EFFECT OF TRANSPORTATION ON BLOOD SERUM COMPOSITION, DISEASE INCIDENCE, AND PRODUCTION TRAITS IN YOUNG CALVES. INFLUENCE OF THE JOURNEY DURATION


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EFFECT OF TRANSPORTATION ON BLOOD SERUM COMPOSITION, DISEASE INCIDENCE, AND PRODUCTION TRAITS IN YOUNG CALVES. INFLUENCE OF THE JOURNEY DURATION

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Résumé
EFFET DU TRANSPORT DES JEUNES VEAUX SUR LA BIOCHIMIE SÉRIQUE, LA PATHOLOGIE ET LES CARACTÉRISTIQUES DE PRODUCTION. INFLUENCE DE LA DURÉE DU VOYAGE. — Cette étude a été menée dans un circuit commercial coopératif. Soixante-deux veaux ont été répartis en deux groupes expérimentaux. Les animaux du premier groupe (circuit court) ont quitté l'exploitation d'origine dans la journée et sont arrivés à l'atelier d'engraissement le soir après passage dans un centre d'allotement. Les autres animaux (circuit long) sont restés au centre d'allotement, à la diète complète, pendant la nuit et ont parcouru 300 km en camion le lendemain avant de gagner l'atelier. Du sang a été prélevé sur chaque animal dans l'exploitation d'origine, à l'arrivée en atelier d'engraissement et une semaine plus tard afin de permettre une étude longitudinale des effets du transport. On a réalisé sur chaque prélèvement un bilan biochimique classique, un dosage de cortisol et d'immunoglobulines. De nombreux paramètres sériques ont été affectés par le transport sans que la longueur du voyage n'ait d'influence. Les animaux en circuit long ont présenté à l'arrivée à l'atelier d'engraissement une déshydratation mise en évidence par l'accroissement des concentrations sériques de protéines et de chlorures. Une semaine après l'arrivée, ces animaux présentaient une hypoglycémie importante (— 45 % par rapport aux taux de base) montrant que le plan de rationnement adopté ne permettait pas à ces animaux de récupérer le déficit énergétique induit par le transport et le jeûne associés. Alors que les caractéristiques de production n'ont pas été différentes entre les deux groupes, les animaux en circuit long ont présenté une fréquence plus élevée de problèmes pathologiques, en particulier respiratoires. Il n'est pas possible de relier directement l'augmentation de la pathologie et les modifications biochimiques constatées. Cette étude fournit une base biologique pour les diverses améliorations permettant de réduire les conséquences néfastes du transport sur la production du veau de boucherie.
Transport has long been recognized as a critical phase in animal production (Hails, 1978; Dantzer and Mormede, 1979). Calf production represents a special problem, due to the separation between those places where the calves are born and the intensive units where fattening takes place and to the very young age at which this transition occurs (calves are generally 1-3 weeks old when moved). This transfer, which can be up to 5 days long, consists of several transports, interrupted by stays in transit centers and markets. At the same time, calves from different origins are brought together and handled in accordance. It is recognized that the animals are given minimal care during this period. Possible improvement of the way the animals are treated is therefore of considerable interest, both in economic terms and from the point of view of animal welfare (Ewbank, 1973).

Restricted aspects of this problem have been dealt with in many studies (Snaw and Nichols, 1964; Hartmann et al., 1973b; Volker et al., 1973; Staples and Haugse, 1974; Groth and Granzer, 1975, 1977; Dvorak, 1975; Crookshank et al., 1979; Simensen et al., 1980; Morisse, 1982) but no comprehensive study has attempted to consider at the same time the whole range of effects produced by transport and to relate them to specific transport factors (Dantzer, 1982). The present work has been undertaken to provide a basic knowledge of the various effects of transport, which is a prerequisite to an analysis of the respective importance of the different factors involved and to suggest improvements in transport conditions.

The study was done in a commercial operation. Biological (blood biochemical profiles) and economical criteria (zootechnical performances and pathology scores) were used to assess the short-term and long-term effects of two different transport durations. The results provide biological support for the identification of those steps which can be improved to reduce the negative consequences of transport.

**Animals and Methods**

**Animals**

Sixty-two calves of both sexes (42 males and 20 females) from either the French Frisian (56) or the Norman (6) breed were included in this study. They were gathered during the same day (D) in the country-side around Rennes (Ille-et-Vilaine, France) in the normal commercial operation of a local cooperative. All these animals had been visited one or two days before, between 2:00 and 8:00 p.m. in the farm of origin, at which time data such as breed, sex, age, weight, birth conditions, colostrum distribution, were collected. The animals were said to be 4 to 32 days old (one third of the calves were 8 days old or less). The facts concerning birth and early postnatal life were however so vague that they could not be used. On the occasion of this visit, blood (20 ml) was collected from the jugular vein in siliconized, air-evacuated tubes, in order to obtain « basal » serum biochemical values.

**Treatments**

Three trucks gathered these animals among others starting at 7:00 a.m. The individual nutritional state of the animals at the time of removal was unknown and probably different from one farm to the other. The calves were unloaded at the transit center between 3:30 and 5:00 p.m., after a variable trucking time (1 to 8 hours, corresponding to 20 to 300 km). On their arrival in the center, the animals were weighed and randomly divided into two groups, according to a block design, with breed and sex as concomitant variables.

The two groups were subjected to a different length of journey. The animals in the « short journey » group (SJ; N : 32) were immediately loaded and trucked to the fattening unit where they arrived at 8:00 p.m. The animals in the « long journey » group (LJ; N : 30) spent the night in the transit center, without any food and water supply, as it is commonly the case. The next morning, they were loaded and trucked about 300 km and arrived at the fattening unit at 5:00 p.m. During both days the temperature and relative humidity were 10.5 °C-23 °C (min-max), 45-89 % RH.

**Maintenance conditions**

On arrival at the fattening unit, blood (20 ml) was taken from the jugular vein and afterwards the animals received warm (40 °C) tap water ad libitum. A third blood sample was taken one week later. Food distribution started the next morning, according to a classical schedule of limited (1.5 liter with 130 g/l of milk powder on the first day) and progressively increasing food intake, to avoid gastrointestinal disorders. The calves were individually fed in buckets twice a day. Growth food (23 % proteins and 18 % fat) was given until the 50th day and finishing food (22 % proteins and 22 % fat) thereafter until slaughtering on the 105th day.
The fattening unit was made of two air-controlled rooms. The mean daily temperature and relative humidity were 15.9-20.5 °C (min-max), 64-78 % RH in room A and 16.3-21.0 °C, 67-82 % RH in room B. The animals were on a slatted wooden floor and individually chained. Small wooden bars separated adjacent animals.

Body weight (every 2-3 weeks), hematocrit (at 0, 56 and 104 days), food consumption and pathological symptoms were regularly checked (every day). Pathology was rated according to frequency and severity (benign diarrhea or respiratory signs : 1 ; umbilical infection, profuse diarrhea or respiratory disease with therapeutic intervention : 3). A global score was given to each animal for the first three weeks of fattening.

**Biochemical analysis**

Blood samples were allowed to clot at room temperature and centrifuged. Aliquots of plasma were frozen pending analysis. A wide blood serum biochemical profile was performed on every sample together with cortisol and immunoglobulin levels.

The biochemical profile was done using a computer driven SMACR biochemical analyzer (Technicon Instruments Corporation, Tarrytown, USA). The procedures are briefly given in table 1 and most of them are fully described in Siest et al. (1981).

Serum cortisol levels were measured by a competitive protein-binding radioassay (Murphy, 1967), using dog serum (1 %) as the transcortin source, tritiated cortisol (107 Ci/mmol, CEA, Gif-sur-Yvette, France) as the tracer and dextran-coated charcoal as the adsorbent of free radioactivity. The cortisol level of the same plasma was measured 10 times, the mean value was 10.6 ng/ml and the standard deviation 1.17 ng/ml (coefficient of variation, 11.1 %).

Serum immunoglobulin levels (IgG) were measured by radial immunodiffusion (Mancini et al., 1965 ; Levieux, 1974).

<table>
<thead>
<tr>
<th>Biochemical parameter (unit)</th>
<th>Mean + SD</th>
<th>Analytical method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose (mmol/l)</td>
<td>4.67 ± 1.84</td>
<td>Glucose oxidase-peroxidase</td>
</tr>
<tr>
<td>Urea nitrogen (mmol/l)</td>
<td>3.60 ± 1.80</td>
<td>Diacetylmmonoxime</td>
</tr>
<tr>
<td>Creatinin (µmol/l)</td>
<td>106 ± 20</td>
<td>Alcaline picrate (Jaffe)</td>
</tr>
<tr>
<td>Uric acid (µmol/l)</td>
<td>65.1 ± 15.9</td>
<td>Phosphotungstate</td>
</tr>
<tr>
<td>Cholesterol (mmol/l)</td>
<td>2.42 ± 0.93</td>
<td>Liebermann - Burchard</td>
</tr>
<tr>
<td>Triglycerides (mmol/l)</td>
<td>0.409 ± 0.226</td>
<td>Enzymatic</td>
</tr>
<tr>
<td>Total Bilirubin (µmol/l)</td>
<td>3.54 ± 2.07</td>
<td>Diazoreaction (Jendrassik and Grof)</td>
</tr>
<tr>
<td>Albumin (µmol/l)</td>
<td>405 ± 42</td>
<td>Bromocresol green</td>
</tr>
<tr>
<td>Total proteins (g/l)</td>
<td>55.7 ± 8.3</td>
<td>Biuret</td>
</tr>
<tr>
<td>Immunoglobulins (g/l)</td>
<td>15.2 ± 9.3</td>
<td>Radial immunodiffusion (Mancini)</td>
</tr>
<tr>
<td>Sodium (mmol/l)</td>
<td>138.7 ± 6.6</td>
<td>Potentiometry (specific electrode)</td>
</tr>
<tr>
<td>Potassium (mmol/l)</td>
<td>5.61 ± 0.52</td>
<td>Potentiometry (specific electrode)</td>
</tr>
<tr>
<td>Chloride (mmol/l)</td>
<td>93.4 ± 5.8</td>
<td>Ferric nitrate - mercunc thioyanate</td>
</tr>
<tr>
<td>Calcium (mmol/l)</td>
<td>2.62 ± 0.24</td>
<td>Cresolptalein complexone</td>
</tr>
<tr>
<td>Inorganic phosphorus (mmol/l)</td>
<td>2.48 ± 0.33</td>
<td>Phosphomolybdate complex</td>
</tr>
<tr>
<td>Alkaline phosphatases (IU/l)</td>
<td>332 ± 163</td>
<td>p-nitrophenyl phosphate</td>
</tr>
<tr>
<td>GOT (IU/l)</td>
<td>39.4 ± 9.9</td>
<td>Enzymatic - UV spectrophotometry</td>
</tr>
<tr>
<td>GPT (IU/l)</td>
<td>14.3 ± 8.8</td>
<td>Enzymatic - UV spectrophotometry</td>
</tr>
<tr>
<td>LDH (IU/l)</td>
<td>785 ± 145</td>
<td>UV spectrophotometry</td>
</tr>
<tr>
<td>Cortisol (µg/l)</td>
<td>16.6 ± 15.4</td>
<td>Dog transcortin binding</td>
</tr>
</tbody>
</table>

a : except for immunoglobulins and GOT (52 animals) and GPT (50 animals).
b : Alkaline phosphatases = EC 3.1.3.1.
c : GOT = Glutamic oxaloacetic transaminase = aspartate aminotransferase = EC 2.6.1.1.
d : GPT = Glutamic pyruvic transaminase = alanine aminotransferase = EC 2.6.1.2.
e : LDH = Lactate dehydrogenase = EC 1.1.1.27.
Statistical analysis

Biochemical results were interpreted by two-way analysis of variance for repeated measures (Snedecor and Cochran, 1967; Gill and Hafs, 1971). Some animals were dropped from the analysis because of incomplete results. For most parameters, 27 animals remained in each group. A more complete study was performed by use of principal components and discriminant function analysis on the results obtained in the homogeneous group of Friesian calves with complete results (35 animals) (Berthier and Bouroche, 1975; Lebart et al., 1979; Fenelon, 1981). Usual statistical tests were also used when necessary (Schwartz, 1963; Lellouch and Lazar, 1974).

Results

1. Choice of blood sampling times

The times of blood sampling for biochemical analysis were chosen on the basis of the results of a preliminary experiment made on four calves submitted to a short journey. In these animals, blood was sampled (1) in the afternoon before transportation, (2) just before being loaded in the lorry, (3) 1 h 30 thereafter, (4) on arrival at the transit center, (5) on arrival at the fattening farm, (6) in the afternoon of the next day, and (7) one week later. Most of the biological changes observed (decrease of blood glucose, increase in serum total bilirubin, GOT, LDH) varied to a larger degree on arrival in the fattening unit (fig. 1). Eight days later, most serum biochemical parameters were back to control values (e.g. GOT, fig. 1b, serum total bilirubin and LDH). At that time, glycemia was still lowered (fig. 1a) and other changes were apparent, such as a decrease in serum calcium, inorganic phosphate and alkaline phosphatases (fig. 1c). On this basis, three sampling times (basal before transportation, on arrival in the fattening unit and one week later) were selected to retain full information on the kinetics of the biological effects of transportation.
2. Effect of transportation on blood serum composition

Influence of the duration of the journey

2.1. Basal serum biochemical values measured in blood obtained in the farm of origin are listed in table 1. The analysis of the values for 35 Friesian calves with complete results shows that the age of the animal at the time of sampling has a big influence on several parameters. Serum cortisol ($r = -0.677; \ P < 0.001$; fig. 2), bilirubin ($r = -0.500; \ P < 0.01$), immunoglobulins ($r = -0.454; \ P < 0.01$), total proteins ($r = -0.389; \ P < 0.05$) significantly decreased with age whereas serum albumin ($r = 0.573; \ P < 0.001$), cholesterol ($r = 0.497; \ P < 0.01$), chloride ($r = 0.436; \ P < 0.02$), inorganic phosphorus ($r = 0.388; \ P < 0.05$) and sodium ($r = 0.374; \ P < 0.05$) increased with age, at least within the limits of our sample (4 to 32 days).

2.2. Basal serum biochemical values were compared with those values measured (1) on arrival at the fattening unit (2) one week later, by two-way analysis of variance for repeated measures. Results are given in table 2.

2.2.1. Serum albumin and protides were increased on arrival at the fattening farm (fig. 3) and serum albumin was significantly higher in animals subjected to the long journey. One week later serum albumin was higher than basal level, whatever the duration of the journey. Serum immunoglobulin levels did not change upon transportation but were decreased one week later.

2.2.2. Numerous metabolites were modified after transport (fig. 4). Glucose levels were strongly depressed (-38 % in SJ group and -54 % in LJ group) on arrival at the fattening farm, but only serum bilirubin was significantly different according to the length of the journey. One week later, cholesterol levels were lowered, urea nitrogen increased, whatever the length of the journey. Conversely the hypoglycemia persisted and was larger in the LJ group (-45 % vs -17 % of basal values).

2.2.3. A transient increase of serum sodium and chloride levels (fig. 5) was observed on arrival at the fattening farm, and was more marked in the LJ group, at least for chloride levels. A system-
atic difference of basal serum potassium levels between groups masked an eventual transport effect. Serum calcium and alkaline phosphatase activity declined regularly during the experiment, without any effect of the journey length.

2.2.4. Serum lacticodehydrogenase (LDH) and aspartate aminotransferase (GOT) activities displayed an acute increase, without any influence of the journey length. Incomplete results showed that serum alanine aminotransferase (GPT) activity was not modified (fig. 6).

2.2.5. Serum cortisol levels were not different from basal values on arrival at the fattening farm. A large decrease was observed in both groups one week later.

In short, although numerous serum biochemical values were acutely affected by transportation and/or modified after one week in the fattening unit, very few parameters were able to discriminate animals according to the experimental group (short versus long journey group). At the end of the transport, the main difference between groups was found in serum albumin levels (+5.6 % and +14.0 % in SJ and LJ groups respectively). A discriminant analysis of the results obtained in 35 Friesian calves showed that 65.7 % of the animals were correctly classified using the information provided by the serum albumin levels on arrival at the fattening farm. The increase in serum chloride and total bilirubin was also larger in the LJ group. One week later the main difference between groups was in serum glucose levels: 80 % of the animals were correctly classified using this information. Hypoglycemia was more marked in the LJ group. This was the only significant difference between groups at that time.

Table 2. - F-values obtained in two-way analysis of variance for repeated measures for the comparison of basal serum biochemical values with those obtained on arrival at the fattening unit and one week later.

<table>
<thead>
<tr>
<th>Biochemical parameters</th>
<th>Group factor</th>
<th>Time factor</th>
<th>Interaction</th>
<th>Group factor</th>
<th>Time factor</th>
<th>Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose</td>
<td>0.47</td>
<td>82.65***</td>
<td>2.96</td>
<td>2.51</td>
<td>40.45***</td>
<td>8.80**</td>
</tr>
<tr>
<td>Urea nitrogen</td>
<td>1.16</td>
<td>28.90***</td>
<td>2.46</td>
<td>0.07</td>
<td>7.53**</td>
<td>0.04</td>
</tr>
<tr>
<td>Creatinin</td>
<td>0.03</td>
<td>4.56*</td>
<td>0.03</td>
<td>0.01</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Uric acid</td>
<td>0.13</td>
<td>11.72***</td>
<td>0.96</td>
<td>0.00</td>
<td>0.07</td>
<td>0.02</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>0.05</td>
<td>7.72***</td>
<td>1.18</td>
<td>0.95</td>
<td>18.56**</td>
<td>1.70</td>
</tr>
<tr>
<td>Triglycerides</td>
<td>0.35</td>
<td>8.15**</td>
<td>2.68</td>
<td>1.95</td>
<td>3.17</td>
<td>0.09</td>
</tr>
<tr>
<td>Total bilirubin</td>
<td>5.00</td>
<td>91.78***</td>
<td>5.74*</td>
<td>0.36</td>
<td>0.10</td>
<td>0.16</td>
</tr>
<tr>
<td>Albumin</td>
<td>0.60</td>
<td>51.91***</td>
<td>9.34**</td>
<td>0.73</td>
<td>36.49***</td>
<td>0.07</td>
</tr>
<tr>
<td>Total proteins</td>
<td>0.07</td>
<td>10.08***</td>
<td>3.96</td>
<td>0.59</td>
<td>0.01</td>
<td>0.04</td>
</tr>
<tr>
<td>Immunoglobulins</td>
<td>0.00</td>
<td>0.03</td>
<td>4.78*</td>
<td>0.04</td>
<td>9.33**</td>
<td>0.02</td>
</tr>
<tr>
<td>Sodium</td>
<td>0.22</td>
<td>9.51**</td>
<td>2.45</td>
<td>0.16</td>
<td>0.66</td>
<td>0.92</td>
</tr>
<tr>
<td>Potassium</td>
<td>0.44</td>
<td>3.14</td>
<td>3.64</td>
<td>8.80**</td>
<td>1.64</td>
<td>0.27</td>
</tr>
<tr>
<td>Chloride</td>
<td>1.13</td>
<td>39.41***</td>
<td>5.51*</td>
<td>0.02</td>
<td>1.71</td>
<td>0.96</td>
</tr>
<tr>
<td>Calcium</td>
<td>1.54</td>
<td>19.42***</td>
<td>0.04</td>
<td>2.70</td>
<td>34.87***</td>
<td>0.03</td>
</tr>
<tr>
<td>Inorganic phosphorus</td>
<td>0.01</td>
<td>0.44</td>
<td>0.34</td>
<td>1.41</td>
<td>3.23</td>
<td>2.63</td>
</tr>
<tr>
<td>Alkaline phosphatases</td>
<td>0.08</td>
<td>36.58***</td>
<td>0.00</td>
<td>0.01</td>
<td>66.77***</td>
<td>0.30</td>
</tr>
<tr>
<td>SGOT</td>
<td>0.24</td>
<td>37.27***</td>
<td>0.06</td>
<td>2.75</td>
<td>1.93</td>
<td>2.63</td>
</tr>
<tr>
<td>LDH</td>
<td>0.75</td>
<td>74.60***</td>
<td>1.17</td>
<td>0.30</td>
<td>9.19**</td>
<td>0.01</td>
</tr>
<tr>
<td>Cortisol</td>
<td>0.57</td>
<td>1.72</td>
<td>3.76</td>
<td>0.12</td>
<td>17.98***</td>
<td>0.53</td>
</tr>
</tbody>
</table>

a: except for immunoglobulins and SGOT 26 animals.
*: P<0.05; **: P<0.01; ***: P<0.001 (degree of freedom : 1 N - 2).
Fig. 3. — Mean values (± SEM) of serum proteins levels. Sample 1 was taken in the nursery, sample 2 on arrival at the fattening unit and sample 3 one week later. 27 calves per group. Short journey group (circles, broken lines), long journey group (squares, solid lines).

Fig. 4. — Mean values of serum organic metabolite levels. Same representation as in figure 3.
3. Production traits and disease

3.1. Four animals died during the fattening period. In both groups one calf died from the complications of a preexisting umbilical infection and two more calves in the LJ group died, one from gastroenteritis (Day 13) and the other from pleuropneumonia (Day 34).

3.2. Pathology data are given in table 3. During the first three weeks, 11 animals in the SJ group (out of 32) and 3 animals in the LJ group (out of 30) did not show any sign of disease ($X^2 = 5.04$, $P<0.05$). Without taking into account the dead animals, the mean rating of pathology was 2.47 in the SJ group and 3.78 in the LJ group, the major difference being observed for treated respiratory diseases (mean rating 0.94 and 2.56). The analysis of the variable « pathology » (as the total score from 1 to 21 days) by means of multiple regression analysis (35 Friesian calves) showed that the length of the journey had a highly significant influence ($F_{1,35} = 7.65; P = 0.018$). Furthermore, some basal biochemical variables (derived from the blood samples collected before transportation) were shown to influence significantly the pathology score: proteins ($F_{1,35} = 6.67; P = 0.024$); inorganic phosphate ($F_{1,35} = 5.72; P = 0.034$); immunoglobulins ($F_{1,35} = 4.75; P = 0.05$). These variables were shown to be correlated with the age of the animal (cf. § 2.1), which could suggest that the age factor was the most important. However, the pathology rating was not directly correlated with either age or serum cortisol levels (which are the most tightly correlated with age). The interrelations between these different variables are shown in figure 7, which derives from a multivariate analysis of the basal serum biochemical values, on which were projected the variables age and pathology.

3.3. The length of the journey did not modify any production trait (table 4). There was a non-significant trend for the mean daily weight gain to be lower in the LJ group. In both groups, the growth rate was nearly null during the first two weeks of fattening.

Discussion

1. Methodology

The aim of this study was a longitudinal, broad-spectrum analysis of the biochemical, technical and pathological consequences of the transfer of young calves from the nursery to the fattening unit. This transfer consists of a complex set of events (handlings, trucking, mixing, food and water deprivation, ...). We used the term « transportation » for the sake of simplification. The intensity of the aggression was experimentally manipulated through the length of the transfer. The animals leaving the nursery

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Table 3: - Pathology data (0-21 days).

<table>
<thead>
<tr>
<th>Duration of journey</th>
<th>Short</th>
<th>Long</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nb. animals</td>
<td>Total rating</td>
</tr>
<tr>
<td>Number of animals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>initial number</td>
<td>32</td>
<td>...</td>
</tr>
<tr>
<td>healthy</td>
<td>11</td>
<td>...</td>
</tr>
<tr>
<td>Pathological symptoms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>umbilical inflammation</td>
<td>6</td>
<td>18</td>
</tr>
<tr>
<td>diarrhea</td>
<td></td>
<td></td>
</tr>
<tr>
<td>benign</td>
<td>7</td>
<td>17</td>
</tr>
<tr>
<td>treated</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>respiratory symptoms</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>benign</td>
<td>8</td>
<td>30</td>
</tr>
<tr>
<td>treated</td>
<td>4</td>
<td>12</td>
</tr>
</tbody>
</table>

*a*: one benign was rated 1 and one treated episode was rated 3.
Fig. 5. — Mean values of serum levels of electrolytes, mineral elements and alkaline phosphatase activity. Same representation as in figure 3.

Fig. 6. — Mean values of serum enzymic activities and cortisol levels. Same representation as in figure 3. Numbers refer to the number of calves when different from 27.
during the day to reach the fattening unit on the evening of the same day may be seen as minimally disturbed (short journey group) when considering the normal commercial operations in which several day journeys are not uncommon, with several transit places such as transit centers, markets. An increased disturbance was induced in the long journey group, for which the transfer was 24 h longer, with a correlative increase in the number of handlings, in the distance travelled and in the duration of complete fasting.

2. Basal serum biochemical values

The population under study was composed of unselected commercial calves of apparent good health, kept in the farm of origin without any special care until transportation. Blood was taken during the afternoon from 2:00 to 8:00 p.m. so that the calves were sampled under different nutritional states. To our knowledge, this is the first published example of a large blood serum biochemical profile of young calves up to 1 month old. The values listed in table 1 generally correlate with those of other authors and it is difficult to analyse the origin of possible discrepancies due to the lack of studies devoted to the systematic analysis of factors affecting blood biochemistry in young calves, apart from the influence of age, ration and feeding time on some serum components (Stockl et al., 1965; Dalton, 1967; Stuhr et al., 1968; Reece and Wahlstrom, 1972 a and b; Michel, 1973; Cabello, 1976; Cabello and Michel, 1977; Grongnet and Michel, 1979). The main interest of the basal sample is to allow the study of the effect of transport through successive samplings in the same animals, used as their own control. Furthermore, the metabolic profile characterizes the initial physiological state of the animals and can be used as such to search for any risk factor likely to influence transport susceptibility or disease predisposition.

The age of the animal influences a number of serum biochemical values. The decrease of plasma corticosteroids in calves from birth to the second week of age is well-documented (Dvorak, 1971; Eberhart and Patt, 1971; Purohit and Estergreen, 1971; Hartmann et al., 1973a; Hudson et al., 1976; Lopez and Phillips, 1976; Bosc and Fève, 1977; Massip et al., 1977; Cabello, 1976, 1979, 1980), though absolute levels are highly variable between studies, due to different analytical techniques. The levels we
found in animals older than two weeks correlate with the values obtained by others with similar methods (binding assays with either transcortin or specific antibodies), i.e. lower than 10 ng/ml. The variations of cortisol according to age account for the large decrease of serum cortisol levels observed in blood samples collected one week after transport. The decrease in serum immunoglobulin levels and the increase in serum albumin levels may also be related to age changes, since both parameters are strongly correlated with age.

3. Effects of transportation on blood serum composition

3.1. Glucocorticoid levels in blood are generally considered to be a good index for the reaction of the animals to any environmental challenge (Dantzer and Mormède, 1979). In this study, serum cortisol reacted poorly to the transport situation. The preliminary experiment showed that a transient and low intensity increase could be observed on arrival at the transit center (fig. 1d). Such an acute change is consistent with data from other authors (Volker et al., 1973; Dvorak, 1975; Johnston and Buckland, 1976; Simensen et al., 1980). No significant change occurred in either group on arrival at the fattening farm. Other articles contain contradictory results on this point. Shaw and Nichols (1964) did not observe elevated levels of plasma 17-hydroxycorticosteroids in calves shipped from Montana to Wisconsin. Conversely, Crookshank et al. (1979) found a long-lasting increase of plasma cortisol after a 12-hour trucking. Numerous data, such as the age of the animals, are lacking in these reports, to allow further discussion on these discrepancies. It has been shown that the adrenal reactivity to an ACTH challenge increases with age and is not yet fully developed in one-week old calves (Hartmann et al., 1973a). Although few studies have been devoted to the developmental aspects of the hypophyso-adreno-cortical axis reactivity of young calves to environmental stimuli (Hartmann et al., 1974), it may be hypothesized that, due to their immaturity, the animals under study were relatively unreactive in their adrenocortical response to transportation and handling.

3.2. The increase in serum LDH and GOT activity in calves as a consequence of transport is well

![Fig. 7. — Multivariate analysis. Graph of the basal serum biochemical variables on two sections defined by the first three principal axis (axis 1 retained 24.2 % of the total variance, axis 2 : 13.7 %, axis 3 : 12.1 %). The variables AGE and PATHology were not included in the analysis but projected on the same sections. (ACU : uric acid ; ALB : albumin ; BIL : bilirubin ; CA : calcium ; CHO : cholesterol ; CL : chloride ; COR : cortisol ; CRE : creatinin ; GLU : glucose ; IgG : immunoglobulins ; K : potassium ; LDH : lacticdehydrogenase ; NA : sodium ; P : inorganic phosphate ; PAL : alkaline phosphatase ; PRO : total proteins ; SGO : aspartate aminotransferase ; SGP : alanine aminotransferase ; URE : urea nitrogen).]
documented (Groth and Granzer, 1975, 1977; Crookshank et al., 1979), the change in SGPT being very low if any. Such a dissociation in the release of different tissue enzymes was described by Nagaraja et al. (1979) in the reaction to bacterial endotoxin injection: serum GOT and LDH activities were shown to be increased, without any change in sorbitol dehydrogenase activity. SGPT predominantly originates from liver tissue, at least in human beings (Vincent-Viry et al., 1981), and its low increase under transportation suggests that serum LDH and GOT increases are of muscular origin, which hypothesis is corroborated by the concomitant increase in serum creatine phosphokinase (CPK) activity found by Groth and Granzer (1975, 1977) and Crookshank et al. (1979). Further basic studies of calf biochemistry are obviously needed to progress in the interpretation of such results.

Serum GOT and LDH activity increases were not dependent on the length of the journey and so did not give any indication on the severity of the treatment to which the animals were subjected, at least not within the limits of this study.

3.3. The main differential effect of the length of the journey on the acute biochemical changes induced by the transportation was in serum albumin and chloride. This can be interpreted as an effect of hemoconcentration which is present only in those animals deprived of water during two successive days (LJ group).

3.4. The hypoglycemia observed on arrival at the fattening farm cannot be accounted for exclusively by the effect of food deprivation (Reece and Wahlstrom, 1972b) but rather by its combination with an increased energetic demand induced by the transport and manipulations. This energetic deficit remained as such during at least one week, the hypoglycemia becoming larger in the LJ group. This might be the result of the low energy diet distributed to the animals at the beginning of the fattening period, which is a common practice to avoid digestive problems during this period of adaptation, and which results in a near null growth during the first two weeks of fattening. It is known (Hartmann et al., 1977) that hepatic glycogen stores drop to very low levels soon after birth so that the young calf has no energetic store to face up to an increased energetic output and/or a decreased energetic input. A more complete experimental study of the energetic balance of the animals during this period is obviously necessary to dissociate the respective influence of the initial fasting and its duration, the transport itself and its length, and the hypocaloric diet during the early fattening period.

3.5. The parallel decline of serum calcium and alkaline phosphatase activity during the period under study suggests the existence of a functional link between both parameters. This decrease cannot be accounted for by an effect of age change since Grongnet (personal communication) did not observe any significant variation of either serum calcium (mean level 2.79 mmol/l) or serum alkaline phosphatase (mean level 238 IU/l) in 30 Holstein x Friesian calves bled at 1, 2 and 3 weeks of age confirming the results of Stuhr et al. (1968) for alkaline phosphatases. This phenomenon is clearly induced by the transport and becomes more marked afterwards. An increased urinary calcium excretion has been described in sheep (Berman et al., 1980) submitted to cold stress and a long-lasting decline in calcemia has been shown in dairy heifers after an injection of corticotropin (Wegner and Stott, 1972), but it is not clear whether this is a general stress response. Serum alkaline phosphatase is considered to reflect the activity of bone metabolism, at least in young human beings (Henny and Schiele, 1981) and the decrease observed here could just be another aspect of the general growth deficit.

3.6. No acute effect of transportation on serum immunoglobulin levels was observed and the decline afterwards may be attributed to an age effect. This result is at variance with the one obtained by Simensen et al. (1980), who first reported a slight and short-lasting decrease of serum IgG under the same conditions. The differences in blood sampling times between both experiments could account for the discrepancies and further studies will be necessary to confirm these results.

Basic knowledge of the young calf serum biochemistry is generally lacking so that some conclusions remain speculative until further work is done. The effect of the transport itself on serum biochemistry, especially when considering its long-term effect, is superimposed on those of other factors such as age and diet, the influence of which is clearly evident from the present results. Other less obvious factors, such as physical (temperature, humidity) or psychological components of the environment could also be of importance. A complex set of components may also be recognized in the acute effect of transport. Careful studies will be necessary to
dissociate the respective influence of these various factors.

4. Technical performances and pathology

4.1. The growth-rate of the calves was very low during the first two weeks of the fattening period, and was not significantly different between groups. Further performances were unaffected by the length of the journey. The restricted food intake schedule imposed from the beginning of the fattening period to avoid gastrointestinal disorders is obviously severe, as evidenced by the growth rate during this period and by biological signs such as blood sugar and possibly serum calcium and alkaline phosphatase or serum cholesterol levels, which are all depressed at the end of the first week of fattening. It would be important to carefully evaluate the benefits of such a drastic reduction of food intake in preventing dietary upsets as compared to its bad influence on growth performances and possibly on the incidence of pathological changes.

4.2. The mortality rate observed in this experiment (6.3 %) was rather high and directly related to the lack of previous selection of the calves, even in the case of unsatisfactory health state at the beginning of the study (umbilical infection or signs of diarrhea). Twelve animals (out of 62) required treatment for umbilical infection.

4.3. Total pathology was significantly different among groups, with a main difference in respiratory diseases. « Transport stress » is generally considered to have an influence on subsequent respiratory pathology (Espinasse, 1977; Meissonier et al., 1977) but no study has attempted to dissociate the differential influence of initial health state, dehydration during transport, energetic imbalance, etc., as causative factors of this predisposition. Staples and Haugse (1974) observed that death losses and sickness within four weeks of purchase were higher when calves were fed with milk replacer as starting feed, rather than whole or skim milk, suggesting an important role of the initial nutritional program. The energetic deficit induced by fasting and/or transportation is intensified by the initially restricted food intake, and is far larger in the long journey group. The influence of this energetic deficit on the pathology incidence cannot be appreciated directly from our results.

Conclusion

The major consequences of a long-lasting transfer of young calves from the nursery to the fattening unit were found to be (1) at the biochemical level, an acute dehydration and a chronic hypoglycemia, and (2) an increased incidence of pathology. The relationship between biochemical and clinical findings is at present unknown and is worthy of further investigation. Dehydration can be directly related to water deprivation. Conversely, the profound and long lasting hypoglycemia results from the interaction of transport induced increase of energetic output, fasting during the transfer and restricted food intake schedule used at the beginning of the fattening period to avoid gastrointestinal disorders, and is therefore of complex origin.

This study provides biological support for different improvements which could reduce the negative consequences of transport:

- In the nursery, besides the classical rules of the young calf management (such as umbilical disinfection which could reduce the incidence of further umbilical pathology), it would be wise to avoid putting on the market too young animals, which are probably predisposed to pathology in the early fattening period.
— During the transfer from the nursery to the fattening unit, food and water have to be provided to the animals. This is a reglementary disposition (Décret 80-791, 1st October 1980, Journal Officiel de la République Française, 5th October 1980, pp. 2326-2328) which is not currently applied in the field, due to inappropriate equipment of transit centers.

— During the early fattening period, the benefits of a drastic reduction of food intake has to be evaluated and compared to its cost for the animal which has to recover from the energetic losses induced by the transport.

In each case, requirements for the economy of veal calves production and for the well-being of the animals are not different.

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Summary

This study was done in the normal commercial operation of a local cooperative in the western part of France. Sixty-two veal calves were randomly divided into two groups. The animals of the first group (short journey) left the farm of origin and arrived at the fattening unit in the evening of the same day after a short passage in a transit center. The animals of the other group (long journey) remained in the transit center, without any food or water supply during the night and were trucked about 300 km before arriving at the fattening unit. Blood was sampled in the farm of origin, on arrival at the fattening unit and one week later in order to allow a longitudinal study of the effects of transportation. A wide blood serum biochemical profile was performed on every sample together with cortisol and immunoglobulin levels. Numerous parameters were modified by the transportation but not by the journey duration. An acute dehydration was apparent in the long journey animals, in the form of an increase in plasma proteins and chloride concentrations on arrival at the fattening unit. One week later serum glucose levels remained low in this group (−45% when compared to basal levels) showing that the feeding regimen was not able to make up the long journey induced energetic deficit. Though production data were not different between the two experimental conditions, the animals in the long journey group displayed an increased incidence of respiratory disease. This study provides a biological basis for improvements likely to reduce the negative consequences of transport in veal calves.

References


