Basic calculations for feeding animals

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How many lawyers does a T. rex need per year?

Body mass T. rex 5000 kg
Energy requirement ‘endotherm’ 293 kJ/KM^{0.75}/d * 2 = 348'440 kJ/d
‘ectotherm’ 29 kJ/KM^{0.75}/d * 2 = 34'844 kJ/d

Body mass lawyer 70 kg
Energy content lawyer 7000 kJ/kg

T. Rex requires 0.7 lawyers/day or 260/year (‘endotherm’)
0.1 lawyers/day or 26/year (‘ectotherm’)

from Spielberg et al. (1993)
Food requirements of ... anything

Requirements do not scale linearly with body mass (to body mass^{1.00}).

This means that for the same food, larger animals need less food in % body mass, but the same amount in body mass^{0.75}.
Morphological, physiological and life history variables scale with body mass.

Linear scaling: \[ y = a \cdot B M^{1.0} \] or \[ \log y = \log a + 1.0 \cdot B M \]

If this is correct, you can use “mg/kg” or “% of body mass”

In other words, if you use “mg/kg” or “% of body mass” you are implying that the scaling is linear

If scaling is not linear, you need “another measure” = allometry

Allometric scaling: \[ y = a \cdot B M^{b} \] or \[ \log y = \log a + b \cdot B M \]
Morphological, physiological and life history variables scale with body mass.

**Linear scaling:**
\[ y = a \cdot BM^{1.0} \]
or \[ \log y = \log a + 1.0 \cdot BM \]

**Allometric scaling:**
\[ y = a \cdot BM^b \]
or \[ \log y = \log a + b \cdot BM \]

(Allometric scaling mostly explained by geometry – e.g. surface-volume shifts, distribution networks etc.)

1 cube
6 surfaces
ratio 6:1

8 cubes
24 surfaces!
ratio 24:8 = 3:1
Geometric scaling

- Volume
- Length
- Surface

64 cubes

Measurement (number of units)

Mass (number of cubes)
Geometric scaling

- Volume: $y = x^1$
- Length: $y = 6x^{0.67}$
- Surface: $y = x^{0.33}$

Mass (number of cubes) vs. Measurement (number of units)
Geometric scaling

![Graph showing geometric scaling relationships]

- **Volume**: $y = x^1$
- **Length**: $y = 6x^{0.67}$
- **Surface**: $y = x^{0.33}$

**Surface:Volume ratio**
- 6:1
- 3:1
- 1.5:1
Geometric scaling

- **Volume**: $y = x^{1.5}$
- **Length**: $y = x^{0.33}$
- **Surface**: $y = x^{0.75}$

**Surface:Volume ratio**

- 6:1
- 3:1
- 1.5:1

**Equations**

- $y = 6x^{0.67}$
- $y = x^1$
- $y = x^{0.33}$

**Chart**

- Measurement (number of units) vs. Mass (number of cubes)
1. Requirement estimate
   - estimate (or weigh) body mass
   - estimate maintenance requirement (e.g., from Basal Metabolic Rate = BMR)
BMR = 293 (kJ ME) * W (kg) 0.75

Maintenance ≈ 2 * 293 (kJ ME) * W (kg) 0.75

Remember: BMR is a requirement in ME (metabolizable energy).
Not GE (gross energy)!
Not DE (digestible energy)!
1. Requirement estimate
   - estimate (or weigh) body mass
   - estimate maintenance requirement (e.g., from Basal Metabolic Rate = BMR)

2. Estimate metabolizable energy content in food
   - from tables, using various equations (e.g., dog & cat NRC)
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<th>Omnivore</th>
<th>Herbivore</th>
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<tr>
<td>grass</td>
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<td>0.5</td>
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</tr>
<tr>
<td>hay</td>
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*Table 23.3: Approximate metabolisable energy densities of some foods*
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### Table 23.3: Approximate metabolisable energy densities of some foods (kcal/g fresh weight). (1 kcal = 4.184 kJ.)

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*dry matter of hay: 90% of fresh weight*
*dry matter of grass: 25% of fresh weight*
Nutrition of Captive and Free-Living Wild Animals

James K. Kirkwood

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4. Monitor and adjust continuously!
But what about diets with several components?

All items must be part of the calculation & weighing/counting.

If animals must be fed as a group, the least-preferred item should be given first, when all are hungry and will eat it, before more preferred items are offered.

If one item cannot be weighed practically (like forages), they are offered ad libitum, assuming the animals will eat enough of them (adjust forage as necessary).
But what about diets with several components?

All items must be part of the calculation & weighing/counting.

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No problem if you really monitor and adjust continuously.

If one item cannot be weighed practically (like forages), they are offered ad libitum, assuming the animals will eat enough of them (adjust forage as necessary).