Prognostic indicators of *post partum* viability of kids born to *Escherichia coli*-vaccinated or unvaccinated does

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ABSTRACT

This study was undertaken to determine some blood and other physiological parameters with potential for use as prognostic indicators of viability of newborn goat kids. Of the 143 kids born during the on-farm study, 97 were crosses of Galla × Small East African (SEA) and 46 were pure SEA. The SEA × Galla kids were 46 single males, with a mean body weight at birth of 2.77 ± 0.22 kg , 43 females with a mean body weight at birth of 2.36 ± 0.76 kg and 5 and 3 sets of female and male twins (mean body weight at birth of 1.8 ± 0.19 kg and 2.05 ± 0.07 kg for the female and male kids, respectively). The SEA kids comprised 36 single male and female kids (mean body weight at birth of 2.48 ± 0.04 kg and 10 sets of twins (both male and female) (mean body weight at birth of 1.50 ± 0.04 kg). Pre-suckling sera obtained on-station from kids born of does vaccinated against *Escherichia coli* (n = 8) and unvaccinated does (n = 7) had a total protein content of <40.0 g/ℓ and no detectable levels of IgG and A or *E. coli* antibodies. Sera obtained 12 hours *post partum* from kids that survived in both groups contained about 19–22 g of Ig g/ℓ, 50–80 g total protein/ℓ, blood glucose of >5 mmol/ℓ and had an *E. coli* antibody titre of between 1/160 and 1/640. On the other hand, kids that died within 48 hours of birth (parturient deaths) and had been classified in categories 3 and 4 righting reaction had low (<40 g/ℓ) total protein, low white blood cell count (4000/mℓ) and low blood glucose concentration (<4.9 mmol/ℓ). It is concluded that kids with delayed righting reaction (>45 minutes), low rectal temperature (<36 °C), low birth weights (<1.5 kg for singles and <1.0 kg for twins), low white blood cells (<4000/ mℓ), low (<2 mmol/ℓ) blood glucose levels, low total protein (<40.0 g/ℓ), low (<1:160) *E. coli* antibody titre and IgG (≤3350 mg/ℓ) in sera obtained 12 hours after birth have a poor prognosis for survival.

Key words: *Escherichia coli*, goats, kid viability, prognostic indicators, vaccination.

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INTRODUCTION

Haematological, biochemical and serological analysis of blood is a useful tool in the diagnosis of a variety of diseases and conditions in goats of all ages[14,20]. Different reports on blood parameters, however, reveal wide variation in relation to these factors, which complicates the evaluation of clinical/haematological values for diagnostic purposes in different breeds of goats[14,20]. In contrast to the findings of Perryman *et al.*[21], who observed that foals are immunocompetent at birth, other workers have shown that calves, kids, lambs and piglets are immune incompetent. In addition, the latter group of workers linked this state of neonatal immune incompetence with increased susceptibility to disease[18,23,24,28,30]. However, the actual relationship between the levels of serum immunoglobulin in newborn farm animals at 24–48 hours of age and subsequent morbidity and mortality is somewhat controversial, as observations in some beef herds have shown that levels of serum immunoglobulin in calves at 48 hours *post partum* were of no value in predicting the incidence or severity of acute, undifferentiated diarrhoea[2].

Although colostral antibodies have been reported to exert a protective effect on newborn kids against the establishment of colibacillosis[30], Newby *et al.*[17] and Hauser[8] observed that the high levels of corticosteroids produced by lambs and calves 8–10 days before parturition resulted in lymphocytopaenia and a decrease in the phagocytic defence capability in the newborn, which suppress the cellular immune mechanisms, thereby decreasing perinatal resistance.

This study was conducted to determine some blood parameters of kids born to unvaccinated dams and those vaccinated against *E. coli* in the pre-weaning period and the use of these blood profiles and physiological parameters in conjunction with the weight at birth, righting reaction and rectal temperature as prognostic indicators of viability of newborn goat kids.

MATERIALS AND METHODS

On-farm study

Study areas

The study areas representative of sedentary and semi-sedentary production systems as shown previously during a field survey[16] were purposefully selected. Machakos and Lower Thika districts were representative of sedentary production systems, while Narok and Kajiado districts were representative of semi-sedentary production systems. In each of the districts, 2 farms were selected on the basis of their accessibility and security throughout the year, farmers' willingness and ability to participate, availability of personnel able to weigh the dams and kids and collect colostrum in sample bottles provided and record these and any other significant events. In addition the selected farms were within 100 km of the Nairobi University Veterinary School Clinic and had a herd of >50 goats with definable ownership. The latter criterion was essential because most producers in the semi-sedentary and pastoral production systems do not allow either counting, because they consider it a taboo, or sampling as the goats are owned by various members of the 'family unit'.

Doe and kid performance and sample collection

The 8 recruited farms were visited once every 4 weeks for 12 months, to collect data on goat production (including flock structure, reproductive performance and wastage) and feed and water resources

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and their availability in different seasons. The kids were allowed to run with the dams and were weighed by a paid farm assistant at birth and at 2-week intervals until weaned at 4 months. Daily weight gains were calculated as for the on-station kids.

During each visit the dams and kids were weighed and flocks scored as suggested by Santucci *et al.*[25]. EDTA and clotted blood samples were obtained for routine haematology and serology in lithium heparinised and plain vacutainer tubes, respectively, by jugular venipuncture. Faecal samples for routine parasitology were collected whenever the packed cell volume (PCV) fell to below 21 % in at least 50 % of the samples obtained. Thick and thin blood smears and skin scrapings for parasitology, rectal swabs for bacteriology and biopsies for histopathology were collected whenever it was considered necessary. Colostrum and milk samples for the measurement of IgA and IgG were collected from does from parturition to weaning at 4 months.

Outbreaks of disease and deaths were recorded as they occurred. Kids and adult goats falling sick during the study period were examined individually and treated according to clinical and laboratory findings.

On-station study

Adaptation of the experimental goats

Thirty pregnant Small East African (SEA) × Galla cross does aged between 2 and 4 years and 1 buck were purchased in the Kajiado district. The does, which were confirmed healthy and pregnant by a thorough clinical examination before purchase, were prophylactically treated with tetracyclines (Norbrook, UK) (10 mg/kg body weight i.m.) for 4 days before being transported to Kabete by road to reduce likelihood of the goats developing transit fever or any other stress-related opportunistic infections.

During the 2 weeks' adaptation period at the station the does were tagged, weighed, sprayed with Steladone®-300EC (Clofenviphos, Kenya Swiss) and drenched with Rintal® based on manufacturers' instructions (Fenbendazole, Bayer EA). This treatment regime was repeated monthly.

Throughout the study period the goats were housed in 2 well-ventilated and well-lit 2.4 ×3.1 m cubicles where they were provided with water and salt licks *ad libitum.* They were also provided with 2 bales of hay, 3 kg of a mixture of bran and maize germ (3:1) per cubicle every morning and allowed to graze outside from mid-morning to late afternoon.

Immunisation

By the end of the adaptation period, 15 does that had not lost >20 % of their body weight were randomly divided into 2 groups of 8 and 7 does each. To enhance the concentration of *E. coli* antibodies, the 1st group (8 does) was vaccinated in the neck region with crude sonicated *E. coli* antigen (strain 0126 K71 (B16) – protein concentration 130 mg/ℓ)[29,30]. Each doe received a total of 3 mℓ (1 mℓ of the crude antigen in 2 mℓ of complete Freud's adjuvant (Sigma Chemicals, UK) in 3 divided doses. This vaccination regime was followed by a booster vaccination after 2, 13 and 20 weeks. The 2nd group of 7 does (controls) were injected with 1 mℓ saline solution in 2 mℓ of the same adjuvants at similar intervals.

Sample and data collection

EDTA blood and serum samples: 1 mℓ EDTA blood was used for routine haematology[27], while 3 mℓ of blood collected in plain venoject tubes (Becton Dickson vacutainer system, England) were used for harvesting serum used to measure total protein (TP), *E. coli* antibody titre (Ecoli ab) and immunoglobulin (IgA and IgG)[9,13] from all kids, whenever it was possible and practical to do so without endangering a kid's life. Kids were bled before suckling, at 6, 12, 24, 48 and 96 hours and subsequently at 2-week intervals.

Any kids showing signs of weakness or pale mucous membranes and accelerated heart rate (>120 heart beats per minute) after blood collection were not bled again until their condition had stabilised. Kids falling sick during the study period were monitored but not treated, to reproduce the situation in most goat-producing areas of Kenya, where producers believe it is 'uneconomical' to treat goat kids. The collected serum was preserved with 200–500 ug of sodium azide and stored at –20 °C till required.

Rectal swabs and faecal samples: two rectal swabs for bacteriology[4] and viral isolation[15] were obtained from all kids whenever any of them showed signs of diarrhoea. Stall floors were swabbed for bacterial isolation at the same time. All *E. coli* isolates were preserved in cooked meat media until they were typed and tested for pathogenicity (adherence and toxin production) using standard laboratory techniques (Wellcome Kenya and Hoechst Kenya *E. coli* typing manuals; KEMRI manual[12]). Faecal samples obtained from kids aged 2 months and over were processed for faecal egg count[7].

Lung aspirates: lung aspirates were collected aseptically from all fresh carcasses of kids presented and processed for bacterial isolation[4].

Righting reaction: the righting reaction, defined as the ability of a kid to get to from lateral to sternal recumbency and attempt to stand and suckle, was divided into 4 categories. Kids were placed in category 1 if they attained sternal recumbency and attempted to stand and suckle within 30 minutes, categories 2 and 3 if the same happened within 45 and 60 minutes, respectively, and category 4 if it took more than 1 hour.

Determination of body weight: the weight of experimental does were recorded every 4 weeks for 9 months, while those of kids were recorded at birth and at monthly intervals thereafter. Daily weight gains were calculated by dividing final weight at weaning by the number of days.

Collection of colostrum and milk samples: each day for the first 5 days *post partum* visit 4–10 mℓ colostrum, and later milk, were collected in sterile universal bottles or plastic containers with 200–500 g sodium azide. In the present study, udder secretion produced in the first 4 days *post partum* was classified as colostrum while secretion thereafter was considered as milk.

Data storage and statistical analysis

Data files of flock information and clinical and laboratory results were prepared separately in DBase IV plus (Ashton-Tate Corporation, Torrance CA, USA). Separate files were prepared for each producer but were later merged into 1 district file. All statistical analyses were done using analysis of variance and descriptive statistics[5].

RESULTS

On-farm performance of kids from birth to weaning (120 days)

Of the 143 kids born during the on-farm study, 97 were of Galla × Small East African (SEA) crosses and 46 of SEA. The SEA × Galla kids comprised 46 single males, 43 single females and 8 sets of twins, while the SEA kids comprised 36 single kids and 10 sets of twins. The mean weight at births of the Galla × SEA kids in the sedentary production systems were 2.77 ± 0.22 kg for single males, 2.36 ± 0.76 kg for single females, 1.8 ± 0.19 kg and 2.05 ± 0.07 kg for female and male twins, respectively. The SEA kids in the semi-sedentary production systems had a combined single male and female mean weight at birth of 2.48 ± 0.04 kg and 1.50 ± 0.04 kg for combined male and female twins (Table 1A). From birth to weaning at 120 days, single male kids grew at an average of 85.33 g/day, single female kids at 80.25 g/day, and female and male twins at 47 and 69 g/day, respectively, in the

Table 1: **A — Mean weights at birth of goat kids born in sedentary and semi-sedentary production systems.**

Breed and production system	Birth weight (kg) of single kids		Birth weight (kg) of twins	
	Male kids	Female kids	Male kids	Female kids
Galla × SEA (sedentary)	2.77 ± 0.22	2.36 ± 0.76	2.05 ± 0.07	1.8 ± 0.19
SEA (semi-sedentary)	2.48 ± 0.04	1.50 ± 0.04		

B — Mean growth rates of goat kids born in sedentary and semi-sedentary production systems.

Breed and production system	Daily weight gain (g) of single kids		Daily weight gain (g) of twins	
	Male kids	Female kids	Male kids	Female kids
Galla × SEA (sedentary)	85.33	80.25	69	47
SEA (semi-sedentary)	62.5		42.5	

Table 2: **Mean** (±SE) **immunoglobulin concentration** (g/ℓ) **in colostrum and sera obtained from experimental does within 3 days of parturition.**

Days *post partum*	Vaccination status			
	Vaccinated		Unvaccinated	
	Colostrum	Serum	Colostrum	Serum
1	53.2 ± 8.3 (n = 6)	19.1 ± 4.6 (n = 6)	45.0 ± 16.7 (n = 7)	19.5 ± 3.0 (n = 6)
2	21.6 ± 5.8 (n = 5)	18.6 ± 4.7 (n = 4)	25.3 ± 4.4 (n = 3)	15.0 ± 6.8 (n = 3)
3	5.3 ± 1.5 (n = 5)	ND	8.5 (n = 1)	ND

ND = not done.

SEA × Galla flocks in the sedentary production systems. In comparison the SEA kids in the semi-sedentary system grew at an average of 62.5 g/day for single kids and 42.5 g/day for twins (Table 1B).

On-station performance of kids

At birth, kids born to unvaccinated dams had an average body weight of 2.09 ± 0.16 (n = 7) while those born to vaccinated dams weighed 2.03 ± 0.29 (n = 8). Kids falling in categories 3 (n = 3) and 4 (n = 4) righting reaction, irrespective of whether the does were vaccinated or not, died within 48 hours of birth while those in category 1 (n = 7) and 2 (n = 2) survived. The kids falling in categories 3 and 4 were not all the smallest (Table 2). One of the does had twins.

Total protein and IgA and IgG in colostrum, milk and sera obtained from does and kids (on-farm study)

Colostrum, milk and serum obtained from does were found to have only traces of IgA, while IgG was detected in large quantities (>10 g/ℓ in the same samples (Tables 2, 3). The IgG concentrations attained in serum obtained from kids between 2 and 8 weeks of age were significantly higher ($P < 0.05$) than those found in sera obtained from dams *post partum.* However, IgG concentrations in kid serum samples obtained thereafter were not significantly different ($P > 0.05$) (Tables 2, 3). Individual and pooled sera from pregnant dams did not have detectable *E. coli* antibodies.

IgA and IgG concentration and *E. coli* antibody titre in sera obtained from kids (on-station study)

Sera obtained from both groups of kids before suckling did not contain detectable amounts of immunoglobulin A and G and *E. coli* antibodies. At 12 hours the sera from kids born to vaccinated dams had an average IgG concentration of 19.5 ± 7.5 g/ℓ and *E. coli* antibody titre of between 1/160 and 1/640 (n = 4). In the same interval, sera obtained from kids born to unvaccinated dams had an IgG concentration of 22 ± 7.9 g/ℓ (n = 2) and *E. coli* antibody of between negative and 1/160. The *E. coli* antibody titres were about 50 % of those recorded for kids born to vaccinated dams (Table 4).

Pre-suckling total protein concentrations were <40 g/ℓ in both groups of kids. In both groups of kids the concentrations were observed to increase to 50–60 g/ℓ by 12–24 hours post-suckling and to 50–80 g/ℓ by 72 hours (n = 3). Kids that died within 48 hours of birth (parturient deaths) without showing signs of severe dehydration had low (<40 g/ℓ) total protein concentrations while those that died with evidence of severe dehydration had slightly elevated concentrations of total protein (55 g/ℓ) (Table 4).

In both groups of kids only traces of 1gA were detectable in post-suckling (up to 96 hours) serum samples.

IgA and IgG concentrations in serum and colostrum from dams (on-station study)

In the first 3 days *post partum* serum IgG concentrations in vaccinated does ranged between 18 and 19 g/ℓ, while those in colostrum ranged between 52 and 53 g/ℓ. Serum IgG concentration in unvaccinated does ranged between 6 and 19 g/ℓ, while those in colostrum ranged between 4 and 45 g/ℓ. While within groups colostral and serum IgG concentrations were not

Table 3: **Mean** (± SE) **serum concentration of total protein** (TP g/ℓ)**, immunoglobulin concentration** (IgG g/ℓ) **and *E. coli* antibody titre** (*E. coli* Ab) **of kids born during the on-farm study.**

Kids' ages	TP	IgG	*E. coli* Ab
2 weeks	60.03 ± 2.20	36.4 ± 4.4	2572 ± 624
4 weeks	58.70 ± 1.23	37.9 ± 3.5	0.0
8 weeks	68.30 ± 2.43	42.9 ± 2.8	<160
12 weeks	90.40 ± 3.91	18.2 ± 2.9	<160
16 weeks	63.60 ± 4.31	18.2 ± 1.8	<160

Table 4: **Righting reaction, total protein** (TP, g/ℓ)**, IgG** (g/ℓ)**, *Escherichia coli* antibody titre, white blood cells** (WBC)**, haematocrit** (%)**, Hb** (mmol/ℓ)**, blood glucose concentrations and rectal temperature** (T, °C) **in blood and serum of kids born to vaccinated and unvaccinated does clustered according to the category of righting reaction.**

Doe Id.	Kid Id	Sex[a]	Age (days)	Weight (kg)	TP	IgG	Antibody titre	WBC (×1000)	HCT (%)	Hb (mmol/ℓ)	Glucose (mmol/ℓ)	T (°C)
Category 1 righting reaction[b]												
6B	72	M	0.5	2.6	59	14.6	1/160	4	31	–	4.7	37
			2.0		58	57.8	1/160	6.7				
26G	74	M	1.0	2.4							5.6	39
			2.0		90	30.4	1/160	4.5	39	13.1	5.5	39
28G	75	F	0.0	2.6	63	-ve	-ve	8.0	39	12.4	6.5	37.5
			1.0		61	22.0	-ve					39.5
			2.0		62	14.6	1/160					39
			3.0		67	22.0	1/160					
12B	12	F	0.0	2.1	45	-ve	-ve				4.4	38
			1.0		92	30.4	1/160	8.0	29	11.9	6.9	39
			3.0		90	40.0	1/160				5.7	39.5
			4.0		62	22.0	1/160				6.4	39
14B	77	M	0.0	2.9	46	-ve	-ve	4.5	30	10.0	4.5	36.5
			0.5		70	14.6	1/640	8.0	28	11.0	4.9	38
			1.0		62	22.0		10	25	10.0	5.8	39
			2.0		68	18.2		8.9	24	9.1	7.2	37.5
			3.0		70	18.2	1/640	10	23		5.5	39
			4.0		72	11.4	1/640		24		6.3	39
2B*	39	F	0.0	2.2	64	-ve	-ve	4.0	34	11.4	4.7	37
			1.0		74		1/160	7.8	36	12.2	6.3	38.5
			2.0		74		1/640	9.8	35	11.8	5.8	39
2R	73	M	0.0	2.1	43	-ve	-ve				5.3	36.5
			0.5		53	14.6	1/160				4.7	39
			1.0		46	31.4	1/320	7.9	39	13.1	5.3	39
			2.0		59	35.0					6.6	39
			4.0		58	35.0					5.9	39
Category 2 righting reaction												
31G	76	F	0.0	1.8	47	-ve	-ve	4.0	41		4.7	37
			2.0		54	39	1/160				5.8	38.5
11B	11	M	0.0	2.4	57	-ve	-ve	4.0		13.7	4.5	39
			1.0		83	18.2	1/160				6.8	39.5
			2.0		101	14.0	1/320				5.7	39
Category 3 righting reaction												
1B	71	F	0.0	2.4							3.5	36.5
4B	80	M	0.0	2.4							3.8	36.5
2B*	38	F	0.5	1.7							5.3	38
Category 4 righting reaction												
35G	70	M	0.0	2.8							<2.0	35
34G	81	F	0.0	2.2	69	-ve	-ve				3.5	38
			0.5		58	18.0						
27G*	22	F	0.5	0.8							<2.0	37.5
	23	M	0.5	0.9							<2.0	37
32G	60	M	0.5	2.4 Died within an hour of birth								

[a]M = male; F = female.
[b]Righting reaction: category 1 = <30 minutes; 2 = 30–45 min; 3 = 45–60 min; 4 = assisted to stand after 1 hour.
*Twins.

significantly different (P 0.05), the IgG concentrations in serum and colostrum between groups were significantly different ($P < 0.05$) (Table 2). The concentrations of IgG in colostrum fell sharply by the 3rd day *post partum* (Table 1). By contrast, only traces of IgA were detectable in serum, colostrum and milk obtained from both groups (vaccinated and unvaccinated does) throughout the study.

Changes in other blood parameters in kids (on-station study)

Sera obtained from kids born to both vaccinated and unvaccinated dams had a total protein concentration of 36–59.0 g/ℓ, while haematocrit (Hct) varied between 0.29 and 0.41, haemoglobin (Hb) concentration between 10–13.0 mmol/ℓ, and white cell counts (WBC) between 2500 and 10 000/mℓ. In kids that had categories 1 and 2 righting reaction, the WBC rose rapidly to between 5000 and 10 000/mℓ, but remained at <4000 in those that were in categories 3 and 4 and died within 48 hours (parturient deaths) (Table 4). Categories 1 and 2 kids weighed >2.4 kg at birth and had rectal temperatures >37 °C, while those in categories 3 and 4 weighed <1.5 kg for singles and <1.0 kg for twins at birth and had rectal temperatures of <36.5 °C (Table 4).

Higher WBC of between 9800 and 15 000/mℓ were observed in kids that became infected. In each case, kids in both groups responded with leucocytosis characterised by neutrophilia if they contracted gastroenteritis, pneumonia and/or polyarthritis. Haematocrit and total protein in terminally ill kids were relatively high ('false high') due to haemoconcentation.

No blood parasites were seen on either thick or thin smears prepared from blood samples collected from the kids at the station throughout the experimental period.

Blood glucose concentrations (on-station)

One set of underweight twins that weighed 0.8 and 0.9 kg at birth and died soon after birth, had a blood glucose concentration of <2.0 mmol/ℓ and a rectal temperature of <36 °C. By comparison, a

Table 5: **Prevalence of diarrhoeagenic agents from kids with diarrhoea compared to their prevalence in kids without diarrhoea both on-farm and on-station.**

Agent	Affected kids (*n* = 52)	Unaffected kids (*n* = 14)	Stall floor (*n* = 5)
Escherichia coli			
EAEC	6 (11.5 %)	1 (7 %)	0
EPEC	15 (28.9 %)	0	0
ETEC	8 (15.4 %)	0	0
Conjunctivitis[a]	11 (21.2 %)	6 (43 %)	1 (2±)[b]
Conjunctivitis[c]	15 (28.9 %)	1 (7 %)	0
Beyond scope[d]	17 (33 %)	9 (64 %)	3
Helminthosis	10 (19 %)	1 (7 %)	ND
Coccidiosis	5 (10 %)	1 (7 %)	ND[e]
Other bacteria[f]	10 (19 %)	2 (14 %)	ND

[a]*E. coli* isolates: EAEC = enteroadherent *E. coli;* EPEC = enteropathogenic *E. coli;* ETEC = enterotoxigenic *E. coli;* EHEC = enterohaemorrhagic *E. coli.*
[b]Doubtful.
[c]Development of conjunctivitis in guinea-pigs at 24 h and 48 h after exposure to *E. coli* strains.
[d]Beyond scope of the test kits used.
[e]Not done.
[f]Other bacterial isolates included *Streptoccus* spp. and *Bacillus* spp.

set of twins that survived weighed 2.2 and 1.6 kg at birth and had blood glucose concentrations of 4.4 and 5.3 mmol/ℓ. This set of twins had a rectal temperature of 39 °C. Four single kids born at the same time weighed between 2.4 and 2.7 kg and had blood glucose levels of between 4.7 and 5.3 mmol/ℓ and rectal temperatures of 39.5 °C.

Four to 6 hours after birth, the underweight twins still had low (<2.0 mmol/ℓ) blood glucose concentrations and rectal temperatures (<36.5 °C), while the surviving twins and the single kids had blood glucose concentrations ranging between 4.4 and 8.4 mmol/ℓ from birth to the 4th day.

On-station *post mortem* findings and lung bacterial isolates

The 17 kids born during the on-station study died between birth and 12 weeks. One was born weak and died within an hour of birth. The 7 that died within 7 days *post partum* died of a variety of conditions, including pneumonia, hepatitis, gastroenteritis and nephritis. The 8 kids that died later suffered from severe gastroenteritis and/or pneumonia. One kid died of *E. coli* polyarthritis (Table 4). No attempts were made to treat the kids on-station.

E. coli (47 %, 7 samples), *Pasteurella* spp. (13 %, 2 samples), *S. zooepidemicus* (13 %, 2 samples) and mixed cultures of *S. aureus* and *Proteus* spp. (27 %, 4 samples) were isolated from 15 lung specimens presented with evidence of pneumonia for bacterial isolation.

On-farm *post mortem* findings and lung bacterial isolates

The most common cause of death on-farm was gastroenteritis with septicaemia, pneumonia, hepatitis and helminthosis. In 2 kids with polyarthritis, widespread accumulation of pus in joints, hepatitis, cystitis and widespread petechial haemorrhages were the main features. In kids that died within the first 3 weeks of birth, nephritis and hepatitis were common findings on histopathological examination.

Prevalence of diarrhoeagenic agents (on-station and on-farm)

E. coli was the most frequently isolated bacterial pathogen (90 %) from rectal swabs obtained from pre-weaned kids with gastroenteritis characterised by diarrhoea. Other diarrhoeagenic agents commonly identified in pre-weaned kids on-farm included helminths and coccidia. During a similar period the pre-weaned kids had less than 50 helminth eggs per gram of faeces (Table 5). No viruses were isolated despite repeated attempts.

DISCUSSION

In the present study the local SEA goat kids were much lighter at birth (1.8–2.7 kg) and attained lower daily weight gains for single and twins (69–85 g/day) than the Galla, which weighed 2.4–3.4 kg and attained a daily weight gain of 118–151.7 g/day[6]. The weights we recorded were similar to those reported by others in Kenya[11] but higher than those reported for SEA in Malawi (42–47 g/day)[10].

Serum harvested from goats during the on-farm and on-station studies indicated that an *E. coli* antibody titre of 1:160 using the ELISA, or 1:8 dilution on agar gel immunodiffusion (AGID) could be used as the minimum cut-off point for the 'positive' response or passive transfer of colostral antibodies. *E. coli* antibody titres in both vaccinated and control does were significantly ($P < 0.05$) higher in colostrum (obtained up to 4 days *post partum*) than in concomitant serum. Antibody titres were significantly higher ($P < 0.05$) in colostrum collected from vaccinated does. The rapid fall, within 3 days of kidding, in colostral IgG and *E. coli* antibodies, observed in both groups of does in the present study reaffirmed the importance of feeding sufficient (in quantity and quality) colostrum as soon after parturition as practical[3,18,23]. Total protein, 1gA and 1gG levels in the same serum samples did not differ significantly between the 2 groups.

Transplacental transfer of immunoglobulins rarely occurs in domestic animals except for very rare occasions in the mare[3,18,26]. The *post partum* immunoglobulin rate of absorption has been shown to depend on the amount of colostrum fed and the time of feeding *post partum,* the ambient temperature and litter size[22,23,28]. Working with the doe, Rabbani *et al.*[22] established that, as in other species[23], immunoglobulins were absorbed in the offspring to produce similar concentrations in serum as those in the dam's serum within 24 hours. A similar situation was observed in the experimental does and their offspring in the present study. In addition, poor mothering ability, which may cause the kid not to suckle, or malnutrition, which may affect the quality and quantity of colostrum available, may greatly affect the availability and/or uptake of immunoglobulin.

Pre-suckling serum obtained from kids born to both vaccinated and unvaccinated does did not have detectable levels of *E. coli* antibodies, 1gA or 1gG. At 12 hours *post partum,* however, the kids from both groups had detectable levels of *E. coli* antibodies, although the kids born to vaccinated dams had levels that were twice as high as those born to unvaccinated dams. The levels of 1gG in serum collected after suckling were, however, similar in the 2 groups of kids. By contrast, only traces of 1gA were detectable in sera obtained from both groups of kids up to 96 hours *post partum.* Similar findings have been observed in the calf, kid and lamb, where there is little IgA and its role is taken over by colostral and milk IgG derived from serum and antigen stimulus probably in the intestines[1,3,22].

The age at which the foetus becomes immunocompetent varies between species, although most of them are capable of responding to antigens by the end of the 1st trimester[2,3]. In addition, Perryman *et al.*[21] concluded that cellular defence mechanisms are more critical in the foal, which is immunocompetent at birth, but has little or no immunoglobulin G (IgG). In the present study, kids were

observed to be capable of responding to natural challenge with a marked leucocytosis within 12 hours of birth. It is thus postulated that, as in the foal, the cellular defence mechanisms in kids play a key role in the prevention of early postnatal infections.

Hauser[8] observed that high levels of corticosteroids, produced by lambs and calves 8–10 days before parturition, resulted in lymphopaenia and a decrease in the phagocytic defence capability in the newborn that may affect the cellular immune mechanisms, thus decreasing perinatal resistance. This phenomenon may partly account for the short-lived low WBC (<4000/ mℓ) level recorded in kids at birth. This situation may be aggravated by poor dam nutrition and mothering ability, which may lead to poor intake and weakening of the kid.

E. coli was the most frequently (90 %) isolated bacterial pathogen from rectal and lung swabs obtained from pre-weaned kids with gastroenteritis and pneumonia. It is probable that this and other bacterial isolates were secondary to stress, including starvation. The presence of other diarrhoeagenic agents, including helminths and coccidia, suggests that there may be a need to drench for helminths and treat pre-weaned kids for coccidiosis before they are released to pasture.

Blood glucose concentrations of the underweight kids that died within 48 hours of birth (parturient deaths) did not exceed 4.9 mmol/ℓ at peak. This level was equivalent to the lowest recorded for surviving single kids 12 hours (0.5 days) *post partum*. The blood glucose concentrations at 2–4 days *post partum* were within the range we recorded (7.2–11.4 mmol/ℓ) for pre-weaned kids aged between 4 and 8 weeks. The hypothermia associated weak and under-weight kids may have been associated with the kid having exhausted its glucose reserves or an imbalance of energy needs and availability.

From the present study it was concluded that the righting reaction of <45 minutes, rectal temperature of >36.5 °C, weights at birth of >1.9 kg for single kids and >1.0 kg for twins, WBC of >5,000/ mℓ, blood glucose concentrations of >4.5 mmol/ℓ, total protein of >45 g/ℓ, *E. coli* antibody titres of >1:160 and immunoglobulin G concentrations of ≥4.5 g/ℓ at least 12 hours after birth were good prognostic indicators of kid survival. The local goat producers can monitor the righting reaction, rectal temperature and birth weights soon after birth, while practitioners in the field may count WBC and measure blood glucose concentrations using dip sticks, estimate total protein using a refractometer and measure serum immunoglobulins using silver nitrate[19,26].

REFERENCES

1. Bourne F G, Newby T J, Ewans P, Morgan K 1978 Immune requirements of the newborn pig and calf. *Annales de Recherche Veterinaire* 9: 227–232
2. Bradley J A, Niilo L, Dorward W J 1979 Some observations on serum gammaglobulin concentrations in suckled beef calves. *Canadian Veterinary Journal* 20: 227–232
3. Constant S B, LeBlanc M M, Klapstein E F, Beebe D E, Leneau H M, Nunier C J 1994 Serum immunoglobulin G concentration in goat kids fed colostrum or a colostrum substitute. *Journal of the American Veterinary Association* 205: 1759–1762
4. Cruickshank R, Dugid J P, Swain B 1969 *Medical microbiology.* The English Language Book Society and E. and S. Livingstone Ltd, London
5. Daniel W W 1983 *Biostatistics: foundation for analysis in the health sciences* (3rd edn). Georgia State University Press, Atlanta
6. *Embu, Meru and Isiolo goat development project annual report* 1987 Ministry of Agriculture, Livestock Development and Marketing, Nairobi
7. Hansen J, Perry B 1990 *Epidemiology, diagnosis and control of gastrointestinal parasites of ruminants in Africa.* International Livestock Research Institute, Nairobi
8. Hauser M A, Koob D M, Roth J A 1986 Variation of neutrophil function with age in calves. *American Journal of Veterinary Research* 47: 152–157
9. Hudson L, Hay F C 1989 Practical immunology and buffers and media: In Perryman *Practical immunology* (3rd edn). Blackwell Scientific Publishers, London: 12, 14, 233, 237, 296, 467–474
10. Karua S K, Banda J W 1992 Dairy goat breeding in Malawi. Gestation length, birth weights and growth of the indigenous Malawi goats and their Saanen crosses. In Ray B, Lebbie S H B, Reynolds L (eds) *Small ruminant research and development in Africa. First Biennial Conference of the African Small Ruminant Research Network, ILRAD, Nairobi (Kenya),* 10–14 December 1990: 453–459
11. Kenya Agricultural Research Institute (KARI) / Overseas Development Agency (ODA) 1996 *Livestock economics and epidemiology project: manual for livestock production systems in Kenya.* KARI/ODA, Nairobi
12. Kenya Medical Research Institute (KEMRI) 1994 Bacteriology laboratory manual. Department of Microbiology, KEMRI, Nairobi
13. Mancini G, Carbonara A O, Heremans J P 1965 Immunochemical quantitation of antigens by simple radical diffusion. *Immunochemistry* 2: 235–240
14. Mbassa G K, Poulsen J S D 1991 Haematological profile in neonatal dwarf and landrace kids. *Journal of Veterinary Medicine* A38: 510–522
15. Merchant I A, Packer R A 1975 *Veterinary bacteriology and virology* (3rd edn). Baillière Tindall, New York
16. Munyua S J M, Mbai K, Karioki D I, Chibeu D M, Gathuma J M, Mitaru B N, Nduhiu J 1996 Reproductive efficiency of indigenous goats in Kenya. 1: slaughterhouse and field surveys. *All Africa Conference on Animal Agriculture, Pretoria, South Africa,* (author to supply dates)1996
17. Newby T J, Stokes C R, Huntley J, Evans P, Bourne F J 1979 The immune response of the pig following oral vaccination with soluble proteins. *Veterinary Immunology and Immunopathology* 1: 37–47
18. O'Brien J P, Sherman D M 1993 Serum immunoglobulin concentrations of newborn goat kids and subsequent kid survival through weaning. *Small Ruminant Research* 11: 71–77
19. O'Brien J P, Sherman D M 1993 Field methods for estimating serum immunoglobulin concentrations in new-born kids. *Small Ruminant Research* 11: 79–84
20. Otsiele E B, Oduye O O 1991 Effect of time of feeding colostrum on serum immunoglobulin concentrations in newborn lambs. *Bulletin of Animal Health and Production Africa* 39: 119–120
21. Perryman L E, McQuire T C, Helbert B J 1977 Selective immunoglobulin M deficiency in foals. *Journal of the American Veterinary Association* 170: 212–215
22. Rabbani S, Irfan M, Muhammad K, Ahmed Z Q 1990 Studies on the transfer of maternal immunoglobulins in kids. *Archiva Veterinaria Bucuresti* 19: 53–59
23. Radostits O M, Blood D C, Gay C C 1994 *Veterinary medicine: a textbook of the diseases of cattle, sheep, pigs, goats and horses* (8th edn). Baillière Tindall, London
24. Rowan K J, Englebright R K, Djajanegara A, Sukmawati A 1994 Effect of colostrum consumption and the level of environmental pathogen load on the health and growth of kids from birth to weaning. *Proceedings of the 7th AAAP Animal Science Congress, Bali, Indonesia,* 11–16 July 1994: 29–30
25. Santucci P M, Branca A, Napoleone M, Bouche R, Aumont G, Poisot F, Alexandre G 1991 Body condition scoring in goats in extensive conditions. In Morand-Fehrs P (ed.) *Goat nutrition.* Pudoc, Wageningen: 240–252
26. Satapathy P K, Dutta N K, Misra P R 1992 Zinc sulphate turbidity test in the diagnosis of hypogammaglobulinemia in kids. *Indian Veterinary Journal* 69: 589–590
27. Schalm O W, Jain N C, Carroll E J 1975 *Veterinary haematology* (3rd edn). Lee and Febiger, Philadelphia
28. Sherman D M, Arendt T D, Gay J M, Maefsky V A 1990 Comparing the effects of four colostral preparations on serum IgG levels of newborn kids. *Veterinary Medicine* 85: 908–913
29. Snodgrass D R 1986 Evaluation of a combined rotavirus and enterotoxigenic *E. coli* vaccine in cattle. *Veterinary Record* 119: 39–42
30. Vihan V S 1993 Use of *Escherichia coli* vaccine for passive protection against neonatal colibacillosis in goats. *Small Ruminant Research* 11: 179–185