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Data Article

Dataset from the literature on the ingestive behaviour of grazing ruminants

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ABSTRACT

The dataset described in this paper was constructed from 90 publications available from bibliographic databases. It presents the values of various quantitative components of ingestive behaviour of grazing ruminants (bite weight, biting rate, intake rate, grazing time, etc.). These values were coded according to the experimental factors tested and described in the publications, of a temporal nature (season, year, grazing cycle) or linked to the sward management strategies (overall density bulk or of the stems, the stage regrowth or the fertilization) or other pasture management strategies (herbage allowance, pasture access time, stocking rate). Other essential factors were also coded, specifying the characteristics of the grass grazed (height of the grass, apparent density, forage species), the characteristics of the animals used (species, stage, age and body weight) or the measurement methods of behavioural components. This coding process aims to facilitate the identification of subsets of data of interest, and have been analysed for example to highlight the main components determining bite weight or the components linking bite weight to intake rate and daily intake (see reference).

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Specifications Table

Subject	Animal science, ruminant nutrition
Specific subject area	Literature data on the ingestive behaviour of grazing sheep, goats and cattle in different geographical and temperate or tropical climatic contexts.
Type of data	Tabular data, description of variables, list of references (.tab files) Interactive map (.html file)
How the data were acquired	The data were acquired within an INRAE research unit (Agriculture, Food and Environment research), at the University of Paris-Saclay, from publications available from online bibliographic databases.
Data format	Raw and coded
Description of data collection	Data related to the ingestive behaviour of ruminants (cattle, sheep or goats) under different grazing conditions, were selected from a systematic review of the literature (webofscience.com). Data comes from a collection of 199 experiments reported in 90 scientific publications, from 1978 to 2019. Reported experiments and treatments levels were coded and listed together with, when available, the quantitative values of nearly forty parameters describing the experimental conditions and the ingestive behaviour. We have integrated only experiments and treatments for which there were documented values of at least one of the following criteria : bite area, bite depht, bite volume, bite weight, biting rate, intake rate, grazing time, intake.biting rate
Data source location	Data originated from 69 experimental sites, distributed in 25 countries in Africa, North and South America, South East Asia, Europe and Oceania. These can be further explored in the provided interactive map.
Data accessibility	Repository name: recherche.data.gouv.fr Data identification number: 10.57745/RPDBI6 Direct URL to data: https://entrepot.recherche.data.gouv.fr/dataset.xhtml?persistentId=doi:10.57745/RPDBI6
Related research article	[1] M. Boval, D. Sauvant. Ingestive behaviour of grazing ruminants: meta-analysis of the components of bite weight, Anim. Feed Sci .Tech. 251 (2019) 96–111, doi:10.1016/j.anifeedsci.2019.03.002

1. Value of the Data

- This dataset contributes to a better assessment of the harvesting efficiency of the different grazers, via the intake rate (kg DM/BW/min of grazing) which, along with the bite depth, helps to choose the optimum grazing pressure and relevant strategies for a given pasture (considering a balance with the grass growth rate, sward height and bulk density, prior to grazing).
- This dataset can also benefit all technicians and developers in precision livestock farming, as well as researchers dealing with ingestive behaviour and nutrition of ruminants in grazing and also stall-feeding contexts.
- For instance, this dataset can be used prior to any study on ingestive behaviour by i) selecting the measurement of relevant traits, e.g. the dental arch, identified as determining for bite weight, ii) assessing the magnitude of effects in order to better select measurement modalities and methods. One could also complement the dataset with relevant information not yet extracted from the examined studies.
- Analysis of this dataset provides additional information for studies within the context of “optimal foraging theory”, (OFT) describing how an animal behaves when searching for food, in particular regarding its functional response [2]. For example, this dataset highlighted for small ruminants a greater number of jaw movement needed to harvest 1 g of dry matter compared to cattle (31.1 vs.3.3, by [3]), thus implying a greater energy expenditure per gram of dry matter. A difference which is surely due to their anatomical traits (namely mobile lips vs. a long and free tongue) that may be of interest for OFT models to understand and predict the best foraging strategy, providing the most energy at a lower cost.

2. Background

Our initial motivation was to investigate the impact of factors determining the feeding behaviour of grazing ruminants, within a broader context than that considered in the majority of studies.

Thus, the sward height is the factor most studied in publications. However, based on our experience of observing ruminants grazing, other factors (such as density, itself dependent on the forage species, or the stage of regrowth/maturity) may have an influence on ingestive behaviour, particularly so on the frequency of bites and the duration of grazing at a given station.

The dataset thus provides an update on a large part of the published data and makes it possible, among other things, to study the impact of interactions between determining factors such as the height and apparent density of the grassland, which is impossible to address in the framework of targeted experiments.

3. Data Description

The dataset described in this datapaper comprises four files: IngestBehav_1_Variables, IngestBehav_2_Data, IngestBehav_3_References and IngestBehav_4_Map. The 51 variables listed within the first column of IngestBehav_1_Variables correspond to the 51 column headers in IngestBehav_2_Data.

The **IngestBehav_1_Variables** provides for each of the 51 variables considered in this dataset, all the information necessary for understanding by future users (one row per variable), namely:

- the name of the variables, organised in 6 main categories, as indicated below in the description of the IngestBehav_2_Data.
- the kind of the information provided via the variable, concerning either the experimental context, the coding or the data measured in the context of each experiment
- the type of the variable, whether it is numeric or not
- the unit when the variable is numeric; the unit indicated results from a harmonization of the set of values and units provided in the 90 various publications. The unit for non-numerical variables is indicated as not available, abbreviated as n_a.
- additional descriptive elements

The **IngestBehav_2_Data** file specifies the values of the variables measured for all the effects tested during the 199 experiments described in the 90 annotated publications (one line per treatment). In addition to the values extracted from the available tables of the publications certain values have been calculated; this was the case, for example, for the variables 3_herbage_bulk density, 3_forage_allowance and 6_intake_rate. Other values were recovered manually from the graphs provided in the publications (e.g. [4,5]).

These values relate to 6 main categories of information.

- the first category comprises information about the annotated publication (journal, author, year), the experimental conditions and the various effects tested, the use of artificial grass or not, and the methodology used to measure ingestive behaviour or the duration of measurement. This information is dispatched in 14 columns with headings prefixed with the Fig. 1.
- the second category provides information relating to the animals involved in each experiment (in 6 columns with headings prefixed with the figure 2, numerical summaries for three of them in Table 1).

- the third category specifies the characteristics of the grass available on the pasture, namely, the forage species, the biomass, the average height and the apparent density of the grass, as well as the quantity available for the animals at pasture (equivalent to the notion of stocking rate). This information is specified in 10 columns prefixed with the figure 3. Seven of those

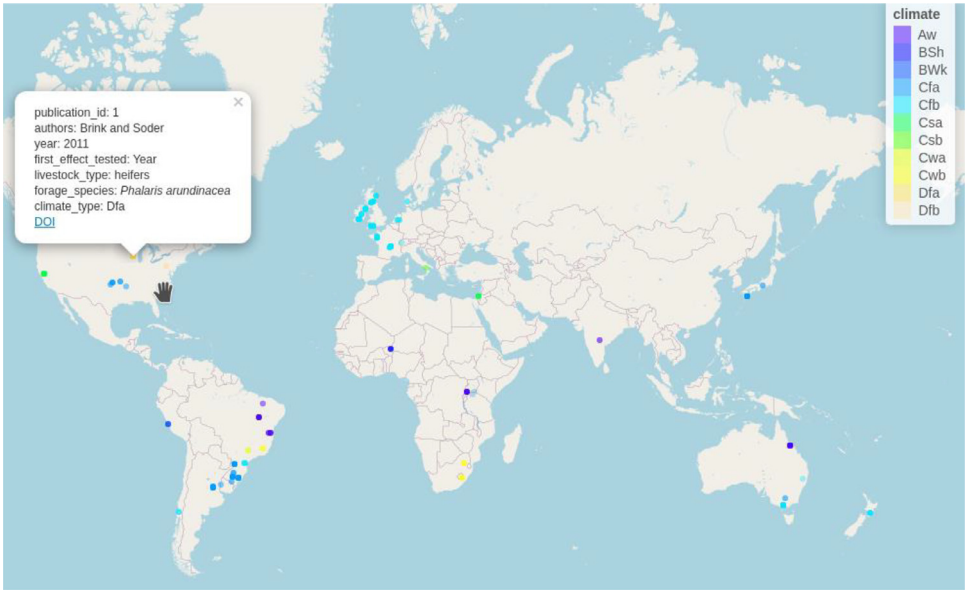

Fig. 1. Screen capture from the interactive map in the IngestBehav_4_Map file, showing the geographical position, climate type and associated information about the 69 experimental sites from the dataset.

Table 1
Descriptive statistics of animal characteristics.

Variable		N	Mean	SD	Min.	Max.
2_age (month)	cattle	214	24.9	14.9	3.0	63.0
	sheep/goat	44	19.5	6.2	3.0	24.0
2_bodyweight (kg)	cattle	560	426.9	174.6	120	817.0
	sheep/goat	108	47.5	18.5	16.9	97.0
2_incisive arcade (cm)	cattle	41	7.3	0.8	6.0	8.3
	sheep/goat	15	3.4	0.4	2.7	4.0

Table 2
Descriptive statistics of sward characteristics.

Variable	N	Mean	SD	Min.	Max.
3_forage_dry_matter_mass (kg DM/ha)	461	2849.6	1941.1	200.0	17,247.0
3_sward_height_before_grazing (cm)	497	18.7	15.2	0.0	133.0
3_herbage_bulk_density (kg DM/m^3)	382	0.5	1.7	0.0	17.7
3_forage_allowance (% BW)	202	79.6	129.5	2.5	935.2
3_forage_leaf_mass (kg DM/ha)	188	1363.3	880.8	117.0	7678.0
3_crude_protein_content (% DM)	332	14.3	6.8	2.0	57.7
3_neutral_detergent_fiber_content (% DM)	260	59.7	13.6	22.6	88.4

columns contain data describing the morphological composition (the masses of leaves, stems and debris) and the chemical composition (dry matter, crude protein and neutral detergent fibre contents). Statistics of the numerical data of this category are summarised in Table 2.

- The fourth category informs about the characteristics of bites, in 15 columns prefixed with the figure 4 (Tables 3A and 3B). These concern the shape of the bite (area, depth, diameter and volume), and also the mass, the density, the duration and frequency. Some variables such as the mass and volume of the bite are expressed in relation to dry matter intake or the live weight of the animal.

Table 3A
Descriptive statistics of bite characteristics.

Variable		N	Mean	SD	Min.	Max.
4_bite_area (cm^2)	cattle	140	72.6	32.3	6.9	170.0
	sheep/goat	47	16.4	6.1	5.6	35.5
4_bite_depth (cm)	cattle	147	10.5	5.3	1.9	29.6
	sheep/goat	46	4.9	3.9	1.3	20.6
4_bite_volume_liter	cattle	137	0.9	0.9	0.0	5.8
	sheep/goat	42	0.1	0.1	0.0	0.4
4_bite_volume_by_bodyweight (ml/kg BW)	cattle	137	1.9	1.5	0.0	7.8
	sheep/goat	42	1.4	1.2	0.3	6.0
4_bite_mass (g DM)	cattle	416	0.7	0.6	0.0	4.0
	sheep/goat	71	0.1	0.1	0.0	0.6
4_bite_mass_by_bodyweight (mg DM/kg BW)	cattle	438	1.6	1.1	0.1	8.4
	sheep/goat	71	2.1	1.6	0.2	7.4
4_bite_duration (s)	cattle	405	1.5	0.6	0.6	5.4
	sheep/goat	52	1.5	0.9	0.7	4.0
4_bite_frequency (n/min)	cattle	409	45.6	13.4	6.0	106.7
	sheep/goat	52	51.7	23.4	15.0	87.4
4_bite_number_per_DM_intake (n/g)	cattle	313	2.5	2.0	0.3	20.9
	sheep/goat	41	14.5	12.4	1.7	77.3
4_daily_number_of_bites (n/day)	cattle	140	25,713	10,062	7000	56,107
	sheep/goat	5	13,981	478	13,291	14,580

Table 3B
Descriptive statistics of chews and total jaw movements (n_a : not available).

Variable		N	Mean	SD	Min	Max
4_chews_frequency (n/min)	cattle	94	22.8	7.7	8.7	44.3
	sheep/goat	12	82.7	18.2	56.4	109.0
4_chews_number_per_bite (n/bite)	cattle	3	1.3	0.0	1.2	1.3
	sheep/goat	0	n_a	n_a	n_a	n_a
4_jaw_movement_number_per_dry_matter-intake (n/g)	cattle	82	3.05	2.8	0.6	20.9
	sheep/goat	12	23.3	7.9	10.7	34.9
4_jaw_movement_number_per_bite (n/bite)	cattle	91	1.7	0.7	1.1	5.0
	sheep/goat	12	3.3	1.6	1.9	6.5
4_jaw_movement_frequency (n/min)	cattle	98	70.7	14.2	28.5	138.7
	sheep/goat	12	130.8	27.6	92.0	171.0

Table 4
Descriptive statistics of duration of grazing, ruminating and idling or rest.

Variable		N	Mean	SD	Min	Max
5_ruminating_time (min)	cattle	90	376.1	118.5	98.0	574.0
	sheep/goat	25	281.2	155.9	31.0	654.0
5_grazing_time (min)	cattle	208	531.8	157.2	137.5	1080.0
	sheep/goat	30	453.3	119.2	187.0	700.0
5_resting time (min)	cattle	99	422.7	169.1	85.8	789.0
	sheep/goat	25	692.2	162.8	352.8	955.0
5_duration_of_observation (min)	cattle	415	15.4	9.9	0.75	24.0
	sheep/goat	59	17.0	7.7	0.80	24.0

For a small part of the annotated publications ($n = 19$), data relating to chewing and total jaw movements (cf 2.2 Intermediate calculations, Boval and Sauvant, 2021) were also available and were recorded in the last 5 columns of this fourth category (Table 3B).

- The fifth category (3 columns prefixed with the figure 5, Table 4) gives information relative to the time budget, namely the distribution of time devoted to various activities such as grazing, rumination or rest. The duration of observation of these different activities for each experiment is also specified, when available in the annotated publications
- The sixth category (three columns with headings prefixed by the figure 6, Table 5) provides the values of intake and rate of intake, expressed in relation to live weight.

Table 5
Descriptive statistics of intake and intake rate.

Variable		N	Mean	SD	Min.	Max.
6_dry_matter_intake_by_bodyweight (% DM/kg BW)	cattle	178	2.7	0.9	0.3	5.7
	sheep/goat	21	4.2	1.5	1.9	8.0
6_intake_rate (g DM/min)	cattle	344	28.3	19.1	1.3	146.3
	sheep/goat	50	4.5	2.3	0.9	11.3
6_intake_rate_by_bodyweight (mg DM/min/kg BW)	cattle	357	69.7	37.9	2.7	248.8
	sheep/goat	45	96.0	44.8	34.4	274.1

The IngestBehav_3_References file provides the list of the 90 publications that were annotated and coded, with their DOI. For each publication selected, we integrated only experiments and treatments for which there were information concerning at least one of the following criteria: bite weight, biting rate, intake rate, daily intake, grazing and ruminating time.

The IngestBehav_4_Map provides an interactive version of the Fig. 1 below, with popup information about each of the 69 experimental sites concerned in the 162 experiments described in the 90 publications referred in the dataset. In some publications where the location of the experimental site was not clearly specified, the address of the main author of the publication was used.

4. Experimental Design, Materials and Methods

This dataset was constructed from several published experiments using different methods used to acquire the data. In order to be able to analyse these data from different sources, and to consider all the factors tested according to a meta design that is neither orthogonal nor balanced, we have developed precise coding for each experiment in each publication. This coding is detailed in IngestBehav_1_Variables and in IngestBehav_2_Data, in particular via the 14 variables in the first category (which specify among other things the experimental conditions, the effects tested, etc.). For each of these 14 variables, the main methods used in the various publications are detailed in Table 6 below:

Table 6
Explanation of the 14 variables describing the experimental conditions and the effects tested.

Variable name	Variable description
1_authors	abreviated authors
1_year	year of publication
1_experimentation_id	This variable represents the number of the experiment described in the publication; the maximum being 6 experiments in the same publication.
1_latitude	Geographic coordinate of the east-west position of each experimental site, relative to the Greenwich meridian
1_longitude	Geographical coordinate of the north-south position of each experimental site, relative to the Equator
1_first_effect_tested	This first effect tested is that declared by the authors of each publication. The authors of the 90 annotated publications thus declared having tested one of the 25 following effects: Access time Animal physiological stage Animal species Day of grazing Density bulk Density of patch Density of stems Density of tillers

(*continued on next page*)

Table 6 (*continued*)

Variable name	Variable description
	Feeding system Fertilization Forage allowance Forage phenological stage Forage regrowth stage Forage species Grazing cycle Grazing down stages Individual Localization Measurement time Season Stocking rate Supplementation Sward height Tillage method Time of day
1_first_effect_tested_ modality	In addition to the effect tested among those listed above, the modalities indicated in each publication are specified for each treatment (per line)
1_second_effect_tested	In addition to the first effect tested, a second effect is sometimes tested by certain authors among those already listed above
1_second_effect_tested_ modality	the modality of this second tested effect is specified as before for the 1st effect tested
1_third_effect_tested	In a few rare cases, a third effect is also tested
1_third_effect_tested_ modality	the modality of this third tested effect is specified as before for the 1st effect tested
1_experimentation_with_ artificial_sward	There are 3 possible modes for this variable: 1) Artificial micro-sward, 2) Natural grazing, 3) Other cases such as micro-parcels, cages, grazing cages or corridors, which are not very common. Artificial micro-swards were used in 20% of treatments. They are built manually with fresh grass collected daily, which is then trimmed and placed in regularly arranged holes in wooden modules (approx. 95×95 cm). This device has been used since [6] in order to better control the variations in height and density of the vegetation. These artificial swards are then bolted to the floor of the pen at ground level, which animals have access to for short periods, allowed to take a limited number of bites. Typically, these short grazing sessions are filmed for detailed study of the grazing process. Micro-plots were used in less than 6 % of treatments. These are small plots, gardened and pruned meticulously under filed conditions, to control both the height and density of the canopy, as with the artificial swards. Access for the animals is also very limited in time (<1 h). Natural pasture was the context for the other experiments considered. In a grazing context, the methodological constraints are stronger, but the measurements reflect more real situations. The measurement times are generally much longer, and sometimes even on a nychthemeron
1_feeding_behaviour_ measurement_method	3 possible modalities: observations, use of recorders (or videotaped or elasticated noseband linked to electrical resistance), or use of accelerometers Observation of animals is the most common (34% of treatments) to assess ingestive behaviour. Generally, observations are made at a given frequency, every 5 or 10 min, for a group of animals ranging from approximately 1 to 6 per observer (depending on the proximity of the observers and the use of binoculars). At each observation, the activity of each animal is noted: the 3 main activities considered being grazing, rumination or rest. In this way, it is possible to estimate the duration of grazing, by multiplying the number of "grazing" observations by 5 or 10 min. That is assuming that the activity observed at a given time is the same until the next observation and the same to estimate the durations of rumination and of rest. Recorders were used in 36 % of treatments. These are devices which measure the stretching of a noseband placed around the jaws, and which deliver a current measured by a device attached to the neck of the animal. Accelerometers were used in less than 2 % of cases, according to the principles described by [7] and [8]
1_ measurement_duration	represents the duration of visual observation or recording, using recorders or accelerometers

Limitations

The sizes of the samples from which the reported data arose, were not included in the dataset. One could recover those sample sizes to build upon and complement the dataset in a future version.

Ethics Statement

The present work did not involve human subjects nor experiments with animals, and does not include material collected from social platforms.

Data Availability

A dataset on the ingestive behaviour of grazing ruminants collated from the literature (Reference data) (recherche.data.gouv.fr).

CRediT Author Statement

Maryline Boval: Conceptualization, Data curation, Methodology, Writing – original draft, Writing – review & editing; **Pierre-Emmanuel Robert:** Writing – original draft, Writing – review & editing; **Daniel Sauvant:** Conceptualization, Data curation, Methodology.

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We would like to pay tribute to Daniel, who very unfortunately passed away during this work, for the open-mindedness he showed throughout this work and which enabled us to apply all his experience of meta-analyses to a subject and a study context, such as grazing, which he had not particularly mastered before.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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