The EWpa system, the actualised Dutch net energy system for horses

Dr. Machiel C. Blok, Central Bureau Livestock Feeding (CVB), Product Board Animal Feed, Lelystad, The Netherlands

1. **EWpa: the actualised net energy system for horses that has replaced the VEP system**

1.1 Why was the VEP system actualised?
- The Dutch feed industry asked for an update of the system
- In the Netherlands several VEP systems, using different data, were used
- CVB wished to re-evaluate the table with digestibility data for horses

1.2 CVB also actualised the energy requirement part of the system

2. **Calculation of the EWpa value of ingredients**

2.1 Both the VEP and EWpa system are based on the UFC system of INRA (Vermorel & Martin Rosset)

2.2 Calculation of GE (Gross energy):
- Both in the VEP and EWpa system the formulas of the Dutch net energy system for ruminants (VEM) system are used:
  - GE (kJ/kg DM) = 24,1*CP + 36,6*CFat + 20,9*CFibre + 17,0*Nfe – 0,63*Sug
  - Corn silage: GE (kJ/kg DM) = 19456 – 19,456 CAsh
- DE (kJ/kg DM) = (0,034 + f + 0,9477*dOM)/100*GE
  - no difference between the UFC and EWpa system
  - for dOM (in %) digestibility's in horses are used
  - different values for dOM in UFC and Ewpa system may/will be used

2.3 ME (kJ/kg DM) = (93,96 – 0,02356*CFibre – 0,217*CP)/100*DE
  - Difference to the UFC system: in the UFC system 3 ME formulas are used

2.4 NEm (kJ/kg DM) = (k_m*(ME – 31,3*CFat) + 0,80*31,3*CFat)/1000
  - The CVB is the opinion that de NE value of dFat is underestimated in the UFC system.
  - Therefore we use the above formula (in both the VEP and EWpa system),

2.5 In the EWpa system ‘Starch determined with amylglucosidase method’ is used, instead of Starch determined with the Ewers method. Therefore in the EWpa system there are two k_m formulas for products from the oil industry:
  a. Linseed, rape seed and soybean products
    - k_m = (68,04 – 0,004261 * CP + 0,01566 * (Starch + Sug))/100
  b. All other product from oil industry
    - k_m = (67,03 – 0,004261 * CP + 0,01566 * (Starch + Sug))/100

2.6 EWpa = Energiewaarde paard (= Energy value horse)
- EWpa (in DM) = NEm / 8,93
  - Where 8,93 = NEm of 1 kg DM ‘standard oat’ (see for calculation of the NEm value of ‘standard oat’ Appendix 1.
- EWpa (in product) = NEm (in DM) / 8,93 * DM/1000

2.5 Comparison of net energy values for some ingredients between the UFC system of INRA and the EWpa system of CVB

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1 For these products, starch determined with the Ewers method is an artefact; the k_m formula for these products has been derived pragmatically from that under b.
3. Actualisation of energy (and protein) requirements

3.1 Basic principles for the calculation of the energy requirements:

**EWpa compared to VEP**

- Maintenance: not modified
- Gestation: modified
- Lactation: not modified
- Growth: modified
- Work/exercise: not modified

3.2 Maintenance requirements

3.2.1 Energy requirements for maintenance

- Expressed as EWpa/BW^{0.75}/d

<table>
<thead>
<tr>
<th>Age (month)</th>
<th>0-6</th>
<th>7-12</th>
<th>13-36</th>
</tr>
</thead>
<tbody>
<tr>
<td>EWpa/BW^{0.75}/d</td>
<td>0.0495</td>
<td>0.0464</td>
<td>0.0443</td>
</tr>
</tbody>
</table>

- Growing horses

<table>
<thead>
<tr>
<th>Age (month)</th>
<th>0-6</th>
<th>7-12</th>
<th>13-36</th>
</tr>
</thead>
<tbody>
<tr>
<td>EWpa/BW^{0.75}/d</td>
<td>0.0495</td>
<td>0.0464</td>
<td>0.0443</td>
</tr>
</tbody>
</table>

- Adult horses

<table>
<thead>
<tr>
<th>Adult</th>
<th>Underbred</th>
<th>Thoroughbred</th>
</tr>
</thead>
<tbody>
<tr>
<td>mare/gelding</td>
<td>0.0390</td>
<td>0.0411</td>
</tr>
<tr>
<td>stallion</td>
<td>0.0432</td>
<td>0.0453</td>
</tr>
</tbody>
</table>

3.2.2 Protein requirement for maintenance

- Expressed as g/BW^{0.75}/d

- For foals till 6 months: 3.5
- After 6 months: 3.0

3.3 Requirements during gestation

3.3.1 Energy requirements for gestation

- In the EWpa system (as in the VEP system) pregnant mares should receive extra energy as from 8 months of gestation
- In the VEP system birth weight was a constant percentage of adult weight. In the EWpa system birth weight depends on the (expected) adult weight:

<table>
<thead>
<tr>
<th>BW_{adult} (kg)</th>
<th>100</th>
<th>200</th>
<th>400</th>
<th>800</th>
</tr>
</thead>
<tbody>
<tr>
<td>BW_{t=0} (% of adult weight)</td>
<td>14.2</td>
<td>12.0</td>
<td>10.0</td>
<td>8.5</td>
</tr>
</tbody>
</table>

- Formula to calculate the extra EWpa requirement for gestation: 
  Ewpagestation (p.day) = growth_{foetus}^{GE_{foetus}}^{1\text{gestation}}/8.93
where \( f_{\text{gestation}} = k_m/k_{\text{gestation}} = 3 \)

- Formula for growth of foetus:
  \[
  \text{growth}_{\text{foetus}} = (\text{BW}_{t=0} + 0.02 \times \text{BW}_{\text{mare}}) \times \frac{\text{PG}}{100} / 30.5
  \]
  with: \( \text{BW} = \) body weight (kg);
  \( \text{BW}_{t=0} = \) birth weight of foal;
  \( \text{PG} = \) growth of foetus per month in % of birth weight

3.3.2 **Protein requirements for gestation**

Extra digestible protein (DCPh) requirement during gestation (g per kg of growth):

<table>
<thead>
<tr>
<th>month</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>extra DCPh</td>
<td>296</td>
<td>360</td>
<td>360</td>
<td>426</td>
</tr>
</tbody>
</table>

3.5 **Requirements for lactation**

3.5.1 **Energy requirements for lactation**

- Basic principles not modified

In EWpa system: \( \text{EW}_{\text{palac}} = \frac{\text{BW} \times m \times \text{GE}_{\text{milk}} \times f_{\text{lac}}}{8.93} \)

where

- \( f_{\text{lac}} = k_m/k_{\text{lac}} = 1.25 \)
- \( m = \text{kg milk/100 kg BW} \) (dependent on BW mare and month of lactation)
- \( \text{GE}_{\text{milk}} \) is variable, depending on the month of lactation

- Values for ‘m’ (kg milk per 100 kg BW):

<table>
<thead>
<tr>
<th>Mare</th>
<th>month 1</th>
<th>month 2-3</th>
<th>month 4-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \leq 200 \text{ kg} )</td>
<td>3.0</td>
<td>3.5</td>
<td>3.0</td>
</tr>
<tr>
<td>&gt; 200 kg</td>
<td>2.5</td>
<td>3.0</td>
<td>2.5</td>
</tr>
</tbody>
</table>

- \( \text{GE}_{\text{milk}} \) (MJ/kg):

<table>
<thead>
<tr>
<th>Month of lactation</th>
<th>1</th>
<th>2-3</th>
<th>4-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{GE}_{\text{milk}} )</td>
<td>2.41</td>
<td>2.09</td>
<td>1.99</td>
</tr>
</tbody>
</table>

3.5.2 **Protein requirements for lactation**

- Extra protein requirement during lactation

<table>
<thead>
<tr>
<th>month</th>
<th>1</th>
<th>2-3</th>
<th>4-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCPh (g/kg milk)</td>
<td>50</td>
<td>44</td>
<td>40</td>
</tr>
</tbody>
</table>

3.6 **Requirements for growth**

3.6.1 **Energy requirements for growth**

Advised growth development in the VEP system was based on previous research of Praktijkonderzoek Paardenhouderij, Lelystad

**Explanation:**

- lichaamsge wicht = body weight;
- groei (g/dag) = growth (g/day);
- leeftijd in weken = age in weeks
- Results from research of Ellis & Van Tilburg on relation growth rate - OCD
  a. In the OCD positive group growth was higher than in the OCD negative group
  b. Advised growth development in the VEP system appeared to be higher than the mean growth in the OCD positive group
  c. Growth development in the German system (DLG) fits well with that of the OCD negative group

- Arguments for a different growth development in Ewpa system Compared to the VEP system
  a. Growth rate is one of the factors determining the risk for OCD
  b. Pony’s and small horses reach the adult weight at an earlier age than large horses

- Basic principles for the growth development in Ewpa system are based on the German system (DLG, 1994):
  a. BW birth is a variable % of the adult BW
  b. Pony’s and small horses reach the adult weight at an earlier age than large horses
  c. Fat and protein accretion have been adopted also from the DLG system (as was also the case in the VEP system)

- Relation birth weight – adult weight (DLG, 1994)

<table>
<thead>
<tr>
<th>Adult weight (kg)</th>
<th>Birth weight (%)</th>
<th>Birth weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>14,2</td>
<td>14,2</td>
</tr>
<tr>
<td>200</td>
<td>12,0</td>
<td>23,9</td>
</tr>
<tr>
<td>300</td>
<td>10,8</td>
<td>32,3</td>
</tr>
<tr>
<td>400</td>
<td>10,0</td>
<td>40,0</td>
</tr>
<tr>
<td>500</td>
<td>9,5</td>
<td>47,5</td>
</tr>
<tr>
<td>600</td>
<td>9,1</td>
<td>54,9</td>
</tr>
<tr>
<td>700</td>
<td>8,7</td>
<td>60,9</td>
</tr>
<tr>
<td>800</td>
<td>8,5</td>
<td>67,0</td>
</tr>
</tbody>
</table>

- Growth development in % of adult weight (DLG. 1994)

<table>
<thead>
<tr>
<th>Age (months)</th>
<th>Weight (in % of adult weight) at the following adult weights (ABW)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100</td>
</tr>
<tr>
<td>0</td>
<td>14,2</td>
</tr>
<tr>
<td>2</td>
<td>28</td>
</tr>
<tr>
<td>6</td>
<td>49</td>
</tr>
<tr>
<td>12</td>
<td>72</td>
</tr>
<tr>
<td>24</td>
<td>92</td>
</tr>
<tr>
<td>36</td>
<td>100</td>
</tr>
</tbody>
</table>

- Fat- and protein content in the body (DLG, 1994)
  a. Fat content: $F_p\ (%\ of\ live\ weight) = 0,1388\ p + 1,11$
  b. Protein content: $P_p\ (%\ of\ live\ weight) = 0,22\ (100 – F_p)$
  where:
  $F_p = fat\ content\ in\ horse\ (in\ %);\ p = %\ of\ adult\ weight\ at\ age\ x;\ P_p = protein\ content\ in\ horse\ (in\ %)$

- Modelling growth of horses by CVB using the data of DLG (1994)
  a. Develop growth curves for the growth development of the 8 adult weights given by DLG
  b. Develop a relation between birth weight and adult weight
  c. Develop a relation ‘exponential growth parameter’ and adult weight
  d. Develop a formula for the growth rate (g/d)
  e. Model fat and protein accretion
• Development of growth curves
  Model used: \( Y = (\text{ABW} - \text{BW}_{t}) = (\text{ABW} - \text{BW}_{t=0})e^{-bt} \)
  where
  \( \text{BW}_{t} \) = weight at moment \( t \) (kg); \( \text{ABW} \) = adult weight (kg); \( \text{BW}_{t=0} \) = birth weight (kg); \( b \) = exponential growth parameter; \( t \) = age (months)
  For two adult body weights the growth curves are given in Figure 1 and 2.

![Figure 1](attachment:figure1.png)  ![Figure 2](attachment:figure2.png)

• Relation birth weight - adult weight
  a. DLG gives information on the birth weight corresponding to the adult weight (for 8 adult weights)
  b. CVB used this information to develop a relation between birth weight and adult weight (see Figure 3)

![Figure 3](attachment:figure3.png)

• Formula for growth rate
  a. Weight development during time \( t \) in months:
    \( \text{BW}_{t} \) (kg) = \( \text{ABW} - (\text{ABW} - \text{BW}_{t=0})e^{-bt} \)
  b. Growth rate (GR\(_{BW}\)) is the first derivative of the formula describing the weight development
    \( \text{GR}_{BW} \) (g/d) = \( b \times (\text{ABW} - \text{BW}_{t=0}) \times 1000/30.5 \)

• Modelling fat accretion
  a. Starting point was the DLG formula: \( F_{p} \) (% of BW) = 0.1388 \( p + 1.111 \)
b. This relation is used to develop a formula for fat accretion (FA):
\[ FA (g/d) = (2 \times 0.1388/ABW \times BW_t + 0.01111) \times GRBW \]
with:
- \( GRBW \) according to the previous formula

- Modelling protein accretion
  a. Starting point was the DLG formula: \( Pp \) (\% of live weight) = 0.22 (100 - \( Fp \))
  b. From this relation a formula for protein accretion (PA) was derived:
\[ PA (g/d) = 0.22 \times (1 - FA_{growth}) \times GRBW \]

- Calculation of energy requirements for growth
  a. Information is needed about a) the expected adult weight and b) the actual age
  b. \( EWpa_{growth} = (0.03931 \times FA \times ffa + 0.02294 \times PA \times fpa)/8.93 \)
    with:
    - \( ffa = km/kfa = 0.75/0.75 = 1 \)
    - \( fpa = km/kpa = 0.75/0.45 = 1.667 \)
    so:
    \[ EWpa_{growth} = (0.03931 \times FA \times 1 + 0.02294 \times PA \times 1.667)/8.93 \]

3.6.2 Protein requirements for growth
- \( DCPh_{growth} = PA/0.45 \) (in g/d)
- Till 6 months: 5 - 6 g lysine/100 g DCPh

3.7 Requirements for work

3.7.1 Energy requirements for work
- Extra energy allowance to maintenance requirements for enhanced metabolism during work (in \( EWpa/LG^{0.75} \)): 0.0021
- Energy requirements for work according to the formula of Pagan and Hintz (1986):
\[ Y = e^{(3.02+0.0065X)} - 13.92 \] (in cal/kg/min)
  or
  \[ NE_{work} (MJ/kg/min) = ((e^{(3.02+0.0065X)} - 13.92) \times 4.184 \times 10^{-6}) \]
  or
  \[ EWpa_{work} (p.kg/min) = ((e^{(3.02+0.0065X)} - 13.92) \times 4.184 \times 10^{-6})/8.93 \]

- Classes of work
  I: All sports recreation to Light level, Recreation step, trot and gallop, e.g. wood ride; riding-school work
  II: All sports Medium to Heavy
  III: All sports Heavy to very Heavy, national / international
  IV: Eventing, trot and racing sport, national / international

- Intensity of the work in minutes per hour for different gaits

<table>
<thead>
<tr>
<th>Class</th>
<th>Step km/hr</th>
<th>Trot m/min</th>
<th>Gallop km/hr</th>
<th>Jumping m/min</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>7</td>
<td>120</td>
<td>32</td>
<td>720</td>
<td>60</td>
</tr>
<tr>
<td>II</td>
<td>14</td>
<td>240</td>
<td>34</td>
<td>720</td>
<td>60</td>
</tr>
<tr>
<td>III</td>
<td>14</td>
<td>360</td>
<td>10</td>
<td>720</td>
<td>60</td>
</tr>
<tr>
<td>IV</td>
<td>12</td>
<td>400</td>
<td>9</td>
<td>720</td>
<td>60</td>
</tr>
</tbody>
</table>
- Energy consumption (EWpa/min per kg) for different weights of (horse + rider).

<table>
<thead>
<tr>
<th>Speed per kg</th>
<th>Horse and rider (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>200+50</td>
</tr>
<tr>
<td>7.2</td>
<td>0.0144</td>
</tr>
<tr>
<td>14.4</td>
<td>0.0392</td>
</tr>
<tr>
<td>21.6</td>
<td>0.093</td>
</tr>
<tr>
<td>24.0</td>
<td>0.123</td>
</tr>
<tr>
<td>32.4</td>
<td>0.315</td>
</tr>
<tr>
<td>43.2</td>
<td>1.028</td>
</tr>
</tbody>
</table>

- Extra energy and protein allowance for work (EWpa and g DCPh per hr)

<table>
<thead>
<tr>
<th>Extra EWpa and VREP for work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight horse + rider + harness (kg)</td>
</tr>
<tr>
<td>Extra to Maintenance Class</td>
</tr>
<tr>
<td>I</td>
</tr>
<tr>
<td>II</td>
</tr>
<tr>
<td>III</td>
</tr>
<tr>
<td>IV</td>
</tr>
<tr>
<td>IV</td>
</tr>
</tbody>
</table>
Appendix: Calculation of the EWpa value of standard Oat

Chemical composition of oat that was used as 'standard oat'

<table>
<thead>
<tr>
<th>Component</th>
<th>g/kg</th>
<th>g/kg DM</th>
<th>g/kg</th>
<th>g/kg DM</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM</td>
<td>889</td>
<td>1000</td>
<td>CFibre</td>
<td>105</td>
</tr>
<tr>
<td>CAsh</td>
<td>26</td>
<td>29,2</td>
<td>Nfe</td>
<td>605</td>
</tr>
<tr>
<td>CP</td>
<td>104</td>
<td>117,0</td>
<td>Sug (sugars)</td>
<td>13</td>
</tr>
<tr>
<td>CFat</td>
<td>49</td>
<td>55,1</td>
<td>Starch</td>
<td>394</td>
</tr>
</tbody>
</table>

Digestibility
dOM (%) = 71

Calculation GE (kJ/kg DM)
If Sug > 80 g/kg DM

GE = 24.1 CP + 36.6 CFat + 20.9 CFibre + 17.0 Nfe - 0.63 SUG*

If Sug ≤ 80 g/kg DM

GE = 24.1 CP + 36.6 CFat + 20.9 CFibre + 17.0 Nfe

Calculation GE per kg DM of Oat:

GE = 24.1 * 117.0 + 36.6 * 55.1 + 20.9 * 118.1 + 17.0 * 680.5
GE = 18873 kJ/kg DM

Calculation of dE(%)
dE(%) = 0.034 + 1.1 + 0.9477* dOM

dE(%) = 0.034 + 1.1 + 0.9477* 71.0

dE(%) = 68,43

Calculation of DE (kJ/kg DM)

DE = dE /100 * GE

DE = 68,43/100*18873 = 12915 kJ/kg DM

Calculation of ME (kJ/kg DM)

ME = (93.96 - 0.02356*CFibre - 0.0217* CP )/100 * DE

ME = (93.96 - 0.02356*118.1 - 0.0217* 117.0)/100 * 12915
ME = 11448 kJ/kg DM

Calculation km

For cereals and seeds km is calculated as follows:

km = (72.34 + 0.0119 * CFibre - 0.0081 * CP + 0.0112  (Starch + Sug))/100

km = (72.34 + 0.0119 * 118.1 - 0.0081 * 117 + 0.0112  (443.2 + 14.6))/100

km = 0,779255

Calculation of NEm (kJ/kg DM)

NEm = km * (ME- 31.3 * CFAT) + 0.80 * 31.3 CFAT

NEm = 0.7793* (11448- 31.3 * 55.1) + 0.80 * 31.3* 55.1
NEm = 8956 kJ/kg DM

Further calculations in DM

NEm (MJ/kg DM) = NEm (kJ/kg DM) /1000 = 8956/1000 = 8,96 MJ/kg DM

EWpa (/kg DM) = NEm (MJ/kg DM)/ 8.93 = 1,00 /kg DM

Further calculations in fresh product

NEm (MJ/kg) = NEm (MJ/kg DM) * DM /1000 = 8,956*889/1000 = 7,96 MJ/kg

EWpa (/kg ) = EWpa (/kg DM) * DM /1000 = 1,00*889/1000 = 0,89 /kg DM