Agonistic behaviour of dairy goats and sheep during feeding – A pilot study on Swiss farms with mixed rations

R. Berthel[1], L. Purtschert[2], M. Braillard[3], D. Wiederkehr[4], A. Scheurer[4], N. Keil[1],

[1]Federal Food Safety and Veterinary Office, Centre of proper housing: ruminants and pigs, Agroscope, Switzerland; [2]Beratungs- und Gesundheitsdienst für Kleinwiederkäuer BGK, Switzerland; [3]Service de l'agriculture SAgri, État de Fribourg, Switzerland; [4]Bern University of Applied Sciences, School of Agricultural, Forest and Food Sciences HAFL, Switzerland

https://doi.org/10.17236/sat00359

Eingereicht: 24.01.2022
Angenommen: 01.04.2022

Agonistisches Verhalten von Milchziegen und -schafen bei der Fütterung – Eine Pilotstudie auf Schweizer Betrieben mit Mischrationen

Die Fütterung von Mischrationen ist eine weit verbreitete Praxis bei Rindern, um eine ausgewogene Ernährung zu gewährleisten und um Nahrungskonkurrenz zu reduzieren. Da kleine Wiederkäuer sich in ihrem Fress- und Sozialverhalten vom Rind unterscheiden, ist unklar, ob die Fütterung von Mischrationen die gleichen Vorteile hat. In dieser Pilotstudie wurde das Fress- und Sozialverhalten von Milchziegen und -schafen auf Schweizer Betrieben untersucht, die ad libitum mit Mischrationen gefüttert wurden.

Während der Winterfütterung wurden 12 Milchziegen- und 12 Milchschafbetriebe mit Mischrationen-Fütterung jeweils einmal besucht. Es wurden Daten zum Fütterungsmanagement, zur Fressplatzgestaltung und zur Zusammensetzung der Mischrationen erhoben. Die Anzahl gleichzeitig fressender Tiere und die Anzahl und Art des agonistischen Verhaltens während der Fütterung wurden während 6 Stunden nach der morgendlichen Futterverteilung bestimmt.

Das Fütterungsmanagement und die Zusammensetzung der Mischrationen waren zwischen den Betrieben sehr heterogen. Die Energie und Eiweiss der Futterrationen waren meist gut ausbalanciert und deckten den Bedarf für die Tagesmilchleistung von ca. 2,5 kg. Die Schafe waren synchroner als Ziegen in der Futteraufnahme. Die durchschnittliche Anzahl agonistischer Interaktionen pro Fressplatz betrug 3,8 bei Ziegen und 1,8 bei Schafen während 6 Beobachtungsstunden, daher ist bei Ziegen die Wahrscheinlichkeit agonistisches Verhalten zu beobachten höher als bei Schafen. Ziegen und Schafe unterschieden sich auch in der Häufigkeit der unterschiedlichen Formen des agonistischen Verhaltens. Insgesamt nahmen die agonistischen Interaktionen zwischen den Tieren während der Fütterung mit

Summary

Feeding mixed rations is a widely used practice for cattle to ensure the intake of a balanced diet and to reduce competition for food. It is unknown, whether mixed rations have the same advantages for small ruminants because they differ from cattle in their feeding and social behaviour. In this observational pilot study, an array of feeding and social behaviour of dairy goats and sheep fed ad libitum with mixed rations on Swiss farms was investigated.

Twelve dairy goat and 12 dairy sheep farms feeding mixed rations were visited once during the winter feeding period. Data on the feeding management, feeding place design and the composition of the mixed rations were collected. The number of animals feeding simultaneously and the number and type of agonistic interactions during feeding were assessed by direct observations for 6 hours after the morning feed-distribution.

The feeding management and the composition of the mixed rations were very heterogeneous among farms. The feed rations were mostly well balanced in relation to energy and protein and covered the requirements for the daily production of about 2,5 kg of milk. In terms of feeding simultaneously, sheep were more synchronous than goats. The mean number of agonistic interactions per feeding place within 6 hours were 3,8 in goats and 1,8 in sheep; thus, the probability to observe agonistic behaviour is higher in goats than in sheep. Goats and sheep also differed in the frequency of types of agonistic interactions. Overall, the occurrence of agonistic interactions between animals during feeding decreased with higher numbers of feeding places per animal and longer periods of time since the feed distribution.

To conclude, when feeding mixed rations, agonistic interactions related to feeding are more frequent in goats but also occur in sheep to a considerable extent. They

einer höheren Anzahl an Futterplätzen pro Tier und längeren Fütterungszeiten ab. Zusammenfassend zeigten Ziegen bei Mischrationsfüttung mehr Interaktionen, aber diese wurden auch bei Schafen in erheblichen Ausmasse beobachtet. Durch zusätzliche Futterplätze kann das agonistischen Verhalten reduziert werden.

Schlüsselwörter: Fressverhalten, Sozialverhalten; kleine Wiederkäuer, Bauernhof

can be decreased by offering more feeding places.

Keywords: feeding behaviour, social behaviour, small ruminants, on-farm

Agonistic behaviour of dairy goats and sheep during feeding – A pilot study on Swiss farms with mixed rations

Roxanne Berthel

Introduction

In Switzerland, the number of farms that keep dairy goats or sheep commercially has increased over the last two decades.[2] To ensure optimal milk production of high quality, all animals in a herd need to get access to feed of equal quality at all feeding places and at all times. Feeding mixed rations ad libitum (ad lib MR) like they are currently widely used in dairy cows[38] could be a solution also for small ruminants. From a nutritional point of view, the advantage is that the cows can consume a balanced diet.[28] When mixed rations are fed ad libitum and the cows can take in the same feed quality at any time of the day, they can adjust their feeding times individually.[20] This is especially advantageous in situations where not all animals can eat simultaneously, e.g. on farms where the animal-feeding place ratio is restricted,[14,21] or for low ranking cows when feeding places are monopolised by the higher-ranking ones.[14]

The scientific literature on feeding mixed rations to dairy goats and sheep is sparse and the conclusions are mainly based on studies done with total-MR with a high proportion of 45–70 % of concentrates.[1,32] In Switzerland however, rations for sheep and goats are roughage-based and concentrates are normally fed individually.[42] It has not been surveyed systematically what kind of mixed rations are fed to Swiss dairy goats and sheep (components, quality), how these are prepared and how they are offered to the animals (feeding frequency, amount per feeding and day, etc.) in practice.

Furthermore, both species differ from cattle as well as from each other in their feeding[27] and social behaviour[6], so that results from dairy cows are not necessarily transferable. Goats and sheep feed up to 6 hours per day in confined housing [22] and strongly synchronize their feeding behaviour within the herd (Goats[6],Sheep[19]). Synchrony is thought to provide fitness advantages to group-living animals (amongst others as an anti-predation strategy), but little is known how animals maintain synchrony.[16] Apart from sun light, synchrony in housed farm animals in the course of a day is likely to be influenced by zeitgeber such as milking and feeding times. However, in a study with cattle, Flury & Gygax[17] found an underlying daily pattern strongly synchronizing lying and feeding behaviour independently of such additional zeitgeber. This might also be true for goats and sheep and possibly be more pronounced in sheep because these show, in general, higher degrees of behavioural synchrony compared to goats.[23] Therefore, even if the availability of the mixed ration would allow for feeding more independently of each other throughout the day, the number of simultaneously feeding animals could be still consistently high and even higher in sheep than in goats.

In this context, it is also important to consider that agonistic interactions at the feed line are responsible for the major part of all agonistic interactions occurring in goats under intensive housing conditions [11] and increase with decreasing number of feeding places available per animal.[31] Consequently, low ranking goats often do not approach the feed line directly after feed delivery presumably to avoid agonistic interactions [26] and probably shift their feeding to time periods with less animals present at the feeding place.[31,34] There are no similar investigations available for dairy sheep. However, female sheep are considered socially much more tolerant than goats,[41] even though preferred individual distances during feeding seem to be similar between goats[9] and sheep[30]. It can thus be expected that the rate of agonistic interactions at the feed line is higher in goats than in sheep, but might be additionally influenced by the number of animals feeding simultaneously and the number of feeding places available even when fed ad lib MR.

Therefore, in this observational pilot study, the array of feeding and social behaviour of dairy goats and sheep fed ad lib MR was investigated. In order to cover as wide a range as possible of conditions that occur in practice, 12 dairy goat and 12 sheep farms were visited. The feeding facilities, the feeding management and the composition of the rations fed were recorded. To make a comparison between species, the number of animals feeding simultaneously and the number and types of agonistic interactions during feeding were assessed by direct observations. They were conducted for 6 hours after the morning feeding. It was hypothesized that goats and

sheep would differ in the quality and quantity of social interactions and in the number of simultaneously feeding animals throughout this period of day under the condition of feeding mixed rations.

Material and Methods

Farm selection and description

Twelve commercial Swiss dairy goat and 12 dairy sheep farms were included. The selection criteria were a herd size of at least 30 lactating animals in group-housing, a feeding regime with mixed or total mixed ration and feed access of at least 14 hours per day during the winter period.

The goat farms kept a herd size of on average 76 lactating animals (from 29–140) with an average milk yield of 350–1100 kg/animal/year. Seven of the farms kept hornless animals only, whereas five had mixed herds of horned and hornless goats. The farms kept various dairy breeds, but the predominant two breeds were *Saanen* and *Chamois Coloured*. All but two farms kept one or both of these two breeds. Other breeds were *Toggenburg*, *Peacock* and *Grisons Striped* goats. One third of the goat farms produced according to Swiss organic standards (910.18 Organic Farming Ordinance[39]), whereas two thirds followed conventional Swiss production standards (455.1 TSchV[40]).

The visited sheep farms kept on average 82 lactating sheep (from 31–167 animals) with an average milk yield between 350–550 kg/animal/year. The predominant dairy sheep breed was *Lacaune* Sheep, whereas four of the visited farms kept a mixed herd of *Lacaune* and *East Friesian* Sheep. All but two farms followed Swiss organic production standards (910.18 Bio-Verordnung[39]).

Data collection

Each farm was visited once during the winter feeding period from February to April 2019. The visit included a short interview with the farmer about the feeding management, the assessment of the ration fed (components and ratios) and weighing of the feed leftovers from the day before, measurements of the feeding area and behavioural observations of the social and feeding behaviour of the animals. All procedures of animal observation were approved by the Swiss Cantonal Veterinary Office Thurgau (TG10/18).

Assessment of the mixed rations

According to the farmer's information the feed components and their proportions based on fresh matter of the ration were recorded. Samples of each roughage feed component was taken. These were oven-dried at for 24h at 60 °C, grinded to 1 mm to be chemically analysed using the NIRS instrument[5] at the research laboratory of Agroscope Posieux. The energy contents were calculated.[3]

Behavioural observations

A protocol to observe behaviour in the feeding area was established (Spp). The feeding area was defined as the area above the manger and approximately one animal length behind the feeding fence inside the pen. Data was collected using time sampling for feeding behaviour and event sampling of defined agonistic behaviours (Table 1) by direct live observation. Observations were carried out by two persons (L.P., M.B.), who defined the ethogram and protocol together and matched their observations at a pilot farm that kept both species.

The observation started at the time of the first feed distribution in the morning. The animals were watched in three 15-min intervals per hour during an observation

Table 1: Ethogram of the recorded feeding and social behaviours of sheep and goats.

Term	Behaviour	Description
Feeding	Head above the manger	Feeding was defined by location of the animal: the animal was in a standing position with its head above the manger irrespective if it was chewing or not.
Agonistic 1	Block at the feeding place	Animal A approaches a feeding place at the feed line. Animal B is feeding at a neighboring feeding place and prevents animal A from putting its head above the manger by physical contact (fight with head, horns, legs or shoulder) or without physical contact (threatening). Animal A moves away for more than half a body length from B.
Agonistic 2	Displacement and use of feeding place	Animal A is feeding. Animal B displaces animal A by body contact (fight with head, horns, legs or shoulder) or without body contact (threatening). Animal A stops feeding and moves away for more than half a body length from B. Animal B starts feeding at the place of animal A or at a neighboring one.
Agonistic 3	Displacement without use of feeding place	Animal A is feeding. Animal B displaces animal A by body contact (fight with head, horns, legs or shoulder) or without body contact (threatening). Animal A stops feeding and moves away for more than half a body length from B. Animal B does not occupy a feeding place thereafter.
Agonistic 4	Displacement while feeding	Animal A and B are feeding next to each other. An interaction (fighting, threatening) occurs between animal A and B. One of the animals stops feeding and moves away for more than half a body length from the other.
Agonistic 5	Displacement in the feeding area	Animal A and B are in the observation area but are not feeding. An interaction (fighting, threatening) between animal A and B occurs. One of the animals sidesteps by changing its direction of movement and walks away from the other animal.

period of at least six hours. This summed up to a total observation of 432 observation intervals. In case the first feed distribution occurred already before milking (n = 7 farms), the time and number of animals leaving or joining the observed pen was additionally recorded to adjust the percentage of feeding animals on the number of animals present in the pen.

At the beginning of each interval, the number of feeding goats/sheep in the whole pen was counted. During each 15 min-interval agonistic behaviours (Agonistic 1 to Agonistic 5 Table 1) were continuously counted in the feeding area of defined segments. As the total area could not be observed at once, the feeding line was divided into segments of approximately 25 feeding places. Depending on the length of the feed line, this resulted in two to six segments per farm. The segments were observed subsequently and switched every interval.

On eight farms (7 goat farms, 1 sheep farm) the animals were fixed in the feeding fence for 30 min to 1,5 hours and not all types of agonistic behaviours could occur. Therefore, social behaviour was not recorded when animals where fixated. For the final analysis, 405 observation intervals were used.

Data analysis

R Studio Version 4.1.2[36] was used for the statistical evaluations.

Description of Variables

The animal-to-feeding-place-ratio was calculated as the number of animals present divided by the total number of feeding places available along the feed axis where MR was provided. Additional feeding places at hay racks inside the pens were not counted. In general, the number of animals present was equal to the group size, expect on farms where feeding and therefore observation started before or during milking. In this case it was counted how many animals were actually present in the pen with access to the observed feeding area, excluding those in the waiting area and milking parlor. Therefore the calculations for «animals present» and animal-to-feeding-place-ratio varied in the first observation intervals at some farms. If there were no physical barriers between feeding places (e.g. neckrails) the length of the segment was divided by 35 cm, as defined by the Swiss Animal Protection Ordonnance (455.1 TSchV, Annex 1, Table 4 and 5[40])

As parameter for synchronous feeding, the «proportion of feeding animals per interval» was calculated (number of feeding animals at the start of the interval divided by the number animals present in the pen at this time).

Further for each interval, «time after feed distribution» was calculated starting from each actual event of feed distribution. For farms with one feed distribution at the beginning of the observations, time after feed distribution was equal to the observation time of 6 hours, whereas for farms with additional events of feed distribution within the 6 hours observation time, the «time after feed distribution» restarted after every such event.

The number of feeding places per segments and the number of segments per farm varied between farms. To be able to compare social interactions between farms, the number of «interactions per feeding place» was used as outcome variable. It was calculated as the total number of interactions counted during the observation interval divided by the number of feeding places in the respective segment.

Statistical models

The proportion of feeding animals was related to the time after the feed distribution by a linear regression model for each farm. The slopes of these linear regressions were compared between goat and sheep farms using a Wilcoxon rank sum test.

Three generalized linear mixed effect models (glmer, lme4 package [12]) were calculated to evaluate the effect of different factors on the agonistic interactions. Residuals of the data were plotted and visually inspected for normal distribution and homoscedasticity using the DHARMa package.[24] For all three models, the model coefficients were calculated on a binomial distribution, as the data could not be transformed to normal distribution. This means the models estimated the effects of explaining factors on the probability that agonistic behaviour occurs (rather than the expected number of agonistic behaviour).

The first model estimated if the occurrence of agonistic behaviour differed between the species, including segment nested in farm as random factor to account for repeated measurements.

The second model analysed the effect of type of agonistic behaviour (Agonistic 1–5) and species and their interaction on the occurrence of agonistic behaviour. To account for repeated measurements segments nested within farm was included as random effect.

The third model focused on the housing conditions. The effects of herd size, animal-to-feeding-place-ratio and the time after feed distribution on the occurrence of interactions per feeding place were estimated. Data of animal-to-feeding-place-ratios above 2 were excluded, as those were rare events compared to the rest of the data (1,7 % of all data points excluded) and not representative for the entire day period. To account for species and the repeated measures within each herd these

two factors were included as crossed random effects. The level of significance was set to 0,05.

Results

Feeding management

The design of the feeding area was very heterogeneous across farms (Table 2). The majority of the sheep farms (n = 9) had neck tubes, without physical separation of feeding places. In contrast, nine goat farms had a feeding fence, which in most cases was used to fix the animals during feeding. This practice was found only once for sheep. On all farms, the animals usually had access to feed for more than 14 hours per day, on most of the farms (n=20) even 22 hours. The animal-to-feeding-place-ratio (when the whole group was present in the pen) was on average slightly above one (1,06) and ranged from 0,52 to 1,52 places per goat and 0,86 to 1,38 places per sheep.

Mixed and total mixed rations on the farms

The main feed components, the amount of concentrates fed and the percentage of left overs are listed in Table 3 for each farm. All but four of the mixed rations contained first cut and/or following cuts of hay, whereas on three of these four farms hay was offered separately to the mixed ration. Six out of the twelve dairy sheep farms fed grass and/or corn silage. Among the farms with dairy goats, only four used silage. A feedstuff that was also very common was dried alfalfa. Furthermore, ten farms fed sugar beet pulp, either ensiled or dried. On eight farms some water was added to the mixed rations consisting of mostly dry feed components. Five farms fed dry component mixed rations without the addition of water. In addition to the basic feeds, most mixed rations for dairy goats also contained concentrates, usually a protein concentrate, whereas, this was the case for only two dairy sheep rations.

The energy contents of all but two of the hay samples were on a good to very good level (4,1 – 6,1 MJ of net energy for lactation (NEL)/kg dry matter (DM). The same applies to the grass and corn silages (5,5 – 6,7 MJ NEL/kg DM and 6,5 – 6,8 MJ NEL/kg DM, respectively). Only the protein contents of the alfalfa were modest with values of less than 150g crude protein per kg DM (68 – 141 g/kg DM APDN; 108 – 217 g/kg DM crude protein). The roughage rations were mostly well balanced in terms of energy and protein contents. They covered the require-

Table 2: Housing conditions and feeding management of the studied 12 goat and 12 sheep farms.

Farm ID	Herd size	Type of manger	Fixation	Feeding place width (cm)	Visual barriers between feeding places	Feeding places per animal*	Feed distributions per day	Access-feed per day
Goats								
G1	52	crib	Yes	45	Yes	1,1	2	> 22 h
G2	130	belt	No	35	No	0,52	1	> 22 h
G3	51	table	No	35	No	1	> 5	> 22 h
G4	55	crib	No	37,5	Yes	1,09	4	10 h–14 h
G5	29	belt	No	35	No	1,52	1	> 22 h
G6	90	table	No	35	No	1	2	> 22 h
G7	54	table	Yes	35	No	1,15	0,25	> 22 h
G8	94	belt	Yes	35	No	1,11	1	> 22 h
G9	48	crib	Yes	35	Yes	1	2	> 22 h
G10	43	crib	Yes	35	Partly	1,06	2	14 h–18 h
G11	140	belt	Yes	35	Yes	1,07	1	> 22 h
G12	120	crib/ table	Yes	35	No	0,88	2	> 22 h
Sheep								
S1	42	crib	No	35	No	1	2	> 22 h
S2	150	belt	No	35	No	1	1	> 22 h
S3	56	belt	No	37,5	No	1	3	> 22 h
S4	56	belt	No	37,5	No	1	2	> 22 h
S5	48	crib	Yes	35	No	0,86	2	> 22 h
S6	83	belt	No	46	No	1,33	4	> 22 h
S7	167	table	No	41,2	No	1,17	2	> 22 h
S8	58	belt	No	37	No	1,12	2	> 22 h
S9	67	belt	No	35	No	1	2	> 22 h
S10	69	belt	No	39	No	1,1	2	18 h–22 h
S11	31	crib	No	36	No	1,38	3	14 h–18 h
S12	159	belt	No	34	No	0,99	2	> 22 h

*where mixed ration was fed

ments for the daily production of about 2,5 kg of milk. Most roughage components lacked some protein, which was often compensated by soybean extraction meal, rapeseed cake or a compound feed. The rations were supplemented with salt and minerals on all farms. Three quarters of the farms (n=16) used concentrate as a teaser in the milking parlour.

Feeding behaviour

In 10 out of 12 goat groups already 25-65 % of the animals had left the manger within one hour after the feed distribution. In the other two farms animals had been fixated in this time. Five hours after the feed distribution there were still on average 18 % of goats at the manger. In 8 of 12 sheep groups, more than 80 % of animals were feeding simultaneously for the first hour after the feed distribution, whereas on average less than 6 % of animals where still at the feed manger after 4,5 hours after the feed distribution. The regression of the proportion of feeding animals per interval in relation to time after feed distribution is depicted for each farm in Figure 1. The slopes of goat groups varied from -2,3 to -19,3 and in sheep groups from -3,8 to -27,0. The proportion of feeding animals per interval in relation to time after the feed distribution decreased faster in sheep than in goats ($W = 29$; $p = 0{,}01$).

Social behaviours

The mean number of the total counted agonistic behaviours per feeding place within the observation period of 6 hours per farm was around 3,8 and 1,8 in the observed goat groups and sheep groups, respectively. In more than half (52 %) of all observation intervals on the sheep farms, not a single agonistic interaction was recorded, whereas this was the case for less than a quarter (22 %) of observation intervals on goat farms (Table 4). The probability to observe agonistic behaviour in goat groups was higher than in sheep groups ($\chi2 = 12{,}37$, $p < 0{,}001$, Table 4).

The occurrence of each type of agonistic behaviour differed between the two species ($\chi2 = 27{,}67$, $p < 0{,}001$). Displacements in the feeding area (Agonistic 5) and displacements without use of a feeding place (Agonistic 3) occurred very rarely in sheep (only in 10 and 4 %, respectively, of all observation intervals in sheep). These two kinds of displacements were more often observed in goats (41 and 9 %, respectively, of all observation intervals in goats) but were also the two interactions types that were observed the least in goats. The probability of recording a displacement while animals were feeding (Agonistic 4) was at 45 % in goats and at 22 % in sheep. The probability to record displacements of feeding animals to take over the feeding place (Agonistic 2) was the highest of all agonistic behaviours in both species with a probability of 47 % in goats and 36 % in sheep.

The data showed an effect of the animal-to-feeding-place-ratio ($\chi2 = 3{,}05$; $p < 0{,}05$), with the occurrence of interactions being less likely the more feeding places were available per animal (Fig. 2). The same effect was found for the time after feed distribution ($\chi2 = 110{,}5$; $p < 0{,}001$), with the occurrence of interactions decreasing with time passed after feed distribution (Fig. 3). An effect of group size on the occurrence of agonistic interactions between the animals could not be statistically supported ($\chi2 = 1{,}14$; $p = 0{,}28$).

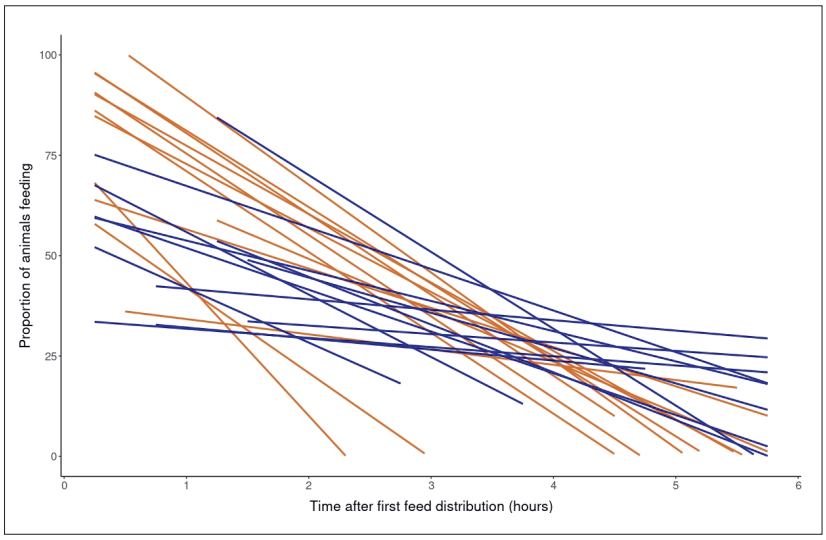

Figure 1: Estimated linear regression slopes of the proportion of animals feeding on 12 goat farms (blue) and 12 sheep farms (orange) in relation to the time after feed distribution

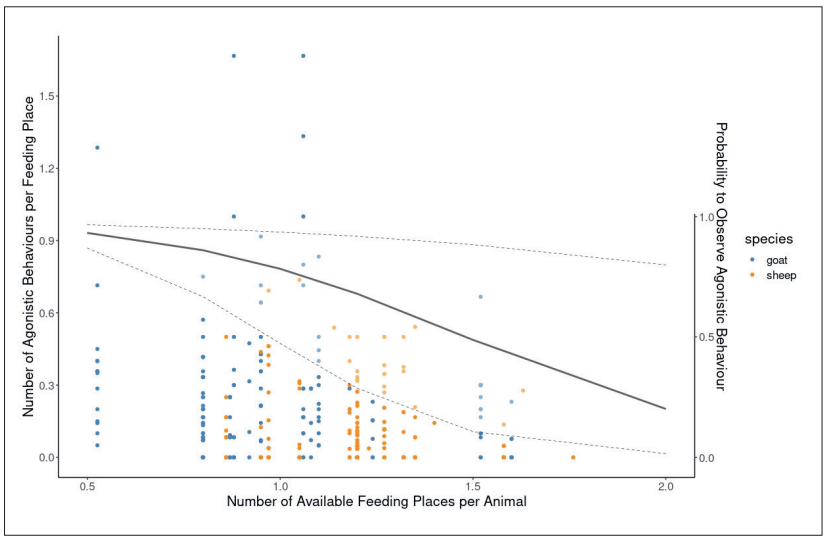

Figure 2: The left y-axis scales the dots of raw data points of the number of agonistic behaviours per feeding place within 15 min intervals (blue dots represent goats and orange dots represent sheep). The right y-axis scales the estimated probability to observe agonistic interactions by the binomial model (the black line represents the model estimates and the dashed lines the 95% confidence interval) in relation to the number of available feeding places per animal where mixed ration was fed

Table 3: Main feed components, concentrate feeding and percentage of left overs of the studied 12 goat and 12 sheep farms.

Farm ID	Components of mixed ration above 10% of total rations on fresh matter basis	- Mixed ration	Concentrate/ animal/ day (g) in/ on the ration	Concentrate in milking parlour	Percent left overs of the fed ration
Goats					
G1	Alfalfa, Hay 2nd cut, Hay 1st cut, Maïs, Water	Part	72	Yes	5%
G2	Maïs silage, Beet pulp, Grass silage	Total	690	Yes	10%
G3	Grass silage 1, hay 2nd cut, Grass silage 2	Total	50	Yes	6%
G4	Hay 2nd cut, Hay 1st cut	Total	0	Yes	6%
G5	Grass silage, Maïs silage, Straw, Alfalfa	Total	125	Yes	3%
G6	Hay 1st cut, Hay 2nd cut, Alfalfa, Concentrate 24, Concentrate 12	Total	450	No	2%
G7	Hay 1st cut, Hay 2nd cut	Part	240	Yes	NA
G8	Hay, Maïs cubes, Alfalfa	Total	0	Yes	25%
G9	Hay 2nd cut, Hay 1st cut	Part	510	No	10%
G10	Potatoes, Beet pulp, Alfalfa, Hay	Part	0	Yes	2%
G11	Hay 2nd cut, Beet pulp, Hay 1st cut,	Total	0	Yes	6%
G12	Hay, Maïs silage	Part	130	No	3%
Sheep					
S1	Alfalfa, Hay 2nd cut, Hay 1st cut, Maïs, Water	Part	500	Yes	9%
S2	Maïs silage, Alfalfa, Grass silage	Total	545	No	10%
S3	Hay 2nd cut, Hay 1st cut, Water	Total	0	No	5%
S4	Grass silage, Hay 2nd cut, Water, Maïs silage, Beet pulp	Part	0	No	9%
S5	Hay	Part	220	Yes	4%
S6	Grass silage , Hay 1st cut, Hay 2nd cut	Part	0	NA	1%
S7	Grass silage, Alfalfa	Part	0	Yes	3%
S8	Hay 1st cut, Hay 2nd cut	Part	0	Yes	1%
S9	Grass silage, Hay 1st cut, Hay 2nd cut	Part	0	Yes	6%
S10	Hay 1st cut, Hay 2nd cut, Water	Total	0	Yes	7%
S11	Hay 2nd cut, Hay 1st cut	Part	0	NA	10%
S12	Grass silage, Hay 2nd cut, Beet pulp	Part	0	Yes	4%

Table 4: Total number and number of five types of agonistic interactions observed [Ethogram see Tab. 1] at the feeding place in 12 goat and 12 sheep groups (mean of the mean number of 15 min-intervals per farm), percentage of intervals where no interaction occurred (mean per farm and SD) and the probability to observe agonistic interactions (model estimate, SE and CI).

	Sum	Agonistic 1	Agonistic 2	Agonistic 3	Agonistic 4	Agonistic 5
Goats						
Interactions per feeding place	0,23	0,04	0,09	0,01	0,06	0,04
Percentage of zero-interaction-intervals (±SD)	22 ±19	72 ±21	51 ±23	91 ±10	56 ±28	59 ±18
Probability (model estimate)	0,812	0,276	0,474	0,076	0,451	0,399
SE	0,045	0,049	0,059	0,022	0,058	0,057
Lower 95% CI	0,707	0,191	0,362	0,043	0,341	0,295
Upper 95% CI	0,885	0,381	0,588	0,132	0,566	0,514
Sheep						
Interactions per feeding place	0,10	0,02	0,06	0,00	0,02	0,01
Percentage of zero-interaction-intervals (±SD)	52 ±18	76 ±17	62 ±19	96 ±9	76 ±18	90 ±7
Probability (model estimate)	0,481	0,218	0,358	0,033	0,223	0,082
SE	0,066	0,042	0,054	0,013	0,043	0,023
Lower 95% CI	0,357	0,147	0,261	0,016	0,150	0,047
Upper 95% CI	0,608	0,312	0,470	0,069	0,318	0,138

SD = Standard Deviation; SE = Standard Error; CI = Confidence Interval

Discussion

This pilot study gives an overview of the feeding and social behaviour of dairy goat and sheep on Swiss farms using mixed rations. It could be shown that despite a huge variation in the composition of the rations and the feeding management between farms, sheep were feeding more simultaneously than goats. Both species differed quantitatively and qualitatively in their agonistic behaviour during feeding. Yet, agonistic interactions decreased with higher numbers of feeding places available for both species.

High quality feed in respect to its nutritional value is a precondition to prevent selection for specific components within the feed [18] and would be an important requirement to reduce competition between animals. The assessment of the rations showed that all of the farms apparently fed components and concentrate rations that seemed to be appropriate for sheep and goats according to recommendations. [7,8] Furthermore, on all farms the animals usually had access to feed for more than 14 hours per day. Therefore, it can be assumed that feeding and social behaviour was not strongly affected by the competition for specific nutrients or feed components or limited time of access to food. However, little is known about whether and to what extent goat and sheep select food components in mixed rations. How the quality of mixed rations decrease in relation to time after distribution should be subject of further research.

Our results show that both species apparently synchronize their feeding behaviour also when feeding on mixed rations. For both goats and sheep, the entire herd began to feed directly after feed distribution in the morning. With increasing time after feed distribution more and more animals left the feedline, probably to lie down and start ruminating. This pattern is typically found in dairy cows under farming conditions.[15] In goat herds, a large proportion of animals stopped feeding already shortly after feed distribution and a fourth to a third of the animals were observed feeding throughout the 6-hour observation period. In sheep, however, the proportion of feeding sheep dropped more quickly during the first two to three hours after feed distribution so that only few or no animals were still eating thereafter, supporting the findings of other studies that sheep are more synchronous than goats.[23,37]

The level of agonistic behaviour measured was comparable with other studies of interactions in feeding goats [10] and displacements in resting sheep.[13] Goats showed more interactions than sheep. They were especially higher in those types that might not necessarily be associated with competition for food like interactions in the feeding area (Agonistic 5) and displacements without using a feeding place (Agonistic 3). Those interactions were very rarely observed in sheep and could be explained by sheep avoiding dominant animals rather than engaging in an interaction.[25] So far, agonistic interactions of goats and sheep had never been directly compared under similar indoor housing and on-farm conditions. It is important to notice that types of agonistic behaviour, where animals competed for an occupied feeding place (Agonistic 1, 2 and 4) were on a similar level in goats and sheep.

In this context, the human observational bias is a factor that should always be considered in studies involving animal observations. It has been described that the perception of sheep behaviour by humans is biased by the narrative of the «calm and gentle sheep».[33] Additionally, ethograms of agonistic interactions in small ruminants are usually defined in relation to the position and use of horns,[25,41] lacking a transfer to hornless individuals. More resent work on intra-species communication in sheep describe rather subtle and hard to detect movements (e.g. ear posture).[35] Hence, it is possible that some interactions (esp. threats) between sheep were not noticed, whereas they were more easily detected in goats. The number of interactions observed in our study might therefore have been rather underestimated in sheep and overestimated in goats, due to expectation and perceptibility by humans.

However, in both species, the lower the number of feeding places per animal, the greater the likelihood of agonistic interactions, which is consistent with the findings of other studies.[29,31] As the individual distances in goats[9]

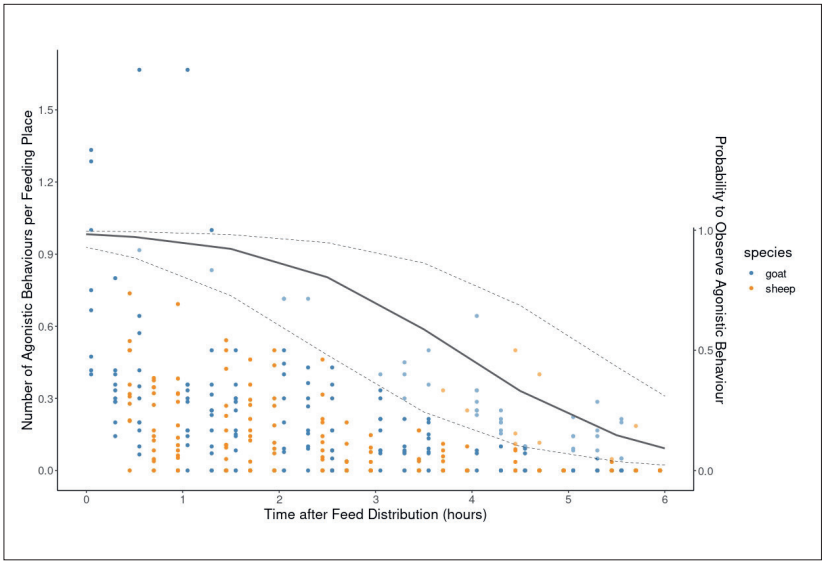

Figure 3: The left y-axis scales the dots of raw data points of the number agonistic behaviours per feeding place within 15 min (blue dots represent goat and orange dots represent sheep). The right y-axis scales the estimated probability to observe agonistic behaviour by the binomial model (the black line represents the model estimates and dashed lines the 95% confidence interval) in relation to time after feed distribution.

and sheep[30] are on average bigger than the sizes of feeding places in farming practice (in Switzerland: 35-40 cm per animal), forcing animals to stand closely side-by-side inevitably provokes agonistic interactions. It has been demonstrated in cows that agonistic behaviours increase in crowded situations.[14] With increasing time after feed distribution, less animals were in the feeding area, which would also explain why a decrease in agonistic interactions was found with increasing time after feed distribution. A decreasing number of feeding animals met fewer other animals and had more feeding places available to avoid each other. This relation seems to be valid independently of herd size, as no effect of herd size on agonistic interactions was found.

In summary, both goats and sheep seemed to synchronize their feeding behaviour even when mixed rations were fed. Agonistic interactions related to feeding were more frequent in goats but also occurred in sheep to a considerable extent. The competition for food could be decreased by offering more feeding places.

Acknowledgments

We want to thank: the farmers for their participation in this study for the information and time they shared and their trust in our work; the Swiss Goat Breeding Association (SZZV) and the Swiss Dairy Sheep Breeding Cooperative (SMG) for their support.

Project was funded by the Swiss Food Safety and Veterinary Affairs Office (2,19).

Comportement agonistique des chèvres et des moutons laitiers lors de l'alimentation – Etude pilote dans des fermes suisses avec des rations mixtes

L'alimentation avec des rations mixtes est une pratique largement utilisée pour les bovins afin de garantir l'apport d'une alimentation équilibrée et de réduire la concurrence pour la nourriture. On ignore si les rations mixtes présentent les mêmes avantages pour les petits ruminants, car ils diffèrent des bovins en matière de comportement alimentaire et social. Dans cette étude observationnelle pilote, un éventail de comportements alimentaires et sociaux de chèvres et de moutons laitiers nourris ad libitum avec des rations mixtes dans des fermes suisses a été étudié.

Douze exploitations de chèvres laitières et 12 exploitations de moutons laitiers, utilisant des rations mixtes, ont été visitées une fois pendant la période d'alimentation hivernale. Des données sur la gestion de l'alimentation, la conception du lieu d'alimentation et la composition des rations mixtes ont été recueillies. Le nombre d'animaux s'alimentant simultanément et le nombre et le type d'interactions agonistiques pendant l'alimentation ont été évalués par des observations directes pendant 6 heures après la distribution matinale des aliments.

La gestion de l'alimentation et la composition des rations mélangées étaient très hétérogènes entre les exploitations. Les rations alimentaires étaient généralement bien équilibrées en termes d'énergie et de protéines et couvraient les besoins pour la production quotidienne d'environ 2,5 kg de lait. En termes d'alimentation simul-

Comportamento agonistico delle capre e pecore da latte durante l'alimentazione – Uno studio pilota nelle aziende svizzere che utilizzano razioni miste

L'alimentazione con razioni miste è una pratica ampiamente utilizzata per i bovini per garantire l'assunzione di una dieta equilibrata e ridurre la competizione per il cibo. Visto che i piccoli ruminanti differiscono dai bovini per il loro comportamento alimentare e sociale non è chiaro se le razioni miste presentino per loro gli stessi vantaggi. In questo studio pilota osservazionale, è stata analizzata una serie di comportamenti alimentari e sociali nelle capre e nelle pecore da latte alimentate ad libitum con razioni miste in aziende agricole svizzere.

Durante il periodo di alimentazione invernale, 12 allevamenti di capre da latte e 12 di pecore da latte con alimentazione mista sono stati visitati per una volta. Sono stati raccolti dati sulla gestione dell'alimentazione, sulla progettazione del luogo di alimentazione e sulla composizione della razione mista. Il numero di animali che si alimentano contemporaneamente e il numero e il tipo di comportamenti agonistici notati durante l'alimentazione sono stati valutati durante le 6 ore successive alla distribuzione del mangime del mattino.

La gestione dell'alimentazione e la composizione delle razioni miste erano molto eterogenee tra le aziende agricole. L'energia e le proteine della razione alimentare erano per lo più ben bilanciate e coprivano il fabbisogno per una produzione giornaliera di latte di circa 2,5 kg. Le pecore erano più sincrone delle capre nell'assunzione

tanée, les moutons étaient plus synchrones que les chèvres. Le nombre moyen d'interactions agonistiques par place d'alimentation dans les 6 heures était de 3,8 chez les chèvres et de 1,8 chez les moutons ; la probabilité d'observer un comportement agonistique est en conséquence plus élevée chez les chèvres que chez les moutons. Les chèvres et les moutons diffèrent également dans la fréquence des types d'interactions agonistiques. Dans l'ensemble, l'occurrence des interactions agonistiques entre les animaux pendant l'alimentation a diminué avec un nombre plus élevé de places d'alimentation par animal et des périodes plus longues depuis la distribution des aliments.

En conclusion, lors de la distribution de rations mixtes, les interactions agonistiques liées à l'alimentation sont plus fréquentes chez les chèvres mais se produisent également dans une large mesure chez les moutons. Elles peuvent être réduites en offrant davantage de places d'alimentation.

Mots clés: comportement alimentaire, comportement social, petits ruminants, sur l'exploitation

del cibo. Il numero medio di interazioni agonistiche per luogo durante le 6 ore di osservazione di alimentazione era di 3,8 nelle capre e di 1,8 nelle pecore, di conseguenza, la probabilità di osservare un comportamento agonistico è maggiore nelle capre che nelle pecore. Le capre e le pecore si differenziano anche per la frequenza del tipo di comportamento agonistico. Nel complesso, le interazioni agonistiche tra gli animali durante la somministrazione di mangime sono diminuite con l'aumento del numero di postazioni di alimentazione per animale e con dei tempi di alimentazione più lunghi.

In conclusione, quando si somministrano razioni miste, il comportamento agonistico legato all'alimentazione sono più frequenti nelle capre, ma si verificano anche nelle pecore in misura considerevole. Questo comportamento agonistico può essere ridotto aumentando il numero di posti di alimentazione.

Parole chiave: Comportamento alimentare, comportamento sociale, piccoli ruminanti, azienda agricola

Literaturnachweis

[1] Abijaoudé J, Morand-Fehr P, Tessier J, Schmidely P, Sauvant D: Influence of forage: concentrate ratio and type of starch in the diet on feeding behaviour, dietary preferences, digestion, metabolism and performance of dairy goats in mid lactation. *Animal Science* 2000: 71(2): 359–368.

[2] Agristat: Kapitel 3 Viehwirtschaft. In: Agristat (ed.)), *Statistische Erhebungen und Schätzungen über Landwirtschaft und Ernährung*. Schweizer Bauernverband, Brugg, 2020.

[3] Agroscope: *Fütterungsempfehlungen für Wiederkäuer (Grünes Buch)*. Agroscope, Posieux. 2021.

[4] Albright JL: Feeding Behavior of Dairy Cattle. *Journal of Dairy Science* 1993: 76(2): 485–498.

[5] Andueza D, Picard F, Martin-Rosset W, Aufrère J: Near-infrared spectroscopy calibrations performed on oven-dried green forages for the prediction of chemical composition and nutritive value of preserved forage for ruminants. *Applied Spectroscopy* 2016: 70(8): 1321–1327.

[6] Arnold G: *Social organization and animal dispersion*. Elsevier Scientific Publishing Company, Amsterdam, the Netherlands. 1978.

[7] Arrigo Y, Frioud E, Schlegel P: Fütterungsempfehlungen für das Schaf), *Fütterungsempfehlungen für Wiederkäuer (Grünes Buch)*. Agroscope, Posieux, 2021: 1–14.

[8] Arrigo Y, Frioud F: Fütterungsempfehlungen für die Ziege), *Fütterungsempfehlungen für Wiederkäuer (Grünes Buch)*. Agroscope, Posieux, 2021: 1–14.

[9] Aschwanden J, Gygax L, Wechsler B, Keil NM: Social distances of goats at the feeding rack: Influence of the quality of social bonds, rank differences, grouping age and presence of horns. *Applied Animal Behaviour Science* 2008: 114(1–2): 116–131.

[10] Aschwanden J, Gygax L, Wechsler B, Keil NM: Loose housing of small goat groups: Influence of visual cover and elevated levels on feeding, resting and agonistic behaviour. *Applied Animal Behaviour Science* 2009: 119(3): 171–179.

[11] Aschwanden J, Gygax L, Wechsler B, Keil NM: Structural modifications at the feeding place: Effects of partitions and platforms on feeding and social behaviour of goats. *Applied Animal Behaviour Science* 2009: 119(3): 180–192.

[12] Bates D, Mächler M, Bolker B, Walker S: Fitting Linear Mixed-Effects Models Using lme4. 2015-10-07 ed. arXiv preprint; arXiv:1406.5823; 2015: 48.

[13] Bøe KE, Berg S, Andersen IL: Resting behaviour and displacements in ewes—effects of reduced lying space and pen shape. *Applied Animal Behaviour Science* 2006: 98(3): 249–259.

[14] Collings LKM, Weary DM, Chapinal N, von Keyserlingk MAG: Temporal feed restriction and overstocking increase competition for feed by dairy cattle. *Journal of Dairy Science* 2011: 94(11): 5480–5486.

[15] DeVries TJ, von Keyserlingk MAG, Beauchemin KA: Short Communication: Diurnal Feeding Pattern of Lactating Dairy Cows. *Journal of Dairy Science* 2003: 86(12): 4079–4082.

[16] Duranton C, Gaunet F: Behavioural synchronization from an ethological perspective: overview of its adaptive value. *Adaptive Behavior* 2016: 24(3): 181–191.

[17] Flury R, Gygax L: Daily patterns of synchrony in lying and feeding of cows: Quasi-natural state and (anti-) synchrony factors. *Behavioural Processes* 2016: 133: 56–61.

[18] Forbes JM: A personal view of how ruminant animals control their intake and choice of food: minimal total discomfort. *Nutrition Research Reviews* 2007: 20(2): 132–146.

[19] Gautrais J, Michelena P, Sibbald A, Bon R, Deneubourg J-L: Allelomimetic synchronization in Merino sheep. *Animal Behaviour* 2007: 74(5): 1443–1454.

[20] Grant R, Albright J: Feeding behaviour. In: D`Mello JPF (ed.), Farm animal metabolism and nutrition. CABI Publishing, Oxon, UK, 2000: 365–382.

[21] Greter AM, Kitts BL, DeVries TJ: Short communication: Limit feeding dairy heifers: Effect of feed bunk space and provision of a low-nutritive feedstuff. *Journal of Dairy Science* 2011: 94(6): 3124–3129.

[22] Hadjigeorgiou I, Gordon I, Milne J: Intake, digestion and selection of roughage with different staple lengths by sheep and goats. *Small Ruminant Research* 2003: 47(2): 117–132.

[23] Hafez ESE: *The behaviour of domestic animals*. 1969.

[24] Hartig F: Package 'DHARMa'; 2017.

[25] Hass CC: Social status in female bighorn sheep *(Ovis canadensis)*: expression, development and reproductive correlates. *Journal of Zoology* 1991: 225(3): 509–523.

[26] Hillmann E, Hilfiker S, Keil NM: Effects of restraint with or without blinds at the feed barrier on feeding and agonistic behaviour in horned and hornless goats. *Applied Animal Behaviour Science* 2014: 157: 72–80.

[27] Hofmann RR: Evolutionary steps of ecophysiological adaptation and diversification of ruminants: a comparative view of their digestive system. *Oecologia* 1989: 78(4): 443–457.

[28] Holter JB, Urban WE, Hayes HH, Davis HA: Utilization of Diet Components Fed Blended or Separately to Lactating Cows. *Journal of Dairy Science* 1977: 60(8): 1288–1293.

[29] Jørgensen GHM, Andersen IL, Bøe KE: Feed intake and social interactions in dairy goats—The effects of feeding space and type of roughage. *Applied Animal Behaviour Science* 2007: 107(3): 239–251.

[30] Jørgensen GHM, Andersen IL, Holand Ø, Bøe KE: Differences in the Spacing Behaviour of Two Breeds of Domestic Sheep (Ovis aries) – Influence of Artificial Selection? *Ethology* 2011: 117(7): 597–605.

[31] Loretz C, Wechsler B, Hauser R, Rüsch P: A comparison of space requirements of horned and hornless goats at the feed barrier and in the lying area. *Applied Animal Behaviour Science* 2004: 87(3–4): 275–283.

[32] Maltz E, Silanikove N, Karaso Y, Shefet G, Meltzer A, Barak M: A note on the effects of feeding total mixed ration on performance of dairy goats in late lactation. *Animal Feed Science and Technology* 1991: 35(1–2): 15–20.

[33] Marino L, Merskin D: Intelligence, complexity, and individuality in sheep. *Animal Sentience* 2019: 25(1): 1–26.

[34] Noack E-M: Untersuchungen zur Tiergerechtheit der Gestaltung des Fressbereichs in Ziegenlaufställen. Universität Hohenheim, 2003.

[35] Nowak R, Porter RH, Blache D, Dwyer CM: Behaviour and the Welfare of the Sheep), *The Welfare of Sheep*. Springer Netherlands, Dordrecht, 2008: 81–134.

[36] R_Core_Team: R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing; Vienna, Austria; 2021.

[37] Rook AJ, Penning PD: Synchronisation of eating, ruminating and idling activity by grazing sheep. *Applied Animal Behaviour Science* 1991: 32(2): 157–166.

[38] Schingoethe DJ: A 100-Year Review: Total mixed ration feeding of dairy cows. *Journal of Dairy Science* 2017: 100(12): 10143–10150.

[39] Schweizerische Eidgenossenschaft. Schweizer Bundesrat. 910.18 Verordnung über die biologische Landwirtschaft und die Kennzeichnung biologisch produzierter Erzeugnisse und Lebensmittel. Bern, Switzerland https://www.fedlex.admin.ch/eli/cc/1997/2498_2498_2498/de (accessed 22.032022)

[40] Schweizerische Eidgenossenschaft. Schweizer Bundesrat. 455.1 Tierschutzverordnung. Bern, Switzerland https://www.fedlex.admin.ch/eli/cc/2008/416/de (accessed 22.03.2022)

[41] Shackleton DM, Shank CC: A Review of the Social Behavior of Feral and Wild Sheep and Goats. *Journal of Animal Science* 1984: 58(2): 500–509.

Wiederkehr D, Purtschert L, Frick A, Keil NM, Berthel R, Scheurer A: Managemant der Winterfütterung auf Milchziegen- und Milchschafbetrieben. *Forum* 2021: 4: 6–8.

Korrespondenzadresse

Roxanne Berthel
Agroscope, Centre of proper housing: ruminants and pigs
Tänikon 1
CH-8356 Ettenhausen
Telefon: +41 58 483 61 92
E-Mail: roxanne.berthel@agroscope.admin.ch