Rearing goat kids away from their dams 1. A survey to understand rearing methods

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Rearing goat kids away from their dams 1. A survey to understand rearing methods

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ABSTRACT

Despite an estimated global goat population of over one billion, little is known about methods being used to feed milk to artificially reared kids (reared away from their dams) and how kids are weaned from these systems. Quantifying and characterising current methods utilised on farms will enable future targeted research to investigate best practice methods for milk feeding and weaning of artificially reared kids. A recall-based survey that investigated on-farm kid-rearing practices (focusing on the milk feeding and weaning stages) was distributed via social media, and regional goat organisations across multiple countries. A total of 242 responses from 16 countries were collected and geographically grouped. Responses that could not be grouped sufficiently were removed (nine responses from eight countries). A total of 233 responses from eight countries (United States of America **(USA)** 72; United Kingdom **(UK)** 71; Australia 33; Canada 23; New Zealand 20; European Union **(EU)** 14), were analysed. Most farms (217; 93%) bred their own kids. The most common milk feeding method was bottle feeding, used on 135 farms (57.9%), followed by *ad libitum* feeding used by 72 (30.9%). A relationship between number of kids reared and feeding system was identified, $\chi^2(3, N = 233) = 89.605$, $P < 0.001$, with farms rearing > 100 kids more likely to feed milk *ad libitum*. A total of 170 farms (72.9%) were weaned based on a target age and 85 (36.4%) on a target weight, 53 (22.7%) used both and 45 (19.3%) neither. Target weaning ages and weights varied across countries; the median age was 84 days (interquartile range **(IQR)** 56–84), and the median weight was 16 kg (IQR 15–18). A difference was found between milk feeding systems for weaning method ($\chi^2(2, N = 232) = 63.797$, $P \leq 0.001$), with kids most likely to be abruptly weaned from *ad libitum* systems (or gradually weaned from bottle feeding). Abrupt weaning was used by 67 farms (28.8%), and gradual weaning was used by 165 (71.1%). Gradual weaning strategies included reducing milk quantity (150 farms; 93% of farms providing detail) and diluting milk (six farms; 4%). A total of 169 (72.5%) supplied enrichment that met the survey's definition; items to climb on/hide in were most common, provided by 157 farms (92.8%). Findings suggest differing practices in smaller-scale bottle-fed versus larger-scale *ad libitum* milk systems, likely reflecting differing system needs. This highlights a requirement for welfare-focused research in kids reared artificially in order to identify and communicate best practices to ensure on-farm welfare is optimised within each system.

Implications

Limited information exists about management practices for artificially reared goat kids, and therefore, an international survey of kid-rearing and weaning methods was conducted. Results suggest that there are likely differing production system needs being encountered by smaller-scale bottle-fed versus larger-scale *ad libitum* milk feeding systems, which impacts management practices such as weaning strategies and subsequent welfare. Variable management practices highlight a need for greater research into the management of kids reared in artificial milk feeding systems that is tailored to farmers' needs; this would enable feasible best practices to be identified and subsequently communicated to optimise kid welfare.

Introduction

Goats may have been the first farmed ruminant species (Hatziminaoglou and Boyazoglu, 2004), having been domesticated approximately 10 000 years ago (Zeder and Hesse, 2000). They are a versatile species, adaptable to many environmental conditions,

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since their domestication have become popular across the globe (Morand-Fehr et al., 2004). The global population was estimated to stand at over one billion in 2018, an increase of 15.9% over a 10-year period (Food and Agriculture Organization of the United Nations (FAOSTAT), 2020). Globally, milk-producing goat numbers have increased by 20.6% from 2008 to 2018 (FAOSTAT, 2020). Despite only owning 4.2% of the world milk-producing goat herd, Europe produces 14.6% of global goat milk (FAOSTAT, 2020), indicating the region's intensive industry and husbandry practices, which could impact animal welfare. Global statistics often do not include home consumption or informal milk sales where records are not kept (Miller and Lu, 2019); therefore, the global goat industry is likely to be larger than currently estimated.

Despite this popularity, documented information about the characteristics of goat production systems and the welfare of the animals within them, either regionally or globally, is scarce. A review by Morand-Fehr et al. (2004) highlighted that basic research related to goat farming, such as understanding systems of production and 'proposing methods and know-how acceptable to farmers' should be a priority, and nutrition, genetics and reproduction were the main scientific topics of papers presented during the International Conference on Goats, with concerns being expressed over the low applicability of this research to commercial farms (Morand-Fehr and Lebbie, 2004), and peer-reviewed goat-specific research applicable for use on-farm is still limited, particularly for youngstock. Therefore, to have the largest impact, it is essential that research aiming to improve kid welfare is targeted and feasible for application on farms.

The milk feeding stage and weaning transition are considered high-risk periods for young ruminants, with the highest mortality occurring in these first months of life (Buddle et al., 1988; Todd et al., 2019). During the milk feeding stage, young ruminants digest milk in their abomasum and to be successfully weaned must develop a functioning rumen capable of microbial fermentation, which is a large physiological change (Baldwin et al., 2004). Rumen development is linked to the ingestion of solid feedstuff, and low consumption is correlated with slower rumen development and subsequent weight loss postweaning (Sweeney et al., 2010). Under natural conditions, weaning would take place over an extended time frame involving a gradual reduction in the intake of milk and contact with the dam (Bungo et al., 1998) alongside increasing solid feed consumption weaning from artificial milk supply systems cannot incorporate these natural cues (such as allelomimicry and dams preventing access to milk) and can cause responses indicative of stress (Greenwood, 1993; Lu and Potchoiba, 1988). Therefore, weaning management in commercial systems is an important potential welfare issue. Yet, the prevalence of different goat kid-rearing systems and the development of optimised youngstock husbandry practices have garnered limited research attention.

A recent survey circulated in the United Kingdom **(UK)** by the industry group the 'Milking Goat Association' highlighted the lack of knowledge surrounding current husbandry practices, and that research on factors affecting kid health was a top priority for farmers (Anzuino et al., 2019). The survey found that 85% of the responding farmers were feeding milk *ad libitum* and that age and weight were common criteria for weaning decisions, a finding supported by a smaller study of 16 farms in New Zealand (Todd et al., 2019). However, the actual methods of weaning from milk were not investigated within either publication. In calves, it has been found that the weaning method can influence growth rates and impact welfare (Roth et al., 2009; Weary et al., 2008) and understanding on-farm weaning practices could inform applied research to improve kid welfare.

The aim of this survey was to expand on the information presented by Anzuino et al. (2019), by collecting detailed information about on-farm kid-rearing practices from a greater range of farmers across multiple target countries. The survey was designed to collect information on milk feeding strategies, solid feed introduction, weaning methods, and environmental enrichment provision as well as key farm characteristics. Preliminary results of this survey have been published in abstract form (Vickery et al., 2021). Quantifying rearing methods currently being used will enable future research to be suitably targeted at investigating best practice methods for milk feeding and weaning of artificially reared goat kids, in order to optimise goat kid welfare.

Material and methods

Ethical approval was granted by the University of Reading, School of Agriculture, Policy and Development (reference number 001095) and Dalhousie University (reference number 2019–4934).

Questionnaire

A questionnaire was designed, for collecting anonymous responses, and consisted of 29 questions, some with multiple parts, across two main sections. The first section focused on background information, milk feeding strategies, feeding management, and weaning management (Supplementary Material S1). The results of this first part of the survey are reported here. Multiple-choice questions (with predefined answers) that allowed for quantitative data analysis were combined with open-ended questions that enabled a greater level of detail in the responses. The survey was designed to be completed from memory within 10 min. Routing meant that respondents did not have to answer all questions but were directed to sections specific to their milk feeding system and weaning method. Five farmers were asked to read and comment on a pilot version, which resulted in minor changes to question format including multiple-choice options. The survey was available in English and translated into Dutch and French. The translations were checked for accuracy by back translation into English, and clarification of specific words was sought from native speakers.

Participation criteria and recruitment

The survey was distributed widely to encourage a range of farmers to participate and the greatest possible participation from parts of the world where goats are commonly farmed in large-scale systems for commercial production. The only criterion for participation was that the respondent must be raising milk-fed goat kids artificially (away from their dams), and that only one response per farm was submitted. Participation was voluntary, and no incentive was offered for submitting a response.

The researchers' presence within the UK was utilised to encourage greater response rates by distributing paper copies, to farmers at the Milking Goat Association Open day (12th September 2019), the Goat Veterinary Society conference (10th October 2019), and the Dairy, Sheep and Goat Conference (27–28th January 2020). An electronic version of the questionnaire was created in the JISC Online Survey format, and an introductory email with a link to the online questionnaire was sent to relevant organisations globally (such as regional goat societies and veterinary services), who were asked to distribute the link within their membership base. A public post was created on the researchers' social media (Facebook & Twitter) with a link to the questionnaire, to encourage further participation. Whilst a large number of responses from English-speaking countries were anticipated, translations to Dutch and French were created to assist in gathering responses from Netherlands, France and Canada where commercial goat produc-

tion is prevalent. The English version was available online from 21st September 2019 to 30th April 2020, the French from 13th January to 15th June 2020, and the Dutch from 30th January to 15th June 2020.

Statistical analysis

JISC online survey responses were downloaded and collated in Microsoft Excel. Open-text responses were thematically analysed and coded based on the contents. Statistical analysis was then conducted in IBM SPSS (version 25; SPSS Inc., Chicago, IL, USA). Most results are presented as simple summary statistics. Comparisons were made for nominal-to-nominal variables using χ^2 tests (milk feeding system by weaning method and type of gradual weaning) and Kruskal-Wallis tests for nominal-to-ordinal variables (number of kids reared by milk feeding system and weaning method).

All weights stated were converted to kilograms (kg), and ages were converted to days; when a range was given, the median was used for analysis. Open-text responses described the enrichment provided, and based on these descriptions, it was subsequently decided whether the description met the survey's definition of enrichment. They were then classified into enrichment types and levels of scientific evidence.

Results

Survey exclusions and response

A total of eight surveys (three paper, five online) were excluded for reasons of incomplete responses, responses for dam-reared kids, or responses for incorrect species. After removals, 14 paper copies were uploaded. The English online version received 212 responses from 16 countries, the Dutch version one response from The Netherlands, and the French version 15 responses (eight from France and seven from Canada). Responses were then grouped geographically, and responses from countries or regions that could not be sufficiently grouped into categories of > 10 were removed (nine responses from eight countries). A European Union **(EU)** category with 14 responses (two from the Netherlands, three from Ireland and nine from France) was created. Final analysis was conducted on 233 responses from eight countries, giving an overall total of 233 surveys included in the analysis (Table 1).

Key farm and system characteristics

Table 1 presents survey responses by country and number of kids reared and shows that most responses were collected from farms rearing < 50 kids. Most farms (217, 93.1%) bred their own kids, 12 (5.2%) brought in kids to rear, and four (1.7%) both bred and brought in kids. Of those who brought in kids, nine (66.7%) collected them at < 7 days old, two (13.3%) at 8–14 days and the remaining three at > 15 days. Farms were asked to select the approximate percentage of kids they reared that were female; 25 (10.7%) were only rearing females, 59 (25.3%) were rearing 80%, 136 (58.4%) were rearing 50%, five (2.1%) raised 20% females, and the remaining eight (3.4%) reared no females at all. The purposes for rearing kids are presented in Fig. 1.

Milk feeding systems

Table 2 provides details on each of the systems used to feed milk to artificially reared goat kids. A statistically significant difference between number of kids reared and feeding system used was identified, $\chi^2(3, N = 233) = 89.605$, $P \leq 0.001$. Dunn's pairwise tests ($P = 0.001$, adjusted using the Bonferroni correction) showed there was significant evidence of a difference between farms rearing > 100 kids compared to < 20 kids, 20–50 kids, and 50–100 kids, with those farms rearing < 100 kids more likely to use bottle feeding and those rearing > 100 kids more likely to use *ad libitum* milk feeding. There was no evidence of a difference between other pairs.

Feeding and weaning management

Feeding management practices are presented in Table 3 and show that most farms provided access to solid feed and forage at < 14 days of age, but that both solid feed and forage type were variable. In terms of weaning practices, most farms that used a target weaning age or weight gave a single set target (Table 4), eight gave separate target weaning ages for males/females or kids reared for different purposes, four used weight related to birthweight as an aim (2×, 2.5×, 3×, and 4× birthweight), one had separate target weights for male and female kids, and one aimed for 50% of their target 12-month weight.

Weaning methods are presented in Table 5. A significant association was found between milk feeding system and weaning method ($X^2(2, N = 232) \geq 63.797$, $P \leq 0.001$), with kids most likely to be abruptly weaned from *ad libitum* milk feeding systems (or gradually weaned from bottle feeding). Weaning methods broken down by country, feeding system and number of kids reared are displayed in Fig. 2. No significant association was found between milk feeding system and method of gradual weaning ($X^2(2, N = 156) \geq 13.318$, $P = 0.346$).

A significant difference was identified between number of kids reared and weaning method used, $\chi^2(3, N = 232) = 58.380$, $P \leq 0.001$. Dunn's pairwise tests (P 0.001, adjusted using the Bonferroni correction) showed there was significant evidence of a difference between rearing > 100 kids compared to < 20 kids, 20–50 kids, and 50–100 kids. Those rearing > 100 kids were more likely to be abruptly weaned.

Environmental enrichment

Fig. 3 shows responses to questions regarding the provision of environmental enrichment, and classification of common enrichment types.

Discussion

Key farm and system characteristics

Responses were collected from multiple countries, with the UK and United States of America **(USA)** making up the largest proportion of respondents. Numerous responses were received from smaller farms (Table 1), possibly due to the sharing of social media posts into specific goat-keeping groups, and therefore, the results are skewed towards those raising a small number of kids each year. This survey identified a significant relationship between the number of kids reared per year and the milk feeding system used, with larger farms more likely to *ad libitum* milk feed. This relationship may affect other aspects of kid management and including data from those farms rearing a small number of kids artificially is therefore important since they may require different management strategies. Collecting data from a wide range of farm sizes and purposes highlights the diversity that exists within the goat sector and a need for further research to be differentially targeted according to herd size.

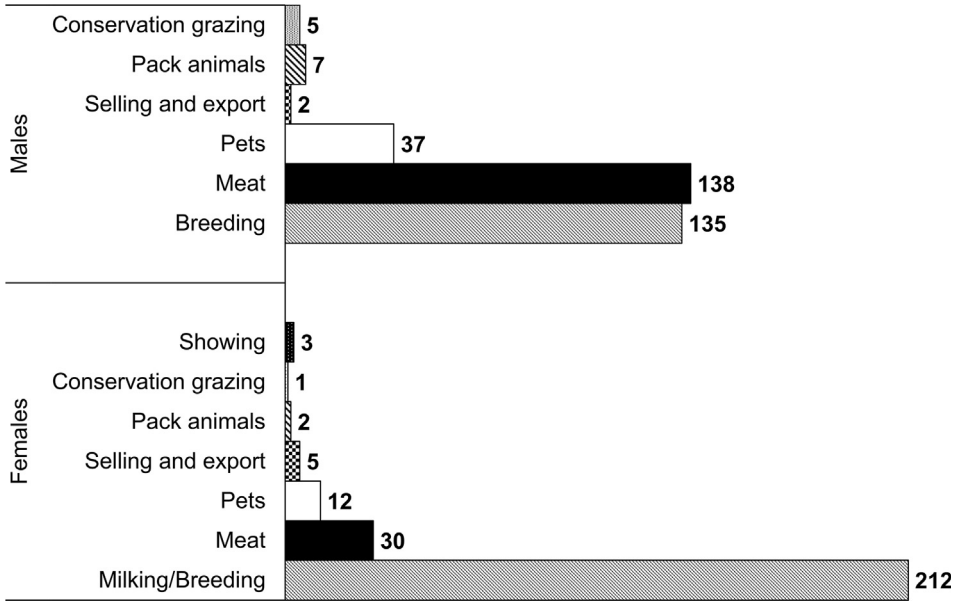

Fig. 1. Reasons for rearing male (n = 208) and female (n = 225) goat kids.

Table 1
Survey response per country by number of goat kids reared artificially (away from their dams).

Country	Number of responses n (%)	Average number of kids reared per year n (%)						
		<20	20–50	50–100	100–200	200–400	400–600	>600
USA	72 (31)	36 (50)	23 (32)	8 (11)	2 (3)	2 (3)	0 (0)	1 (1)
UK	71 (30)	31 (44)	10 (14)	3 (4)	8 (11)	6 (8)	7 (10)	6 (8)
Australia	33 (14)	15 (45)	10 (30)	3 (9)	1 (3)	1 (3)	1 (3)	2 (6)
Canada	23 (10)	8 (35)	2 (9)	2 (9)	4 (17)	5 (22)	0 (0)	2 (9)
NZ	20 (9)	10 (50)	3 (15)	4 (20)	0 (0)	0 (0)	0 (0)	3 (15)
EU[1]	14 (6)	2 (14)	1 (7)	0 (0)	5 (36)	4 (29)	2 (14)	0 (0)
Total	233	102 (44)	49 (21)	20 (9)	20 (9)	18 (8)	10 (4)	14 (6)

Abbreviations: USA: United States of America; UK = United Kingdom; NZ = New Zealand; EU = European Union.
[1] EU responses include 2 from the Netherlands, 3 from Ireland and 9 from France.

Milk feeding systems

A previous survey of UK dairy goat farmers found that all but one farm raised kids without suckling from their dams (Anzuino et al., 2019). Information on artificial milk feeding systems is limited and currently focuses on large-scale commercial farms within the dairy industry, however, kids are reared artificially in non-dairy systems for a multitude of reasons including those related to management, rejection by the dam, multiple births, and mastitis. As the aim of this survey was to quantify current on-farm rearing methods for welfare research to be suitably applied, goats being reared artificially for any purpose (Fig. 1) were included. Milk feeding systems could be impacted by housing management, including regional variation in common facility styles, and whilst not an objective of this survey, this is an area that could be investigated in further detail.

Despite the prevalence of goat kids being reared artificially, little research exists surrounding optimal milk intakes and methods of feeding milk after the colostrum feeding stage (last reviewed by Lu and Potchoiba, 1988). In Canada, *ad libitum* milk was fed on 55% of 104 farms (Bélanger-Naud, 2020) and in the UK, 85% of 46 farms (Anzuino et al., 2019); both were higher than found in the current survey. However, the respondents in both surveys were from commercial dairy farms with median herd sizes of 190 (Bélanger-Naud, 2020) and 400 adult milking females (Anzuino et al., 2019), and whilst adult herd size was not collected in the current study, the majority (44%) of farms were artificially rearing < 20 kids per year. The finding that those rearing larger numbers of kids were significantly more likely to use *ad libitum* milk feeding system could therefore explain this difference in the prevalence of *ad libitum* feeding between surveys.

High milk intakes such as those permitted by *ad libitum* systems have benefits including higher weight gains and increased natural behavioural expression (Jasper and Weary, 2002). However, of concern is the issue of one teat supplying multiple kids, and the related competition over access to milk. There are no studies specifically investigating the feeding behaviour of goat kids reared on artificial milk supply systems, but in calves, reduced access to milk due to a higher calf to teat ratio increases competitive interactions and causes reduced milk intake (von Keyserlingk et al., 2004). In the current survey, most farms allowed a ratio of either < 5 kids or 6–10 kids per teat, however, 11–20 per teat was also widely used (Table 2). Feeding competition and the resulting impacts on welfare could be an issue within *ad libitum* milk supply systems and warrant further investigation.

Table 2
Systems used to feed milk to artificially reared goat kids.

Milk feeding system management	Total number of respondents	Respondents in category: n (%)
Part A: Bottle feeding[1]	233	135 (57.9)
Number of milk meals per day at 8 days of age	130	
6×		7 (5.4)
5×		8 (6.2)
4×		62 (47.6)
3×		40 (30.7)
2×		13 (10.0)
Does the meal frequency change after 8 days?	124	
Yes		111 (89.5)
No		13 (10.5)
Minimum number of milk meals per day if decreased after 8 days:	88	
3×		1 (1.1)
1×		87 (98.9)
Part B: Ad libitum milk feeding[1]	233	72 (30.9)
Type of *ad libitum* milk feeder used:	72	
Förster-Technik		27 (37.5)
Homemade		12 (16.6)
Bucket/bar		9 (12.5)
Britmix		4 (5.5)
Other		20 (27.7)
Number of kids per *ad libitum* milk teat:	72	
<5		27 (37.5)
6–10		28 (38.8)
11–20		15 (20.8)
>21		2 (2.8)
Part C: Other milk feeding (open text)[1]	233	26 (11.2)
Description of feeding system:	26	
Bucket/bar type		17 (65.3)
Boiler with teats		2 (7.6)
Modified *ad libitum*		2 (7.6)
Homemade		1 (3.8)
Bottles		1 (3.8)
Combination of methods		1 (3.8)
No description		2 (7.6)

[1] The survey responses have been divided into three types of milk feeding, Part A shows information regarding bottle feeding, Part B *ad libitum* feeding, and Part C the 'other' strategies used.

Feeding management

It has been evidenced that goat kid reticulo-rumen development is affected by the physical form of the diet (Hamada et al., 1976); therefore, it is essential that young ruminants ingest solid feed and forage during the preweaning phase in order to develop a fully functioning rumen prior to weaning. In this survey, forage was considered plant-based feedstuff, whereas solid feed was compound/grain based. It was positive that most farms provided both at a young age (Table 3), as this enables the kids to become familiar with solid feeds before weaning and therefore develop a rumen capable of coping with the loss of milk-based nutrients.

Significant growth differences have been found between kids fed high and low protein diets (Greenwood, 1993), evidencing that adequate dietary protein intake is important for successful kid rearing. This survey found high variability in the type of solid feed offered but divided them into commercial complete feeds and home blends. The overall nutritional breakdown of a homemade blend is often unknown, and care should be taken to ensure a balanced diet that allows for good growth is achieved. Indeed, it has been found that feeding goat kids a pelleted complete feed alone compared to a combination of pellets and cereal grains increased weight gain (Hadjipanayiotou and Sanz, 1997). Goats are often considered a 'minority species', and therefore, access to goat-specific complete feed options is typically limited and other feedstuffs for small ruminants utilised (Table 3).

Solid feed intake has been positively correlated with reticulo-rumen weight (Hamada et al., 1976), and it has been found that kids consume more solid feed if milk is restricted rather than offered *ad libitum* (Economides, 1986). Therefore, the consumption of feed in *ad libitum* milk supply systems should be carefully considered, particularly around the weaning transition. Whilst solid feed is important for preweaning growth, feeding a diet high in concentrated solid feeds to goat kids during the growth phase can increase stereotypies and lead to impaired welfare (Tölü et al., 2017), and therefore, offering *ad libitum* forage is important. It was positive that the vast majority of farms provided forage; comparable to the 95.7% found by Anzuino et al. (2019). However, there is limited evidence to inform the optimum balance of forage and solid feed for rumen development during the milk feeding stage and further research in this area would be beneficial.

Weaning

Weaning (nutritionally; the process of transitioning from a milk-based diet to one composed of solid feedstuff) represents an important transitional phase of management. Whilst early weaning may be desirable in terms of management (including reducing labour and feed costs), timing weaning correctly is essential to animal welfare. There is increasing evidence from cattle that early high growth rates have long-lasting impacts beyond the milk feeding and weaning period. Higher early growth rates result in higher BW at 24 months of age, increased milk yields (Moallem et al., 2010), and reduced age at first calving (Raeth-Knight et al., 2009). Successful weaning (without significant morbidity and mortality) of goat kids has been documented at 5 weeks of age provid-

Table 3
Feeding management of artificially reared goat kids during the milk feeding stage.

Feeding management	Total number of respondents	Respondents in category n (%)	Median age first given (days)	IQR[1]
Is forage provided?	233			
Yes		229 (98.2)	7	1–14
No		4 (1.8)		
Type of forage fed	233			
Hay				
As singular source		137 (58.7)		
In combination		42 (18.0)		
Straw				
As singular source		21 (8.8)		
In combination		41 (17.2)		
Haylage				
As singular source		4 (1.7)		
In combination		15 (6.3)		
Silage				
As singular source		3 (1.3)		
In combination		0 (0)		
Natural pasture/browse				
As singular source		2 (0.8)		
In combination		22 (9.4)		
Other[2]				
As singular source		1 (0.4)		
In combination		7 (3.0)		
Is solid feed provided?	233			
Yes		223 (95.7)	14	7–20
No		10 (4.3)		
Type of solid feed	233			
Commercial complete		187 (83.9)		
Home blend		36 (16.1)		
Species designed for[3]	133			
Caprine		53 (40)		
Bovine		45 (33.3)		
Ovine		26 (19.3)		
Equine		8 (6.7)		
Rabbit		1 (0.7)		

[1] IQR = Interquartile Range.
[2] Other: alfalfa (2), chaff (2), Lucerne (2), Tree hay (1), Silage based total mixed ration (1).
[3] Species designed for was identified when respondents gave details of the manufacturer/feed name in their open-text response.

Table 4
Strategies for deciding when to wean artificially reared goat kids from milk.

Country	Do you use a target age?	Target age (days)		Do you use a target weight?[1]	Target weight (kg)		Do you use both a target age & weight?
	Yes *n* (%[2])	Median	IQR	Yes *n* (%[2])	Median	IQR	Yes *n* (%[2])
USA	55 (76.4)	84	70–84	16 (22.2)	18	15–23	8 (11.1)
UK	37 (52.9)	56	42–84	25 (35.7)	15	15–15.88	13 (18.6)
Australia	29 (87.9)	84	66.5–91	8 (24.2)	16	12–20	8 (24.2)
Canada	19 (82.6)	56	56–84	14 (60.9)	15.5	14.25–16	11 (47.8)
NZ	13 (65)	98	84–168	9 (45)	20	18–25	5 (25)
EU	8 (57.1)	60	56–72.5	13 (92.8)	16.5	16–17.5	8 (57.1)
Total	170 (72.9)	84	56–83	85 (36.4)	16	15–18	53 (22.7)

Abbreviations: USA: United States of America; UK = United Kingdom; NZ = New Zealand; EU = European Union; IQR = Interquartile range [1] Without further detailed information regarding breeds and production systems, weights can only be considered a broad indication.
[2] Percentages displayed are of total respondents for each country, presented in Table 1.

ing they were consuming at least 30 g of solid feed daily preweaning (Lu and Potchoiba, 1988). The consumption of solid feed may be an important consideration in determining optimal weaning times, however, unlike in many calf operations, the technology able to monitor individual intakes is generally not used when rearing goat kids; therefore, weaning strategies tend to be based on easy to measure traits such as weight or age.

The current survey relied on farmer recollection of their weaning methods, and therefore, the results should be interpreted with some caution due to the limitations of recall-based methodology, however, this study gives valuable insight into this underdocumented area. The decision to wean based on age was the most common strategy found, with weaning based on a target BW used less frequently (Table 4). This contrasts with dairy farms in New Zealand where most were using BW as the criteria for weaning;

Table 5
Strategies for weaning artificially reared goat kids from milk.

Weaning strategies		Total number of respondents	Respondents in category n (%)
From bottle feeding		134[1]	
	Abruptly weaned		19 (14.2)
	Gradually weaned		115 (85.8)
From *ad libitum* feeding		72	
	Abruptly weaned		48 (66.7)
	Gradually weaned		24 (33.3)
From other feeding		26	
	Abruptly weaned		0 (0)
	Gradually weaned		26 (100)
Gradual weaning strategy used		152	
	Reduction in milk quantity		142 (93.2)
	Dilution of milk		5 (3.7)
	Reduction in quantity & dilution		2 (1.2)
	Other[2]		3 (1.9)
Time frame gradual weaning occurred over		116	
	<7 days		12 (10.9)
	8–14 days		17 (14.3)
	15–21 days		7 (5.9)
	22–28 days		17 (14.3)
	>29 days		63 (54.6)

[1] One farm did not wean from bottle feeding and kept their kids on one milk meal a day indefinitely.
[2] Other: One combined milk quantity reduction and milk temperature reduction; One reduced milk temperature then provided water through the feeding machine at night for three days, and one full day; one gradually increased the number of kids per *ad libitum* teat before complete milk removal.

however, only two of those farmers routinely weighed their kids (Todd et al., 2019). It was not investigated if farmers were weighing their kids prior to weaning or estimating weight visually which could be an important consideration for accuracy.

In Canada, Bélanger-Naud (2020) found that most farms used a combination of age and weight as a weaning criterion, and the median target weight was 15 kg (Bélanger-Naud, 2020), comparable to the Canadian median found in this study. In the UK, 75.6% of dairy farmers used a target weaning age and 41.3% used a target weight (Anzuino et al., 2019), higher than found in the current study, perhaps due to the differences in purposes the kids are reared for. The current study found that target weaning ages and weights varied across countries and as this may be influenced by breed and purpose, it is important to note that the existing literature focuses on goats being raised for commercial dairy purposes, whereas the current study included all kids being reared artificially regardless of purpose. It has been suggested that weaning shock is more closely related to weight rather than kid age (reviewed by Lu and Potchoiba, 1988), however, it seems difficult to separate the two, and the evidence surrounding this is based on old data and limited sample sizes.

The process of weaning from artificial milk feeding systems can be conducted in two main ways, and this survey found that the weaning method chosen was related to the milk feeding system used. Abrupt weaning (the sudden and complete removal of milk) was more likely to be used by those feeding milk *ad libitum* whereas gradual weaning (the incremental reduction of milk before complete removal) was used more commonly by those bottle feeding. Calf research suggests that abrupt weaning results in lower growth rates than gradual weaning (Roth et al., 2009; Weary et al., 2008). However, there are minimal published studies specifically looking at method of weaning goat kids from artificial milk supply systems; (Zobel et al., 2019) and (Magistrelli et al., 2013) both found no significant effects of gradual weaning (by reduction in milk quantity or milk concentration) on weight or behaviour. In Canada, 37% of dairy farms were abruptly weaning, and methods of gradual weaning used were skipping milk feedings (20%), reducing milk quantity (19%), and diluting milk with water (10%) (Bélanger-Naud, 2020). In the current study, reducing milk quantity was favoured by the vast majority (Table 5) – a strategy difficult to implement in *ad libitum* milk systems and may explain why those systems were less likely to gradually wean.

Calf research has documented that high milk intake results in decreased solid feed intake postabrupt weaning (Weary et al., 2008) and reduced weight gain linked to slower rumen development (Sweeney et al., 2010); suggesting that goat kids fed on *ad libitum* milk systems may have issues surrounding lower solid feed intake and slower rumen development that impact them at weaning. As this survey found that kids fed on *ad libitum* milk systems are more likely to be abruptly weaned, this could be a welfare concern, and the lack of species-specific weaning research should be addressed to fully understand how weaning strategies affect goat kid welfare. Weaning targets and management may have been influenced by breed and housing effects; investigation of these was not the primary objective of this study, but the inclusion of this in further studies could be warranted.

Environmental enrichment

It is widely accepted that commercial environments can restrict behavioural expression and environmental enrichment is often used with the aim of improving the welfare of captive animals (Newberry, 1995). Indeed, many farming industries use enrichment to these purposes. Species ethology is important when considering providing enrichment; wild goats generally inhabit complex topography consisting of steep mountainous terrain at high elevations (Parrini et al., 2003). Opportunities for goats to perform their full behavioural repertoire may be restricted by commercial housing, which generally allow little variation in elevation, surfaces and hiding opportunities.

This survey is the first to investigate the provision of enrichment to artificially reared goat kids, and it found that farmers had a variable understanding of what enrichment is, with some descriptions given not meeting the definition provided. Therefore, some may be providing items of enrichment but not recognising them as such, and the prevalence of enrichment use reported in our study could be an underestimate. Kids may also utilise structures that are part of the environment as unintentional enrichment

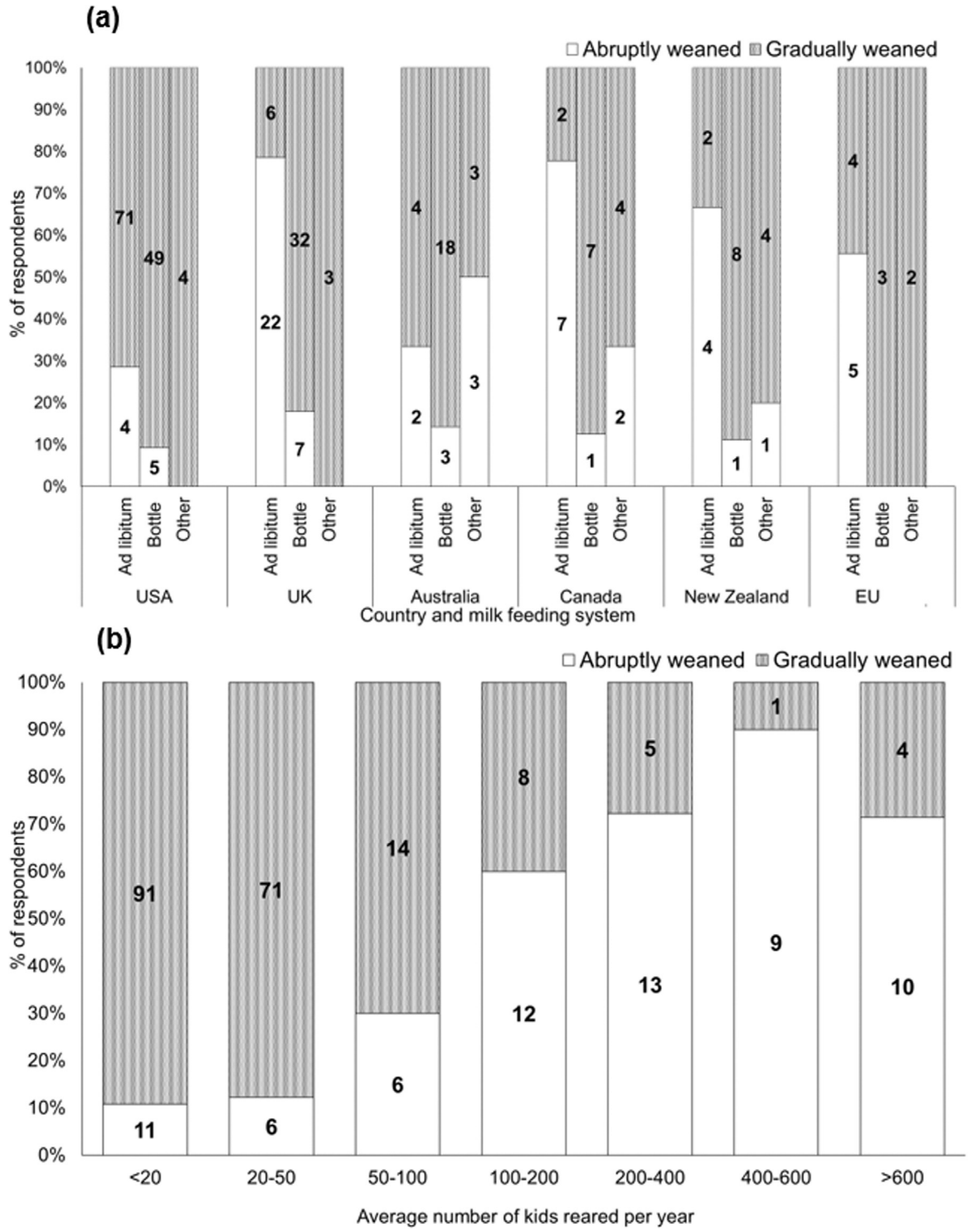

Fig. 2. Goat kid weaning method by milk feeding system and country (a) or by number of kids reared per year (b). Actual n is represented on the bars.

such as stumps and trees in paddocks. However, for the purposes of this survey, only specific items provided to the kids for the purposes of enrichment were acknowledged.

The most common type of enrichment provided were those classified as 'occupational enrichment' (Fig. 3), including both physical and psychological/cognitive enrichment (Bloomsmith et al., 1991). Altering the physical environment by providing items that add complexity has been shown to increase feeding bout duration and decrease agonistic behaviour in adult goats (Aschwanden et al., 2009). Sensory enrichment (stimulation designed to trigger an animal's senses; Bloomsmith et al., 1991) were mentioned in survey responses by a small number of farms (Fig. 3). It has been found that in cows, music decreases stress levels (Kıyıcı et al., 2013), however, it is unknown if the effect was due to changing human behaviour, and it has been noted that calves' behavioural

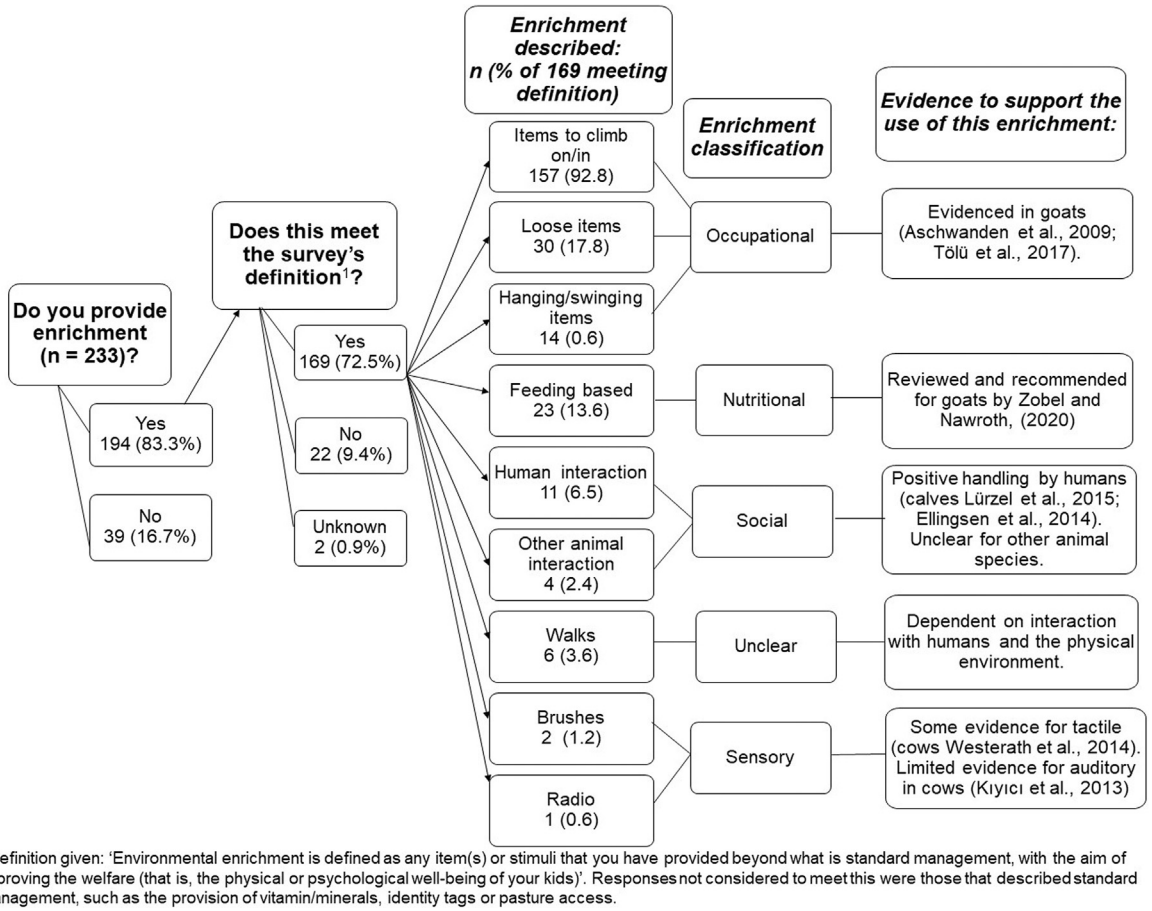

Fig. 3. Environmental enrichment provided to artificially reared goat kids and the evidence for its use.

responses to brushes potentially indicate enjoyment (Westerath et al., 2014).

Social enrichment involves access to contact with other animals or humans (Bloomsmith et al., 1991), human contact was commonly regarded as enrichment; however, it is important to note that not all contact is equal. In calves, positive early-life handling results in higher growth rates (Lürzel et al., 2015), and a more positive affective state (Ellingsen et al., 2014). However, negative interactions cause increased flight distances and reduced milk protein (Hemsworth et al., 2000). Social enrichment using other species is nuanced, for example, canine interaction causes indicators of stress in sheep (Hansen et al., 2001) but evidence specifically related to the interaction between goats and other species could not be found.

Nutritional enrichment involves presenting feed in a different way or offering novel feedstuff (Bloomsmith et al., 1991; Newberry, 1995) and can allow for increased expression of natural feeding behaviour. Raised feeding surfaces increase the feed intake of adult dairy goats (Neave et al., 2018), and Zobel and Nawroth (2020) suggest that feed presentation should be considered as a strategy to improve goat welfare. Nutritional enrichment made up a small percentage of the types of enrichment farms described; however, those offering natural browse or allowing pasture access may also be unintentionally providing nutritional enrichment.

It was encouraging that this first investigation into the provision of enrichment to goat kids on-farm found that most provided some form of enrichment, however, there has been little peer-reviewed research into enrichment for goat kids and therefore evidence-based recommendations for species-specific enrichment are limited. There is a need for further investigation into appropriate enrichment for goat kids in order to ensure enrichment is fulfilling its essential aim of improving welfare.

Conclusion

Greater understanding of on-farm management can ensure research aimed at improving goat welfare is relevant and applicable to the various systems employed, and the scale and objectives of those systems. Whilst bottle feeding was the most common milk feeding method, followed by *ad libitum* systems, it was found that farms rearing > 100 kids were significantly more likely to *ad libitum* milk feed. Kids were significantly more likely to be abruptly weaned from *ad libitum* milk feeding systems, or gradually weaned from bottle feeding. With evidence from other species suggesting that gradual weaning has welfare and production advantages over abrupt weaning, research on weaning strategies for *ad libitum* milk systems is needed. Enrichment was supplied on the vast majority of farms, with occupational enrichment being the most common type, but a greater understanding of the role of enrichment in improving the welfare of artificially reared kids, and how this interacts with other management practices is needed to help farmers make the right management decisions about the use of enrichment. Overall, whilst consideration should be given to the representativeness of results from countries with a limited number of responses, this survey helps to build a knowledge base of on-farm management practices during the kid milk feeding stage and weaning transition, with the variability in practice suggesting that applied research, tailored to the prevalent systems identified, is needed to inform best practice guidelines for rearing goat kids to

ensure welfare is optimised. Several areas in need of further investigation have been highlighted.

Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.animal.2022.100547.

Ethics approval

Ethical approval was granted by the University of Reading, School of Agriculture, Policy and Development (reference number 001095) and Dalhousie University (reference number 2019-4934).

Data and model availability statement

None of the data were deposited in an official repository; however, the data that support the study findings are available from the authors upon request.

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Declaration of interest

The authors declare that there is no conflict of interest.

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References

Anzuino, K., Knowles, T.G., Lee, M.R.F., Grogono-Thomas, R., 2019. Survey of husbandry and health on UK commercial dairy goat farms. Veterinary Record 185, 267. https://doi.org/10.1136/vr.105274.
Aschwanden, J., Gygax, L., Wechsler, B., Keil, N.M., 2009. Structural modifications at the feeding place: Effects of partitions and platforms on feeding and social behaviour of goats. Applied Animal Behaviour Science 119, 180–192. https://doi.org/10.1016/j.applanim.2009.04.004.
Baldwin, R.L., McLeod, K.R., Klotz, J.L., Heitmann, R.N., 2004. Rumen development, intestinal growth and hepatic metabolism in the pre- and postweaning ruminant. Journal of Dairy Science 87, 55–65.
Bélanger-Naud, S., 2020. Raising healthy and productive kids: A survey of dairy goat kid rearing practices on Canadian farms and their associations with farm performance. McGill University, Montreal, Canada, Master of Science.
Bloomsmith, M.A., Brent, L.Y., Schapiro, S.J., 1991. Guidelines for developing and managing an environmental enrichment program for nonhuman primates. Laboratory Animal Science 41, 372–377.
Buddle, B.M., Herceg, M., Ralston, M.J., Pulford, H.D., Millar, K.R., Elliott, D.C., 1988. A goat mortality study in the southern North Island. New Zealand Veterinary Journal 36, 167–170. https://doi.org/10.1080/00480169.1988.35523.
Bungo, T., Shimojo, M., Nakano, Y., Okano, K., Masuda, Y., Goto, I., 1998. Relationship between nursing and suckling behaviour in Tokara native goats. Applied Animal Behaviour Science 59, 357–362. https://doi.org/10.1016/S0168-1591(98)00144-0.
Economides, S., 1986. Comparative studies of sheep and goats: milk yield and composition and growth rate of lambs and kids. The Journal of Agricultural Science 106, 477–484. https://doi.org/10.1017/S0021859600063358.
Ellingsen, K., Coleman, G.J., Lund, V., Mejdell, C.M., 2014. Using qualitative behaviour assessment to explore the link between stockperson behaviour and dairy calf behaviour. Applied Animal Behaviour Science 153, 10–17. https://doi.org/10.1016/j.applanim.2014.01.011.
FAOSTAT, 2020. Food and Agriculture Organization of the United Nations statistical databases Retrieved 19 August 2020 from http://www.fao.org/faostat/en/#data/QL, .
Greenwood, P.L., 1993. Rearing systems for dairy goats. Small Ruminant Research 10, 189–199. https://doi.org/10.1016/0921-4488(93)90123-Y.
Hadjipanayiotou, M., Sanz, M.R., 1997. The utilization of nutrients for growth in goat kids and lambs: Aspects to be considered. In: Lindberg, J.E., Gonda, H.L., Ledin, I. (Eds.), Recent advances in small ruminant nutrition. CIHEAM, Zaragoza, Spain, pp. 233–242.
Hamada, T., Maeda, S., Kameoka, K., 1976. Factors influencing growth of rumen, liver, and other organs in kids weaned from milk replacers to solid foods. Journal of Dairy Science 59, 1110–1118. https://doi.org/10.3168/jds.S0022-0302(76)84330-5.
Hansen, I., Christiansen, F., Hansen, H.S., Braastad, B., Bakken, M., 2001. Variation in behavioural responses of ewes towards predator-related stimuli. Applied Animal Behaviour Science 70, 227–237. https://doi.org/10.1016/S0168-1591(00)00155-6.
Hatziminaoglou, Y., Boyazoglu, J., 2004. The goat in ancient civilisations: from the Fertile Crescent to the Aegean Sea. Small Ruminant Research 51, 123–129. https://doi.org/10.1016/j.smallrumres.2003.08.006.
Hemsworth, P.H., Coleman, G.J., Barnett, J.L., Borg, S, 2000. Relationships between human-animal interactions and productivity of commercial dairy cows. Journal of Animal Science 78 (11), 2821–2831. https://doi.org/10.2527/2000.78112821x.
Jasper, J., Weary, D.M., 2002. Effects of ad libitum milk intake on dairy calves. Journal of Dairy Science 85, 3054–3058. https://doi.org/10.3168/jds.S0022-0302(02)74391-9.
Kıyıcı, J.M., Koçyİgİt, R., Tüzemen, N., 2013. The effect of classical music on milk production, milk components and milking characteristics of Holstein Friesian. Journal of Tekirdag Agricultural Faculty 10, 74–81.
Lu, C.D., Potchoiba, M.J., 1988. Milk feeding and weaning of goat kids — A review. Small Ruminant Research 1, 105–112. https://doi.org/10.1016/0921-4488(88)90025-9.
Lürzel, S., Windschnurer, I., Futschik, A., Palme, R., Waiblinger, S., 2015. Effects of gentle interactions on the relationship with humans and on stress-related parameters in group-housed calves. Animal Welfare 24, 475–484. https://doi.org/10.7120/09627286.24.4.475.
Magistrelli, D., Aufy, A.A., Pinotti, L., Rosi, F., 2013. Analysis of weaning-induced stress in Saanen goat kids. Journal of Animal Physiology and Animal Nutrition 97, 732–739. https://doi.org/10.1111/j.1439-0396.2012.01315.x.
Miller, B.A., Lu, C.D., 2019. Current status of global dairy goat production: an overview. Asian-Australasian Journal of Animal Science 32, 1219–1232. https://doi.org/10.5713/ajas.19.0253.
Moallem, U., Werner, D., Lehrer, H., Zachut, M., Livshitz, L., Yakoby, S., Shamay, A., 2010. Long-term effects of ad libitum whole milk prior to weaning and prepubertal protein supplementation on skeletal growth rate and first-lactation milk production. Journal of Dairy Science 93, 2639–2650. https://doi.org/10.3168/jds.2009-3007.
Morand-Fehr, P., Boutonnet, J.P., Devendra, C., Dubeuf, J.P., Haenlein, G.F.W., Holst, P., Mowlem, L., Capote, J., 2004. Strategy for goat farming in the 21st century. Small Ruminant Research 51, 175–183. https://doi.org/10.1016/j.smallrumres.2003.08.013.
Morand-Fehr, P., Lebbie, S.H.B., 2004. Proposals for improving the research efficiency in goats. Small Ruminant Research 51, 145–153. https://doi.org/10.1016/j.smallrumres.2003.08.012.
Neave, H.W., von Keyserlingk, M.A.G., Weary, D.M., Zobel, G., 2018. Feed intake and behavior of dairy goats when offered an elevated feed bunk. Journal of Dairy Science 101, 3303–3310. https://doi.org/10.3168/jds.2017-13934.
Newberry, R.C., 1995. Environmental enrichment: Increasing the biological relevance of captive environments. Applied Animal Behaviour Science 44, 229–243. https://doi.org/10.1016/0168-1591(95)00616-Z.
Parrini, F., Grignolio, S., Luccarini, S., Bassano, B., Apollonio, M., 2003. Spatial behaviour of adult male Alpine ibexCapra ibex ibex in the Gran Paradiso

National Park, Italy. Acta Theriologica 48, 411–423. https://doi.org/10.1007/BF03194179.
Raeth-Knight, M., Chester-Jones, H., Hayes, S., Linn, J., Larson, R., Ziegler, D., Ziegler, B., Broadwater, N., 2009. Impact of conventional or intensive milk replacer programs on Holstein heifer performance through six months of age and during first lactation. Journal of Dairy Science 92, 799–809. https://doi.org/10.3168/jds.2008-1470.
Roth, B.A., Keil, N.M., Gygax, L., Hillmann, E., 2009. Influence of weaning method on health status and rumen development in dairy calves. Journal of Dairy Science 92, 645–656. https://doi.org/10.3168/jds.2008-1153.
Sweeney, B.C., Rushen, J., Weary, D.M., de Passillé, A.M., 2010. Duration of weaning, starter intake, and weight gain of dairy calves fed large amounts of milk. Journal of Dairy Science 93, 148–152. https://doi.org/10.3168/jds.2009-2427.
Todd, C.G., Bruce, B., Deeming, L., Zobel, G., 2019. Short communication: Survival of replacement kids from birth to mating on commercial dairy goat farms in New Zealand. Journal of Dairy Science 102, 9382–9388. https://doi.org/10.3168/jds.2019-16264.
Tölü, C., Göktürk, S., Savaş, T., 2017. Effects of housing environment on social isolation response, weaning stress, and immune reaction in goat kids. Turkish Journal of Veterinary and Animal Sciences 41, 635–642.
Vickery, H., Neal, R., Meagher, R., 2021. 90 A survey to understand methods of rearing goat kids away from their dams. Animal - Science Proceedings 12, 69. https://doi.org/10.1016/j.anscip.2021.03.091.
von Keyserlingk, M.A.G., Brusius, L., Weary, D.M., 2004. Competition for Teats and Feeding Behavior by Group-Housed Dairy Calves. Journal of Dairy Science 87, 4190–4194. https://doi.org/10.3168/jds.S0022-0302(04)73563-8.
Weary, D.M., Jasper, J., Hötzel, M.J., 2008. Understanding weaning distress. Applied Animal Behaviour Science 110, 24–41. https://doi.org/10.1016/j.applanim.2007.03.025.
Westerath, H.S., Gygax, L., Hillmann, E., 2014. Are special feed and being brushed judged as positive by calves? Applied Animal Behaviour Science 156, 12–21. https://doi.org/10.1016/j.applanim.2014.04.003.
Zeder, M.A., Hesse, B., 2000. The initial domestication of goats (Capra hircus) in the Zagros mountains 10,000 years ago. Science 287, 2254–2257. https://doi.org/10.1126/science.287.5461.2254.
Zobel, G., Freeman, H., Watson, T., Cameron, C., Sutherland, M., 2019. Effect of different milk removal strategies at weaning on feed intake and behavior of goat kids. Journal of Veterinary Behavior 35, 62–68. https://doi.org/10.1016/j.jveb.2019.10.004.
Zobel, G., Nawroth, C., 2020. Current state of knowledge on the cognitive capacities of goats and its potential to inform species-specific enrichment. Small Ruminant Research 192, 106208. https://doi.org/10.1016/j.smallrumres.2020.106208.