Effect of passive transfer status on preweaning growth performance in dairy goat kids

Genesio Massimini, DVM; Vincenzo Mastellone, DVM; Domenico Britti, DVM, PhD; Pietro Lombardi, DVM; Luigi Avallone, DVM

Objectives —To evaluate the effect of passive transfer status (determined from measurements of serum IgG concentration at 24 hours after parturition [sIgG-24]) on preweaning growth performance in dairy goat kids.

Design —Prospective observational study.

Animals —20 healthy nursing dairy doe kids in a natural nonintensive breeding environment.

Procedures —For each kid, sIgG-24 was measured. Body weight was measured at birth and at the time of weaning 30 days (ie, 29 to 31 days) after birth; average daily gain from birth to day 30 and weight at day 30 were used as measures of preweaning growth performance. Regression analysis was used to evaluate associations between sIgG-24 and measures of preweaning growth performance.

Results —Mean ± SD sIgG-24 was 31.7 ± 10.3 mg/mL. Mean body weights at birth and weaning were 4.105 ± 0.981 kg (9.031 ± 2.158 lb) and 9.310 ± 2.554 kg (20.482 ± 5.619 lb), respectively; average daily gain was 0.174 ± 0.072 kg/d (0.383 ± 0.158 lb/d). No significant association was detected between sIgG-24 and birth weight. However, sIgG-24 was significantly associated with average daily gain ($R^2$ = 0.48) and weight at day 30 ($R^2$ = 0.56). Each increase in sIgG-24 of 1 mg/mL was associated with an increase in average daily gain of 0.005 kg/d (0.011 lb/d) and an increase in weight at day 30 of 0.185 kg (0.407 lb).

Conclusions and Clinical Relevance —Results indicated that passive transfer status (determined as sIgG-24) was a significant source of variation in preweaning growth performance in dairy doe kids reared in this nonintensive breeding environment. (J Am Vet Med Assoc 2007;231:1873–1877)

G oat kids depend on the passive transfer of colostral IgG to provide humoral immunity during the neonatal period,1–4 and adequate passive transfer of immunity, determined by measurement of serum IgG concentration, is a critical determinant of short-term health and survival for neonatal goats.3–8 To ensure adequate passive transfer of immunity, neonatal goats should receive good-quality colostrum in an amount equivalent to 10% to 20% of their body weight (or a dose of colostral IgG that is ≥ 3.0 g/kg [≥ 1.36 g/lb] of body weight) divided into 4 to 6 feedings of equal proportions, preferably within 3 to 12 hours after birth.2,9,10 Failure to ingest and absorb sufficient colostral IgG, termed FPT, is a secondary immunodeficiency condition that has been linked to increased risk of illness and death from bacterial septicemia and common neonatal infectious diseases and is well recognized among ruminant species.1,11–18 Goat kids with FPT have an increased risk of illness and death until at least 6 to 7 weeks of age; in neonatal goats < 4 days old, an increased risk of illness and death is associated with serum IgG concentration < 12 mg/mL (ie, 1,200 mg/dL).3,6,8,19 The influence of management practices on passive transfer of immunity is well established for goat kids.2,4,10,19 Administration of previously described colostrum substitutes2,3 or heat-treated goat colostrum (processed to control transmission of caprine arthritis-encephalitis virus)4,19 has had limited success in goats kids because the products did not increase serum IgG concentration and did not prevent illness and death associated with FPT.

Increases in neonatal morbidity and mortality rates among juvenile ruminants, both before and after weaning, are well-accepted consequences of FPT.1,3,5,8,11–18 Nevertheless, relatively little has been done in the recent years to quantify the potential long-term effects of inadequate passive transfer of immunity on growth and productivity outcomes, especially in juvenile kids.

From the School of Veterinary Medicine, University of Catanzaro Magna Gracia, Viale Europa Campus Universitario “S. Venuta” Germaneto, I-88100 Catanzaro, Italy (Massimini, Mastellone, Britti); and the Department of Biological Structures, Functions and Technologies, School of Veterinary Medicine, University of Napoli Federico II, Via Delpino 1, I-80137 Napoli, Italy (Lombardi, Avallone). Dr. Massimini’s present address is Corso Umberto I 219, I-66043 Casoli, Chieti, Italy.

Supported by the School of Veterinary Medicine, University of Catanzaro. Address correspondence to Dr. Britti.

Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FPT</td>
<td>Failure of passive transfer</td>
</tr>
<tr>
<td>sIgG-24</td>
<td>Serum IgG concentration at 24 hours after parturition</td>
</tr>
<tr>
<td>ADG</td>
<td>Average daily gain</td>
</tr>
<tr>
<td>RID</td>
<td>Radial immunodiffusion</td>
</tr>
</tbody>
</table>

JAVMA, Vol 231, No. 12, December 15, 2007 1873

Unauthenticated | Downloaded 01/27/24 03:01 AM UTC
A significant correlation between slgG-24 and weaning weight in beef calves has been reported.\(^2\) Robison et al\(^2\) determined that serum IgG concentration 24 to 48 hours after parturition was a significant source of variation in ADG through the first 180 days of life among dairy heifer calves. Furthermore, serum IgG concentration 24 to 48 hours after parturition has been associated with first lactation milk production and milk fat content in dairy heifer calves.\(^2\) Virtala et al\(^2\) reported that FPT reduced ADG by 0.048 kg (0.11 lb) during the first month of life in dairy heifer calves. Passive transfer status, determined as slgG-24 or plasma protein concentration at 24 hours after parturition, was indirectly associated with pre- and postweaning growth performance in crossbred calves because of the effect of FPT on calf morbillity rate.\(^2\) In another study,\(^2\) serum IgG1 concentration 24 to 72 hours after parturition accounted for 29% of the variability in preweaning ADG (ie, from birth to the time of weaning at 205 days after birth) in beef calves. In that study, calves with serum IgG1 concentrations ≥ 27 mg/mL weighed 3.35 kg (7.37 lb) more at 205 days after birth than calves with lower serum IgG1 concentrations. Massimini et al\(^2\) determined that slgG-24 accounted for 26% and 25% of the total variation in ADG from birth to the time of weaning 28 days after birth and in weight at day 28, respectively, in dairy lambs. In that study, each 1 mg/mL increase in slgG-24 was linearly associated with an increase in ADG (1.8 g/d [0.004 lb/d]) and an increase in weight (60.8 g [0.134 lb]) at day 28. To our knowledge, the association between passive transfer status and preweaning growth performance in dairy goat kids has not yet been thoroughly investigated.

The purpose of the study reported here was to evaluate the effect of passive transfer status (determined from measurements of slgG-24) on preweaning growth performance in dairy goat kids. Measures of growth performance that were evaluated included preweaning ADG and body weight 30 days after parturition. The intent was to derive information that would enable recommendations on colostral intake to be appropriately integrated into management practices in an attempt to improve growth performance of dairy kids.

### Materials and Methods

#### Animals

Twenty healthy Cilentana doe kids from a single dairy goat farm in central Italy were used in the study. Kids were allowed to suckle naturally and remained with their dams until they were weaned, according to a natural nonintensive breeding system. All dams were housed under standard management procedures for the farm. Other than routine deworming and vaccination against clostridial diseases, drugs and other compounds were not administered to the dams during gestation or parturition. Four weeks before the expected parturition date, dams received a 2-mL booster dose of a formalin-inactivated vaccine containing *Clostridium perfringens* types A, B, C, and D toxoids; *Clostridium chauvoei* anaculture; *Clostridium septicum* toxoid; *Clostridium novyi* type B toxoid; *Clostridium sordelli* toxoid; *Clostridium tetani* toxoid; and aluminium hydroxide adjuvant.\(^4\) After parturition, dams were hand milked at 6 AM and then allowed to graze for 9 hours during the day. During the evening, dams were housed collectively in a single free-stall barn and fed a 14% crude protein concentrate\(^b\) (1 kg [2.2 lb]/goat/d), together with alfalfa hay and olive tree leaves ad libitum. Water was available at all times.

Twenty doe kids from observed single parturitions were included in the study. After parturition, all goat kids were identified and weighed. Goat kids were then allowed to suckle their dams naturally to satiety until 24 hours (ie, 23.5 to 24.5 hours) after parturition. No attempt was made to ensure that goat kids suckled, and no supplemental colostrum was fed to the goat kids during the 24-hour period. Goat kids were then removed from their dams for 15 hours during the evening and allowed to suckle for 9 hours during the day, according to a mixed suckling-and-milking weaning system. Beginning at 10 days of age, all goat kids had ad libitum access to a 19% crude protein goat kid commercial starter feed.\(^6\) The goat kids were weaned 30 days (ie, 29 to 31 days) after parturition and weighed at the time of weaning. Vaccines, drugs, and other compounds were not administered to the goat kids during the study.

The 20 doe kids included in the study were considered by the producer to be healthy, and no clinical abnormalities were detected during physical examinations. The passive transfer of immunity status (classified as failure, marginal, or adequate), health status, management interventions, and other animal factors (ie, age of the dam, sex of the kid, duration of gestation, type of birth [singlet vs twin], and dam and kid behavior) were not considered as continuous or catarhmic predictor variables in the study.

#### Sample collection and processing

Blood samples were collected by means of jugular venipuncture from the goat kids 24 hours (ie, 23.5 to 24.5 hours) after parturition. Serum was harvested after centrifugation and stored at 4°C (39.2°F) until analyzed. Serum IgG concentration was determined by use of a commercially available RID assay for goat IgG,\(^6\) according to the manufacturer’s specifications. Briefly, 5 µL of serum was added to 1 well of a 48-well plate containing anti-goat IgG antiserum, Tris-buffered saline solution, and 0.1% sodium azide in a 1.5% agarose matrix. Three reference standards (2.5, 10, and 20 mg of goat IgG/mL) included in the kit were tested concurrently with each sample. The plate was incubated at room temperature (approx 23°C [73.4°F]) for 24 hours, and the precipitin ring diameter was measured. The IgG concentration of test samples was determined by comparison of the precipitin ring diameter for test samples with a semilog plot generated from results for the reference standards. Serum samples with IgG concentration > 20 mg/mL were diluted 1:10 with sodium barbital buffer solution\(^6\) and reanalyzed. For statistical analyses, all samples having a serum IgG concentration less than the assay’s lowest detectable limit of 2.5 mg/mL were designated as having a concentration of 0 mg/mL.

### Statistical analysis

Mean ± SD values for slgG-24, birth weight, weight at day 30, and ADG from birth to day 30 were calculated. For all analyses, a value of P < 0.05 was considered significant. Least squares sim-
ple linear regression\textsuperscript{27,28} was used to evaluate the association between sIgG-24 (continuous predictor variable) and preweaning growth performance measures, including ADG and weight at day 30 (continuous outcome variables). Serum IgG concentration at 24 hours after parturition and birth weight were also compared by means of simple linear regression analysis. Only variables with nonzero regression coefficients ($P < 0.05$) were permitted to enter the models. The goodness of fit of the models was established on the basis of the coefficient of determination ($R^2$), which was multiplied by 100 and expressed as a percentage to indicate the total variation in growth performance that was accounted for by variation in sIgG-24; the remaining percentage indicated the total variation in growth performance that was unexplained by variation in sIgG-24 (residual variance). The quadratic form of the models was also screened by use of the F (extra sum-of-squares) test; differences between $R^2$ values were tested by calculation of F values to determine significance ($P < 0.05$) of the contribution of the quadratic models, compared with the simple linear models. Calculations were performed with the assistance of standard\textsuperscript{4} and statistical\textsuperscript{5} software packages.

**Results**

Among the 20 goat kids, sIgG-24 values ranged from 15.3 to 52.7 mg/mL (mean $\pm$ SD, 31.7 $\pm$ 10.3 mg/mL). Birth weights ranged from 2.3 to 7.3 kg (5.06 to 16.06 lb); mean birth weight was $4.105 \pm 0.981$ kg ($9.031 \pm 2.158$ lb). At 30 days after birth, weights ranged from 5.8 to 15.0 kg (12.76 to 33.0 lb); mean weight was $9.310 \pm 2.534$ kg (20.482 $\pm$ 5.619 lb). The ADG ranged from 0.077 to 0.370 kg/d (0.169 to 0.814 lb/d); the mean ADG was $0.174 \pm 0.072$ kg/d ($0.383 \pm 0.138$ lb/d).

No significant association was detected between sIgG-24 and birth weight. Serum IgG concentration at 24 hours after birth was significantly ($P < 0.001$) associated with ADG ($R^2 = 0.48$) and weight at day 30 ($R^2 = 0.56$) in goat kids (Figure 1). Each 1 mg/mL increase in sIgG-24 was associated with an increase in ADG of 0.005 kg/d (0.011 lb/d) and an increase in weight at day 30 of 0.185 kg (0.407 lb). The quadratic models were screened and rejected because these models did not result in $R^2$ values that were significantly different from values obtained with the simple linear models.

**Discussion**

Results of the present study indicated that passive transfer status, determined as sIgG-24, was a significant source of variation in preweaning growth performance in dairy doe kids that were allowed to suckle naturally and remain with their dams in a nonintensive breeding system. This is similar to results of other studies involving dairy heifer calves\textsuperscript{21-23} and beef calves\textsuperscript{20,24,25} and dairy lambs\textsuperscript{26} that were allowed to suckle naturally and were left with their dams until at least 24 hours after birth. In our study, linear regression analysis revealed significant positive associations between sIgG-24 and ADG and between sIgG-24 and body weight at 30 days after birth. Coefficients of determination indicated that the variation attributable to sIgG-24 accounted for 48% and 56% of the total variation in ADG and weight at day 30, respectively. The remaining percentage of the variation in ADG and weight at day 30 that was unexplained by the variation in sIgG-24 was attributable to some other factors. Because many goat kid (ie, breed, sex, type of birth, and health status) and management factors (ie, all kids were from a single dairy farm and received the same level of intervention) were controlled in the present study, other variance components for kid growth (ie, age of the dam, duration of gestation, dam and kid behavior, gastrointestinal absorptive ability of goat kids, and inherent differences among individuals) likely accounted for the bulk of the residual variance in ADG and weight at day 30 in the present study. These findings suggest that improving passive transfer status in neonatal goats within the first 24 hours after parturition may enhance their growth rate during the first month after birth. Proper management and intervention strategies designed for improving passive transfer status will likely result in increases in preweaning performance measures in dairy doe kids.

In the present study, birth weight did not influence sIgG-24 in dairy doe kids. This is consistent with results of other studies involving calves,\textsuperscript{21} lambs,\textsuperscript{26} and kids.\textsuperscript{3} Nevertheless, a significant negative association between birth weight and immunoglobulin transfer in neonatal lambs has been reported.\textsuperscript{23,26} Negative associations between birth weight and duration of gestation and between birth weight and plasma thyroxine concentration have also been reported for neonatal lambs.\textsuperscript{26} Consequently, it appears that the relationship between birth weight and passive transfer of immunity in newborn ruminants could be an indirect association that reflects the effects of
other important physiologic factors, such as duration of gestation and hormonal status at birth. However, the effect of these variables was not evaluated in our study.

No direct biological basis for the association between passive transfer of immunity and goat kid growth can be elucidated from the data obtained in the present study. It has been hypothesized that the relation between passive transfer status and growth in calves could reflect increased resistance to disease,20 and, consequently, improved growth. Wittum and Perino21 determined that passive transfer status has an indirect effect on calf growth through the effect of FPT on development of respiratory tract–associated illness; calves with adequate passive transfer of immunity developed less respiratory tract disease and were better able to grow normally than calves with FPT.24 On the basis of these observations, the association between sIgG-24 and goat kid growth in our study could be considered a direct cause-and-effect relationship. Goat kids with higher levels of passive transfer of immunity (ie, those that acquired greater serum concentrations of antibodies against pathogens) could develop more efficient protective and metabolic systems that contribute to growth than goat kids with lower levels of passive transfer of immunity. Thus, vaccination of dams before parturition might improve goat kid growth by enhancing passive transfer of antibodies against specific pathogens. Nevertheless, other nonimmunoglobulin factors in colostrum might have interacted in conjunction with IgG concentration or acted directly to influence the growth response or to improve the immune and metabolic systems of the goat kids. For instance, colostrum is rich in lymphocytes (mainly T lymphocytes), cytokines (ie, interleukin-1β, tumor necrosis factor-α, and interferon-γ), immune regulatory proteins (ie, complement and lactoferrin), growth factors (ie, insulin-like growth factor I and growth hormone), vitamins, minerals, and enzymes.31-38 However, to the authors’ knowledge, the potential associations between passive transfer of nonimmunoglobulin factors and subsequent growth and productivity outcomes in ruminants have been hypothesized21,22,24,26 but have not yet been confirmed. Further research in this area is warranted to clarify the biological basis of the long-term effects of passive transfer status.

The association between sIgG-24 and preweaning growth performance in dairy doe kids identified in the present study is in contrast to findings of a study by O’Brien and Sherman,6 which is the only other published study of which we are aware that addresses the association between passive transfer status and preweaning growth performance in dairy kids. In that study,6 no significant association was detected between serum immunoglobulin concentration 48 to 96 hours after parturition (determined by use of a spectrophotometric zinc sulfate turbidity test) and ADG through the first 6 to 7 weeks of life in 19 of 39 intensively managed dairy kids that survived until weaning. We can propose a few explanations for this difference in results. First, the use of an RID method for assessing passive transfer status, such as that used in the present study, is more accurate than the spectrophotometric zinc sulfate turbidity test because of the direct measurement of serum IgG concentration.12,13,39,40 The spectrophotometric zinc sulfate turbidity test provides an indirect semiquantitative estimation of serum immunoglobulin concentration41 but is purported to be less accurate for assessment of neonatal serum for passive transfer of immunoglobulins because of the influences of hemolysis, concentration of solutions used in the test, and atmospheric carbon dioxide on test performance.12,14,15 Second, the study herd investigated previously by those researchers was characterized by high rates of animal (ie, breed, sex, and health status) and management variation. In their study,6 male and female goat kids from mixed dairy-breed dams were raised under different intensive management conditions. Back kids were bottle-fed whole goat colostrum at birth or were occasionally allowed to suckle the dam directly, whereas doe kids were bottle-fed goat colostrum that had been treated with heat (at 54.4°C [129.9°F] for 60 minutes) at birth. Goat kids in that previous study also had high rates of morbidity and mortality, compared with the goat kids of the present study. In our investigation, many animal influences were removed by inclusion of kids from a single dairy breed; at birth, kids were selected by sex (female) and type of birth (singlet), and no clinical abnormalities were detected during the study. It has been reported42 that sIgG-24 is higher among calves that are allowed to suckle their dams than the value among bottle-fed calves, although the biological basis for improved absorption in the former group has not yet been clarified. Furthermore, studies16,17 of the effects of pasteurized goat colostrum on passive transfer of immunity in goat kids have revealed that the mean colostrum IgG concentration is decreased by approximately 35% in colostrum treated with heat (ie, at 56°C [132.8°F] for 60 minutes or at 57°C [134.6°F] for 10 minutes), compared with untreated colostrum, and that goat kids fed untreated colostrum have significantly higher values of immunologic variables, especially mean peak serum IgG concentration 48 hours after birth and delayed type hypersensitivity response, compared with kids fed colostrum treated with heat (ie, at 36°C for 30 minutes). Decreases of serum IgG and lactoferrin concentrations and neutrophil function have also been reported18 for calves fed pasteurized bovine colostrum. Consequently, the method of colostrum feeding may have influenced the passive transfer of immunity in the study of O’Brien and Sherman,6 and the heating of the colostrum performed in their study may have destroyed the immunoglobulins and other nonimmunoglobulin factors or affected their functions. To our knowledge, the present study is the only investigation involving dairy doe kids that were allowed to suckle naturally and were kept with their dams in a natural on-farm setting that has revealed a significant effect of passive transfer status on preweaning gain. On the basis of our findings, it is expected that passive transfer of immunity differs dramatically among management systems of livestock, resulting in differences in the statistical significance of the association between passive transfer status and subsequent growth performance of goat kids.

Overall, results of our study suggested that passive transfer status is an important source of variation for preweaning growth performance in nonintensively managed dairy doe kids that remain with and suckle naturally from their dams. Optimization of passive transfer within 24 hours after parturition may improve kid growth from birth to 30 days of age, and this effect may affect future management decisions. Management programs designed simply to identify kids with FPT will not replace comprehensive herd management programs. Colostrum and immunization management strategies should therefore receive appropriate attention.
References


