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The effect of caprine arthritis encephalitis virus infection on production in goats

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ABSTRACT

Three consecutive years of monitoring 248 goats in the same flock, found that the first lactation milk yield was significantly higher in seronegative (578 L) than in seropositive (447 L) animals but this difference disappeared in the subsequent second to fourth lactations. No significant differences were found in the proportions of seronegative and seropositive does in the flock, the percentage of animals culled, the number of offspring, or in the number of cases of udder bacterial infection, irrespective of age.

Removal of kids from their dams before suckling and the feeding of pasteurised colostrum resulted in reduced numbers of seropositive animals. Nevertheless, by approximately 24 months of age, 76.9% of these initially seronegative animals were seropositive, a factor that significantly contributed to flock seropositivity. This finding could be attributed to lateral virus transmission from seropositive to seronegative kids because of lack of segregation within the flock.

Introduction

Caprine arthritis encephalitis virus (CAEV) infection occurs worldwide (Adams et al., 1984; Peterhans et al., 2004) and, like other lentiviruses, it may cause persistent, lifelong infection, resulting in subclinical inflammation in one or more organs such as articular joints, brain, lungs and mammary gland (Nord and Ådnøy, 1997; Blacklaws et al., 2004). The virus is transmitted to kids primarily via colostrum, although transmission via aerosol, animal-to-animal contact, and sexual activity can also occur (Phelps and Smith, 1993; Rowe and East, 1997; Peterhans et al., 2004; Le Jan et al., 2005).

Clinical signs of infection are frequently subtle and, in the small number of goats that develop arthritis, may take years to develop (Phelps and Smith, 1993). The high rate of viral transmission, the difficulties associated with eradicating the virus, and the occasional outbreaks of clinical disease are the reasons CAEV infection causes substantial economic loss. This, in turn, accounts for the considerable body of research into this disease (Greenwood, 1995; Nord and Ådnøy, 1997; Sanchez et al., 2001; Luengo et al., 2004; Peterhans et al., 2004; Turin et al., 2005) that has resulted in varying opinion regarding its economic importance and the most effective control methods.

Preventing the spread of CAEV infection includes the pasteurisation of colostrum and the segregation and culling of seropositive animals (Rowe et al., 1992; Turin et al., 2005). Increased feed and labour costs, combined with increased pressure to produce high quality milk through bulk milk tank somatic cell count (SCC) monitoring, has motivated the farming industry to reduce the incidence of mastitis. This requires the application of effective preventive management protocols. Recent studies indicate that under intensive management systems, mastitis is the single most important factor affecting milk production (Mavrogenis et al., 1999; Luengo et al., 2004; Leitner et al., 2008). Given that CAEV infection has the capacity to spread widely in intensively managed goat flocks, its impact on milk production and animal culling rates merit attention.

The present study was designed to assess the effect of CAEV seropositivity on flock production parameters and in particular on udder health. We also looked at the feeding of pasteurised colostrum as a single measure aimed at reducing the spread of CAEV infection within goat flocks.

Materials and methods

Animal selection

The study was conducted on 700 Alpine, Saanen and Shami crossbred goats from a large dairy farm in Israel. The animals were housed in 4 m^2 closed sheds, with an additional 4 m^2 of open space available to each animal. Feed, freely available in mangers, consisted of approximately 1.8 kg of 16% protein concentrates and 1.0–1.2 kg of hay.

Replacement does were raised separately from the older goats, and were bred by natural mating with CAEV-seronegative males at 12 months of age. All goats were synchronised in groups for mating at scheduled periods to ensure continuous milk supply. The average annual milk yield in the flock was approximately 510 L with a 3.7% fat and 3.9% protein and an average bulk tank SCC of approximately 10^6 cells/mL. Goats were dried-off when their milk yield dropped to <0.5 L/day,

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Table 1
Details of how goat 'cull status' ('present' or 'out' of flock) related to CAEV infection category Neg, Pos, or Inf, following two serological tests between 9 and 11 months and at approximately 24 months of age. Animals were designated Neg (two negative tests), Pos (two positive tests), or Inf (a negative followed by a positive test result).

CAEV infection category	Cull status (%)	
	Present	Out
Neg (61)	48 (78.7%)	13 (21.3%)
Inf (71)	59 (83.1%)	12 (16.9%)
Pos (116)	89 (76.7%)	27 (23.8%)
Total (248)	196 (79.0%)	52 (21.0%)

or 60 days before their next parturition. On average, goats produced 1.9 kids/year. Does were machine-milked daily (at 06.00 and 17.00 h), and an automatic identification system was used for milk recording. Goats were culled as a result of mastitis, low milk yield, or infertility.

Before study commencement, kids were given untreated colostrum and approximately 80% of the animals >12 months of age were CAEV seropositive. During the study, kids were removed from their mothers immediately after birth and were artificially reared using 'pasteurised' colostrum, before being permitted to suckle their dams. The colostrum was 'pasteurised' by heating to 55 °C for 60 min.

Study design

Two studies were carried out over a 3 year period on a total of 248 goats divided into three groups. The study assessing the effect of CAEV seropositivity on production parameters included the three groups. The first group comprised 118 does, and parameters were recorded over at least their first three lactations. The second and third groups comprised 85 and 45 does and parameters were recorded over their first and second and over their first lactation, respectively.

Kids in groups 2 and 3 were given pasteurised colostrum and served as the 'treatment' groups in assessing the transfer of the virus via the colostral route. The kids from the first group were given untreated colostrum and acted as controls. Serological assessment of CAEV infection was carried out on two occasions in each goat, between 9 and 11 months and at approximately 24 months of age, and animals were then designated as negative, negative (Neg); positive, positive (Pos); or negative, positive (Inf), based on these two test results.

Sampling and analyses

The number of offspring produced by each doe was recorded as was the composite daily milk yield from parturition until 'drying off'. Bacteriological culture, the California mastitis test (CMT), the SCC and an assessment of milk composition (Leitner et al., 2004), testing was carried on every udder-half, right and left side, between three and five times during each lactation, from approximately 30 days postpartum to the end of lactation. Cases of clinical mastitis and dates of culling were recorded by the owner.

Milk samples (a 2 mL sterile sample plus an additional 100 mL sample) were taken during morning milking following teat cleaning and disinfection. Samples used to determine the SCC and milk composition were preserved using Broad Spectrum Microtabs II (D and F control systems) and dispatched to the Central Laboratory of the Israeli Cattle Breeders Association at Caesarea for analysis. The milk fat, protein and lactose content were analysed using a Milkoscan FT6000 (Foss electric) and the SCC was carried out using the Fossomatic 360 (Foss electric). Both instruments were calibrated for goat's milk.

Bacteriological culture was performed according to the US National Mastitis Council's guidelines (Oliver et al., 2004). A 0.01 mL aliquot of each sample was plated onto blood agar (Bacto-Agar, Difco Laboratory, Becton Dickinson), containing 5% washed sheep red blood cells, and onto MacConkey plates. All plates were incubated at 37 °C and examined for bacterial growth after 18 and 42 h. Suspect *Staphylococcal* spp. were further investigated using the ID-32-API STAPH test (BioMérieux). Udder 'halves' were then categorised as having no bacterial infection, or as being infected, during lactation. Serological evidence of CAEV infection was assessed using a CAEV antibody cELISA Test Kit (VMRD), according to the manufacturer's instructions.

Statistical analysis

All statistical analyses were carried out using JMP software (SAS Institute, 2002). According to their serological CAEV infection status, goats were divided into the three categories Neg, Pos or Inf (see above) and analysed in relation to their 'cull status', number of offspring, evidence of udder bacterial infection, milk production and milk quality. For 'cull status' each doe was defined as 'present' or 'out', according to whether or not the animal was in the flock at the end of the lactation. The effect of CAEV infection on this parameter was analysed using the Pearson chi-square (χ^2) test. The effect of CAEV infection status on number of offspring was tested using a one-way ANOVA model in a random design, with the CAEV infection category (Neg, Pos or Inf) as the main effect as represented by the equation

$$\text{Model}[1] : Y_{ij} = \mu + \alpha_i + e_{ij}$$

where Y is the dependent variable, μ the overall mean, α_i the difference between the mean of CAEV category i and the trial mean and e_{ij} the residual variance between measurements (random error).

The effect of CAEV infection on udder bacterial infection was assessed using Pearson's chi-square (χ^2) test, for the first lactation and the effect on milk production was determined separately for each lactation, by applying a one-way ANOVA model in a random design with CAEV infection category Neg, Pos or Inf as the main effect (model [1]).

The effect of CAEV infection on milk quality (based on the CMT and SCC) was determined separately for each lactation by applying a three-way ANOVA model in a 'split plot' design, with CAEV infection, bacterial infection, and lactation stage (lactating or dry) as the main effects. Two experimental units were used: a goat (for the CAEV infection effect); and an udder half (for the bacterial infection and lactation stage effects) and was represented by the equation

$$\text{Model}[2] : Y_{ij} = \mu + \alpha_i + e^1_{ij} + \beta_k + \alpha\beta_{ki} + \gamma_l + e^2_{ijklm}$$

where Y is the dependent variable, μ the overall mean, α_i the difference between the mean of CAEV infection category i and the trial mean, e^1_{ij} the variance between goats (error1), β_k the difference between the mean of bacterial infection k and the trial mean, $\alpha\beta_{ki}$ the interaction between CAEV infection group and bacterial infection, γ_l the difference between the mean of lactation stage l and the trial mean, and e^2_{ijklm} the residual variance between measurements (error 2).

In this model, the effects of CAEV infection categories were tested against the variance between goats, and the other sources were tested against the residual error.

Results

Effect of CAEV infection on production

Of the 248 goats used in the trial, 116 were CAEV positive and 132 CAEV negative at the first test. Of the latter, 61 remained negative and 71 had serological evidence of infection by the second test. As a result the goats were divided into the three CAEV infection categories as follows: Neg (61 goats); Inf (71 goats); and Pos (116 goats) (Table 1).

Over the 3 three years of the study, 21% of the does were culled. No significant differences were found in culling rate between the

Table 2
Details of how 'numbers of offspring' and lactation number related to CAEV infection category Neg, Pos, or Inf, following two serological tests between 9 and 11 months and at approximately 24 months of age. Animals were designated Neg (two negative tests), Pos (two positive tests), or Inf (a negative followed by a positive test result).

	1st Lactation		2nd Lactation		3rd Lactation		4th Lactation	
Mean (number of goats)								
Neg	1.7	(88)	2.0	(29)	2.3	(7)	2.5	(2)
Inf	1.5	(40)	2.0	(11)	–	(0)	–	(0)
Pos	1.7	(116)	2.0	(101)	1.9	(42)	1.9	(11)
P value								
CAEV category	0.3541		0.9710		0.2220		0.2964	
n	231		137		46		13	
R^2	0.009		0.000		0.034		0.098	

Table 3
Details of how 'udder bacterial infection' in first lactation related to CAEV infection category Neg, Pos, or Inf, following two serological tests between 9 and 11 months and at approximately 24 months of age. Animals were designated Neg (two negative tests), Pos (two positive tests), or Inf (a negative followed by a positive test result).

CAEV category	Udder bacterial infection	
	Absent	Present
Neg (160)	90 (56.3%)	70 (43.7%)
Inf (64)	44 (68.8%)	20 (31.2%)
Pos (192)	111 (57.8%)	81 (42.3%)
Total (420)	245 (58.3%)	171 (40.7%)

three CAEV infection categories. The average number of offspring produced at first gestation was approximately 1.7. This increased to approximately 2.0 in the 2nd–4th gestations. Viral infection did not significantly affect the number of offspring regardless of lactation number (Table 2). In the first lactation, on average 41.7% of udder 'halves' were infected with bacteria, mostly subclinically (Table 3). Most bacterial isolates were the coagulase-negative staphylococci (CNS) *Staphylococcus epidermidis*, *S. caperae*, *S. simulans, S. xylosus* and *S. chromogenes*. Infection with CAEV did not significantly affect the incidence of bacterial udder infection. Of the does with subclinical infections, approximately 80% became infected at the beginning of the lactation period, the rest becoming infected during lactation. Approximately 90% of infected udders remained infected throughout subsequent lactations and approximately 10% of un-infected udders became infected between lactations. The number of infections that resulted in clinical mastitis was negligible.

During their first lactation, goats in both the Neg and Inf CAEV infection categories had significantly ($P < 0.0001$) higher milk yields than those in the Pos group (Table 4). It should be noted that during first lactation, most of the Inf group goats were seronegative. No differences in milk yield were found in the three infection categories in pluriparous animals. During all lactations, the SCC and CMT were significantly affected by bacterial udder infection and by lactation number, but not by CAEV infection category (Table 5). Variation between does was highly significant and accounted for approximately 20% of the variation in the results of the SCC and CMT.

Effect of feeding pasteurised colostrum

Of the kids in group 1 which received untreated colostrum, 61% (72/118) were CAEV seropositive at 9–11 months of age. Removal of kids from their dams before suckling, and the feeding of pasteurised colostrum, decreased to approximately 35% (45/130) the number of seropositive goats at that age. In contrast, at the second serological test at approximately 24 months of age, approximately 65% of kids previously seronegative, were now seropositive.

Discussion

Although 3 years of monitoring revealed that the first lactation milk yield was significantly higher in seronegative goats than in seropositive goats, this difference was not observed in subsequent lactations. No significant differences were found in the proportions of seronegative and seropositive does in the flock, the percentage of animals culled, the number of offspring or in the number of cases of udder bacterial infection, irrespective of age. Removal of kids from their dams before suckling and the feeding of pasteurised colostrum resulted in reduced numbers of seropositive animals. However, by approximately 24 months of age, 76.9% of these initially seronegative animals were seropositive, a factor that significantly contributed to flock seropositivity. This finding was

Table 4
Details of how mean milk production related to CAEV infection category Neg, Pos, or Inf, following two serological tests between 9 and 11 months and at approximately 24 months of age. Animals were designated Neg (two negative tests), Pos (two positive tests), or Inf (a negative followed by a positive test result).

	1st Lactation		2nd Lactation		3rd Lactation		4th Lactation	
Mean (number of goats)								
Neg	578[a]	(80)	619	(28)	510	(7)	–	
Inf	707[a]	(32)	494	(10)	–		–	
Pos	447[b]	(97)	534	(94)	536	(32)	686	(9)
P value								
CAEV category	<0.0001		0.3351		0.5021			
n	758		275		63			
R^2	0.996		0.999		0.926			

[a,b] Means within a column with no common superscript differ significantly ($P < 0.05$).

Table 5
Details of how CAEV infection category, udder bacterial infection, udder bacterial infection and CAEV infection and lactation stage affect California milk test (CMT) and somatic cell count (SCC) results over the 1st and 2nd–4th lactations.

	CMT		SCC	
	1st Lactation	2nd–4th Lactation	1st Lactation	2nd–4th Lactation
P value				
CAEV category	0.2459	0.4301	0.9466	0.8648
Goat (e^1)	<0.0001	<0.0001	<0.0001	0.0002
Udder bacterial infection	<0.0001	0.032	0.0006	0.1254
Combined udder bacterial and CAEV infection	0.2649	0.8010	0.9338	0.9655
Lactation stage	<0.0001	<0.0001	0.0052	0.0312
n	1261	467	713	234
R^2	0.497	0.464	0.346	0.421
Variance between goats	19.4%	20.6%	16.9%	21.8%

Goat (e^1) – variance between goats (error 1).

probably due to lateral transmission from seropositive to seronegative kids because of lack of segregation within the flock.

The findings of this study suggest that CAEV infection has an influence on overall milk yield as has been previously suggested (Peterhans et al., 2004; Turin et al., 2005). However, given that our study refers to a single flock, caution must be exercised in making broad generalisations, and further studies involving more farms, different goat breeds and older animals would be required to substantiate our findings.

The key consequence of CAEV infection in the goat is the potential increased risk to health and welfare, and in particular to the development of mastitis. It is well established that subclinical mastitis impairs production performance in terms of the quantity and quality of meat and milk produced (Leitner et al., 2004). Clinical mastitis is found mostly in older goats, and in intensive dairy flocks an average of around 35% of animals are replaced each year, as a result of disease, death, infertility, udder health and low milk yield (Malher et al., 2001; Bergonier et al., 2003). Thus, the typical lifespan of a goat in such systems is about 2.5 lactations.

Given that a number of the steps required to eradicate CAEV infection from a flock are costly, the reduced income due to the infection must be weighed against the expense of eradication.

Conclusions

Despite the finding that CAEV infection had only a minor effect on flock performance parameters, we suggest that goat breeders, in cooperation with government and private agencies, should develop systems to control the infection. In the current study, colostrum 'pasteurisation' proved an effective preventive measure, reducing the number of new cases of infection in kids. However, lack of segregation of the seronegative kids facilitated virus transmission as the animals grew older. Thus, in isolation, this procedure is only of minor benefit in eradicating CAEV infection and needs to be combined with effective isolation procedures. Such an approach would also require the ongoing serological assessment of animals in the flock.

Conflict of interest statement

None of the authors of this paper has a financial or personal relationship with other people or organisations that could inappropriately influence or bias the content of the paper.

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