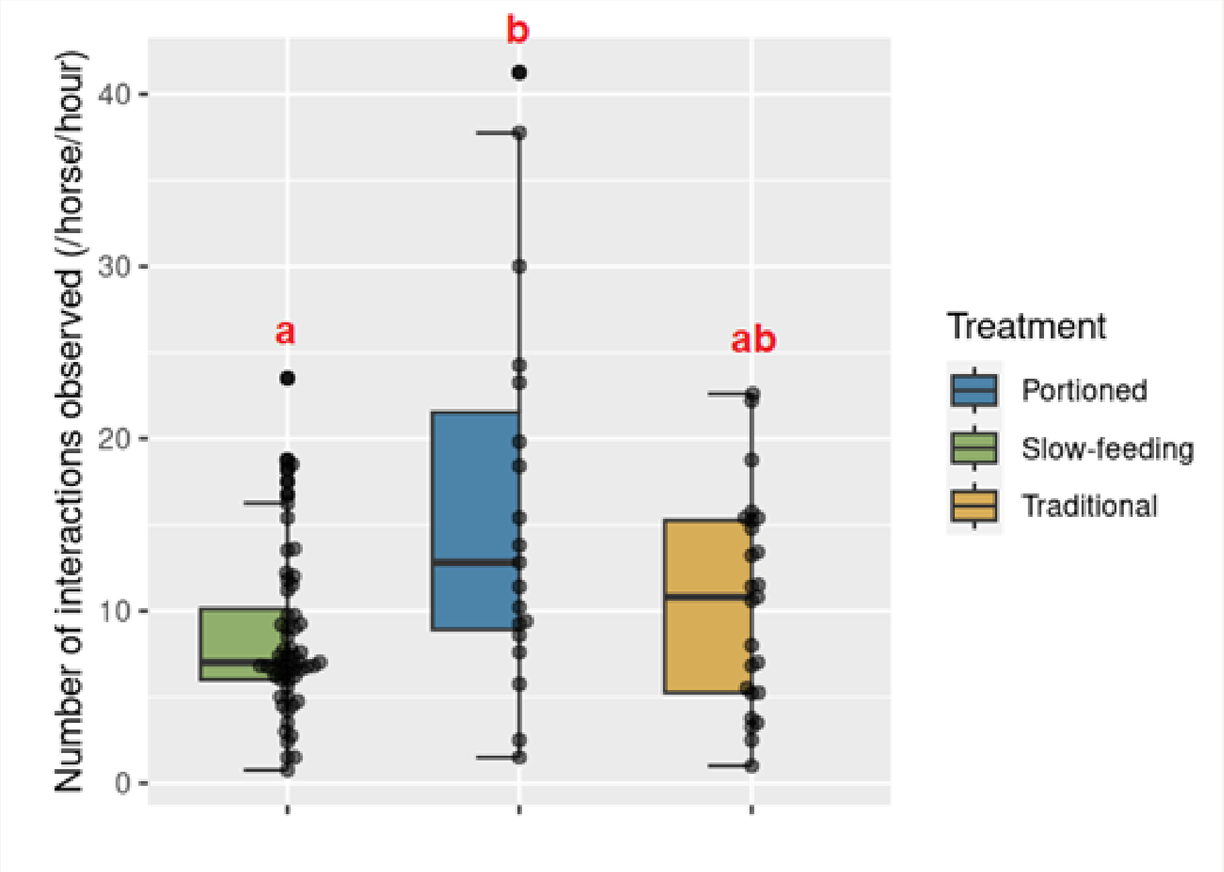


Affiliative interactions

- **No effect of treatment**

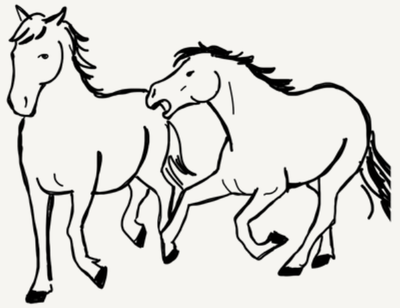
Agonistic interactions

- **SF: significant decrease during meals compared to PO** *(p < 0.01)*
- **No significant difference TD/PO**



Chap. 4 - Key findings

Diurnal time-budget



Social interactions

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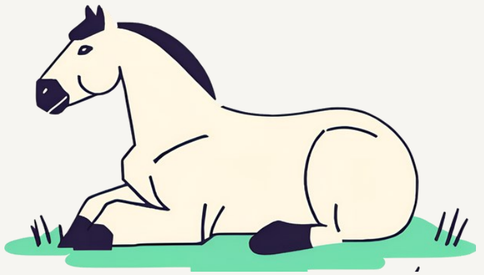
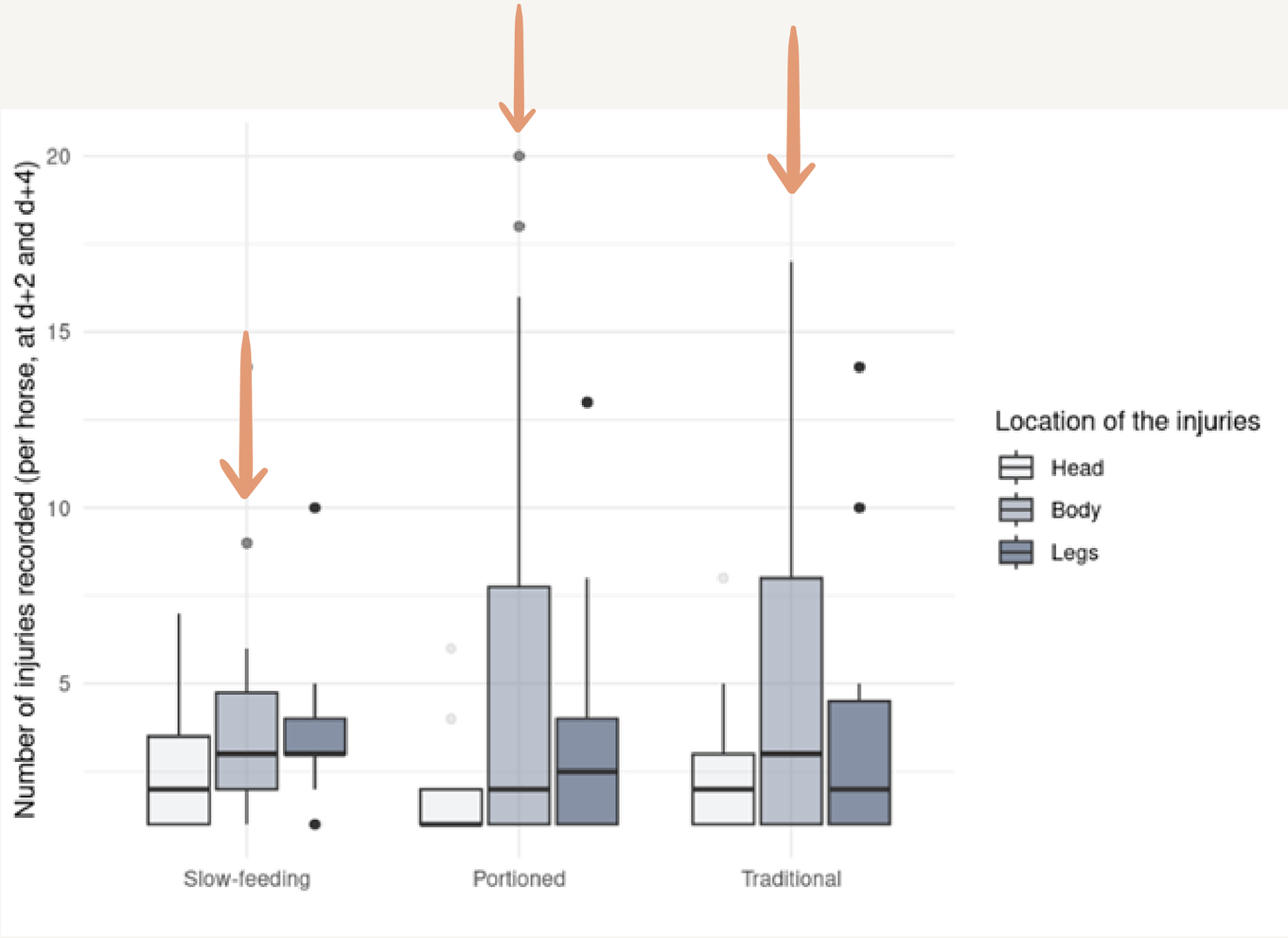


Lying behaviour

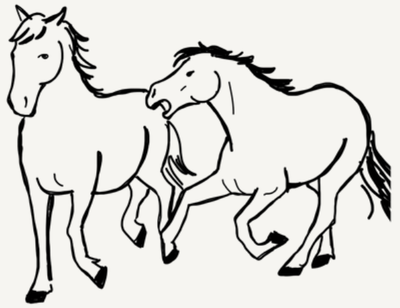
Chap. 4 - Key findings

- **No effect of treatment on injury incidence**
- **Less body-located injuries in SF**



Chap. 4 - Key findings

Diurnal time-budget



Social interactions

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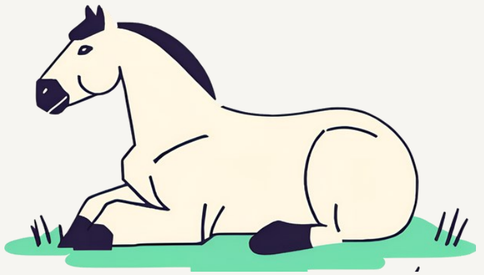
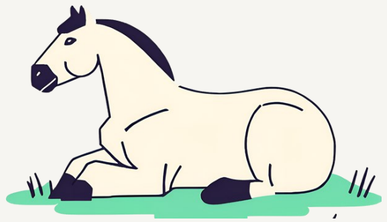
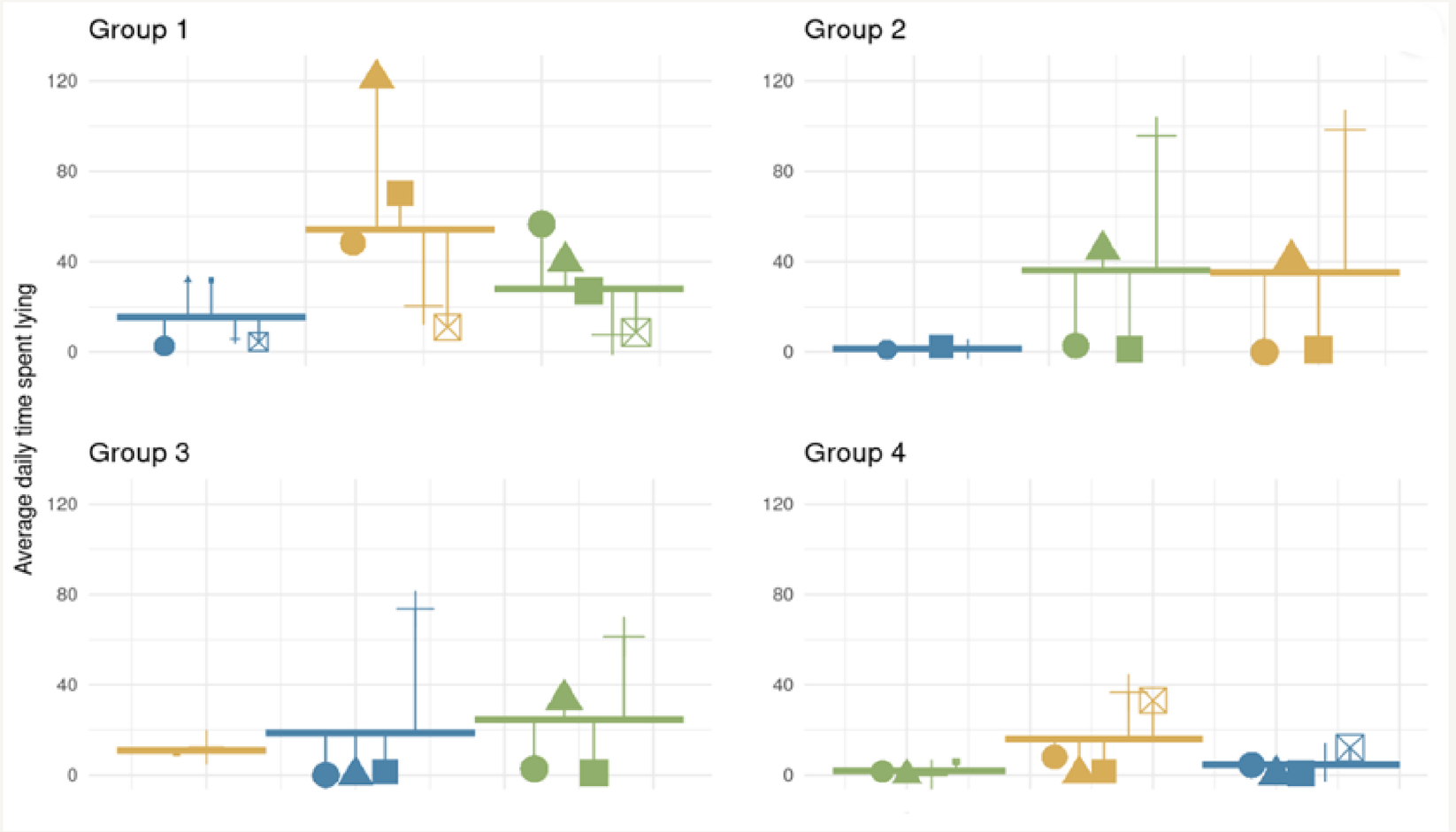


Lying behaviour

Chap. 4 - Key findings



- **Significant reduction in time spent lying in PO** *($p < 0.001$)*



Chapter 4 - Conclusions

Hypotheses

- Slow-feeding (ad libitum with a net) enhances welfare by promoting a natural time budget and reduce aggression compared to portioned feeding ✓
- Slow-feeding may cause frustration ~
- Dividing daily feed into smaller and more regular meals may improve horse welfare ✗

Take-away

- **Slow-feeding treatment positively enhanced the welfare of horses compared to multiple portioning** (reduced agonistic level / more natural time-budget)

-> SF = valuable option to optimize time spent feeding, body condition and regulate risk of injuries

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- **No behaviours indicative of frustration** but increased agonistic level compared to ad libitum loose hay
- **Reducing fasting periods did not effectively reduce the level of aggressiveness and risk of injury**
- **Further research is needed** to assess the welfare implications of the timing, frequency and duration of feeding sessions

6 General discussion and perspectives

General discussion

Let’s remember the initial hypotheses …

- *Slow-feeder can improve human-horse relationship*
- *Slow-feeder can promote a more natural feeding behaviour compared to loose hay*
- *Slow-feeding is associated with health impairments: (teeth, gums and vibrissae)*
- *Slow-feeding is associated with health impairments (musculoskeletal health)*
- *Slow-feeding promote a more natural time-budget compared to multiple portioning but may also be frustrating to horses*

General discussion

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- *Slow-feeder can improve human-horse relationship* ~

--> No clear association but SF may improve horse-human relationship for rationed horse

- *Slow-feeder can promote a more natural feeding behaviour compared to loose hay* ✓

--> **Hay net** = **more natural collection of forage** & **unchanged number of chews remain** over 24h

- *Slow-feeding is associated with health impairments: (teeth, gums and vibrissae)* ~

--> **Hay nets** = **risk factor** for **redden and raised gingiva margins**, but nor for increased teeth and vibrissae wear

- *Slow-feeding is associated with health impairments (musculoskeletal health)* ✗

--> **Hay nets** = **not a risk factor** for **increased musculoskeletal impairments**

- *Slow-feeding promote a more natural time-budget compared to multiple portioning but may also be frustrating to horses* ✓

--> **Ad libitum hay in net** = **more natural time-budget & lower agonistic level** than portioned feeding

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--> **Ad libitum hay in net** = **more natural time-budget & lower agonistic level** than portioned feeding

General discussion

General limitations & associated perspectives

- Although lots of different type of studies: some of them only observational --> **need to be confirmed with experimental studies**
- Some sample sizes are limited --> **need replication** (preference test)
- Could not quantify hay consumption in last study and only compared it to portioned feeding

--> would be beneficial to **compare with other weight management strategies**

- **Only focused on hay net**s (except for Manuscript 1) --> part of SFs is still a mysterious world

General discussion - Implications

Should we recommend the use of slow-feeding?

General discussion - Implications

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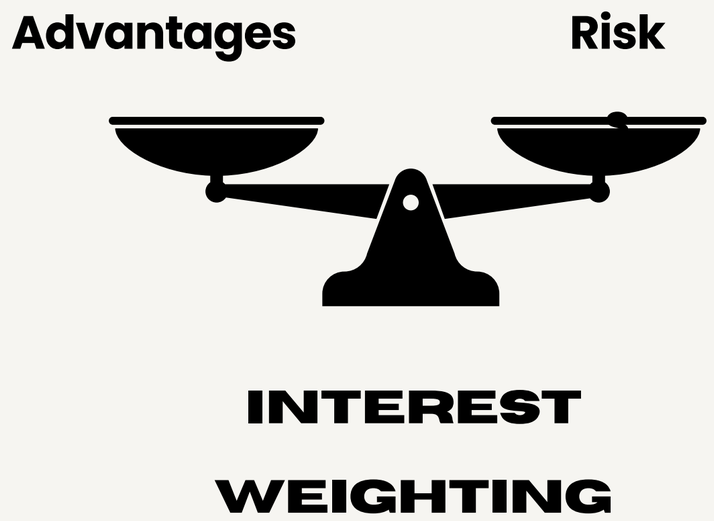
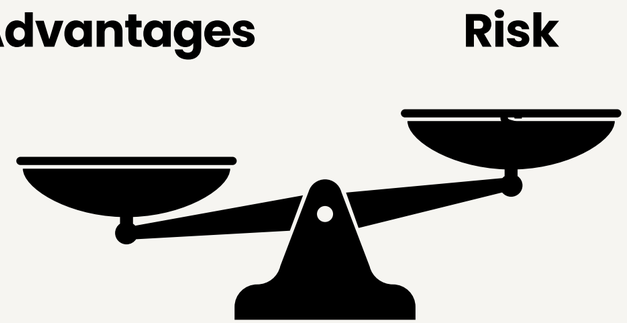


General discussion - Implications

Should we recommend the use of slow-feeding?



- No access to pasture
- No ad libitum hay
- Overweight horses

General discussion - Implications

Should we recommend the use of slow-feeding?

- Horses who can receive ad libitum hay
- Population different from our study populations
- Mobile, vertical and high SFs

General discussion - Implications

Slow-feeding as an enrichment ?

What is an enrichment ?

- change that is beneficial to the animal
- add behavioral choices / increase behavioural diversity
- promote species-appropriate repertoires;
- increase ability to cope with challenges

Newberry 1995; Young 2003, Mc Gowan 2007; Westlund 2014,

General discussion - Implications

Slow-feeding as an enrichment ?

What is an enrichment ?

- change that is beneficial to the animal
- add behavioral choices / increase behavioural diversity
- promote species-appropriate repertoires;
- increase ability to cope with challenges

- Not associated with major impairments
- Increases time spent feeding
- May promote better dental health
- Provide opportunity of choice

- Promote more natural collection of forage
- Contrafreeloading phenomenom

- Promote more natural collection of forage
- Browsing behaviour of horses
- Foraging behaviour
- Chewing-type oral movements

Tyler, 1972; Bergeron et al., 2006; Goodwin et al., 2007; Van Den Berg et al., 2015

Acknowledgments









UniBern, Agroscope

Stagiaires

Biopraxia, ostéo

Horse owners
Horses

UNIVERSITÄT BERN

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Economic Affairs,
Education and Research EAER
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Acknowledgments

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ÉCOLE D'OSTÉOPATHIE ANIMALE biopraxia ENSEIGNEMENT SUPÉRIEUR PRIVÉ

UniBern & Agroscope

Animal Welfare Division & Swiss National Stud Farm

Biopraxia & practitioners

- Kim Périchon-Naour, Philippe Ertzer, Alice Jeammes, Anne-Catherine Weber
- Clémence Pérot
- Tessa, Tess, Camille, Caroline & Jeanne

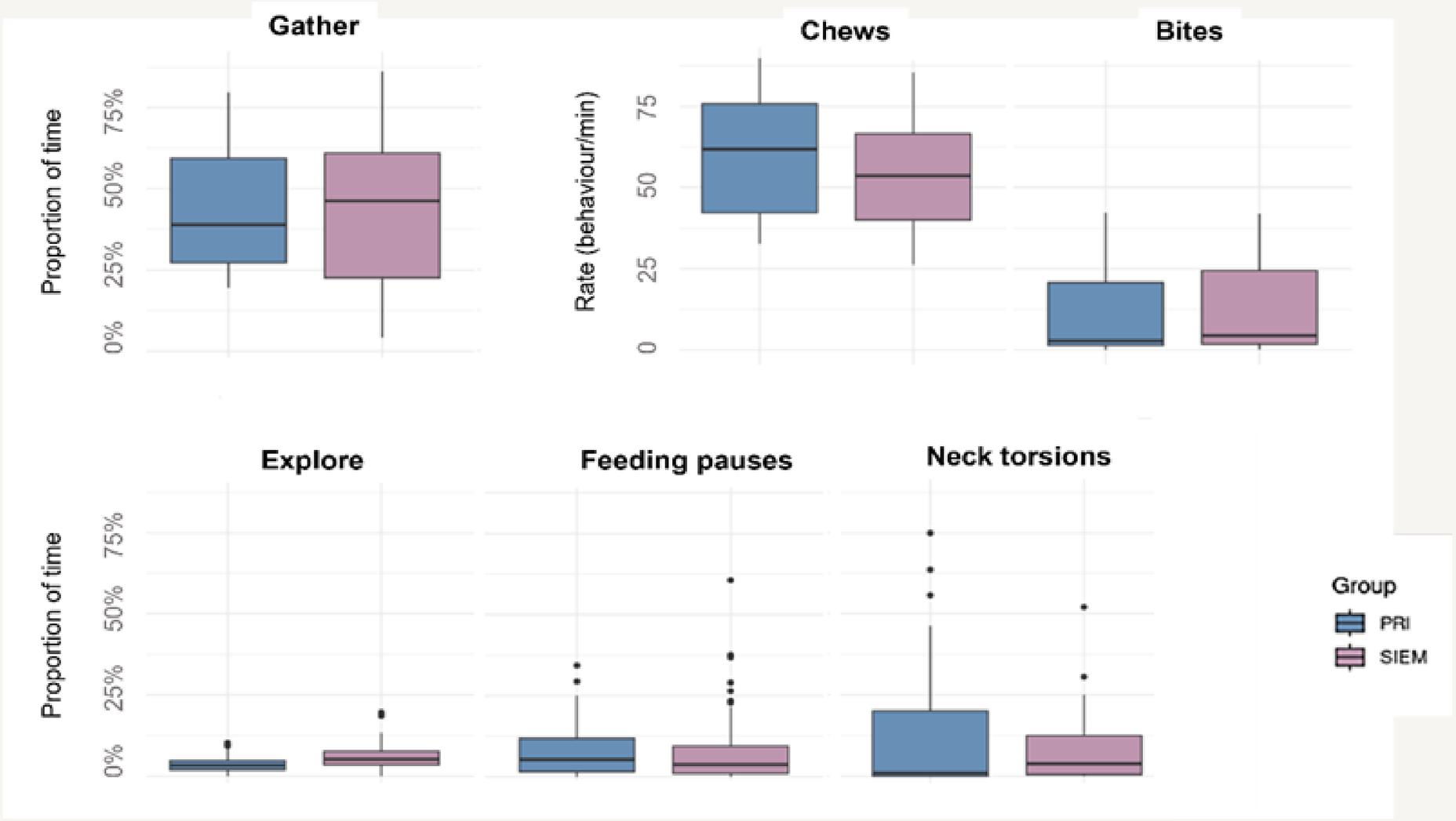
Interns

Clémence, Aurélia, Laurie, Claire, Chloé, Stérenn, Maëlle, Emilie, Johann,, Loic & Romane

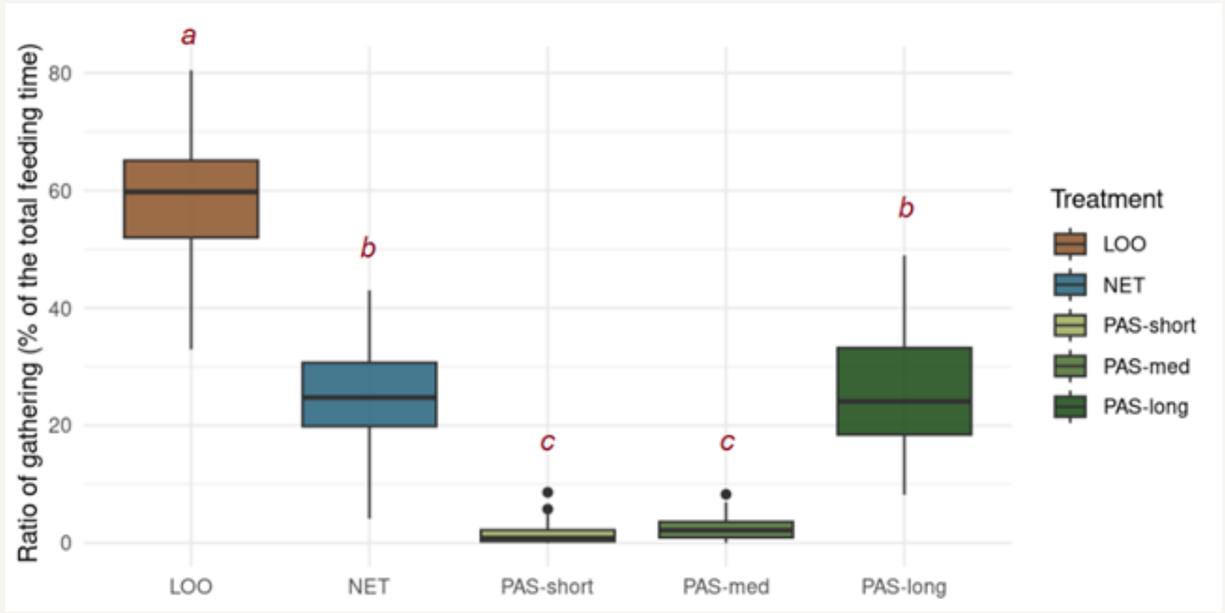
Horses & Horse owners

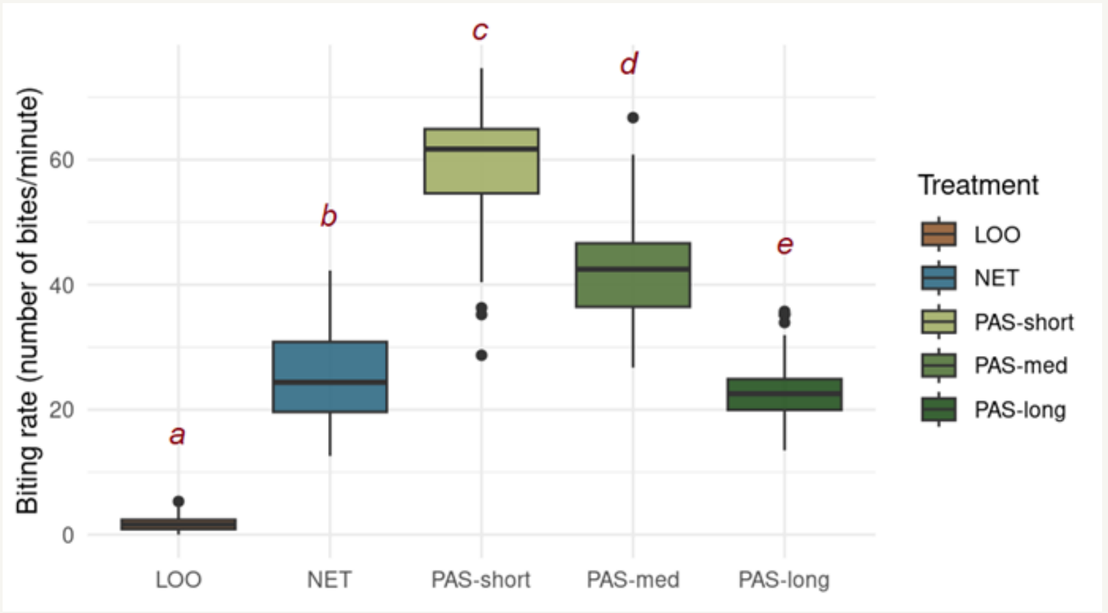
Friends & Family

Feeding behaviour

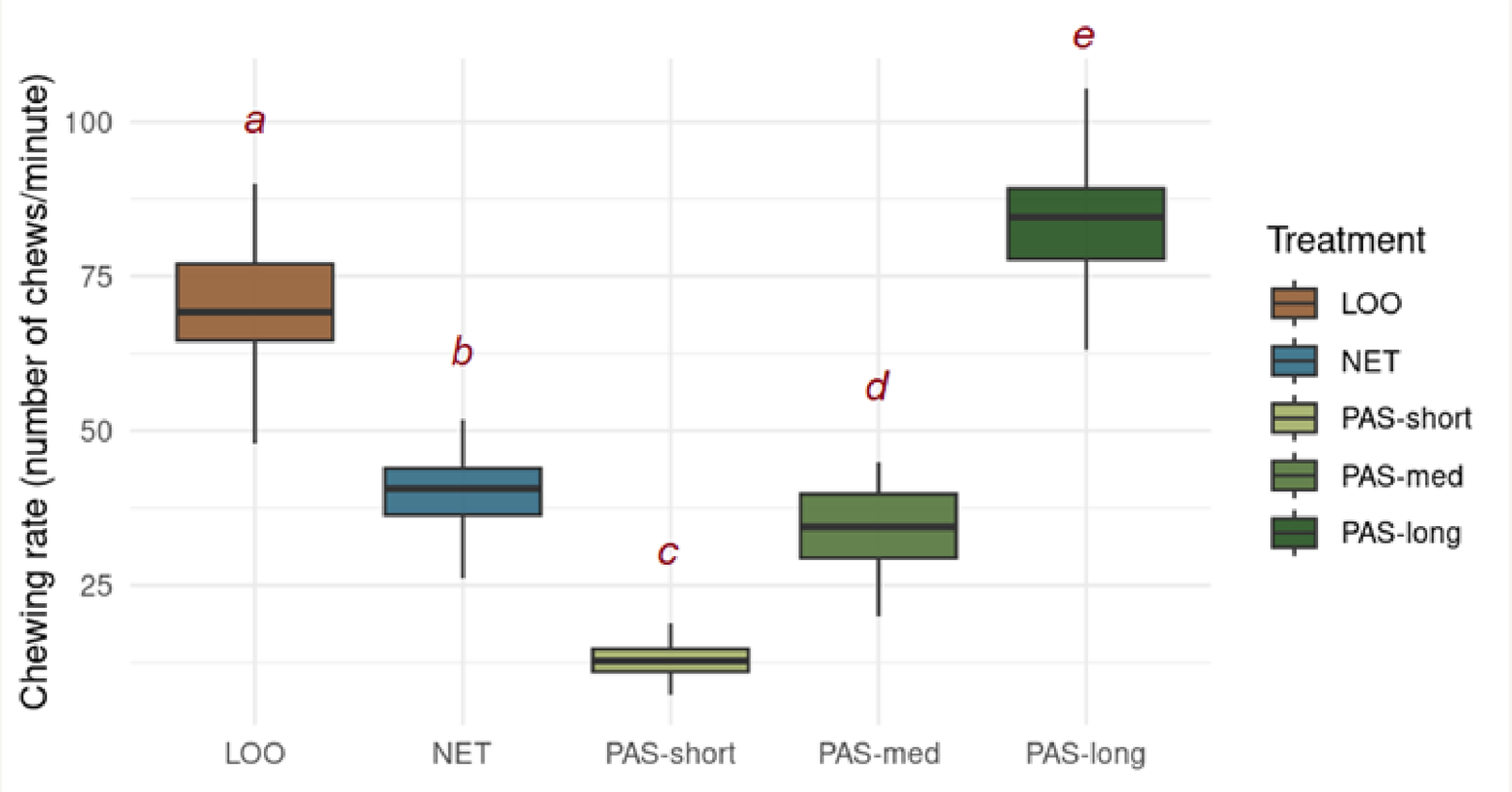


Feeding behaviour (forage collection)

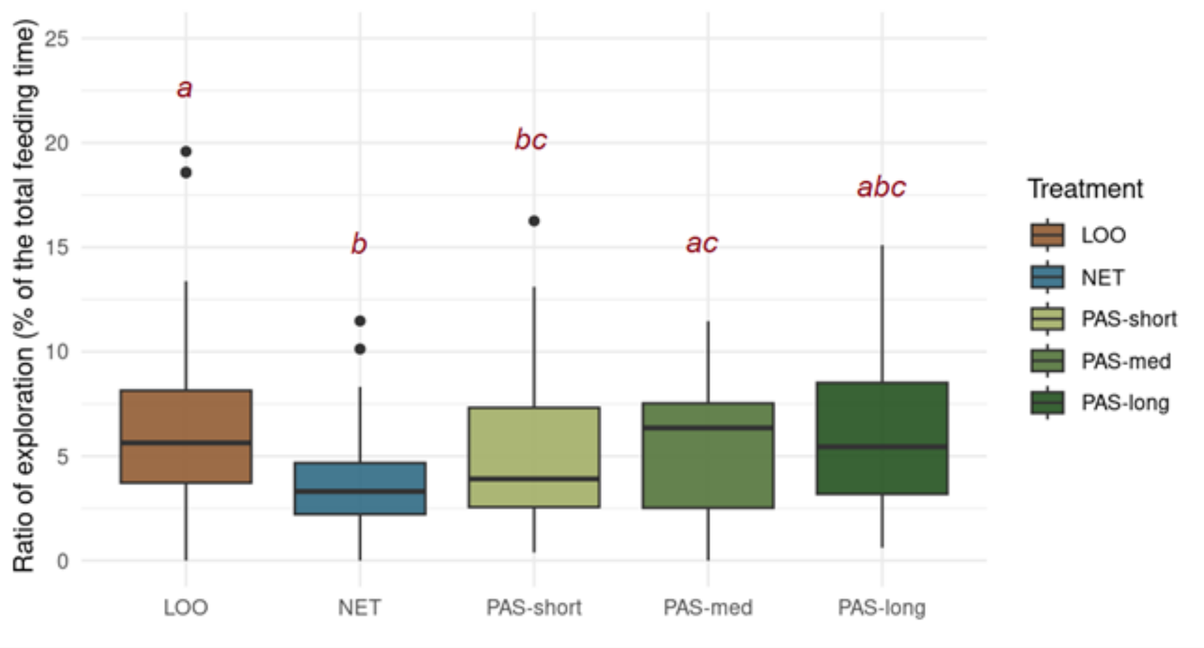


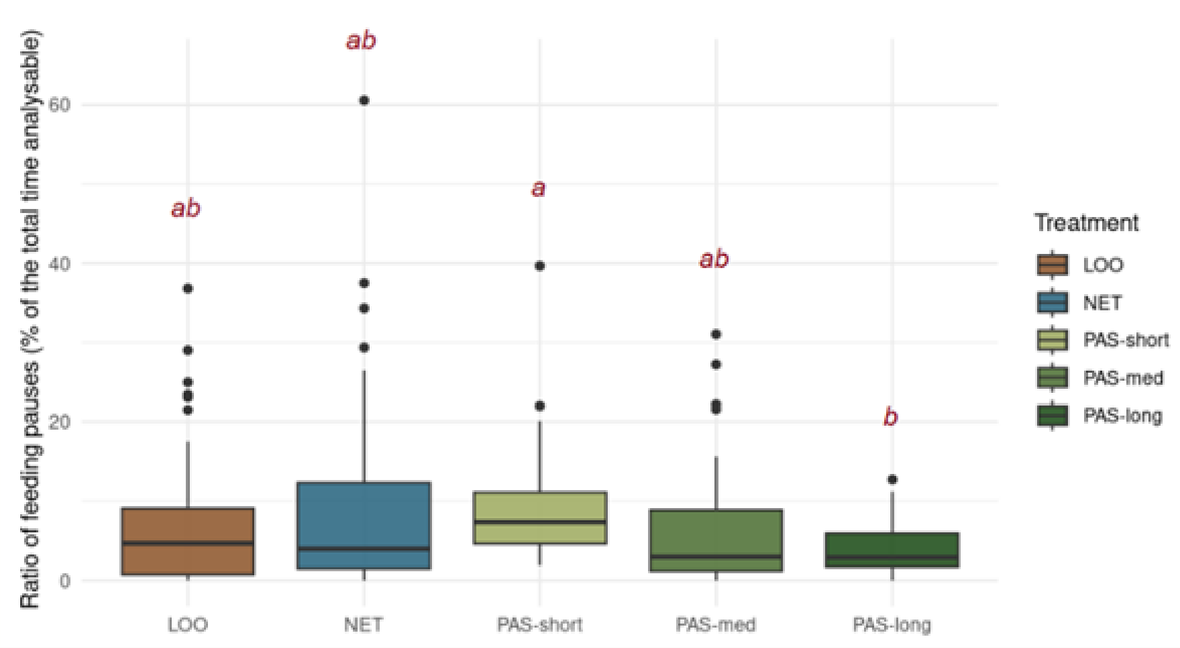


Feeding behaviour (forage mastication)



Feeding behaviour (exploration & pauses)





Feeding behaviour (preference test)

Table 6 - Total time and ratio of time spent feeding from the loose hay (LOO), from the net (NET) and doing some voluntarily feeding pauses for the 3 tests of the five horses during the preference test.

Horse	Test	TotalTime.min	RatioLOO	RatioNET	RatioPauses
AL	Test1	30.04	89.41	2.54	8.02
AL	Test2	31.5	90.32	2.67	6.97
AL	Test3	30.03	76.4	13	10.58
CH	Test1	30.02	50.4	1.13	48.4
CH	Test2	30	0	78.85	21.1
CH	Test3	30.21	66.64	0	29.88
DE	Test1	30.02	55.12	0	0
DE	Test2	30.02	56.86	0	0
DE	Test3	26.76	16.49	2.31	66.65
FO	Test1	30.1	64.81	21.59	13.25
FO	Test2	34.06	22.84	54.94	17.62
FO	Test3	30	74.53	5.51	18.86
US	Test1	30.33	93.9	0	6.05
US	Test2	30.02	54.71	0	45.28
US	Test3	30.03	63.45	0	36.53

Feeding behaviour (pilot-study)

	Ground	Hay Bag	Heu Toy	Porta Grazer
Frequency of «chews» *(nb/min)*	71.21 ±7.72	49.94 ±14.19	33.54 ±9.45	41.18 ±8.47
Frequency of «bites» *(nb/min)*	0.62±0.95	8.78±4.27	9.75±2.88	12.44±4.63
Gathering *(% of the time spent feeding)*	63.39±14.27	15.47±11.00	41.43±9.44	23.91±13.86
Exploration *(% of the time spent feeding)*	3.13±3.27	3.22±4.07	5.53±5.58	1.64±3.52
Neck torsion *(% of the time spent feeding)*	0	7.12±5.44	40.33±17.64	1.52±2.05

Feeding behaviour (pilot-study)

	Ground	Hay Bag	Heu Toy	Porta Grazer
Frequency of frustration-related behaviours *(number/min spent feeding)*	0	0.49	0.79	0.47
Ratio of feeding breaks *(% of analysable time)*	19.70	42.13	24.55	22.46
Average total time of feeding breaks *(min.)*	2.89	6.40	4.47	3.41
Mean duration of the feeding breaks *(sec.)*	73	195	86	108

Chap.3.2 - Methods

- Agreement
- Intra-rater reliability
- Inter-rater reliability
- Feasability

- 2 sub-projects: : one for ROC, one for MSH

- Agreement
- Gwet and Kappa indices
- Measure time & report experience

ROC : photographs, **6 items** *(gingiva margin, tartar closest to margin and on the tooth, cememntum cracks, level and type of abrasion)*

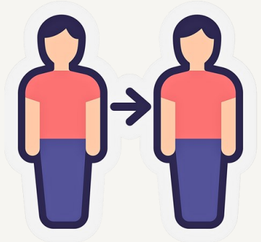
- 15 photographs , 3 raters
- 50 photographs, 3 raters

MSH : live evaluation, manual palpation of 4 types of structure *(12 muscles, 11 peri-articular tissues, 11 articular, 3 visceral)*

- 9 horses, 1 practitioner
- 12 horses, 6 practitioners

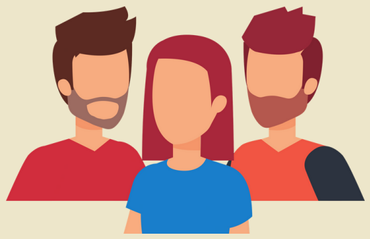
Chap.3.2 - Key findings

Musculoskeletal health (MSH)



- **Gwet indices** ranged from **0.70** to **0.84**

- **16'42" on average** (11'00"–27'25")
- **Importance of prior exeperience** (distribution score, time taken)

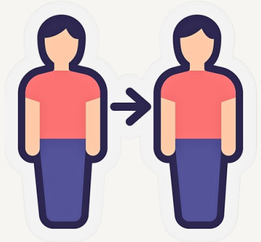


- **Gwet indices** ranged from **0.62** to **0.70**, except for “Viscera” (0.55)

- **Concordance results obtained / literature** : suggest validity ?

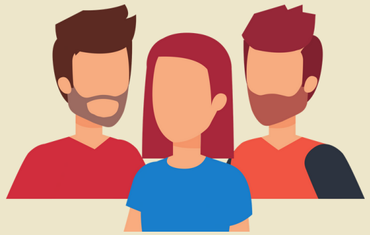
Chap.3.2 - Key findings

Rostral oral cavity (ROC)



- **Gwet indices** ranged from **0.23** to **1** (0.80 to 1 without Rater 3)

- **14'22" to 5'50"** per photograph
- **1.8% of NAs**
- **Training > Background**



- **Gwet indices** ranged from **0.60** to **0.72**

- **Concordance ROC score / dental abnormalities** *(De Boer et al, 2024)*
- **Cordance ROC score / age** *(previous study)*

Chap.3.2 - Key findings

General

- **Impact overall distribution of scores on indices** : “Kappa paradox”
- **Importance of training** (MSH: improved results from 3rd horse; ROC: improved results for 2 most trained raters)

Chap.3.2 - Key findings

Musculoskeletal health (MSH)

- Intra-rater reliability: **Gwet indices** between **0.70** and **0.84**
- Inter-rater reliability: **Gwet indices** between **0.62** and **0.70**, except for “Viscera” (0.55)
- Feasability: **16'42" on average** (11'00"-27'25"). **Importance of prior exeperience** (distribution score, time taken)
- Validity: **Concordance results obtained / literature** : suggest validity ?

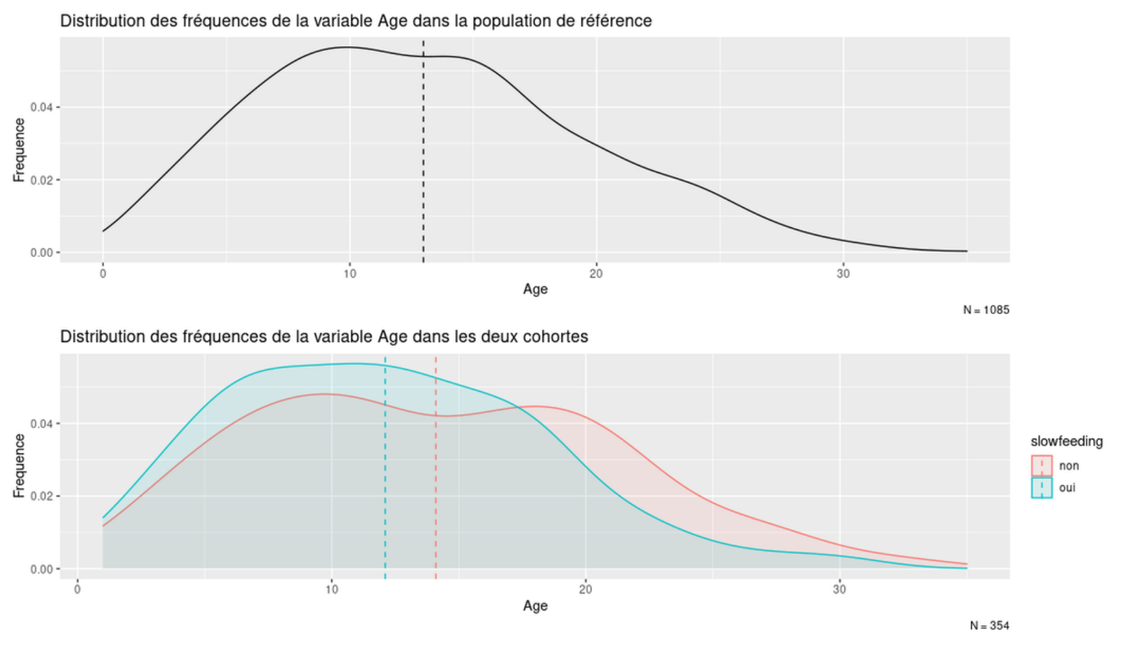
Rostral oral cavity (ROC)

- Intra-rater reliability: **Gwet indices** between **0.23 to 1** (0.80 to 1 without Rater 3)
- Inter-rater reliability: **Gwet indices** between **0.60 to 0.72**
- Feasability: **1.8% of NAs _ 4'22" to 5'50"** per photograph _ **Training > Background**
- Validity: **Concordance ROC score / dental abnormalities** (*De Boer et al, 2024*) and **age** *(previous study)*

General

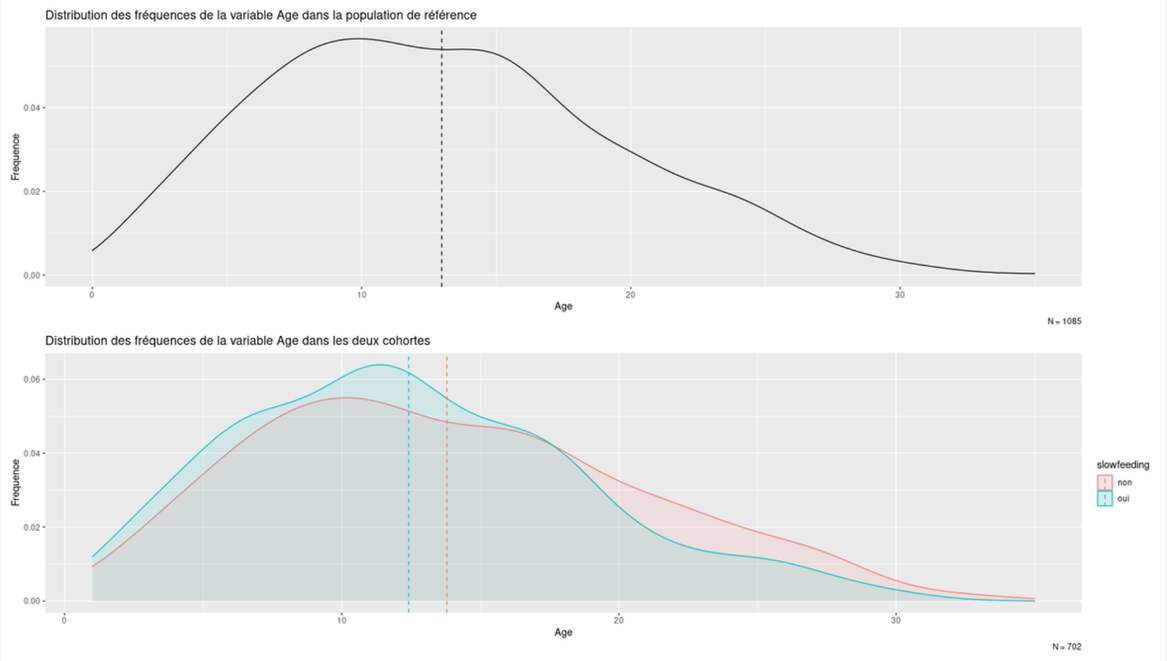
- **Impact overall distribution of scores on indices** : “Kappa paradox”
- **Importance of training** (MSH: improved results from 3rd horse; ROC: improved results for 2 most trained raters)

Cross-sectional study : stratas



202

1



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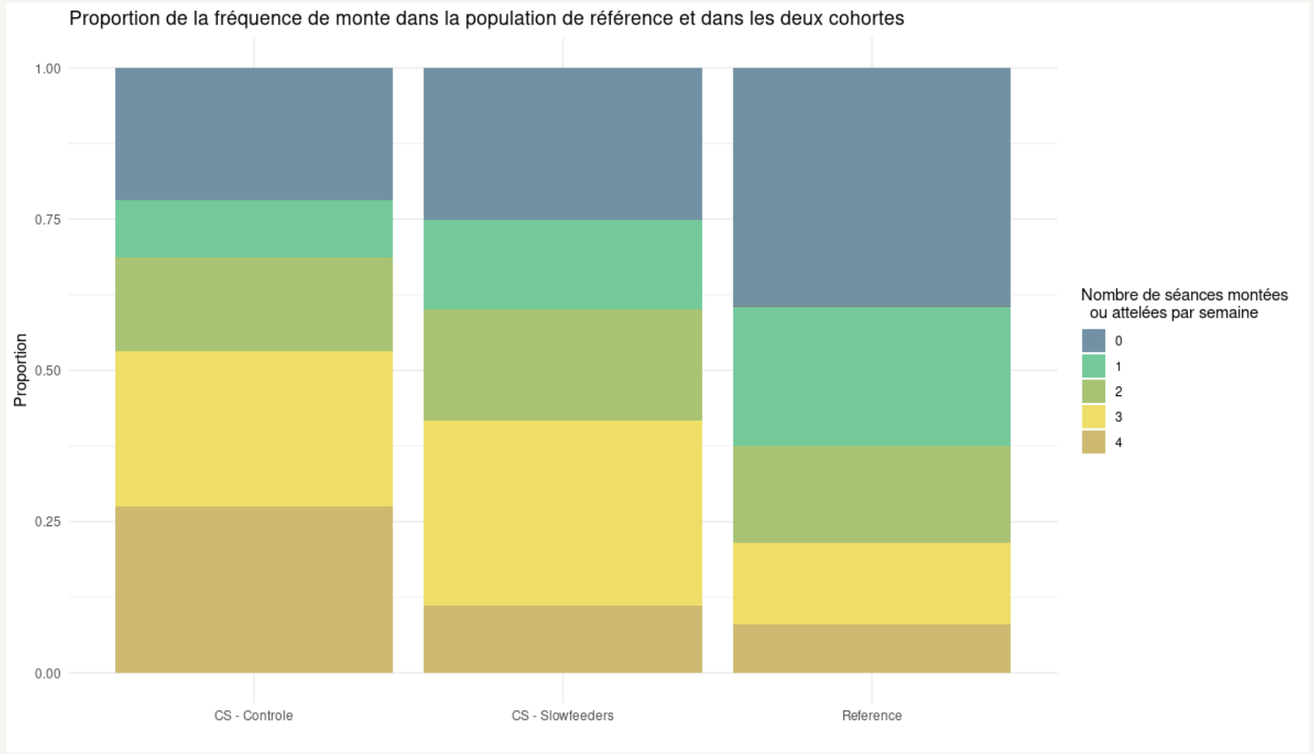
2

Cross-sectional study : stratas



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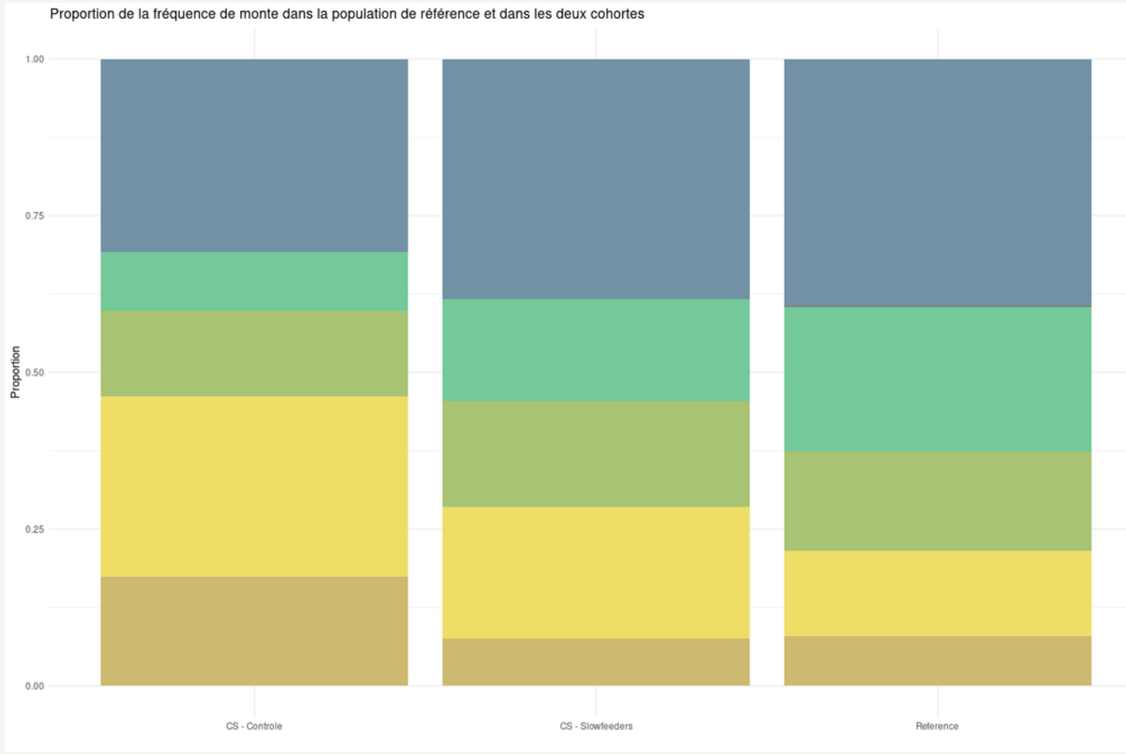

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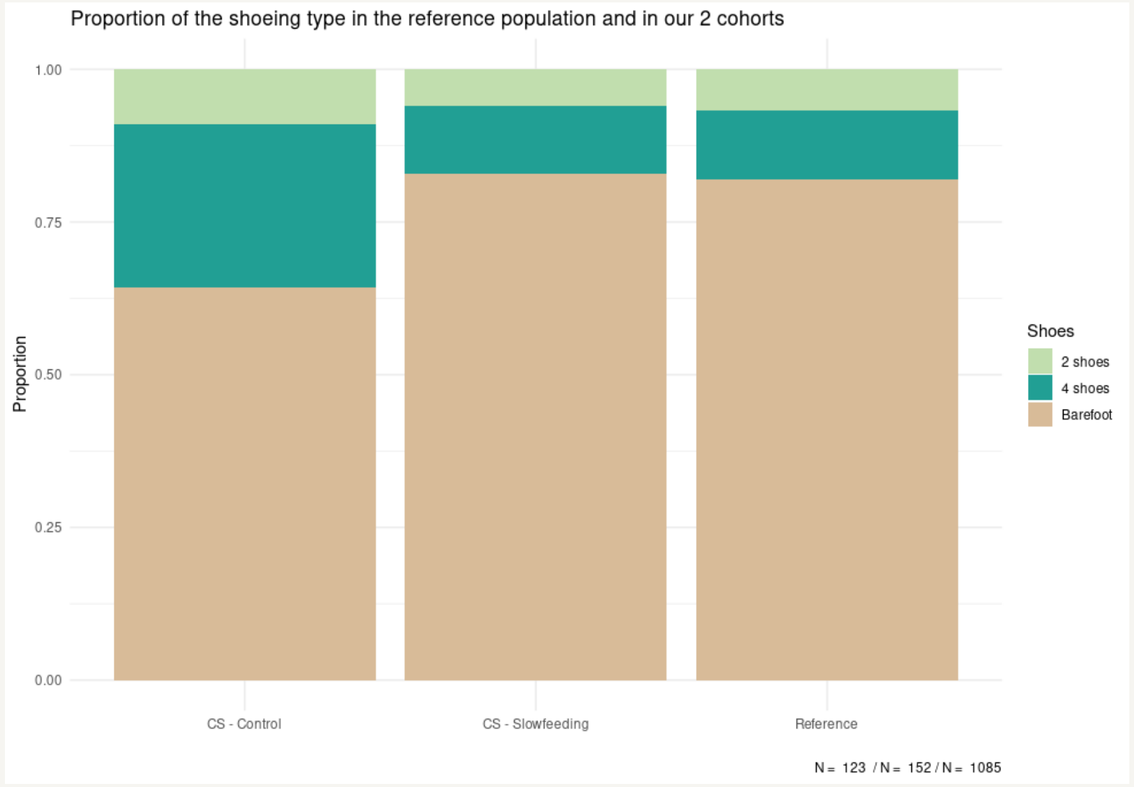
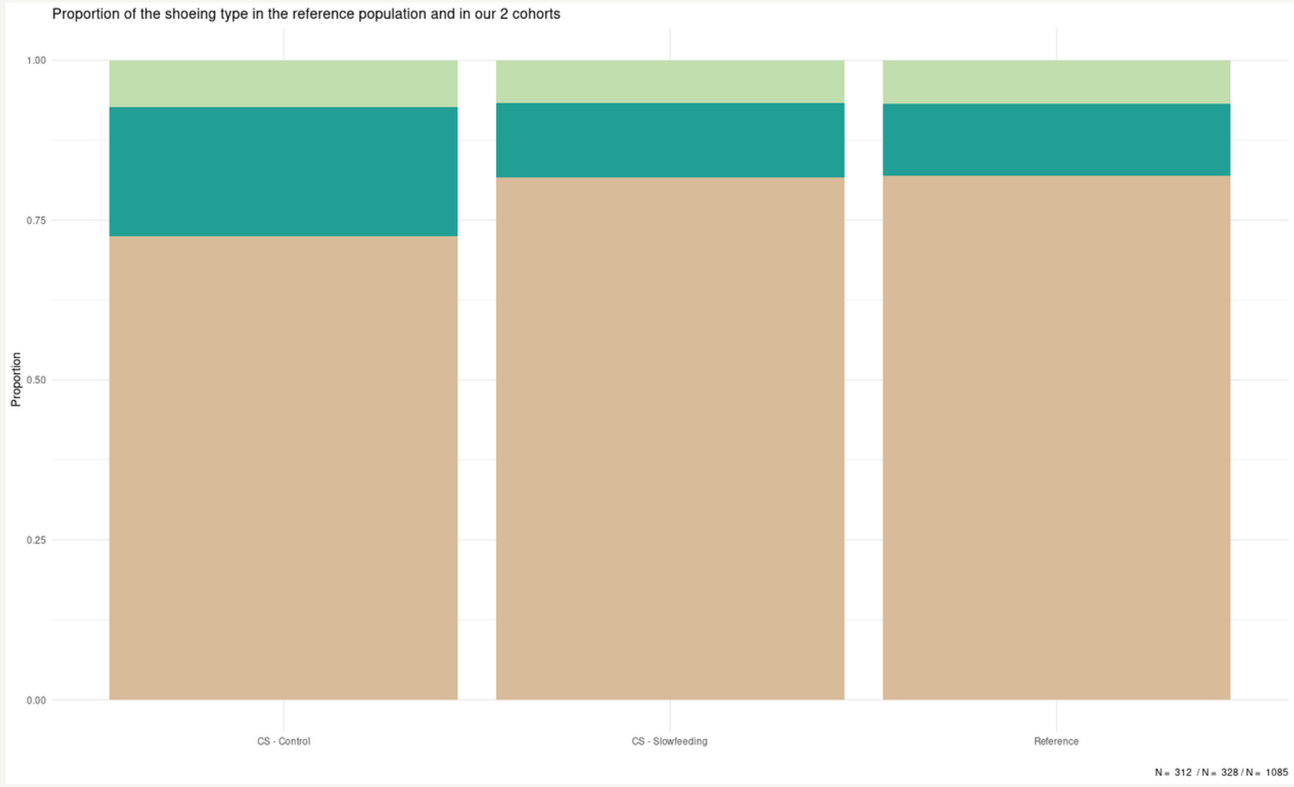
Cross-sectional study : stratas

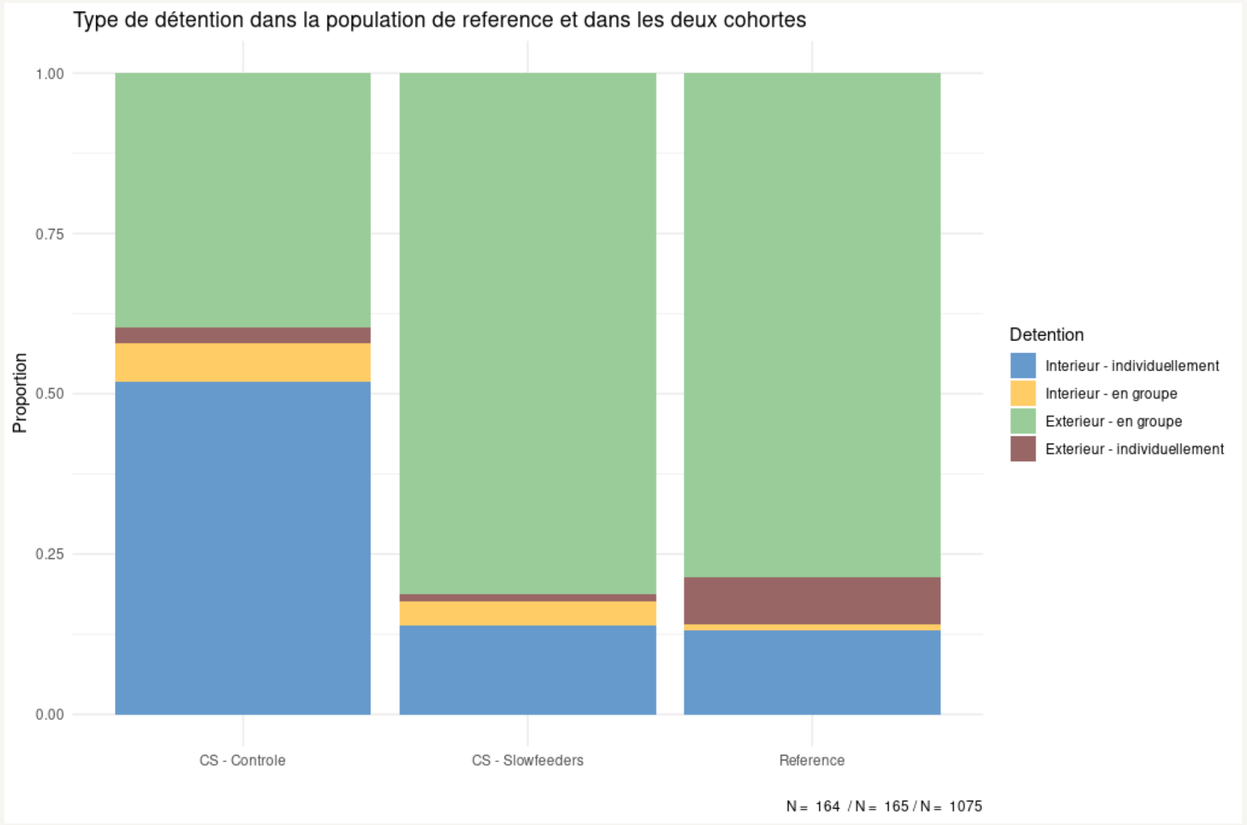


2021



2022

Cross-sectional study : stratas



202

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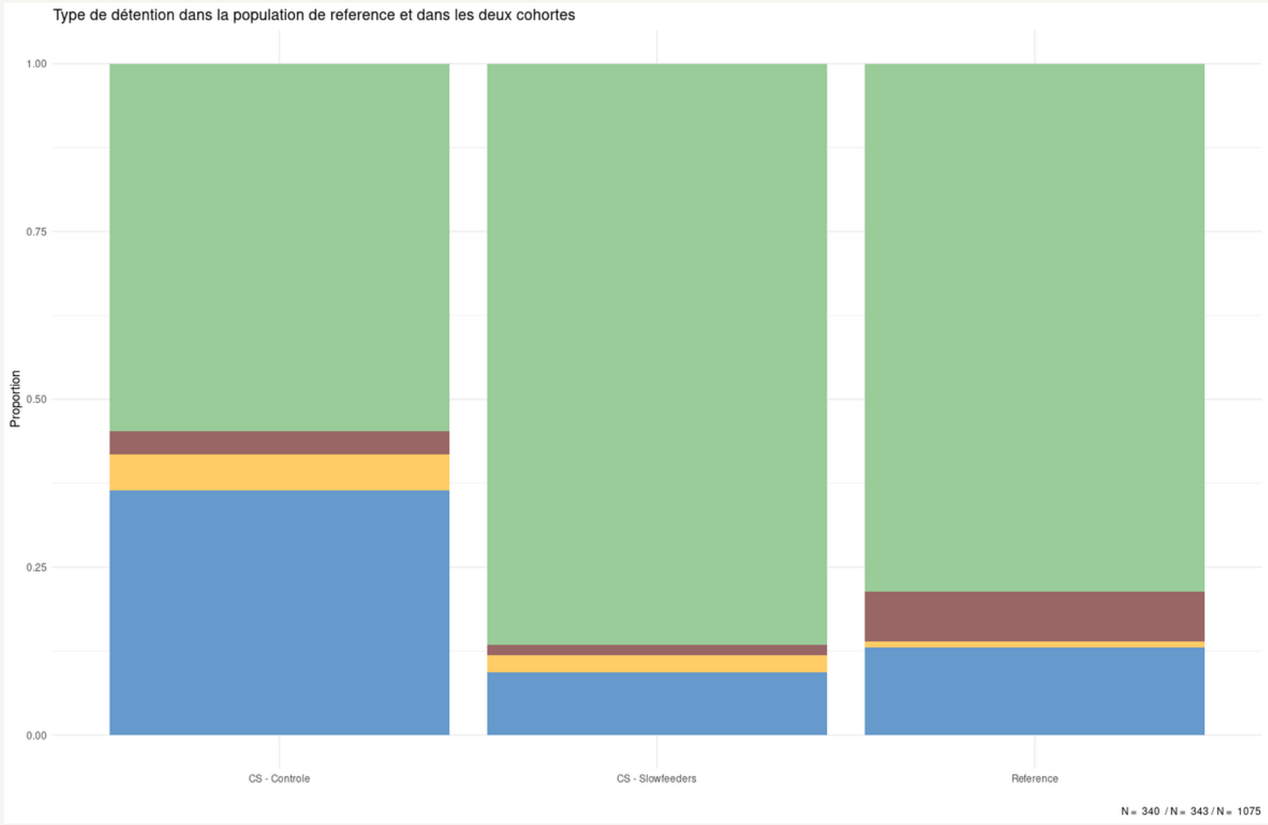

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2

Cross-sectional study : vibrissae

Cross-sectional study : MSH

			Total MSH score mean (sd)	Coefficient est. [95% CI]
Strata	**Shoes**	Barefoot	46.6 (8.7)	-
		2 shoes	49.5 (7.4)	2.35 [-0.73; 5.44]
		4 shoes	49.6 (8.1)	2.04 [-0.21; 4.30
	Training frequency	Less than once a week	47.2 (9.3)	1.24 [-1.30; 3.77]
		Once a week	46.0 (7.5)	-
		Twice a week	47.4 (8.1)	0.42 [-2.4 ; 3.33]
		Three to four times a week	46.5 (7.9)	0.10 [-2.57; 2.76]
		Five times or more a week	50.7 (9.2)	4.75 [1.36; 8.15]
	Age		47.3 (8.6)	0.42 [0.30; 0.54]
Dispenser characteristics	**RatioMinHeightForage**		47.3 (8.6)	0.12 [0.01; 0.22]

N = 446, Log-likelihood = -1556.34, R-squared = 0.14, Adjusted R-squared = 0.13

Cross-sectional study : gingiva

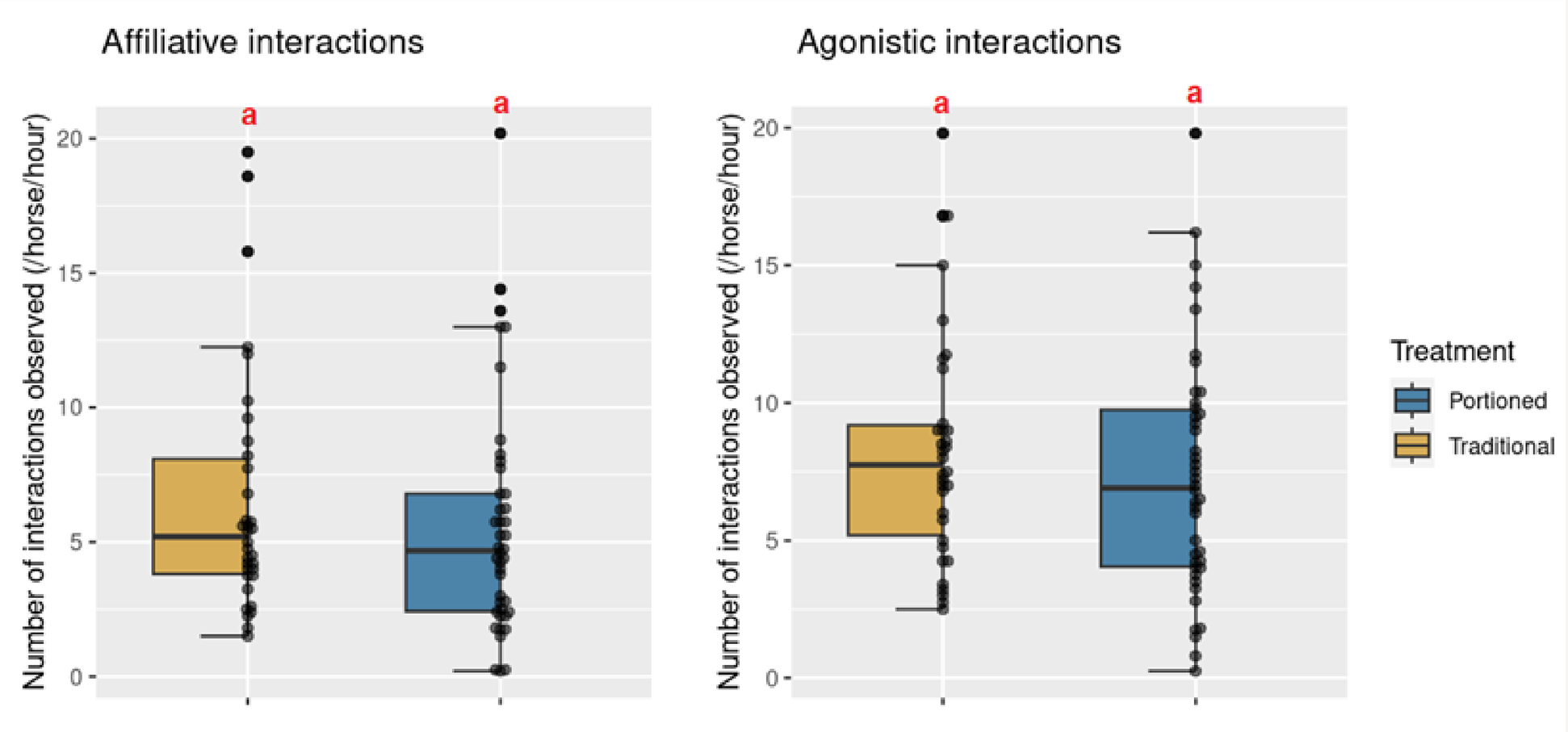
			Gingiva colour - redness	Gingiva colour - redness (NH)	Gingiva margin	Gingiva margin (NH)
			OR [2.5-97.5% CI]	OR [2.5-97.5% CI]	OR [2.5-97.5% CI]	OR [2.5-97.5% CI]
Cohort	**Cohort**	CH	1		1	
		NH	3.45 [1.67; 7.54]		3.38 [2.23; 5.18]	
Strata	**Housing**	Outside	1			/
		Inside	2.1 [0.9; 4.95]			/
	Shoes	Barefoot	1	1	1	
		Shod	2.4 [1.34; 4.28]	2.46 [1.2; 5.03]	1.97 [1.24; 3.18]	
	Training frequency	Less than once a week				0.67 [0.25; 1.7]
		Once a week				1
		Twice a week				2.23 [0.69; 7.47]
		Three to four times a week				0.75 [0.25; 2.26]
		Five times or more a week				4.21 [1.13; 17.25]
	Age	/	1.04 [1; 1.09]		1.04 [1.01; 1.07]	1.04 [0.99; 1.09]
Dispenser characteritics	**Number of dispenser(s) in use**	One type of dispenser only	1			
		At least two different dispensers	2.58 [1.14; 6]			
	Inclination of dispenser(s)	Horizontal	1			1
		Vertical	2.29 [0.59; 8.48]			0.53 [0.12; 2.54]
		Both	0.63 [0.32; 1.2]			0.39 [0.18; 0.83]
	Mobility of dispenser(s)	Fixed only (or ground)		1		
		With Mobility		4.3 [1.3; 14.76]		
	Various height	Yes	0.46 [0.21; 0.98]	0.31 [0.12; 0.74]		
		No	1	1		
	Min. limit of dispenser(s)	/	1.01 [1; 1.03]	1.03 [1.01; 1.06]	0.99 [0.98; 1]	0.98 [0.96; 1]
	Metrics	*C-statistics*	*0.76*	*0.712*	*0.68*	*0.68*
		H&L	*Chi-sq(8)=7.75, p=0.46*	*Chi-sq(8)=13.76, p=0.09*	*Chi-sq(8)=3.08, p=0.93*	*Chi-sq(8)=5.70, p=0.68*

Feeding management - Obs

	Repeat 1	Repeat 2	Repeat 3	Total number per group
Group 1	Observations = 16 Scans = 79	Observations = 15 Scans = 69	Observations = 14 Scans = 74	Observations = 45 Scans = 222
Group 2	Observations = 17 Scans = 74	Observations = 14 Scans = 69	Observations = 12 Scans = 76	Observations = 43 Scans = 219
Group 3	Observations = 17 Scans = 80	Observations = 15 Scans = 64	Observations = 16 Scans = 69	Observations = 48 Scans = 213
Group 4	Observations = 16 Scans = 76	Observations = 15 Scans = 67	Observations = 13 Scans = 74	Observations = 44 Scans = 217
Total number per repeat	Observations = 66 Scans = 309	Observations = 59 Scans = 269	Observations = 55 Scans = 293	Observations = 180 Scans = 871

Feeding management - Space

Feeding management - TD/PO



Feeding management - lying behaviour

	Daily time spent lying	
Fixed effects (estimate ± SE) | [upper; lower 95%CI]		
Intercept	1.79 ± 0.336	[1.12; 2.46]
Treatment		
Portioned	- 0.54 ± 0.134	[-0.80; -0.28]
Traditional	0.25 ± 0.133	[-0.01; 0.51]
Random effects (variance ± SD)		
Group:Horse	1.68 ± 1.294	[0.93; 1.83]
Repeat:Day	0.37 ± 0.608	[0.24; 0.84]
Residual	1.25 ± 1.120	[1.05; 1.40]