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Management and goat kid mortality on Southern German dairy goat farms

Management und Kitzsterblichkeit in süddeutschen Milchziegenbetrieben

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Summary

Benchmarking is an important tool to improve health and profitability but requires available data from similar production systems for comparison of performance. This study was conducted to generate a first dataset regarding dairy goat management and kid health in Southern Germany. Participation was voluntary, and 33 farmers contributed to a questionnaire survey, while 19 additionally recorded kidding and mortality data for twelve months in 2018/2019. A total of 2,371 kids were born at term, 154 of which were stillborn. Of the 2,217 live-born kids, a total of 195 died during the rearing period, with total losses (stillbirth and mortality of live-born kids) accounting for 14.7%. Farm-specific mortality parameters were variable, with a mean stillbirth rate of 6.4% (median: 5.8%; range: 0–20.7%). The average mortality of live-born kids was 9.1% (median: 8.7%; range: 1.6–25.5%). Predominant clinical signs associated with mortality were diarrhoea (25.6%), followed by weakness at birth (20.3%). Active control of colostrum intake (p=0.032) and selenium supplementation (p=0.008) were associated with lower overall mortality rates, while early weaning (aged 6–8 weeks) was associated with increased mortality in animals >1 month (p=0.043). A considerable percentage of post-weaning deaths and commonly observed diarrhoea in this age group also highlight the importance of appropriate management of coccidiosis. This study generated first benchmarking data for the specific conditions of predominantly organic Southern German dairy goat farms. Data analysis was also useful to identify individual areas of improvement on the participating farms and should be further promoted in small ruminant health management.

Keywords: benchmarking, health planning, weaning, selenium, colostrum

Zusammenfassung

Die Arbeit mit Vergleichsdaten ist ein wichtiges Instrument zur Verbesserung von Herdengesundheit und Wirtschaftlichkeit, erfordert jedoch das Vorhandensein von Daten aus vergleichbaren Haltungssystemen. Diese Studie diente der ersten Erfassung von Daten bezüglich des Managements und der Kitzgesundheit in süddeutschen Milchziegenherden. Die Teilnahme war freiwillig und 33 Milchziegenhalterinnen und Milchziegenhalter nahmen an einer Fragebogenstudie teil, von denen 19 zusätzlich über einen Zeitraum von zwölf Monaten (2018/2019) Ablamm- und Mortalitätsdaten aufzeichneten. Von insgesamt 2.371 geborenen Kitzen wurden 154 tot geboren. Von den 2.217 lebend geborenen Kitzen starben 195 während der Aufzuchtperiode. Die Gesamtverluste (Totgeburten und Verluste lebend geborener Kitze) betrugen 14,7 %. Zwischen den Betrieben variierten die Mortalitätsparameter deutlich. Die mittlere Totgeburtenrate lag bei 6,4 % (Median: 5,8 %; Spannweite: 0–20,7 %), die durchschnittliche Mortalität lebend geborener Kitze bei 9,1 % (Median: 8,7 %; Spannweite: 1,6–25,5 %). Durchfall (25,6 %) und angeborene Lebensschwäche (20,3 %) waren die im Zusammenhang mit Mortalität häufigsten genannten klinischen Symptome. Aktive Kontrolle

der Biestmilchaufnahme (p = 0,032) und Selen-Supplementation (p = 0,008) zeigten einen signifikanten Zusammenhang mit geringerer Kitzmortalität, während ein frühes Absetzen mit sechs bis acht Wochen mit einer höheren Sterblichkeit in der Altersgruppe > 1 Monat assoziiert war (p = 0,043). Ein nicht unerheblicher Teil der Todesfälle ereignete sich nach dem Absetzen. Im Zusammenhang mit häufig in dieser Altersgruppe beobachteten Durchfällen zeigt dies zudem die Bedeutung einer adäquaten Kokzidioseprophylaxe. Diese Studie konnte erstmals Vergleichsdaten für die speziellen Bedingungen süddeutscher, überwiegend biologisch bewirtschafteter Milchziegenbetriebe generieren. Die Datenanalyse war auch hilfreich, um für jeden Betrieb individuell durch verändertes Management eine Verbesserung der Tiergesundheit zu ermöglichen. Diese Methode der Gesundheitsberatung sollte in Kleinwiederkäuerbetrieben vermehrt Anwendung finden.
Schlüsselwörter: Vergleichsdaten, Gesundheitsmanagement, Absetzen, Selen, Kolostrum

Introduction

Consumer demand for dairy goat products has been continuing to rise in recent years, leading to increasing farm numbers particularly across Europe and North America (Manek et al. 2017, Bélanger-Naud et al. 2021, Meijer et al. 2021). While optimal management of female kids forms the basis of future success and production (Bélanger-Naud et al. 2021), the limited market for goat meat in Northern and Central Europe (Ringdorfer 2009, Zenke et al. 2009, Mack and Enzler 2018, Meijer et al. 2021) poses a challenge to the management and welfare of surplus and male animals, with many farmers facing a dilemma of how to deal with large numbers of kids born. Ethical treatment of these animals is however paramount (Meijer et al. 2021), and management methods must ensure best possible health and survival despite financial pressures. Many studies on neonatal survival in small ruminants have been conducted over the years, and the relative prevalence of the various causes of lamb and kid mortality varies with different husbandry systems (Dwyer et al. 2016). The health status and management of the dam also plays an important role in health and survival of the offspring. Nutrition, the maternal immune system, good hygiene practices and colostrum supply are important management factors that directly affect the survival of lambs and kids (Chaarani et al. 1991, Binns et al. 2002, Dwyer et al. 2016). Specific studies focusing on goats and particularly dairy goat production are however rare (Bélangeur-Naud and Vasseur 2021, Anzuino et al. 2019), and many studies on goat kid mortality originate from less industrialized countries and husbandry systems that are very often not comparable to European dairy goat production (Turkson et al. 2004, Slayi et al. 2014, Upadhyay et al. 2015, Bhattarai 2021). Chauhan et al. (2019) and, in a more comparable setting, Todd et al. (2019) identified the pre-weaning period as the time with the highest risk for kid mortality, with more than 90% of deaths observed before weaning. The latter study from New Zealand reported a mortality of 10.4% in 1,262 goat kids from 16 commercial dairy farms throughout the whole rearing period, it however only included live-born female kids intended for use as replacements, thus excluding stillbirth and the less valuable male counterparts. A Canadian study reported pre-weaning kid mortality between 0% and 70% (median: 8%) on 104 examined dairy goat farms (Bélanger-Naud et al. 2021), while a study from Cyprus found an average mortality of 11.4% (range 0% to 66%) until weaning on 42 examined farms (Arsoy 2020). Other authors from the UK and USA focus on dairy goat husbandry and management systems (Anzuino et al. 2019, Hempstead et al. 2021a) or welfare assessments (Anzuino et al. 2010, Hempstead et al. 2021b) but these studies did not investigate mortality rates despite their impact on welfare (Dwyer et al. 2016). Data from Germany is limited to an economic survey from the southern federal state of Baden-Württemberg, reporting an average kid mortality of 12.6% on the 15 dairy farms examined. The losses ranged from 3.9 to 20.3% on 80% of the farms, with outliers not being reported and no reference to the causes or timing of kid mortality (LEL 2014). A high percentage of German dairy goat farms is located in the South, particularly Bavaria and Baden-Württemberg (Manek et al. 2017), where small to medium-size, organic family-run farms are predominant (Voigt et al. 2016). Data from larger-scale, predominantly conventionally farmed settings in other countries are therefore difficult to apply to these farms. Record keeping and benchmarking own performance data to the industry average are however an important tool to assess and continuously improve health, profitability and welfare, and these methods are increasingly being recommended and applied to small ruminant health management (Phythian et al. 2014, Voigt et al. 2019). Considering the difficult market situation for goat meat it was hypothesized that financial pressures might lead to low incentives for rearing success and thus potentially high kid mortality rates. This study was therefore conducted to explore methods used in goat kid management and associated breeding management under the conditions of Southern German dairy goat farms, to identify important health issues during the pre- and post-weaning rearing periods, to generate first benchmarking data regarding kid mortality on these farm types and to assess the potential association of certain management practices with mortality rates.

Material and methods

The study was advertised by the Bavarian goat breeders' association (Landesverband Bayerischer Ziegenzüchter

e.V.) and the various organic agricultural associations (Bioland e.V., Biokreis e.V., Naturland e.V.), and a questionnaire was distributed by email to their members in autumn 2018. A total of 147 emails were sent to member farms in the Southern German federal state of Bavaria and neighbouring Baden-Württemberg. This call was additionally followed up by letters sent to the contractors of a regional dairy company. Participation was restricted to commercial full-time or part-time dairy goat farms, thus excluding any other purposes of goat farming or hobby herds.

The questionnaire included 66 detailed questions regarding farm structure, lactation management, reproductive management, rearing and weaning practices, health management and nutrition. Particular focus was set on the practice of prolonged lactations, dry periods, colostrum management, rearing strategies, preventive measures and management of the pregnant does, as well as retrospective kidding and kid mortality data. Full details of the questionnaire have been published by Kalić (2021). The farmers were given the option of returning the questionnaire anonymously, or of signing up to a follow-up, prospective study, which included detailed recording of kidding data over the course of a 12 month period between November 2018 and December 2019. In return to consent being given to their data being used, the participants of this prospective part of the study received a minimum of three veterinary advisory visits during crucial times for kid health (late pregnancy, pre- and post-weaning phases) and a final analysis of their data. Standardized lists were supplied to the farmers to record the number of abortions and parturitions, the number of stillborn and live born kids, any kid mortality, the approximate age at time of death, and any observed clinical signs or farmer-suspected causes of death. In addition, the participants were asked to record whether a kid had died suddenly or following a period of illness, plus the litter size of the affected kids (single, twin, multiple). Post mortem examination at the Department of Veterinary Pathology, LMU Munich, was offered to the participants free of charge.

The kidding and mortality data were handled using Microsoft Excel 2016, and the following parameters were calculated for each individual farm:

$$\text{Abortion rate in \%} = \frac{\text{number of abortions}}{\text{total number of parturitions}} \times 100$$

$$\text{Stillbirth rate in \%} = \frac{\text{number of stillborn kids at term}}{\text{total number of kids born at term}} \times 100$$

$$\text{Kid mortality in \%} = \frac{\text{number of live born kids which died until the end of rearing}}{\text{number of all live born kids}} \times 100$$

$$\text{Total kid losses in \%} = \frac{\text{number of live born kids which died + number of stillborn kids at term}}{\text{total number of kids born at term}} \times 100$$

In addition, kid mortality was described according to the time of death, which was categorized using the following age groups: ≤2 days, 3–7 days, >1–4 weeks, >4 weeks:

$$\text{Mortality in age category in \%} = \frac{\text{number of deaths in age category}}{\text{number of all deaths}} \times 100$$

For the participants of the prospective study, data gathered by questionnaire were statistically evaluated to examine potential associations of specific farm traits or management practices with the above kid mortality parameters. The examined factors included: herd size (<100/>100 adult females), number of animals bred per year (<50, 51–100, >100), duration of breeding period (≤7, 8–12, >12 weeks), prolonged lactations (yes/no), colostrum management (control of intake: yes/no), selenium supplementation (yes/no) and weaning age (6–8 weeks, 9–12 weeks, >12 weeks). Statistical analyses were performed using Microsoft Excel 2016 and R-Studio (version 3.6.3). The data were tested for normal distribution using the Shapiro-Wilk test. Subsequently, the homogeneity of the variances of associated numerical data was checked using the Levene test. For data with normal distribution and homogenic variances, parametric Student's T-test was performed, if variances were not homogenic, Welsh's T-test was applied. For not-normally distributed data non-parametric Mann-Whitney U test was performed. Potential independence of two nominal or categorical variables was tested using the Chi-square test. A p-value ≤0.05 was considered significant.

Results

A total of 33 completed questionnaires were received following the described advertising approach. Due to potential duplicate memberships of some farmers in the various organizations there was some uncertainty when calculating a return rate. Based on the total number of 147 emails sent, the theoretical return rate was 22.5% (33/147). The true return rate is however likely to be higher due to several farmers most likely being approached twice.

The majority of these 33 participants managed their herd full-time (21/33; 63.6%), while twelve were part-time farmers. There were 31 organic (31/33; 93,9%) and two conventional farms (2/33; 6.1%) in the study cohort. At the time of data collection, the average herd size was 131 adult female goats (median: 118; range: 18–365), 35 female replacements (median: 18; range: 4–170), 36 kids (median: 30; range: 2–150) and 3 bucks (median: 3; range: 1–8). A variety (and often multiple) breeds were kept on the participating farms, with German Improved Fawn/Alpine goats (25/33 farms; 75.8%) and German Improved White/Saanen goats (21/33 farms; 63.6%) the most frequent breeds. Other breeds included crossbred animals (11/33 farms; 33.3%), Thuringian Forest goats (4/33 farms; 12.1%), Toggenburg goats (2/33 farms; 6.1%) and Anglo-Nubians (2/33 farms; 6.1%), plus an individual farm also keeping Peacock goats (n=1; 3%). The goats had access to pasture on 27 of the 33 participating farms (81.8%).

Prolonged lactations were common practice among the participants. Twenty-two (22/33; 66.7%) farmers milked their goats for an average period of 2.6 years (median: 2; range 1.5–7 years) without breeding, while the remaining farmers bred all their animals annually. The main reasons that led to the practice of prolonged lactations were a reduction in the number of kids born (17/22; 77.3%), followed by the aim of year-round milk production (11/22; 50%). Other reasons included a reduction in work load (5/22; 22.7%) and lower health risks for the does by avoiding pregnancy and parturition (3/22; 13.6%). The participants' perception regarding the

TABLE 1: *Farmers' perception regarding effects of prolonged lactations on health and production parameters in Southern German dairy goat herds according to questionnaire results (n=22 farms practicing a prolonged lactation system)*

	Improved	Unchanged	Inferior	Not specified
Fertility	0/22 (0%)	14/22 (63.6%)	6/22 (27.3%)	2/22 (9.1%)
Gestation and parturition	0/22 (0%)	21/22 (95.5%)	0/22 (0%)	1/22 (4.6%)
Kid health	1/22 (4.6%)	17/22 (77.3%)	1/22 (4.6%)	3/22 (13.6%)
General herd health	7/22 (31.8%)	5/22 (22.7%)	0/22 (0%)	10/22 (45.5%)
Doe body condition score	4/22 (18.2%)	7/22 (31.8%)	1/22 (4.6%)	10/22 (45.5%)
Mastitis	3/22 (13.6%)	8/22 (36.4%)	1/22 (4.6%)	10/22 (45.5%)
Annual milk yield	4/22 (18.2%)	6/22 (27.3%)	2/22 (9.1%)	10/22 (45.5%)
Cell count	0/22 (0%)	10/22 (45.5%)	2/22 (9.1%)	10/22 (45.5%)

effects of prolonged lactations on health and production parameters is summarized in Table 1.

In line with the practice of prolonged lactations on many farms, the average number of animals bred in the year preceding prospective data collection was 82 goats (median: 52, range 0–330) and thus lower than the average herd size. Information provided regarding the average annual breeding percentage ranged from 20% to 100% of the does, with a mean breeding percentage of 58.8% (median: 50%). The animals were joined with the buck for an average breeding period of 10.7 weeks (median: 10 weeks; range 4–40) for yearling animals, and 8.8 weeks (median: 8 weeks; range: 4–27) for adult does. The vast majority of the farmers (32/33; 97.0%) dried off their late pregnant animals for a mean dry period of 7.3 weeks (median: 7.3; range: 4–10). One farmer (1/33; 3.0%) practiced continuous milking without applying any dry period prior to parturition.

Regular checks of the lambing herd were carried out by the vast majority of the goat keepers (30/33; 90.9%). The percentage of parturitions requiring assistance was estimated at up to 2% by three farmers (3/33; 6.1%), up to 5% by 17 (17/33; 51.5%), up to 10% by seven (7/33; 21.2%), and over 10% by the remaining six (6/33; 18.2%). Any dystocia cases were attended by the farmer, family members or employees on most participating farms. Six farmers (6/33; 18.2%) reported that veterinary involvement and caesarean section had been required in individual cases (in up to 2% of the parturitions).

Rearing methods were variable between herds and sometimes on farm in the treatment of male and female kids, or farmers used a combination of various methods for different groups or at different times (Table 2). Most frequently, the farmers left female (9/33; 27.3%) and male kids (8/33; 24.2%) with the dam for the first day of life, followed by artificial rearing techniques. In other cases the kids were left with the dam for 2 days (females: 3/33; 9.1%; males: 4/33; 12.1%), 3 days (2/33; 6.1% for both females and males) or longer (up to eight days: females: 3/33, 9.1%; males 5/33, 15.6%) prior to removal. Including any kids left with the dam until weaning, dam-based colostrum supply was practiced on 27 farms. Successful colostrum intake was checked by 19 of these farmers (19/27; 70.4%) either by palpation of the kid's abdomen or the dam's udder, or by observation of suckling. Motherless rearing with separation from the dam immediately post natum was also practiced on a number of farms (females: 8/33; 24.2%; males: 7/33; 21.2%). Colostrum sources were variable and sometimes included multiple sources, with pooled colostrum used on four farms, individually hand-milked colostrum of the dam on three and cow colostrum on two. No information regarding colostrum source was provided by one participant. The first feed of colostrum was given within the first three hours of life on all these farms. The total amount of colostrum offered during the first 24 hours of life however varied considerably between farms and ranged from 300 ml to 1,200 ml (average: 679 ml; median: 600 ml).

The weaning age varied from 6 to 16 weeks (mean: 10.1; median: 9.5 weeks). On most farms the kids were offered concentrate feed in the pre-weaning period (female kids: 31/33 farms; 93.9%; male kids: 28/33; 84.8%). Preventive health measures applied to the newborn kids included Vitamin E and selenium supplementation on 19 farms (19/33; 57.6%), and navel treatments on seven (7/33; 21.2%). Young goats were vaccinated for clostridial diseases in 16 herds (16/33; 48.5%), while clostridial vaccinations of the adults were carried out on 20 farms (60.6%). Vaccination programmes for enzootic abortion (4/33; 12.1%) or Q fever (2/33; 6.1%) were also in place on some farms.

Records relating to the number of kids born had been kept on 31 of the 33 farms (93.9%) prior to the questionnaire study, while two farmers (6.1%) did not keep any such records. An average of 162 kids (median: 128; range 18–600) were born on these 31 farms during the kidding period preceding the questionnaire study. More detailed data to also include the number of stillbirths and abortions had been kept on 25 farms (25/33; 75.8%). The stillbirth rate in the 2017/18 season ranged from 1.3 to 22.2% (mean: 6.2%; median: 4.7%) of all kids born at term on these 25 farms. On average, the abortion rate was 3.4% (median: 2.2%; range: 0–16%) of all parturitions (n=25 farms with available records). Farmers who did not keep exact abortion records (n=8) were asked to provide an estimate, with three farmers rating the abortion rate on their farm as up to 2%, another three as up to 5%, and one farmer providing an estimate of up to 10%, while no information was provided by one participant.

Twenty-seven of the participants (27/33; 81.8%) shared details regarding kid mortality during the 2017/18 kidding period. Mortality of live-born kids during the whole

TABLE 2: *Principal rearing methods for male and female kids on Southern German dairy goat farms participating in a questionnaire study (n=33)*

Rearing method	Number of farms (%)	
	Male kids	Female kids
Hand-rearing from day 1	7 (21.2%)	8 (24.2%)
Initial suckling phase followed by hand-rearing	19 (57.8%)	17 (51.5%)
Dam-based rearing until weaning	7 (21.2%)	8 (24.2%)

rearing period had ranged from 0.6 to 38.8% (mean: 10.8%; median: 6.5%).

The marketing situation for male and surplus kids was seen as difficult by the participants, and this was reflected in the variety of marketing strategies used on the 33 farms, with most farmers simultaneously using multiple strategies. These included farmers' markets (n=21), home consumption (n=17), dog food (n=8), sale to conventional fattening units abroad (n=11) or in Germany (n=3), sale as breeding animals (n=12), to restaurants (n=7) or retail/shops (n=3).

Prospective field study

Twenty of the initial 33 participants decided to take part in the prospective field study. These included 18 farms from Bavaria and two from Baden-Württemberg, with a mean herd size of 118 dairy goats (median: 116; range: 13–320). Of these, 19 managed their farms to organic standards. One organic Bavarian farm was subsequently excluded from the analysis for failing to provide the required farm records. The results are therefore based on data recorded on 19 farms, which were each studied for a 12-month-period between autumn 2018 and autumn 2019. On these 19 farms, 1,306 parturitions and the birth of 2,371 kids were recorded during the study period. The number of parturitions ranged from 8 to 175 per farm (mean: 65; median: 50). Single litters accounted for 31.6% (413/1,306), while 893 goats (893/1,306; 68.4%) delivered more than one kid. One hundred and fifty-four goat kids (154/2,371; 6.5%) were stillborn, with the majority of stillbirths (130/154; 84.4%) being part of multiple litters (≥2 kids). There was however no significant association between litter size and stillbirth (p=0.123). Abortions were observed in 3 primiparous and 26 multiparous goats (29/1,306 parturitions; 2.2%). No information was available regarding the number of aborted foetuses. Of all 2,217 live-born kids across the 19 participating farms, 195 (195/2,217; 8.8%) died during the rearing period. Mortality of live-born kids was significantly higher for kids from multiple litters (p=0.018). Total kid losses (to additionally include the 154 stillborn kids) reached a rate of 14.7% (349/2,371 kids born at term) across all participating farms. Mortality of live born kids throughout the rearing period accounted for 55.9% (195/349), stillbirths for 44.1% (154/349) of the total losses. Abortion rate, stillbirth rate, kid mortality and total kid losses were also determined individually for each participating farm. Analysis of the individual farm data showed a wide variation between farms and is summarized in Table 3

Any mortality of live born kids was assigned to a specific age group (≤2 days, 3–7 days, >1 and <4 weeks and >4 weeks). Many of the 195 deceased kids across all participating farms died within the first week of life (83/195; 42.6%). However, one third of the deaths (64/195; 32.8%) occurred in kids over four weeks of age. Of these 64 later deaths, 31 (48.4%) were 8 weeks of age or older and thus occurred around or post weaning. The age distribution of all 195 cases is illustrated in Figure 1. The percentage of deaths assigned to the respective age groups was also calculated for each individual farm to identify specific risk periods in the individual herds. The age distribution of affected kids varied considerably between farms, and farm-specific values are shown in Table 4.

Observed clinical signs or farmer-suspected causes of death were also recorded by the participants, and each kid could be assigned more than one symptom. The majority of the kids (112/195; 57.4%) died following a phase of disease, while the farmers classified 42.6% of the cases (83/195) as sudden death. A total of 281 farmer observations regarding clinical signs and suspected causes of death were received (Fig. 2). Diarrhoea was the most frequently mentioned cause (72/281; 25.6%), followed by weakness at birth, which accounted for 20.3% (57/281) of the observations. Other clinical signs associated with mortality included acquired weakness (39/281; 13.9%), reduced growth (20/281; 7.1%), pneumonia (14/281; 5.0%), suffocation (while sleeping in a pile, 12/281; 4.3%), bloat (11/281; 3.9%), omphalitis (6/281; 2.1%), insufficient suckling reflex (5/281; 1.8%), seizures (3/281; 1.1%) and arthritis (3/281; 1.1%). The remaining observations (39/281; 13.9%) only stated „sudden death" without any reference to a suspected cause.

TABLE 3: *Farm-specific results of prospectively recorded kid mortality on 19 Southern German dairy goat farms during the 2018/2019 kidding season*

	Average	Median	Range
Abortion rate	1.8%	1.1%	0–6.9%
Stillbirth rate	6.4%	5.8%	0–20.7%
Mortality of live born kids	9.1%	8.7%	1.6–25.5%
Total kid losses	14.9%	12.5%	4.7–30.7%

TABLE 4: *Farm-specific age distribution of dairy goat kid mortality on 19 Southern German farms (n=195 perished, live-born kids). Percentages (and mean/median thereof) are calculated as deaths in a certain age group in relation to all deaths on an individual farm.*

Age group	Average	Median	Range
≤2 days	24.1%	20.0%	0–100%
3–7 days	16.1%	5.9%	0–57.1%
>1–4 weeks	20.0%	20.0%	0–57.1%
>4 weeks	39.8%	40.0%	0–100%

During each advisory visit, a minimum of ten kids were randomly selected and examined clinically. In total, 251 goat kids aged 2–4 weeks (pre-weaning) and 219 older kids between 3 and 4 months of age (post-weaning) were examined. Diarrhoea (pre-weaning: 16.3%/post-weaning: 21.9%) and poor growth (pre-weaning: 10.4%/post-weaning: 21.9%) were the most frequently observed problems in both age groups.

The uptake of free post mortem examinations was poor. Only four farmers used this option and submitted a total of six kids. Diagnoses in the six examined kids included bronchopneumonia (n=2), bronchopneumonia and coccidiosis (n=1), coccidiosis (n=1), clostridial enterotoxaemia (n=1) and *E. coli* enteritis (n=1). Pathogens isolated from the cases of bronchopneumonia included *Bibersteinia trehalosi, Mannheimia haemolytica* and *Streptococcus ovis*.

Herd size, duration of breeding period and prolonged lactations did not show significant associations with any of the mortality parameters. The number of animals mated per year was associated with the abortion rate: farms with >100 animals bred per year had a significantly higher proportion of animals suffering an abortion (p=0.018).

Active control of colostrum intake showed significance for kid survival, with farms not checking adequate intake having significantly higher kid mortality (p=0.032) until the end of the rearing period. Goat farmers who supple-

mented the newborn kids with vitamin E and selenium had a significantly lower kid mortality rate (p=0.008). Farmers weaning their kids early at 6 to 8 weeks of age had significantly higher proportionate losses in the age group >4 weeks (p=0.043). Overall kid mortality was however not significantly associated with this early weaning practice (p=0.838).

Discussion

The present study is the first approach to explore management systems and to generate benchmarking data regarding kid health and mortality on Southern German dairy goat farms, and to promote detailed keeping of kidding and mortality records and farm specific evaluation of these health indicators. Many participants had not previously kept records to such detail, and no comparable data has previously been collected and published for these farm types. Participation was lower than in a comparable previous study in Southern Germany covering different health topics (Sieber 2014, Voigt et al. 2016). The sensitive subject of kid mortality may have led to a degree of hesitation amongst the farming community. Direct farm recruitment was not possible due to German data protection legislation, and the resulting advertising approach required a degree of initiative by the prospective participants. This farmer self-selection inevitably bears a risk of overrepresentation of more proactive farmers. It is however

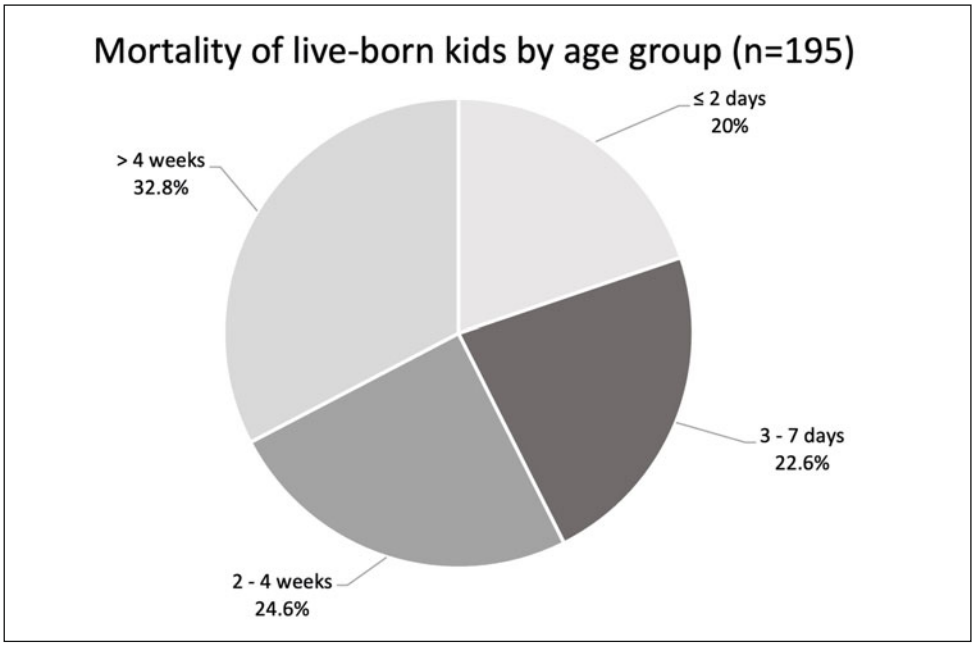

FIGURE 1: *Kid mortality by age group (n=195 live-born kids) on 19 Southern German dairy goat farms. Percentages are presented for all 195 deceased kids across all 19 participating farms.*
Figure: Viktoria Balasopoulou

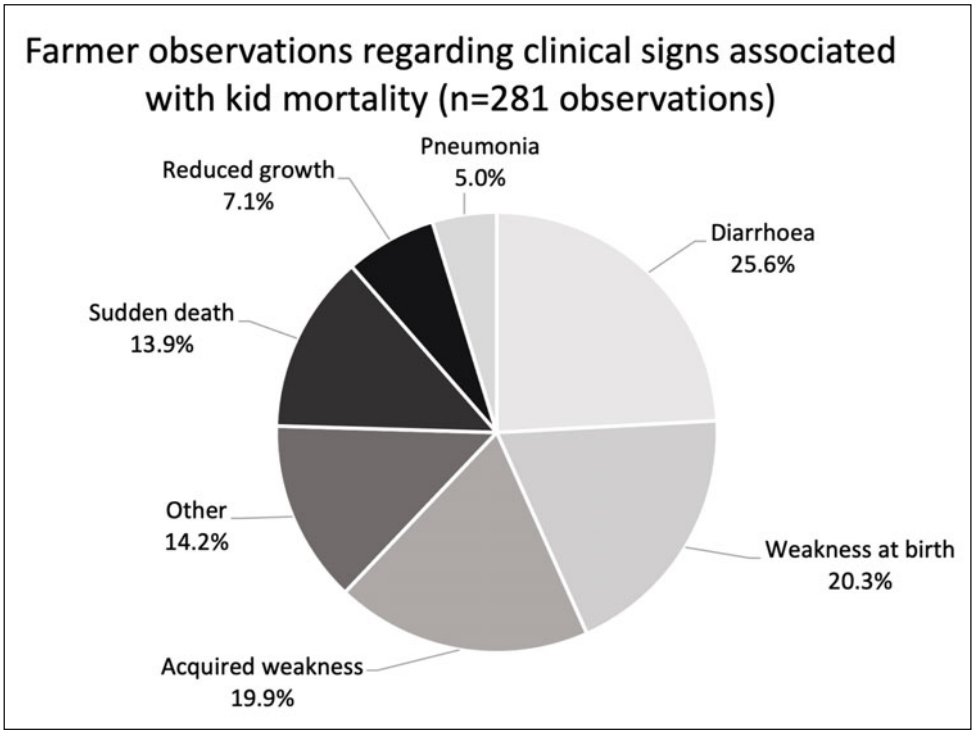

FIGURE 2:
Prospectively recorded, farmer-observed clinical signs (n=281 observations) associated with goat kid mortality (n=195 perished kids) on 19 Southern German dairy goat farms over a 12 month period in the 2018/2019 kidding season. More than one clinical sign could be assigned to each case.
Figure: Viktoria Balasopoulou

also possible that farmers with perceived problems in youngstock health or mortality were particularly attracted to the study in order to gain independent veterinary input in solving their problems. In either case, the results cannot be seen as representative for a wider number of dairy goat farms. Farmer-dependent data collection bears a risk of inaccuracies or inconsistencies, which was reflected in the fact that the sex of perished kids was frequently not recorded. We were therefore unable to assess any potential differences in mortality of male or the potentially more valuable female kids. Despite these limitations, this study is the first to generate detailed health and youngstock mortality data for Southern German dairy goat farms and the results will be useful in setting achievable targets for herd health planning. Dairy goat kid mortality rates were similar to lamb mortality in Southern German sheep flocks (Voigt et al. 2016). These results dismiss the hypothesis of low economic margins potentially affecting the level of youngstock care on the examined farms. While the overall statistical analysis of management factors potentially associated with kid mortality was hampered by the relatively small number and the great diversity of participating farms, herd-specific evaluation of mortality records and inter-herd comparison proved a very valuable tool to identify individual areas of improvement. The data generated in this study thus presents a very valuable base for focused health planning and allows comparison of a farm's own performance data to those of their peers.

Kid mortality rates can fluctuate markedly from year to year (Holmøy and Waage 2015), depending on external factors or disease outbreaks. While only a 12-month period was included in the prospective study, information from the year preceding the field study was collected by questionnaire and was essentially similar to the prospectively gathered mortality records. We are therefore confident that the results of the field study are a realistic reflection of typical kid mortality rates on the examined farms.

Mean mortality rates were similar to a recent study from Canada (Ratsep 2020) and within the targets set by Ganter et al. (2012), but these targets were exceeded by a number of farms. Exceptional circumstances (Kritas 2002) or disease outbreaks (Mahmoud et al. 2004) such as, for instance, floppy kid syndrome (Bleul et al. 2013) have been reported to lead to extreme mortality in individual cases, but such events were not observed during the study period.

Well-known factors for better rearing success such as colostrum supply (Anzuino et al. 2019, Bélanger-Naud 2020, Bahri et al. 2021) and adequate selenium supplementation (Kachuee et al. 2013, Rashnoo et al. 2020, Bélanger-Naud 2020) were also shown to be significant in our study population, with farmers actively checking colostrum intake of kids left with the dam and farmers supplementing kids with selenium and Vitamin E achieving better survival. For kids immediately separated from the dam, early colostrum intake within the first 3 hours of life was ensured on all the farms practicing this rearing method. However, the total amount of colostrum offered to the kids within the first 24 hours of life varied considerably between 300 ml and 1200 ml. The effect of these differences on survival rates could not be assessed statistically in our study cohort due to low farm numbers practicing immediate separation from the dam, but an effect of total colostrum intake on survival rates has previously been shown (Argüello et al. 2004, Massimini et al. 2007, Bélanger-Naud 2020).

Other management practices like, for instance, dam-based versus artificial rearing methods (Delgado-Pertíñez et al. 2009), or differences between various artificial rearing techniques (Argüello et al. 2004), could not be adequately assessed within the study population due to the use of various techniques within the same farm, and the great diversity of the participating farms.

The practice of prolonged (extended) lactations is common in the dairy goat industry to minimize or avoid seasonal fluctuations in milk production (Goetsch et al. 2011, Meijer et al. 2021), but also helps to reduce the number of kids born, and this is seen as an important factor to increase kid health and reduce mortality rates (Ringdorfer 2009, Douhard et al. 2014). This practice and the number of animals mated per year were however not significantly associated with better rearing outcomes in the studied herds, most likely due to the great variation of other management practices, and thus a large number of potentially confounding factors. Herds with higher numbers of mated females however showed a significantly higher abortion rate. This may be explained with a potentially higher probability of shedding, and thus spreading, infectious abortion agents.

Perinatal mortality (stillbirth and any deaths up to 48 hours of age; Wong et al. 2021) is frequently seen as one of the major contributors to both kid and lamb mortality under a variety of husbandry and production systems (Sharif et al. 2005, Holmøy et al. 2017, Murray et al. 2019, Robertson et al. 2020), and also accounted for 55.3% (193/349) of total kid mortality across the 19 participating farms in the present study. Stillbirth accounted for the largest proportion of these perinatal deaths (154/193; 79.8%), an observation which is in accordance with previous studies in sheep, and which highlights the importance of good and frequent observation of the lambing herd and appropriate action in cases of dystocia (Voigt et al. 2019, Swarnkar et al. 2021).

The uptake of the free post mortem examinations was very poor, with only 6 of the 195 perished, live-born kids (and no stillbirths or abortions) submitted for post mortem examination. Farmers blamed time constraints and long distances to the pathology department for this poor uptake. They may, however, also feel confident in their own assessment of the cause of death and thus consider post mortem examination unnecessary. Todd et al. (2019) compared farmer observations with post mortem results in dairy goat kids, and while they were more accurate for the more obvious problems like gastrointestinal disorders or disbudding-related injury, less obvious signs may be masked and attributed to other obvious, albeit not causative events, like, for instance, suffocation. A similar degree of inaccuracy of the given diagnoses is also likely to be the case in our studied cohort. Clinical signs observed by the farmers are however still a useful aid in assessing the herd health status and in identifying key areas for kid mortality despite these constraints. In our case, farmers frequently mentioned diarrhoea, acquired weakness, poor growth, sudden death or, less frequently, respiratory signs, and this corresponded well with the observations made during the veterinary farm visits and the, albeit few, post mortem results. Diarrhoea and poor

growth in both the pre- and post-weaning age groups were also the most frequently observed problems during the farm visits. Linking these signs with the affected age groups will enable the attending veterinarian to draw conclusions on likely causes, to initiate targeted diagnostic tests and to turn their attention to potentially pre-disposing factors related to management. The clinical signs associated with kid mortality were partly similar to other studies, for instance in terms of the frequency of neonatal diarrhoea (Ramirez-Bribiesca et al. 2001, Donkin and Boyazoglu 2004, Todd et al. 2019, Ratsep 2020). Pneumonia was the leading cause of death in pre- and postweaning kids in a Canadian post mortem study, accounting for over 50% of deaths in weaned kids (Ratsep 2020), it however only accounted for 5% of farmer observations in our study. Three out of the six kids submitted for post mortem examination were however diagnosed with pneumonia. Rapid courses of disease following infection with pathogens such as *Mannheimia haemolytica* and/or *Bibersteinia trehalosi* are likely to be misdiagnosed by farmers and may be wrongly attributed to "sudden death" or other suspected causes. The same applies to other less obvious causes such as septicaemia, which accounted for between 11.6% (weaned kids) to 25.5% of deaths (neonatal kids) in different age groups in a post-mortem study (Ratsep 2020). Other frequently mentioned causes by other authors such as, for instance, disbudding injuries (Todd et al. 2019, Ratsep 2020), exposure (Kritas 2002) or predator attacks (Ershaduzzaman et al. 2007, Snyman 2010) were irrelevant in our case load, since disbudding is not common practice in Southern German dairy goat herds, and husbandry conditions with indoor lambing systems protect newborn kids from predators and exposure.

While other comparable studies report the vast majority of deaths during the first days of life (Singh et al. 2008) or in the pre-weaning period (Petros et al. 2014, Todd et al. 2019, Ratsep 2020), a notable percentage of deaths occurred in kids over 8 weeks of age (31/195, 15.9%) and thus around or after weaning in our study cohort. A young weaning age was identified as significantly associated with higher mortality in older kids. This highlights the importance of proper weaning technique and associated nutrition at this crucial time, particularly when weaning at a young age (Htoo et al. 2018, Zhang et al. 2019). The high percentage of mortality in older kids, in conjunction with the observed frequency of diarrhoea and poor growth in this age group also suggests the importance of coccidiosis on the examined farms. A Canadian study reported better rearing outcomes for farms using coccidiostats in medicated feed (Bélanger-Naud et al. 2021), thus highlighting appropriate management of coccidiosis as an important factor in improving rearing outcomes. Such feed additives are not licensed in Germany. Frequent application of medicated feed in other countries is likely to have masked the importance of coccidiosis in many previously published studies.

Conclusion

This study generated previously unavailable benchmarking data for dairy goat kid mortality for the specific conditions of Southern German dairy goat farms and showed the importance of colostrum and selenium supply and adequate weaning techniques for kid health. A relatively high percentage of post-weaning deaths and a high percentage of kids suffering from poor growth and diarrhoea additionally highlight the importance of adequate management of coccidiosis. Stillbirth was the most frequent cause of death, and reduction of stillbirth rates by timely intervention in cases of dystocia will have a large impact on reducing overall kid mortality. Accurate record keeping is a useful tool in identifying areas of improvement on individual farms and should be further promoted in small ruminant health management.

Conflict of interest

The authors hereby declare that they have no proprietary, professional or other personal interests in any product, service and/or company that could have influenced the contents or opinions expressed in this publication.

Ethical approval

The authors hereby declare that they have followed the universally accepted guidelines of good scientific and good veterinary practice while preparing the present paper. This non-invasive field study did not include any procedures requiring formal ethical approval.

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Authors contribution

VB: collection, analysis and interpretation of data, creation of manuscript; MK: collection, analysis and interpretation of the data, statistical analyses, critical revision of the manuscript; YZ: statistical analyses, critical revision of the manuscript; HZ: advice on data evaluation and study design, critical revision of the manuscript; KV: study design, evaluation of the data, support to VB in creation of and critical revision of the manuscript.

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