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Absence of protection against *Eimeria ninakohlyakimovae* after primo-infection with *E ovinoidealis* in new-born kids

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Summary — One group of kids (n = 23) was given 2 x 10^5 oocysts of *Eimeria ovinoidealis* (sheep coccidia) at birth; a second group (n = 23) was kept as an uninoculated control. Body weights, *E ninakohlyakimovae* oocyst output and serum coccidial antibody levels were monitored up to 77–102 d of age. No significant difference in any of these parameters was seen between the 2 groups, suggesting that no immune response to *E ovinoidealis* inoculation occurred. These results could be relevant to the absence of development of the endogenous stages of *E ovinoidealis* in kids and/or to the mode of inoculation (moderate and not repeated).

Résumé — Absence de protection vis-à-vis d’*Eimeria ninakohlyakimovae* après une primo-infection avec *Eimeria ovinoidealis* chez le chevreau nouveau-né. Un groupe de 23 chevreaux a été inoculé à la naissance avec 2 x 10^5 ookystes d’*Eimeria ovinoidealis* (coccidie ovine), un second groupe de 23 chevreaux a été gardé comme témoin. Les poids, les excrétions d’ookystes de *E ninakohlyakimovae* et les niveaux d’anticorps sériques ont été mesurés jusqu’à l’âge de 77–102 j. Aucune différence significative n’est apparue pour ces 3 critères entre les 2 groupes d’animaux, suggérant ainsi l’absence d’une réponse immunitaire à l’inoculation d’*E ovinoidealis*. Ces résultats pourraient être liés à l’absence de développement des stades endogènes d’*E ovinoidealis* chez le chevreau ou/et au mode d’inoculation (modéré et non répété).

kid / *Eimeria ninakohlyakimovae* / *Eimeria ovinoidealis* / immunisation / cross-infection

* Correspondence and reprints
INTRODUCTION

Coccidiosis in goats is an important disease of kids reared under intensive husbandry. Animals are affected when unweaned or weaned between 1 and 5 months of age in French conditions (Yvoré et al., 1981; Chartier et al., 1991). Among the numerous species occurring in goats, *Eimeria ninakohlyakimovae* is by far the most pathogenic (Yvoré et al., 1985).

Catchpole et al. (1993) have recently demonstrated that lambs receiving 10^4 oocysts of *E ovinoideal*is once at birth failed to pass oocysts in their faeces and developed a partial resistance to further *E ovinoideal*is infection assessed by reduction of mortality and oocyst output. In another study, Augustine and Danforth (1989) succeeded in protecting chickens with a turkey coccidia (*E adenoeides*) against a subsequent challenge with *E tenella*. Such heterologous immunization was not attempted between sheep and goats, despite the fact that the species of *Eimeria* are quite similar in morphology and prepatent period between these 2 hosts (Foreyt, 1990). This method could be of particular interest to immunize goats against *E ninakohlyakimovae* in farms as major sheep coccidia (*E ovinoideal*is) do not reach patency in goats (Lotze et al., 1961; Tsygankov et al., 1963; McDougald, 1979) and thus do not contaminate the environment.

The purpose of this study was to evaluate the effect of the inoculation of kids at birth with *E ovinoideal*is on their further resistance to *E ninakohlyakimovae* natural challenge infection.

MATERIALS AND METHODS

The experimental design was conducted in a French alpine purebred dairy goat flock (*n* = 230) where animals were reared in a zero-grazing system. Between 26 October and 11 November 1991, 46 male kids were divided at birth into 2 groups according to birth-weight. Both groups were raised in the same pen. One group was an unoinoculated control and the other received orally 2 x 10^5 oocysts of *E ovinoideal*is in the 4 h following birth. The oocyst suspension, approximately 1 month old, was prepared from a pure strain (INRA Tours 84 strain) and tested in one, coccidia-free, 15-d-old lamb which died 3 weeks after inoculation (2 x 10^5) with a haemorrhagic enteritis. The kids were immediately separated from their dams at birth, were given goat colostrum and milk of the flock for 4–8 d and then milk replacer feed with an automatic device. After weaning at 2 months of age, feed consisted of free-choice hay with a daily measured mixture of barley and soybean oil meals. The body weights and oocyst outputs were monitored individually at d 33, 61, 77 and 102. In addition, oocyst outputs were measured individually in 15 kids (7 from the uninoculated group, 8 from the inoculated group) at d 18. Oocysts were counted in rectal faeces samples according to Yvoré et al. (1987). As cross-infection of goats with *E ovinoideal*is did not produce any oocyst discharge, oocysts were identified on goat basis, *ie* *E ninakohlyakimovae* and other *Eimeria* sp (Yvoré et al., 1987). Serum was taken from the kids at d 33, 61 and 77. An indirect enzyme-linked immunosorbent assay (Nolan et al., 1987) was used against crude *E ovinoideal*is oocyst antigens (2 x 10^-7 g antigen per well) using rabbit IgG anti-goat Ig alkaline-phosphatase-labelled at a dilution of 1:9 x 10^-3 (Ref A–7650; Sigma, France). The dilution of kid sera was 1:50 and the optical density was measured at 405 nm. Blood samples were not performed between birth and 1 month of age as the only anticoccidial antibodies during this period are of colostral origin and wane gradually, reaching a minimum at 4 weeks of age (Gregory, 1989).

Statistical analyses included comparisons of means (Mann and Whitney test) and analysis of variance (Fisher test) with oocyst counts being transformed to log (*x* + 1). The statistical significance of the variables was tested at the 0.05 level of confidence.

RESULTS

There was no evidence of clinical coccidiosis in any of the kids, with appetite and faeces remaining normal during the experi-
ment. Oocyst output data are shown in table I for *Eimeria ninakohlyakimovae*. They revealed no significant difference between the groups and a very low natural coccidial challenge. There was no significant difference in weight gain between the 2 groups for the 102-d experiment although higher values were observed in the inoculated group throughout the study (table II). Mean antibody titres had a similar pattern (no significant difference) for the 2 groups (table III). No serological response to the inoculation was evident.

**DISCUSSION**

This experiment showed that inoculation of kids with 2 x 10⁵ oocysts of *E ovinoidalis* at birth caused neither *E ninakohlyakimovae* oocyst output reduction nor weight-gain increase compared with the uninoculated control group. These results are in contrast with those obtained in similar conditions in lambs with the homologous strain (Catchpole *et al*, 1993). The very low natural coccidial challenge existing in our study could prevent the eventual development of resistance to be expressed. The eventual interaction between the administration of colostrum containing anticoccidial antibodies and the immune response of kids to *E ovinoidalis* inoculation could probably be precluded. Catchpole and Devonshire (1989) have shown that the course of *E ovinoidalis* infection in new-born kids does not depend on the administration of colostrum. On the other hand, the results of Catch-

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**Table I.** *Eimeria ninakohlyakimovae* oocyst counts (log (x +1)) in control and inoculated (2 x 10⁵ oocysts of *Eimeria ovinoidalis* at birth) groups of kids (mean ± SE).

<table>
<thead>
<tr>
<th>Mean age of kids (d)</th>
<th>Group of kids</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non-inoculated (n = 23)</td>
<td>Inoculated (n = 23)</td>
<td></td>
</tr>
<tr>
<td>18ᵃ</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>0.09 ± 0.43</td>
<td>0.58 ± 1.16</td>
<td></td>
</tr>
<tr>
<td>61</td>
<td>1.29 ± 1.24</td>
<td>1.61 ± 1.24</td>
<td></td>
</tr>
<tr>
<td>77</td>
<td>1.00 ± 1.11</td>
<td>1.24 ± 1.34</td>
<td></td>
</tr>
<tr>
<td>102</td>
<td>1.76 ± 1.30</td>
<td>1.36 ± 1.22</td>
<td></td>
</tr>
</tbody>
</table>

ᵃ 15 animals only (7 non-inoculated and 8 inoculated).

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**Table II.** Body weights and weight gains in control and inoculated (2 x 10⁵ oocysts of *Eimeria ovinoidalis* at birth) groups of kids (mean ± SE).

<table>
<thead>
<tr>
<th>Group of kids</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-inoculated (n = 23)</td>
<td>Inoculated (n = 23)</td>
<td></td>
</tr>
<tr>
<td>Body weight at birth (kg)</td>
<td>3.9 ± 0.8</td>
<td>3.7 ± 0.5</td>
</tr>
<tr>
<td>Mean daily body-weight gain (g)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–33 d</td>
<td>179 ± 51</td>
<td>185 ± 32</td>
</tr>
<tr>
<td>33–61 d</td>
<td>178 ± 37</td>
<td>188 ± 36</td>
</tr>
<tr>
<td>61–77 d</td>
<td>43 ± 65</td>
<td>45 ± 64</td>
</tr>
<tr>
<td>77–102 d</td>
<td>128 ± 34</td>
<td>130 ± 27</td>
</tr>
<tr>
<td>0–102 d</td>
<td>144 ± 24</td>
<td>151 ± 18</td>
</tr>
</tbody>
</table>
pole et al (1993) obtained in suckling lambs demonstrated that the ingestion of colostrum did not prevent the immunization of lambs at birth with E ovinoideal.

Insofar as measured antibodies play a part in resistance to the disease (Gregory and Catchpole, 1989), the absence of specific pattern in the serological response for the inoculated group could indicate that no immune response occurred. Moreover, natural E ninakohlyakimovae infection in the control group, resulting in a slow rise of mean antibody titres from 33 d onwards, suggests that cross-reactions probably exist between E ovinoideal and E ninakohlyakimovae. According to Rose (1973), it is accepted that the specific antigens that elicit the immunity are associated with the schizogonic stages of the parasite. Thus the lack of immunization in kids receiving E ovinoideal in our study could be relevant to the concomitant absence of development of the endogenous stages as already observed for E ovina (sheep coccidia) in goats (Sayin et al, 1980). However, a partial immune response against E tenella was obtained by Augustine and Danforth (1989) in chickens after a heavy inoculation (10 times over 12 d) with a turkey coccidia despite the absence of development to any degree of the latter in chicken, sug-
gesting that sporozoite antigens might also contribute to the immunity (Jeffers and Long, 1985). Further investigations are needed to evaluate the effect of repeated inoculations in kids with E ovinoideal related to a development of resistance of E ninakohlyakimovae experimental challenge.

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