A comparison of commercially available feeds for rabbits, guinea pigs, chinchillas and degus with evidence of their diet and feeding behaviour in natural habitats

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Ein Vergleich handelsüblicher Futtermittel für Kaninchen, Meerschweinchen, Chinchillas und Degus mit Kenntnissen zu ihrer Ernährung und ihres Fressverhaltens in natürlichen Lebensräumen

Im Handel ist eine grosse Auswahl an Futtermitteln für Heimtiere erhältlich. Diese Futtermittel können sich in ihrer Nährstoffzusammensetzung von der natürlichen Nahrung unterscheiden und ein anderes Fressverhalten auslösen als das in natürlichen Lebensräumen beobachtete. Hier haben wir die Literatur über die natürliche Ernährung und das Aktivitätsbudget von Kaninchen (*Oryctolagus cuniculus*), Meerschweinchen (*Cavia porcellus*), Chinchillas (*Chinchilla lanigera*) und Degus (*Octodon degus*) untersucht sowie 260 Mischfuttermittel, die für diese Arten zwischen 1982 und 2020 kommerziell erhältlich waren. Die Arten werden als Pflanzenfresser eingestuft; die verfügbaren Daten zur natürlichen Nahrung deuten auf einen Rohfasergehalt (Rfa) von etwa 250 g/kg Trockenmasse (TM) und eine natürliche Fressaktivität von 4 bis 7 Stunden pro Tag hin, wobei die Fressdauer bei der Fütterung mit Mischfutter deutlich kürzer ist. Nur bei einer Minderheit der Futter enthielten die ersten 5 aufgelisteten Zutaten keine stärkehaltige Zutat oder nur Zutaten, die nicht für den menschlichen Verzehr geeignet sind. Der Prozentsatz der Futtermittel, deren Rfa unter 150 g/kg TM lag, betrug 22 % bei Produktionskaninchen, 18 % bei Heimtierkaninchen, 26 % bei Meerschweinchen, 18 % bei Chinchillas und 14 % bei Degus; mit anderen Worten, die Mehrheit der derzeit vermarkteten Produkte weist Rfa-Gehalte auf, die den veröffentlichten Empfehlungen entsprechen, auch wenn dies eine Abweichung von der natürlichen Ernährung bedeutet. Die Überprüfung der Fütterungsanweisungen der Hersteller legt nahe, dass diese im Allgemeinen nicht unkritisch befolgt werden sollten. Eine systematische Veränderung der Rfa-Gehalte dieser Futtermittel war für den untersuchten Zeitraum nicht erkennbar. Es besteht kein Konsens darüber, ob nur Produkte, die der natürlichen Nahrung ähneln, in Heimtierfuttermitteln enthalten sein sollten, oder ob zusätzlich nur pflanzliche Nebenprodukte, die für den Menschen nicht geniessbar sind, enthalten sein sollten. Die beobachtete Praxis der Zusammensetzung von Heimtierfuttermitteln entsprach weitgehend keinem der beiden Konzepte, was die allgemeine Logik der Zusammensetzung von Heimtierfuttermitteln

Summary

A large variety of pet feeds is commercially available for pet herbivores; these feeds may differ in nutrient composition from the natural diet, and may trigger different feeding behaviours than observed in natural habitats. Here, we surveyed literature on the natural diet and activity budget of rabbits (*Oryctolagus cuniculus*), guinea pigs (*Cavia porcellus*), chinchilla (*Chinchilla lanigera*) and degus (*Octodon degus*), as well as 260 compound feeds commercially available for these species between 1982 and 2020. The species are classified as herbivores, with available data on natural diets suggesting a crude fibre (CF) level of approximately 250 g/kg dry matter (DM), natural feeding activity at a magnitude of 4–7 h per day, with distinctively shorter feeding when fed on compound pet feeds. Only for a minority of feeds did the first 5 listed ingredients not include a starchy ingredient, or only ingredients not considered suitable for human consumption. The percentage of feeds whose CF level was less than 150 g/kg DM was 22 % for production rabbits, 18 % for pet rabbits, 26 % for guinea pigs, 18 % for chinchillas and 14 % for degus; in other words, a majority of currently marketed products have CF levels in accord with published recommendations, even if that means a discrepancy to natural diets. Screening the producers' feeding instructions suggests they should generally not be followed uncritically. No temporal trends in the CF levels of these diets was evident. There is no consensus whether only products resembling natural diet items should be included in pet feeds, or whether vegetable byproducts not edible by humans should also be included. The observed practice of pet feed composition largely did not follow either concept, questioning the general rationale of pet feed composition. Whole forage like hay is recommended as the main diet component for these species, and 76 % of pet feed products noted that hay should be fed in the feeding instructions.

Keywords: activity budget, compound feed, chinchilla, feed composition, degu, guinea pig, natural diet, nutrient composition, sustainability, rabbit

in Frage stellt. Raufutter wie Heu wird als Hauptfutterkomponente für diese Arten empfohlen, und 76 % der Heimtierfuttermittel wiesen in den Fütterungsanweisungen darauf hin, dass Heu gefüttert werden sollte.

Schlüsselwörter: Aktivitätsbudget, Mischfutter, Chinchilla, Futterzusammensetzung, Degu, Meerschweinchen, natürliche Ernährung, Nährstoffzusammensetzung, Nachhaltigkeit, Kaninchen

A comparison of commercially available feeds for rabbits, guinea pigs, chinchillas and degus with evidence of their diet and feeding behaviour in natural habitats

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Introduction

Given the aspiration that decisions in animal husbandry should be evidence-based, those responsible for making decisions or giving recommendations face the challenge to separate true evidence from the large amount of unsubstantiated claims. Such claims abound both in the so-called 'grey' or lay literature, and also as information accompanying commercially available products. With respect to the veterinary literature, such claims are sometimes perpetuated when textbooks do not cite primary, peer-reviewed literature, but older textbooks. While not good scholarly practice, unsubstantiated claims need not be wrong. For example, the statement that rabbits, guinea pigs, chinchillas and degus are herbivores is typically considered true, even if it is not made with the citation of supporting peer-reviewed literature that actually investigated the diet of free-ranging animals in natural habitats. For practicing veterinarians who have to provide advice on the husbandry of these species, it may be important to understand the extent and limitations of actual biological knowledge.

Animal husbandry is subject to legally binding standards. In Switzerland, the Animal Protection Ordinance (Tierschutzverordnung TSchV) demands that «*the species-specific behaviour related to food intake must be facilitated*»[a] (TSchV 4.2), which is specified for domestic rabbits as requiring that roughage such as hay or straw have to be provided daily and that gnawing objects must be available at all times (TSchV 64.1). For guinea pigs, chinchillas or degus, which are defined as wild animals in that Ordinance (TSchV 2.1), the generic demand applies that «*the feeding must simulate species-specific characteristics of food intake including spatial and temporal variation in food supply, food acquisition, food processing, and the duration of food intake*»[b] (TSchV Anh. 2, L), and the provision of roughage and gnawing material is mandatory. In theory, persons responsible for making decisions or giving recommendations with respect to the feeding of these animals should have evidence-based knowledge on the natural diet composition and the duration of food intake in natural habitats.

Yet, such knowledge may not be readily available, even though recommendations exist at various levels already mentioned – from lay publications to information issued by animal protection associations or state agencies, to veterinary textbooks and to peer-reviewed review articles. Another source that inadvertently influences the concept of an adequate feeding are commercially available products and their advertising and product information. In the European Union, as well as in Switzerland, the required declaration on compound feeds sold for rabbits and pet rodents comprises the species or species group for which the product is designated, a list of ingredients, and instructions for appropriate use (i.e., feeding recommendations) (EU FMVV 767/2009; CH FMV, SR 916.307 and FMBV, SR 916.307.1). For rabbits – which are classified as farm animals – additionally the concentrations of crude nutrients and the level of calcium, phosphorus and sodium must be declared for complete feeds.

The aim of the present study was to first review the peer-reviewed literature with respect to the natural diets of rabbits, guinea pigs, chinchillas and degus and its nutrient composition, and to compare it to the ingredients and nutrient composition of commercially available products designated for these species, including the question whether ingredients suitable for human consumption were used in these products. Additionally, we attempted to locate information on the duration of feeding activity in natural habitats. Thus, we aimed to compile current knowledge, provide a current summary of available products, and identify areas where knowledge is lacking.

Materials and Methods

Natural diet and feeding behaviour

A series of literature searches was performed using the databases Google Scholar and Pubmed, using the generic and scientific species names and relevant search terms, e.g. 'natural diet' or 'feeding behaviour', and using both backward (cited literature) and forward (citing literature) referencing for further steps. Only literature presenting original quantitative data were considered.

Commercial diet survey

From 2017 to 2020, the declarations of a total of 260 dry feeds for rabbits, guinea pigs, chinchillas and degus available in Europe were collected. We aimed for compound feeds declared as complete or supplementary feeds, and which were

[a] «Den Tieren ist die mit der Nahrungsaufnahme verbundene arttypische Beschäftigung zu ermöglichen. / Les animaux doivent pouvoir exprimer le comportement d'occupation propre à l'espèce en relation avec la prise de nourriture.»

[b] «Mit der Fütterung sind die arttypischen Merkmale der Nahrungsaufnahme (räumlich und zeitlich variierendes Futterangebot, Futterbeschaffung, Futterbearbeitung und Dauer der Futteraufnahme) zu simulieren. / Les modalités de l'alimentation doivent simuler les caractéristiques de la prise de nourriture»

available at the time of the study, irrespective of whether they represented pelleted, extruded or mixed ('muesli'-type) diets. 'Complete' feeds declared that either the product should be fed as the only diet ingredient, or that the addition of other feeds was not necessary. Products marketed for production (farm) rabbits were included, but no products marketed for laboratory animals. In addition, the declaration of analytical nutrient composition had to be available either on the packaging or accessible via the internet. Declarations were categorized as 'closed' (if only feed categories were indicated, e.g. 'grain') or 'semi-open' (if specific feeds were listed, e.g. 'barley'). Diets specifically marketed as 'grain free' were counted separately. Because an unpublished smaller-scale survey a decade earlier had suggested that crude fibre levels of feeds for these species had increased over time, the year of the first marketing of the respective products as well as ingredient information (if not publicly available) were requested from the product managers of the individual companies by e-mail.

For each food, the declared nutrient composition (total ash TA, crude protein CP, crude fat EE, crude fibre CF, calcium) was noted, and was re-calculated to a dry matter (DM) basis, assuming a DM concentration for all feeds of 900 g/kg. Nitrogen-free extracts were calculated by subtracting the concentrations of TA, CP, EE and CF from DM. Levels of neutral detergent fibre (NDF) were estimated using the transformation equation from Kamphues et al.[18] (mainly in use for ruminant forages) where NDF = 1,58 CF + 135,7.

For products with semi-open declaration, the first five listed ingredients were noted; these ingredients were classified as 'starchy ingredient' if they could be considered a source of starch (including brans). The ingredients of products of both semi-open and closed declaration were categorized with respect to their suitability for human consumption.

Finally, feeding recommendations were noted: whether the feed should be offered for *ad libitum* consumption, or whether a certain daily amount was recommended, and whether the additional feeding of hay was recommended. Notably, feed declared as complete feed might nevertheless include additional hay feeding in the feeding recommendations.

Correlations between information on nutrient composition (e.g., between crude protein and crude fibre concentrations) were calculated as Spearman's correlation (rho) using R[38], and the results are given in the respective figure legends.

Results

Natural diet

Botanical composition

Peer-reviewed overview articles of mammal diets[13,22,47] typically refer to a classic mammalian textbook[32]. In these overviews, rabbits, guinea pigs and chinchillas are described as purely folivorous herbivores, whereas for degus, additionally the consumption of fruits and seeds is indicated; however, the textbook source does not represent detailed original data. Original literature on the quantitative botanical diet composition (represented by only 15 sources) is summarized in Table 1. The ranges of the proportion of different plant categories contributing to the natural diets confirm that these species are herbivores, and apart for the guinea pig that appears to be a grazer, the other species do not seem to have a specific preference for monocot or dicot material; the range of diet contribution of seeds is higher for degus than for the other species. This latter fact gains relevance in the light of a single, yet comprehensive report on scatter as well as larder hoarding behaviour in degus.[37]

Table 1: Ranges or average of quantitative botanical diet composition of free-ranging rabbits *(Oryctolagus cuniculus),* guinea pigs *(Cavia aperea),* chinchillas *(Chinchilla laniger)* and degus *(Octodon degus)*

Species	Monocots (grasses)	Dicots (herbs, forbs, browse)	Monocot & Dicot (incl. unidentified plants)	Fruit	Seeds	Source
Rabbit	16–86 %	10–83 %	89–100 %	–	0–11 %	1,3,19,24,25,39,40,49
Guinea pig	85–97 %	3–15 %	100 %	–	–	16
Chinchilla	3–47 %	16–44 %	92–95 %	–	1–4 %	7,43
Degu	0–25 %	26–53 %	65–96 %	–	4–31 %	27–29,36

differences to 100 % represent insects, bait (in study traps), and other unidentified material

Table 2: Nutrient composition of natural diets (in g/kg dry matter)

Species	Condition	Protein	NDF*	CF*	Source
Rabbit	Spain, all year	50–95	–	–	23
	Netherlands, all year	198	570	275	46
	France, spring/summer	120–200	531–610	250–300	44
Degu	Chile, all year	27–72	373–611	150–301	4

*re-calculation of neutral detergent fibre (NDF) or crude fibre (CF) from each other according to [18]

Nutrient composition

Studies that measured the nutrient composition of natural diets of our focus species are rare (represented by only four sources, three of which dealt with rabbits). The few available data are compiled in Table 2. Notably, no data is available for guinea pigs or chinchillas.

Feeding behaviour – Activity Budget

Only nine studies report the quantitative activity budget of the focus species so that the time spent feeding can be calculated, of which only four referred to free-ranging animals (Table 3). Notably, no data is available for free-ranging chinchillas. For degus, a detailed report outlines hoarding behaviour observed under captive conditions in animals originating from two different free-ranging populations, suggesting this is a species-specific behaviour.[37]

Commercial feeds

Information was acquired for a total of 260 feeds, of which eight were designated for both chinchillas and degus (Table 4). These included 27 production rabbit feed and 233 pet feeds. Whereas 63 % of production feeds were labelled as complete feeds, 22 % were 'muesli'-type, none had a closed declaration, 33 % recommended hay feeding in the instructions, and none were marketed as 'grain free', nearly all pet feeds were labelled as complete feeds, 51 % were of the 'muesli'-type, 43 % used a closed declaration, 75 % recommended hay feeding, and 27 % were marketed as 'grain free' (Table 4). The oldest pet feed was first sold in 1982 (a pellet), the oldest 'muesli'-type mix and extrudate were from 1999 and 2007, respectively, and the oldest product marketed as 'grain free' originated from 2008.

Ingredient composition

A large variety of ingredients was used in the different feeds (Table 5). The three most often listed ingredients across all pet feeds were vegetable byproducts (typically not considered suitable for human consumption, e.g. extraction meals or brans), grains, and whole plant meals (made from lucerne, hay or herbs). There was no feed for production rabbits,

Table 3: Reported durations of feeding / foraging behaviours of rabbits *(Oryctolagus cuniculus)*, guinea pigs *(Cavia aperea/porcellus)*, chinchilla *(Chinchilla lanigera)* and degus *(Octodon degus)*

Species	Condition	Feeding / Foraging	Source
Rabbit	Free-ranging	3,8–7,0 hours	31
Rabbit	Pet, hay only	10,2 hours	35
Rabbit	Pet, muesli mix only	2,5 hours	35
Rabbit	Laboratory, complete feed	2,2 hours	34
Guinea pig	Free-ranging	6,5 hours	2
Guinea pig	large outside pen	7,7–10,6 hours	12
Chinchilla	Fur farm	4,6–5,3 hours	11
Degu	Free-ranging	4,5–6,4 hours	21
Degu	Free-ranging	2,3–3,3 hours	8
Degu	Laboratory, alfalfa pellets	2,9 hours	20

Table 4: Overview over commercial feed information acquired for feeds for rabbits *(Oryctolagus cuniculus)*, guinea pigs *(Cavia porcellus)*, chinchilla *(Chinchilla lanigera)* and degus *(Octodon degus)* in the present study

Species	Condition	n diets [complete/ supplementary[1]]	n type P/E/M[2]	n declaration semi/closed[3]	hay recomm. yes/no[4]	n marketed as 'grain free'	n companies [CH/D/NL/ BE/UK/USA[5]]	Time period
Rabbit	Production	27 [17/10]	21/0/6	27/0	9/18	–	4 [3/1/0/0/0/0]	1997–2019
Rabbit	Pet	107 [106/1]	40/15/52	59/48	85/22	27	23 [5/12/2/1/2/2]	1987–2020
Guinea pig	Pet	78 [75/3]	31/7/40	42/36	58/20	24	24 [8/10/2/1/1/2]	1987–2020
Chinchilla	Pet	34 (26+ 8*) [34/0]	14/4/16	21/13	26/8	9	11 [2/4/1/1/1/2]	1982–2020
Degu	Pet	22 (14 + 8*) [22/0]	5/3/14	14/8	14/7	6	9 [2/5/0/1/1/0]	2007–2020
Total	Pet	233 [229/4]	87/27/119	132/101	177/56	64	26 [7/12/2/1/2/2]	1982–2020

[1]declared as complete or supplementary feed
[2]P pellet, E extrudate, M mixed ('muesli')
[3]declaration either semi-open (stating individual ingredients) or closed (stating only feed categories)
[4]additional feeding of hay recommended in the feeding instructions
[5]countries of origin: CH Switzerland, D Germany, NL Netherlands, BE Belgium, UK United Kingdom, USA United States
*diets designated for both chinchilla and degu

chinchillas or degus that was based on only green plant material (lucerne, hay, herbs etc.), and a single one each for pet rabbits and guinea pigs. Including wheat bran as a food not aimed for human consumption,[9] 8 feeds (30 %) for production rabbits had only ingredients in the top 5 listed not for human consumption; the same applied to 20 pet rabbit feeds (19 %), 9 for guinea pigs (12 %), 2 for chinchillas (6 %), and 3 for degus (14 %).

For products with semi-open declaration, production rabbit feeds had generally a higher number of starchy ingredients, and more often a starchy ingredient as the primarily listed ingredient, than the pet feeds (Table 5). For each species, pet feeds most often contained two or three starchy ingredients (Table 5).

Nutrient composition

Large ranges in nutrient composition were observed, but the averages of the pet feeds for the different species were very similar (Table 6). Production rabbit feeds generally had slightly less fibre and more NfE than pet feeds; among the pet feeds, those for degus had on average the lowest fibre and highest NfE levels. However, the largest extremes both in terms of minimum and maximum fibre levels were observed in pet rabbit feeds – the group of feeds with the largest sample size in our study (Table 6). The percentage of feeds whose CF level was less than 150 g/kg DM was 22 % for production rabbits, 18 % for pet rabbits, 26 % for guinea pigs, 18 % for chinchillas and 14 % for degus.

Table 5: Overview over ingredient information acquired for feeds for rabbits *(Oryctolagus cuniculus)*, guinea pigs *(Cavia porcellus)*, chinchilla *(Chinchilla lanigera)* and degus *(Octodon degus)* in the present study, for all products[1] and products with semi-open declaration[2]

Species	Condition	Most frequent among top 5 ingredients (% of feeds)[1]	Starchy ingredient[2]		Number starchy ingredients in top 5 ingredients[2] in n (%) feeds					
			mean n among top 5 ingredients	first ingredient n (%)	0	1	2	3	4	5
Rabbit	Production	extraction meal (93 %) bran (89 %) green meal (74 %)	2,9	14 (52 %)	0 (0 %)	2 (7 %)	6 (22 %)	12 (44 %)	7 (26 %)	0 (0 %)
Rabbit	Pet	vegetable byproducts (91 %) green meal (58 %) grains (51 %)	2,4	13 (22 %)	5 (8 %)	9 (15 %)	16 (27 %)	18 (31 %)	9 (15 %)	2 (3 %)
Guinea pig	Pet	vegetable byproducts (81 %) grains (68 %) green meal (64 %)	2,6	11 (26 %)	3 (7 %)	4 (10 %)	13 (31 %)	11 (26 %)	8 (19 %)	3 (7 %)
Chinchilla	Pet	vegetable byproducts (100 %) grains (68 %) green meal (65 %)	2,6	5 (24 %)	0 (0 %)	4 (19 %)	5 (24 %)	9 (43 %)	2 (10 %)	1 (5 %)
Degu	Pet	vegetable byproducts (73 %) green meal (68 %) grains (64 %)	2,2	4 (29 %)	1 (7 %)	3 (21 %)	4 (29 %)	4 (29 %)	2 (14 %)	0 (0 %)

[1]both products with semi-open and closed declaration
[2]only in products with semi-open declaration (as individual ingredients cannot be identified in closed declaration)

Table 6: Overview over nutrient composition information acquired for feeds for rabbits *(Oryctolagus cuniculus)*, guinea pigs *(Cavia porcellus)*, chinchilla *(Chinchilla lanigera)* and degus *(Octodon degus)* in the present study

Species	Condition	Total ash	Crude protein	Crude fat	Crude fibre	NDF	NfE	Calcium
		g / kg dry matter | mean± SD (range)						
Rabbit	Production	82±12 (56–106)	169±19 (122–200)	37±7 (27–54)	161±34 (67–194)	390±54 (241–443)	552±51 (489–656)	11±2 (7–14)
Rabbit	Pet	82±23 (33–190)	158±20 (110–208)	36±8 (22–77)	191±50 (44–300)	437±78 (206–610)	533±64 (411–733)	8±3 (1–14)
Guinea pig	Pet	78±23 (20–133)	163±25 (116–228)	38±11 (22–89)	182±49 (78–294)	423±78 (259–601)	539±66 (417–674)	8±2 (2–13)
Chinchilla	Pet	85±27 (52–206)	169±20 (132–222)	38±7 (26–61)	188±40 (89–233)	433±63 (276–504)	520±47 (433–631)	9±3 (1–14)
Degu	Pet	76±19 (36–122)	160±17 (129–200)	38±10 (24–72)	186±36 (111–244)	430±57 (311–522)	539±50 (472–621)	8±3 (4–14)

Across all feeds, NfE was tightly correlated to crude fibre (Figure 1A) but less so to crude protein (Figure 1B); there was no correlation between crude fibre and crude protein (Figure 1C). There was no evident trend of changes in crude fibre levels across the years (*rho* = 0,00, *P* = 0,999). Across feeds with semi-open declaration, the level of NfE increased with the number of starchy ingredients among the top 5 listed ingredients (*rho* = 0,42, *P* < 0,001).

Across the pet feeds, the average CF levels increase and NfE decrease from 'muesli'-type feeds (in g/kg DM - CF: 166±43, NfE: 566±63) to pellets (CF: 204±46, NfE: 498±39) and extrudates (CF: 219±30, NfE: 512±41). Pet feeds with a closed declaration had slightly lower average CF and higher NfE levels compared to those with a semi-open declaration (CF: 179±44 vs 192±49, NfE: 548±59 vs 524±63, respectively). Feeds marketed as 'grain free' had higher CF and lower NfE levels compared to the rest (CF: 212±22 vs 177±51, NfE: 500±25 vs 547±67, respectively).

Feeding instructions

For the pet feeds, either a recommendation to offer the feed for *ad libitum* consumption (64 of 233 feeds = 27 %), a specific amount or range of amounts (135, 58 %), or no feeding recommendation (34, 15 %) was given. Feeds with an *ad libitum* recommendation had average CF levels of 203±36 g/kg DM and were more often above the 150 g/kg DM CF level (88 %) than feeds without such a recommendation (180±50 g/kg DM, 77 % above the recommendation).

Seventy-six % of feeding recommendations stated that hay should be given in addition to the pet compound feed. Pet feeds whose label recommended additional hay feeding had average CF levels of 190±48 g/kg DM and were more often above the 150 g/kg DM CF level (82 %) than feeds without such a recommendation (175±43 g/kg DM, 71 % above the recommendation).

The recommended daily amount per animal showed no correlation with the feeds' crude fibre level (Figure 2). There were no feeding instructions specifically aiming at spatial and temporal variation in food supply (as would help pet owners fulfil the Animal Protection Ordinance requirements), or with instructions on the desired duration of food intake. In degu feeds, there was no indication of the potential hoarding behaviour.

Discussion

Our survey points out the limits of knowledge on the natural diet and feeding behaviour of four small mammals commonly kept as pets. Additionally, it gives an overview over feeds marketed for these species, highlights potential discrepancies between these feeds and natural diets, and indicates that crude fibre (CF) may be the best single measure to

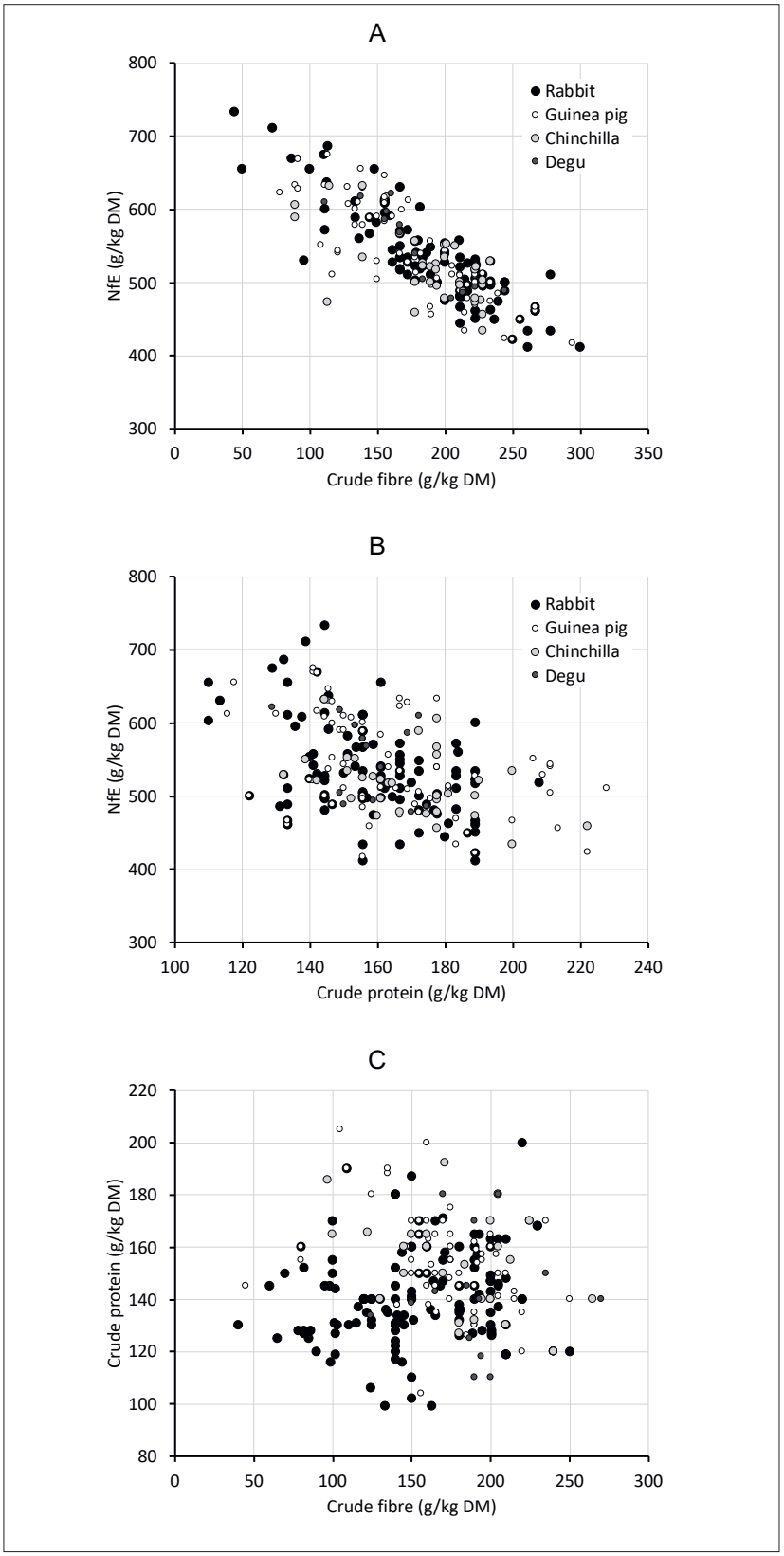

Figure 1: Relationship of the levels of (A) crude fibre and nitrogen-free extracts (NfE, a measure for starches and sugars) (*rho* = -0,82, *P* < 0,001), (B) crude protein and NfE (*rho* = -0,39, *P* < 0,001), (C) crude fibre and crude protein (*rho* = 0,01, *P* = 0,847) in feeds for rabbits *(Oryctolagus cuniculus)*, guinea pigs (*Cavia porcellus)*, chinchilla *(Chinchilla lanigera)* and degus *(Octodon degus)*.

characterize such feeds. It cautions against the uncritical use of producers' feeding instructions, but it also suggests that a majority of currently marketed products have CF levels that are in accord with published recommendations, even if that means a discrepancy to natural diets. In contrast to our expectation, no temporal trends in the CF levels of these diets was evident.

The typical constraints of a survey apply. The number of products included in the survey was determined by their web-based availability and the logistics of our web surveys. It is well known that nutrient declarations on animal feeds need not necessarily correspond to actual concentrations if these were measured.

In terms of ingested diet items, the natural diet of the four species is relatively well-described, focussing mainly on monocot and dicot green plant material. Notably, wild fruit are not reported to represent a relevant part of the diet, and the well-known inability of guinea pigs to synthesize vitamin C should not be associated with habitual fruit consumption in their natural habitat. By contrast, seeds are mentioned in particular for degus. Given this overall information, recommendations to feed these four species mainly on fresh or dry monocot or dicot stems and leaves, like fresh grass, grass hay, herbs and green leafy vegetables,[5,17] are understandable. By contrast, the use of compound feeds as compiled in the present study, of commercial fruit and 'nongreen' vegetables (such as carrots), seeds mixes, grains and grain products, can mostly not be derived from information on natural diets. For commercial fruit and 'nongreen' vegetables, it has been known for a long time that they contain more sugar, and less fibre, than wild fruit.[33,41,42] Similar comparisons do not exist, to our knowledge, for wild seeds and cultivated seeds and grains. But it appears reasonable to assume that cultivated seeds and grains are higher in starch than their wild counterparts, and that cultivated seeds have a larger volume of the starch body and a lower proportion of hull or husks.[14] Thus, the first realization when composing the diet of a small pet herbivore is that many of the items conventionally used, like compound feeds, fruits and seed mixes,[45] cannot be used with the aim of imitating a natural diet, but must be due to tradition (based on agricultural feeding practice) or convenience.

When considering the composition of compound feeds, additional considerations apply. Keeping production animals is often considered a reasonable option to use unavoidable byproducts of human vegetable food production that are not edible, or not preferred, by humans.[10] Designing production animal diets with high proportions of such ingredients, so that these are used efficiently, is desirable and will gain relevance in the near future.[10] It appears plausible that the proportion of feeds composed of only such items was highest in the feeds for production rabbits, yet even the majority of these feeds still included human-edible feeds. While the same concept should apply to pet feeds, there is, to our knowledge, no consensus whether this implies that only products resembling natural diet items should be included in pet feeds (in the case of our study animals, this would represent the very few compound feeds consisting mainly of dried grass, lucerne or herbs), or whether vegetable byproducts not edible by humans should also be included. But regardless of this question, the observed practice of pet feed composition did not follow either concept: The proportion of pet feeds composed only of ingredients not used for human consumption was very low (from 19 % of all pet rabbit feeds to 6 % of all chinchilla feeds). Thus, the conclusion is that the majority of pet feeds are neither designed to imitate natural diets (because they include ingredients suitable for human consumption and vegetable byproducts), nor are they designed to reduce the use of ingredients suitable for human consumption (because the majority of them do). What then, one might ask rhetorically, is the underlying principle of pet food design? Without specific investigations into the portfolio development of pet food producers, we are left to assume that it is ingredient availability and costs, tradition and customer demands, technical feasibility and considerations of quality control, with a guiding approach of 'what can be done without triggering negative effects', rather than principles of animal biology or ecosystem sustainability, that drive pet food design. Possibly, the inclusion of products suitable for human consumption aims at increasing the energy density and hence the palatability of the compound feeds, factors not necessarily related to health or behavioural benefits for the animals (see below).

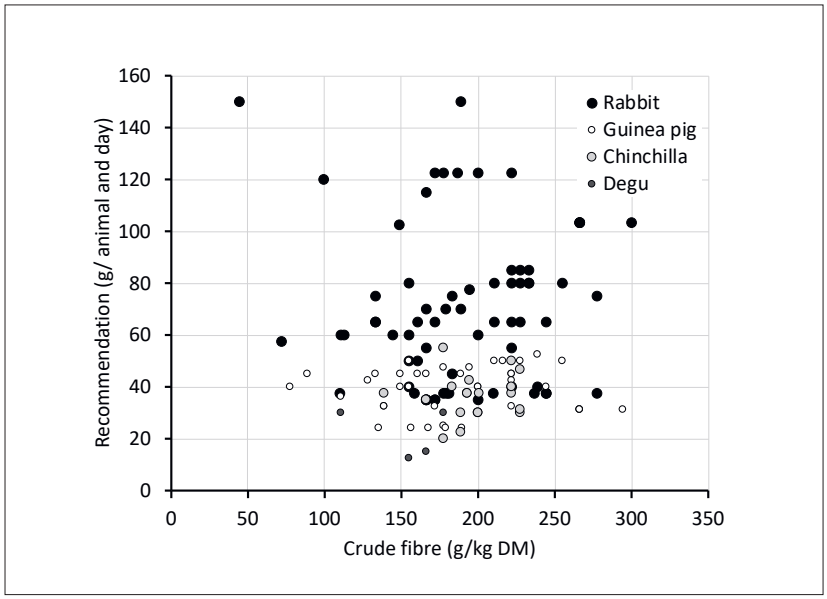

Figure 2: Crude fibre level and the recommend feeding amount in feeds for pet rabbits (*Oryctolagus cuniculus; rho* = 0,15, *P* = 0,204), guinea pigs (*Cavia porcellus; rho* = 0,13, *P* = 0,409), chinchilla (*Chinchilla lanigera; rho* = 0,13, P = 0,606) and degus (*Octodon degus;* no statistical evaluation).

Some consequences of ingredient choice for the nutrient composition of pet feeds are self-evident: the more starchy products are added to a compound feed, the higher its content of NfE. NfE levels do not have to be indicated on feed labels, most likely because they can be calculated from other information on these labels. However, even though the calculation includes a subtraction of four nutrient groups – total ash, protein, fat and crude fibre – from the total dry matter, it is the crude fibre level, in the feeds investigated in this study (as well as in other herbivore feeds, M. Clauss, pers. obs.), that shows the most distinct correlation with NfE (Figure 1). Therefore, for a quick evaluation of a herbivore compound feed, typically a recommendation for the fibre level is given. In the case of rabbits and the other small herbivores covered in the present study, this recommendation generally is that the compound feed should have a crude fibre level of 15 % DM or higher.[18]

At 18,2–19,1 % DM, the average crude fibre levels of the pet feeds of our study were well above this requirement. As expected, the average level of the production rabbit feeds were closer to it, at 16,1 % DM, testifying that in general, feeds used in animal production are closer to recommended minimum fibre levels, to maintain a maximum energy density for faster growth. Across the pet feeds of our survey, having a semi-open declaration (rather than the more restricted closed declaration), being marketed as a 'grain free' product (which corresponds to the natural diet of the species), not being a 'muesli'-type mix (but either pellet or extradate), and having feeding instructions that recommend feeding for *ad libitum* consumption and additional feeding of hay all tended to be associated with higher CF levels. Rather than suggesting a causal relationship (apart for the *ad libitum* feeding recommendation), it is plausible to understand these factors as indication that the corresponding producers are more transparent and more oriented towards current feeding recommendations.

Fibre levels – and due to their inverse relationship, NfE levels – are generally related to digestive tract and overall health, as especially well documented in rabbits reviewed in [5,6,15,17] (note that for dental health, the main factor is most likely not the fibre level of the compound feed, but the presence of whole forage like hay [26,30]). In short, low fibre levels are related to malfermentation/dysbiosis, diarrhoea, obesity, and reduced water intake. Therefore, the average levels reported here are a positive sign that pet feed producers are following recommendations, as is the low proportion of instructions that recommended feeding for *ad libitum* consumption, and the high proportion of instructions recommending hay. Diets consisting mainly of forage and a compound feed of these fibre levels are generally considered adequate to maintain the physical health of the rabbits, guinea pigs, chinchillas and degus.[18]

Against our expectation and a smaller unpublished survey we had conducted more than a decade ago, no trend in fibre levels over the years were evident, indicating that pet feed producers have been producing diets of these fibre levels for a long time. However, it is also evident that these averages are far off the fibre levels reported for the diets of free-ranging rabbits, and are only at the lower range of the fibre levels observed in free-ranging degus (Table 2). Evidently, more research on nutrient composition of the natural diet of these species would be welcome. Nevertheless, whether the adequacy of the nutrient composition of a diet in human care should be judged mainly by its effect on physical health, or by closeness to the natural diet, remains debatable.

One aspect that is related to the use of compound feeds, and that is exacerbated the lower these feeds are in fibre, is feeding behaviour. The required amount of feed intake is lower if the feed is of a higher energy density – i.e. has low fibre and high NfE levels. The higher the fibre level of a compound feed, the more time an animal should spend ingesting, because it needs more of it – a logical but to our knowledge untested assumption. What has been tested repeatedly, however, is the difference in feeding time on a forage feed, such as whole hay with lower instantaneous intake rates and longer daily feeding times, in comparison to a compound feed with higher instantaneous intake rates and shorter daily feeding times,[30,35,48] also evident in Table 3. Thus, the more a diet is composed of forages, and the higher the fibre level of its compound feed component, the longer the feeding activity required of the animals. As feeding activity can be considered time spent in a meaningful way, this will contribute to welfare. In Switzerland, this welfare aspect is addressed by making the provision of forage compulsory for the species addressed in our study (TSchV 64.1 & Anh. 2), even though fulfilling this demand using straw (which most likely will not be consumed be the animals in larger amounts) is permitted. One should be aware that any addition of compound feeds will reduce the time spent feeding compared to a forage-only diet.

With respect to the recommendation – compulsory in Switzerland – that *feeding must simulate species-specific characteristics of food intake including spatial variation in food supply* (TSchV Anh. 2, L), feeding instructions should suggest avoiding feeding any diet component at a single location (e.g., not in one bowl, or in one hay rack). The onus of educating pet owners in this respect does not necessarily lie with pet feed producers, but owner education would benefit from the participation of any players. With respect to simulating *species-specific duration of food intake*, awareness of owners should be increased by making specific recommendations. In order to do this, more knowledge on natural activity budgets of guinea pigs and chinchillas are desirable. Additionally, more knowledge on the influence of diet composition on the daily feeding budget of the four species would make more specific diet recommendations particularly aiming at behavioural management possible.

A comparison of commercially available feeds for rabbits, guinea pigs, chinchillas and degus with evidence of their diet and feeding behaviour in natural habitats

M. Rothacher, J.-M. Hatt, M. Clauss

Comparaison des aliments pour lapins, cochons d'Inde, chinchillas et dégus disponibles dans le commerce avec les données relatives à leur régime et à leur comportement alimentaire dans leurs habitats naturels

Une grande variété d'aliments pour animaux de compagnie est disponible dans le commerce pour les herbivores de compagnie; ces aliments peuvent différer du régime naturel dans leur composition en nutriments et peuvent déclencher des comportements alimentaires différents de ceux observés dans les habitats naturels. Nous avons étudié la littérature sur le régime alimentaire naturel et le budget d'activité des lapins *(Oryctolagus cuniculus)*, des cochons d'Inde *(Cavia porcellus)*, des chinchillas *(Chinchilla lanigera)* et des dégus *(Octodon degus)*, ainsi que 260 aliments composés disponibles dans le commerce pour ces espèces entre 1982 et 2020. Les espèces sont classées comme herbivores et les données disponibles sur leurs régimes alimentaires naturels suggèrent une teneur en fibres brutes (FB) d'environ 250 g/kg de matière sèche (MS), une activité alimentaire naturelle de l'ordre de 4 à 7 heures par jour, avec une durée d'alimentation nettement plus courte lorsque l'animal est nourri avec des aliments composés pour animaux de compagnie. Ce n'est que pour une minorité d'aliments que les cinq premiers ingrédients énumérés ne comprenaient pas d'ingrédient amylacé, ou seulement des ingrédients considérés comme impropres à la consommation humaine. Le pourcentage d'aliments dont la teneur en FB était inférieure à 150 g/kg MS était de 22 % pour les lapins de production, 18 % pour les lapins de compagnie, 26 % pour les cochons d'Inde, 18 % pour les chinchillas et 14 % pour les dégus ; en d'autres termes, la majorité des produits actuellement commercialisés ont des teneurs en FB conformes aux recommandations publiées, même si cela signifie une divergence par rapport aux régimes naturels. L'examen des instructions d'alimentation des producteurs suggère qu'elles ne doivent généralement pas être suivies sans discernement. Aucune évolution temporelle dans les teneurs en FB de ces régimes n'a été mise en évidence. Il n'y a pas de consensus sur la question de savoir si seuls les produits ressemblant à des aliments naturels doivent être inclus dans les aliments pour animaux de compagnie ou si des sous-produits végétaux non comestibles pour l'homme doivent également être inclus. La pratique observée en matière de composition des aliments pour animaux de compagnie n'a en grande partie respecté aucun de ces deux concepts, ce qui remet en question la logique générale de la composition de ces aliments. Les fourrages entiers, comme le foin, sont recommandés comme principale composante de l'alimentation de ces espèces et 76 % des produits alimentaires pour animaux de compagnie indiquent, dans les instructions d'alimentation, que du foin doit être donné.

Mots clés: budget d'activité, aliment composé, chinchilla, composition des aliments, dégu, cochon d'Inde, alimentation naturelle, composition des nutriments, durabilité, lapin

Un confronto tra i mangimi disponibili nel commercio per conigli, porcellini d'India, cincillà e degu sulla base della loro dieta e comportamento nel loro habitat naturale

Una vasta varietà di mangimi per animali è disponibile nel commercio per gli erbivori domestici; questi mangimi possono differire nella composizione nutrizionale rispetto alla dieta naturale e possono innescare comportamenti alimentari diversi da quelli osservati negli habitat naturali. In questo studio, abbiamo esaminato la letteratura disponibile sulla dieta naturale e il bilancio dell'attività di conigli *(Oryctolagus cuniculus)*, porcellini d'India *(Cavia porcellus)*, cincillà *(Chinchilla lanigera)* e degu *(Octodon degus)*, nonché su 260 mangimi composti disponibili nel commercio per queste specie tra il 1982 e il 2020. Le specie sono classificate come erbivori, con dati disponibili sulla dieta naturale che suggeriscono un livello di fibra grezza (FG) di circa 250 g/kg di materia secca (MS), un'attività alimentare naturale con una durata di 4–7 ore al giorno, con un comportamento alimentare chiaramente più breve quando vengono alimentati con mangimi per animali domestici composti. Solo per una minoranza di mangimi, i primi 5 ingredienti elencati non includevano un ingrediente ricco di amido o solo ingredienti non considerati adatti al consumo umano. La percentuale di mangimi il cui livello di FG era inferiore a 150 g/kg di MS era del 22 % per i conigli da produzione, del 18 % per i conigli domestici, del 26 % per i porcellini d'India, del 18 % per i cincillà e del 14 % per i degu; in altre parole, la maggior parte dei prodotti attualmente commercializzati ha livelli di FG in accordo con le raccomandazioni pubblicate, anche se ciò comporta una discrepanza rispetto alle diete naturali. L'esame delle istruzioni per l'alimentazione dei produttori suggerisce che generalmente non dovrebbero essere seguite in modo assoluto. Non sono emerse evidenze temporali nei livelli di FG di queste diete. Non c'è consenso su fatto che nei mangimi per animali domestici dovrebbero essere inclusi solo prodotti simili agli alimenti della dieta naturale o se dovrebbero essere inclusi anche sottoprodotti vegetali non commestibili per gli esseri umani. La pratica osservata nella composizione dei mangimi per animali domestici per lo più non seguiva nessuno dei due concetti, mettendo perciò in discussione la logica generale della composizione dei mangimi per animali domestici. Si raccomanda di utilizzare il fieno grezzo come principale componente della dieta per queste specie, e il 76 % degli alimenti per animali domestici indicava nelle istruzioni per l'alimentazione la necessità di somministrare fieno.

Parole chiave: bilancio dell'attività, mangimi composti, cincillà, composizione del mangime, degu, porcellini d'India, dieta naturale, composizione dei nutrienti, sostenibilità, coniglio

Literaturnachweis

[1] Alves J, J Vingada, P Rodrigues: The wild rabbit (*Oryctolagus cuniculus*) diet on a sanddune area in central Portugal: A contribution towards management. *Wildlife Biology in Practice* 2006; 2: 63–71.

[2] Asher M, E Spinelli de Oliveira, N Sachser: Social system and spatial organization of wild guinea pigs (*Cavia aperea*) in a natural population. *Journal of Mammalogy* 2004; 85: 788–796.

[3] Bonino N, L Borrelli: Variación estacional en la dieta del conejo silvestre europeo (*Oryctolagus cuniculus*) en la región andina de Neuquén, Argentina. *Ecología Austral* 2006; 16: 7–13.

[4] Bozinovic F: Nutritional energetics and digestive responses of an herbivorous rodent (*Octodon degus*) to different levels of dietary fiber. *Journal of Mammalogy* 1995; 76: 627–637.

[5] Clauss M: Clinical technique: feeding hay to rabbits and rodents. *Journal of Exotic Pet Medicine* 2012; 21: 80–86.

[6] Clauss M, J-M Hatt: Evidence-based rabbit housing and nutrition. *Veterinary Clinics of North America – Exotic Animal Practice* 2017; 20: 871–884.

[7] Cortés A, E Miranda, JE Jiménez: Seasonal food habits of the endangered long-tailed chinchilla (*Chinchilla lanigera*): the effect of precipitation. *Mammalian Biology* 2002; 67: 167–175.

[8] Ebensperger LA, MJ Hurtado: Seasonal changes in the time budget of degus (*Octodon degus*). *Behaviour* 2005; 142: 91–112.

[9] Ertl P, Q Zebeli, W Zollitsch, W Knaus: Feeding of wheat bran and sugar beet pulp as sole supplements in high-forage diets emphasizes the potential of dairy cattle for human food supply. *Journal of Dairy Science* 2016; 99: 1228–1236.

[10] Flachowsky G, U Meyer, K-H Südekum: Resource inputs and land, water and carbon footprints from the production of edible protein of animal origin. *Archives Animal Breeding* 2018; 61: 17–36.

[11] Franchi V, AO Aleuy, TA Tadich: Fur chewing and other abnormal repetitive behaviors in chinchillas (*Chinchilla lanigera*), under commercial fur-farming conditions. *Journal of Veterinary Behavior* 2016; 11: 60–64.

[12] Fuchs S: Spacing patterns in a colony of guinea pigs: predictability from environmental and social factors. *Behavioral Ecology and Sociobiology* 1980; 6: 265–276.

[13] Gainsbury AM, OJ Tallowin, S Meiri: An updated global data set for diet preferences in terrestrial mammals: testing the validity of extrapolation. *Mammal Review* 2018; 48: 160–167.

[14] Gegas VC, A Nazari, S Griffiths, J Simmonds, L Fish, S Orford, L Sayers, JH Doonan, JW Snape: A genetic framework for grain size and shape variation in wheat. *Plant Cell* 2010; 22: 1046–1056.

[15] Gidenne T: Dietary fibres in the nutrition of the growing rabbit and recommendations to preserve digestive health: a review. *Animal* 2015; 9: 227–242.

[16] Guichón ML, MH Cassini: Role of diet selection in the use of habitat by pampas cavies *Cavia aperea pamparum* (Mammalia, Rodentia). *Mammalia* 1998; 62: 23–36.

[17] Irlbeck NA: How to feed the rabbit (*Oryctolagus cuniculus*) gastrointestinal tract. *Journal of Animal Science* 2001; 79: 343–346.

[18] Kamphues J, M Coenen, K Eder, C Iben, E Kienzle, A Liesegang, Q Zebeli, J Zentek. *Supplemente zur Tierernährung: Für Studium und Praxis. 12., überarbeitete Auflage.* M. & H. Schaper, 2014.

[19] Katona K, Z Bíró, I Hahn, M Kertész, V Altbäcker: Competition between European hare and European rabbit in a lowland area, Hungary: a long-term ecological study in the period of rabbit extinction. *Folia Zoologica* 2004; 53: 255–268.

[20] Kenagy GJ, C Veloso, F Bozinovic: Daily rhythmus of food intake and feces reingestion in the degu, an herbivorous chilean rodent: optimizing digestion through coprophagy. *Physiological and Biochemical Zoology* 1999; 72: 78–86.

[21] Kenagy GJ, RF Nespolo, RA Vásquez, F Bozinovic: Daily and seasonal limits of time and temperature to activity of degus. *Revista Chilena de Historia Natural* 2002; 75: 567–581.

[22] Kissling WD, L Dalby, C Fløjgaard, J Lenoir, B Sandel, C Sandom, K Trøjelsgaard, J-C Svenning: Establishing macroecological trait datasets: digitalization, extrapolation, and validation of diet preferences in terrestrial mammals worldwide. *Ecology and Evolution* 2014; 4: 2913–2930.

[23] Lombardi L, N Fernández, S Moreno: Habitat use and spatial behaviour in the European rabbit in three Mediterranean environments. *Basic and Applied Ecology* 2007; 8: 453–463.

[24] Marques C, ML Mathias: The diet of the European wild rabbit, Oryctolagus cuniculus (L.), on different coastal habitats of central Portugal. *Mammalia* 2001; 65: 437–449.

[25] Martin GR, LE Twigg, L Zampichelli: Seasonal changes in the diet of the European rabbit (*Oryctolagus cuniculus*) from three different Mediterranean habitats in south-western Australia. *Wildlife Research* 2007; 34: 25–42.

[26] Meredith AL, JL Prebble, DJ Shaw: Impact of diet on incisor growth and attrition and the development of dental disease in pet rabbits. *Journal of Small Animal Practice* 2015; 56: 377–382.

[27] Meserve PL: Trophic relationships among small mammals in a Chilean semiarid thorn scrub community. *Journal of Mammalogy* 1981; 62: 304–314.

[28] Meserve PL, RE Martin, J Rodriguez: Feeding ecology of two Chilean caviomorphs in a central mediterranean savanna. *Journal of Mammology* 1983; 64: 322–325.

[29] Meserve PL, RE Martin, J Rodriguez: Comparative ecology of the caviomorph rodent *Octodon degus* in two Chilean Mediterranean-type communities. *Revista Chilena de Historia Natural* 1984; 57: 79–89.

[30] Müller J, M Clauss, D Codron, E Schulz, J Hummel, M Fortelius, P Kircher, J-M Hatt: Growth and wear of incisor and cheek teeth in domestic rabbits (*Oryctolagus cuniculus*) fed diets of different abrasiveness. *Journal of Experimental Zoology A* 2014; 321: 283–298.

[31] Mykytowycz R, I Rowley: Continuous observations of the activity of the wild rabbit (*Oryctolagus cuniculus*), during 24 hour periods. *CSIRO Wildlife Research* 1958; 3: 26–31.

[32] Nowak RM, JL Paradiso. *Walker's mammals of the world.* Johns Hopkins University Press, 1999.

[33] Oftedal OT, ME Allen. in *Wild mammals in captivity. Principles and techniques* (eds D G Kleiman, M E Allen, K V Thompson, & S Lumpkin) 148–157 (University of Chicago Press, 1996).

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[34] Olivas I, A Rodríguez-Latorre, F Estellés, S Calvet, A Villagrá: Assessment of activity patterns of growing rabbits in a flux-controlled chamber. *World Rabbit Science* 2013; 21: 107–110.

[35] Prebble JL, FM Langford, DJ Shaw, AL Meredith: The effect of four different feeding regimes on rabbit behaviour. *Applied Animal Behaviour Science* 2015; 169: 86–92.

[36] Quirici V, RA Castro, L Ortiz-Tolhuysen, AS Chesh, JR Burger, E Miranda, A Cortés, LD Hayes, LA Ebensperger: Seasonal variation in the range areas of the diurnal rodent *Octodon degus*. *Journal of Mammalogy* 2010; 91: 458–466.

[37] Quispe R, CP Villavicencio, A Cortés, RA Vásquez: Inter-population variation in hoarding behaviour in degus, *Octodon degus*. *Ethology* 2009; 115: 465–474.

[38] R: A language and environment for statistical computing. version 3.6.3. R Foundation for Statistical Computing, Vienna, http://www.R-project.org/ (2020).

[39] Robley AJ, J Short, S Bradley: Dietary overlap between the burrowing bettong (*Bettongia lesueur*) and the European rabbit (*Oryctolagus cuniculus*) in semi-arid coastal Western Australia. *Wildlife Research* 2001; 28: 341–349.

[40] Rogers PM, RC Soriguer, CP Arthur. in *The European rabbit* (eds H V Thompson & C M King) 22–63 (Oxford University Press, 1994).

[41] Schmidt DA, MS Kerley, JH Porter, JL Dempsey: Structural and nonstructural carbohydrate, fat, and protein composition of commercially available, whole produce. *Zoo Biology* 2005; 24: 359 - 373.

[42] Schwitzer C, SY Polowinsky, C Solman. in *Zoo animal nutrition IV* (eds M Clauss *et al.*) 131–168 (Filander Verlag, 2009).

[43] Serra MT: Composición botánica y variación estacional de la alimentación de *Chinchilla lanigera* en condiciones naturales. *Ciencias Forestales* 1979; 1: 11–18.

[44] Thompson HV, CM King. *The European rabbit, the history and biology of a successful colonizer*. Oxford Science Publications, 1994.

[45] Tschudin A, M Clauss, J-M Hatt: Umfrage zur Fütterung und Tränke von Kaninchen (*Oryctolagus cuniculi*) in der Schweiz 2008/2009. *Schweizer Archiv für Tierheilkunde* 2011; 153: 134–138.

[46] Wallage-Drees JM, B Deinum: Quality of the diet selected by wild rabbits (*Oryctolagus cuniculus*) in autumn and winter. *Netherlands Journal of Zoology* 1986; 36: 438–448.

[47] Wilman H, J Belmaker, J Simpson, C de la Rosa, MM Rivadeneira, W Jetz: EltonTraits 1.0: Species-level foraging attributes of the world's birds and mammals. *Ecology* 2014; 95: 2027.

[48] Wolf P, J Kamphues: Untersuchungen zu Fütterungseinflüssen auf die Entwicklung der Incisivi bei Kaninchen, Chinchilla und Ratte. *Kleintierpraxis* 1996; 41: 723–732.

[49] Wolfe A, J Whelan, TJ Hayden: Dietary overlap between the Irish mountain hare *Lepus timidus hibernicus* and the rabbit *Oryctolagus cuniculus* on coastal grassland. *Biology and Environment: Proceedings of the Royal Irish Academy* 1996; 96B: 89–95.

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