GROWTH, HUSBANDRY, AND DIETS OF FIVE SUCCESSFULLY HAND-REARED ORPHANED GIRAFFE CALVES (GIRAFFA CAMELOPARDALIS ROTHSCILDI AND GIRAFFA CAMELOPARDALIS RETICULATA)

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Source: Journal of Zoo and Wildlife Medicine, 50(1) : 205-218

Published By: American Association of Zoo Veterinarians

URL: https://doi.org/10.1638/2018-0016
GROWTH, HUSBANDRY, AND DIETS OF FIVE SUCCESSFULLY
HAND-REARED ORPHANED GIRAFFE CALVES (GIRAFFA
CAMELOPARDALIS ROTHSCHILDII AND GIRAFFA
CAMELOPARDALIS RETICULATA)


Abstract: Giraffe in the wild are in ongoing decline because of poaching and habitat loss and fragmentation,
and were recently assessed as “vulnerable” on the IUCN (International Union for Conservation of Nature) Red
List of Threatened Species. Captive breeding and saving each individual are therefore becoming more important
to save this species from extinction. This paper describes the husbandry and diets of successfully hand-reared
Rothschild’s giraffes (Giraffa camelopardalis rothschildii; n = 3) and reticulated giraffes (Giraffa camelopardalis
reticulata; n = 2). All calves were initially fed with bovine colostrum followed by cow’s milk (Holstein milk;
Holstein milk with 10% of bovine colostrum; Jersey and Guernsey milk). Additionally, lactase enzymes (Lactaid®,
Johnson & Johnson Inc., Guelph, Ontario N1K1A5, Canada) and probiotics (Probios®, Vets Plus, Inc.,
Menomonie, WI 54751, USA) were used. Average growth varied from 764 to 1,239 g/day from birth until 2
mo of age and between 508 and 1,161 g/day from birth until last measurement before weaning. Hand-reared calves
gained up to 21 cm in height within the first month and 82–138% of their birth weight during the first 2 mo. The
giraffes were weaned at 6 (n = 1), 8 (n = 3), and 11.5 (n = 1) mo and successfully socialized and introduced to other
giraffes. The described diets and husbandry proved to be effective in all five calves. Large amounts of cow’s milk
per feeding (up to 6 L) did not result in gastrointestinal problems.

Key words: Giraffa, growth measurements, hand-rearing, maternal rejection, nutrition.

INTRODUCTION

Because of poaching, human population growth, and habitat loss and fragmentation,
giraffes were recently assessed as “vulnerable” on the IUCN (International Union for Conservation of Nature) Red
List of Threatened Species. Overall the population declined 36–40% in three decades, with a decline of about
80% in the reticulated giraffe (Giraffa camelopardalis reticulata) in the past 15 yr to less than
8,700 individuals. As a result, this subspecies was categorized as “endangered” by the IUCN,
and the Nubian giraffe (Giraffa camelopardalis camelopardalis) and Kordofan giraffe (Giraffa
camelopardalis antiquorum) are now classified as “critically endangered.” Saving each individual
is important to the genetic diversity of endangered species, with hand-rearing being one of the possible contributions. Neonatal calves in the wild have a high mortality rate of about 50%.
Maternal rejection is not uncommon, especially in captive giraffes. Hand-rearing giraffes has been described as difficult, time-consuming, and labor-intensive. Appropriate milk replacement is critical and the composition of milk replacers must be similar to giraffe’s milk to guarantee optimal and steady growth. Despite lower fat and protein contents of cow’s milk and milk replacers in comparison with giraffes’ milk (Table 1), bovine milk and colostrum have been successfully used and recommended for hand-rearing giraffes. Adequate colostrum administration is essential in ungulates because of the lack of intrauterine immunoglobulin transfer. Insufficient colostrum quantity and quality is associated with immune deficiency, polyarthritis, and phlegmon in hand-reared giraffes. The calf’s growth rate should be monitored to evaluate the efficacy of the milk replacer, as reference data about growth in giraffes are limited. Large individual variations among calves complicate the development of general advice and guidelines. Another challenge to overcome is the possibility of mal-imprinting, which can lead to reduced
This paper discusses the complete and successful hand-rearing protocols of three *G. c. rothschildi* and two *G. c. reticulata* calves on different formulas in different institutions. Detailed information about growth obtained by measurements of total height and withers (\(n = 3\)), weight (\(n = 4\)), and chest girth (\(n = 1\)) of hand-reared (\(n = 4\)) and dam-raised (\(n = 2\)) calves are provided.

### CASE REPORTS

The background information of the study animals (\(n = 5\); C1–C5), two male and one female Rothschild's giraffe and two female reticulated giraffes, reared in different institutions from 2007 to 2013, is found in Table 2. Gender, year and location of birth, the parity of dam, the reason for hand-rearing, the equipment used, diet and feeding technique, age of weaning, housing, re-introduction, growth measurements taken, neonatal health monitoring, vitamin supplementation, and health issues were included. The detailed recordings of the feeding schemes are presented in Table 3. Limited data of the first calf of C1’s dam, hand-reared in 2010 (C6), and of two mother-raised Rothschild’s giraffe calves (male: C7; female: C8) both born in 2010 in African Lion Safari, Canada, are included for comparison. C6 was hand-reared on Holstein milk only and weaned at 8 mo of age. Measurements of weight (C1, C2, C4–C8; Fig. 1), total height (C1, C4–C8; Fig. 2), withers (C1, C4–C8; Fig. 3), and chest girth (C1; Fig. 4) are given.

### DISCUSSION

Maternal rejection and initial hand-rearing considerations

Maternal negligence in wild giraffes is associated with weak and less viable calves, as maternal instincts are stimulated by an active calf that rises quickly and reaches for the udder. However, in captivity, nervousness and aggressive behavior of giraffes are common. Fear towards humans and a decreased sexual fitness are also observed.

### Table 1. Fat, protein, and lactose contents of giraffe’s colostrum and milk, Holstein milk (used in C2, C4, C5, and C6), bovine colostrum, sheep milk, and different formulas used for hand-rearing giraffe *Giraffa* sp. calves.

| Species | DM (%) | Fat (%) | Protein (%) | Lactose (%) | Energy (kcal/L) 
<table>
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</thead>
<tbody>
<tr>
<td>Giraffe</td>
<td>22.8–37.0</td>
<td>12.5–17.0</td>
<td>5.9–17.0</td>
<td>3.4</td>
<td>1,621–2,667</td>
</tr>
<tr>
<td>Milk</td>
<td>18,32,34</td>
<td>25.7</td>
<td>7.94 ± 1.72</td>
<td>4.90 ± 0.86</td>
<td>6.62 ± 0.66</td>
</tr>
<tr>
<td>Cattle</td>
<td>13</td>
<td>17.3 ± 1.4</td>
<td>7.2 ± 1.1</td>
<td>6.3 ± 1.4</td>
<td>3.0 ± 0.8</td>
</tr>
<tr>
<td>Holstein</td>
<td>19,39</td>
<td>12.2</td>
<td>3.5</td>
<td>3.1</td>
<td>4.9</td>
</tr>
<tr>
<td>Colostrum</td>
<td>27.6</td>
<td>6.7</td>
<td>14.9</td>
<td>2.5</td>
<td>1,565</td>
</tr>
<tr>
<td>Sheep</td>
<td>18.1</td>
<td>6.82</td>
<td>5.59</td>
<td>4.88</td>
<td>1,138</td>
</tr>
</tbody>
</table>

### Used hand-rearing formulas

- **Holstein milk + 10% colostrum (C1)**: 4.4\(^c\) 4.6\(^c\) 4.7\(^c\) 853
- **Gold Top\(^TM\) milk (C3)**: 5.0\(^d\) 3.7\(^e\) 4.7\(^e\) 857
- **100 g Denkovit\(^b\) + 1 L water**: 1.7\(^d\) 2.2\(^e\) 4.1\(^e\) 444
- **Evaporated milk diluted 1:1 with water**: 3.3\(^d\) 3.3\(^e\) 5.0\(^e\) 689
- **Cow’s milk (3.5% fat)**: 3.8\(^e\) 4.0\(^e\) 4.8\(^e\) 767
- **Gold Top\(^TM\): milk of Jersey and Guernsey cow’s, Graham’s Family Dairy, FK94RW Stirling, UK.**
- **Denkovit\(^b\): artificial milk replacer for dairy calves, Murray Goulburn Cooperative Footscray, Victoria 3006, Australia. This product is no longer manufactured.**

### Notes
- \(^a\) Calculation of kilocal/L milk or milk replacer made by an equation used in bovine calves for an estimation of the energy content of the milk feed: cal/kg = 5.7 protein% + 9.2 fat% + 3.95 lactose%.
- \(^b\) Contents of diets given of the final composition (on wet basis).
- \(^c\) Calculated by the authors based on average contents of Holstein milk (average fat and protein contents of HF in Flemish farms in 2013, CRV; lactose\(^c\)) and bovine colostrum.
- \(^d\) Information given by manufacturer (Gold Top\(^TM\): milk of Jersey and Guernsey cow’s, Graham’s Family Dairy, FK94RW Stirling, UK).
- \(^e\) Calculation made by the first author according to manufacturer’s information (Denkovit\(^b\): artificial milk replacer for dairy calves, Murray Goulburn Cooperative Footscray, Victoria 3006, Australia. This product is no longer manufactured."

This paper discusses the complete and successful hand-rearing protocols of three *G. c. rothschildi* and two *G. c. reticulata* calves on different formulas in different institutions. Detailed information about growth obtained by measurements of total height and withers (\(n = 3\)), weight (\(n = 4\)), and chest girth (\(n = 1\)) of hand-reared (\(n = 4\)) and dam-raised (\(n = 2\)) calves are provided.

Fear towards humans and a decreased sexual fitness are also observed.

This paper discusses the complete and successful hand-rearing protocols of three *G. c. rothschildi* and two *G. c. reticulata* calves on different formulas in different institutions. Detailed information about growth obtained by measurements of total height and withers (\(n = 3\)), weight (\(n = 4\)), and chest girth (\(n = 1\)) of hand-reared (\(n = 4\)) and dam-raised (\(n = 2\)) calves are provided.
Table 2. The background information of five hand-raised giraffe calves C1, C2, C3, C4, and C5 (Giraffa camelopardalis rothschildi and Giraffa camelopardalis reticulata): gender, year and location of birth, parity of dam and reason for hand-rearing, equipment used, diet and feeding technique, age of weaning, housing, reintroduction, growth measurements taken, neonatal health monitoring, vitamin supplementation, and health issues.

<table>
<thead>
<tr>
<th></th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>C5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td>♂</td>
<td>♂</td>
<td>♂</td>
<td>♂</td>
<td>♂</td>
</tr>
<tr>
<td><strong>Species</strong></td>
<td>Rothschild giraffe</td>
<td>Rothschild giraffe</td>
<td>Reticulated giraffe</td>
<td>Reticulated giraffe</td>
<td>Rothschild giraffe</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td>Bellewaerde Park, Belgium</td>
<td>Albuquerque Biopark, USA</td>
<td>Africa Alive, UK</td>
<td>African Lion Safari, Canada</td>
<td>African Lion Safari, Canada</td>
</tr>
<tr>
<td><strong>Year</strong></td>
<td>2013</td>
<td>2013</td>
<td>2013</td>
<td>2007</td>
<td>2010</td>
</tr>
<tr>
<td><strong>Parity of dam</strong></td>
<td>Multiparous (third calf)</td>
<td>Multiparous (eighth calf)</td>
<td>Primiparous</td>
<td>Primiparous</td>
<td>Primiparous</td>
</tr>
<tr>
<td><strong>Reason for hand-rearing</strong></td>
<td>Aggression towards calf (rejected previous two and fourth calves)</td>
<td>Weak bonding with calf resulting in its failure to suckle (reared previous calves)</td>
<td>Aggression towards calf</td>
<td>Refused to let calf suckle, although showing normal maternal behavior</td>
<td>Aggression towards calf</td>
</tr>
<tr>
<td><strong>Initial feedings</strong></td>
<td>Fresh bovine colostrum; D2,3: colostrum alternating with electrolytes</td>
<td>Fresh bovine colostrum mixed with 10 g Probios® and 20 mL sodium bicarbonate</td>
<td>Fresh bovine colostrum</td>
<td>Bovine freeze-dried colostrum mixed with 2 % fat cow's milk; D2: + maternal colostrum</td>
<td>Bovine freeze-dried colostrum</td>
</tr>
<tr>
<td><strong>Follow up diet</strong></td>
<td>Holstein milk with bovine colostrum (10%), Holstein milk only from M4: W1: consuming fibers, W4: consuming concentrates</td>
<td>Holstein milk; D5: consuming fibers</td>
<td>Gold Top milk©</td>
<td>Cow's milk (3 % fat) with Lactaid© (10 drops/L); W1: consuming fibers, W4: consuming concentrates</td>
<td>Cow's milk (3 % fat) with Lactaid© (10 drops/L)</td>
</tr>
<tr>
<td><strong>Feeding equipment</strong></td>
<td>Soft yellow calf teat (20 × 2.5 cm) fixed on a 2-L bottle</td>
<td>Stomach tube for calves, black rubber calf teat on a 2-L bottle</td>
<td>Stomach tube for calves, small calf teat (9.5 × 2 cm)</td>
<td>Black rubber lamb teat; dish</td>
<td>Soft black rubber lamb's teat (5 cm) on a 1-L bottle, red rubber calf teat on a 2-L bottle</td>
</tr>
<tr>
<td><strong>Feeding technique</strong></td>
<td>Acceptance of bottle feeding on D1 when standing with the bottle held at udder height</td>
<td>Tube feeding twice daily while sitting with eyes covered; acceptance of bottle on D4; conditioned to approach feeding area by showing bucket lid</td>
<td>Tube feeding until D4; acceptance of bottle on D5</td>
<td>Refused bottle feeding; acceptance of dish on D2; trained to approach feeding area voluntarily</td>
<td>Acceptance of bottle feeding on D1 when standing with the bottle held at udder height</td>
</tr>
<tr>
<td></td>
<td>C1</td>
<td>C2</td>
<td>C3</td>
<td>C4</td>
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<td>-----------------------------------------</td>
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<td>-----------------------------------------</td>
</tr>
<tr>
<td><strong>Age of weaning</strong></td>
<td>250 days</td>
<td>8 M</td>
<td>243 days</td>
<td>188 days</td>
<td>350 days</td>
</tr>
<tr>
<td><strong>Housing</strong></td>
<td>Initially housed individually, with visual, auditory, and olfactory stimulation and physical contact with a primiparous end-of-term giraffe</td>
<td>Initially housed individually, with visual, auditory and olfactory stimulation from other giraffes</td>
<td>Initially housed individually separated with a mesh with visual, auditory, and olfactory stimulation and physical contact</td>
<td>Housed with dam; once trained to approach the pen door for feedings, within the giraffe herd during daytime</td>
<td>Initially housed individually, with visual, auditory, and olfactory stimulation from other giraffes and physical contact</td>
</tr>
<tr>
<td><strong>Reintroduction into herd</strong></td>
<td>Successfully introduced in W7 to female that had lost own calf during birth. Separated as calf refused to suckle. Introduction to herd in M7.</td>
<td>Under supervision in W3</td>
<td>Under supervision in W3</td>
<td>Housed with dam</td>
<td>Under supervision in W15</td>
</tr>
<tr>
<td><strong>Growth measurements taken</strong></td>
<td>Weight; total height (head to floor), withers (shoulder to floor); chest girth (at broadest point of the chest)</td>
<td>Weight</td>
<td>Not taken</td>
<td>Weight; total height (head to floor), withers (shoulder to floor)</td>
<td>Weight; total height (head to floor), withers (shoulder to floor)</td>
</tr>
<tr>
<td><strong>Neonatal health monitoring</strong></td>
<td>Daily rectal temperature until D5 Plasma sample:* Total protein: 8.1 g/dL Total globulin (G): 5.2 g/dL, α-G: 1.4 g/dL, β-G: 0.9 g/dL, γ-G: 2.9 g/dL</td>
<td>No specific actions taken</td>
<td>Daily rectal temperature until D4; preventive antibiotics (Excenel®, 1 mg/kg intramuscularly (i.m.) once a day (s.i.d.), D1–2)</td>
<td>Daily rectal temperature until D45; plasma transfusion:* 300 mL paternal plasma intrajugular at D2; plasma sample: values N/A; preventive antibiotics (Excenel®, 1 mg/kg, i.m., s.i.d., D2–9)</td>
<td>Plasma sample: values N/A</td>
</tr>
<tr>
<td>C1</td>
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<td>C5</td>
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<tr>
<td><strong>Vitamin supplementation</strong></td>
<td>Rovisol® E-Se, 1 mL orally (p.o.), twice a day (b.i.d.), D5–6</td>
<td>Enfamil® Poly-Vi-Sol® with iron, 1 mL p.o., b.i.d., D4–5</td>
<td>Abidec®, 6 drops, p.o., D2</td>
<td>Dystosel®, 1.5 mL s.c., D1</td>
<td></td>
</tr>
<tr>
<td><strong>Health issues</strong></td>
<td>None</td>
<td>None</td>
<td>Hypothermia D1–3; diarrhea W3 treated with antibiotics (Duphatrim® IS, 5 mL, i.m., s.i.d., for 3 days)</td>
<td>None</td>
<td>Constipation until D5, repeatedly treated with rectal enemas of 50 mL (50% water + 50% lubricating jelly)</td>
</tr>
</tbody>
</table>

* D = day, W = week, M = month.
* Probios® (Probiotics), Vets Plus, Inc., Menomonie, WI 54751, USA.
* Gold Top™ (milk of Jersey and Guernsey cows), Graham’s Family Dairy, FK94RW Stirling, UK.
* Lactaid® (lactase enzymes), Johnson & Johnson Inc., Guelph, Ontario N1K1A5, Canada.
* Analyzed in Medic Lab, 9300 Aalst, Belgium.
* Excenel® 50 mg/mL, Zoetis UK Limited, EC4A 3AE London, UK.
* Collected with a 450-mL blood pack unit (Anticoagulant Citrate Phosphate Dextrose Solution, USP [CPD], Baxter Healthcare Corporation, Deerfield, IL 60015, USA); separation of plasma in laboratory.
* Excenel® 50 mg/mL (Ceftiofur), Zoetis Canada Inc., Kirkland QC H9H4M7, Canada.
* Rovisol®E-Se (Vitamin E and selenium supplement), Orcovet, 3500 Hasselt, Belgium.
* Enfamil® Poly-Vi-Sol® with iron (multivitamin), Mead Johnson & Company, Chicago, IL 60606, USA.
* Emcelle® Tocopherol (Vitamin E supplement), Stuart Products, Bedford, TX 76022, USA.
* Abidec® multivitamin drops, Omega Pharma Ltd., SW1V 2SA London, UK.
* Dystosel® injection (Vitamin E and selenium supplement), Zoetis Canada Inc., Kirkland, QC H9H4M7, Canada.
* Duphatrim® IS (sulfadiazine + trimethoprim), Zoetis, UK Limited, EC4A 3AE London, UK.
Table 3. Feeding schemes used for hand-rearing giraffe *Giraffa* sp. calves C1, C2, C3, C4, and C5: feedings per day, volume per feeding in liters (L) and total volume in liters (in parentheses).

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<th>C4</th>
<th>C5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>D1</strong></td>
<td>7×/day: 0.6 (2.5)</td>
<td>2×/day: 0.64+ 0.8 (1.4)</td>
<td>2×/day: 2.0+ 1.0 (2.5)</td>
<td>2×/day: 1.0 (2)</td>
<td>3×/day (1.8)</td>
</tr>
<tr>
<td><strong>D2</strong></td>
<td>8×/day: 0.75 (6.0)</td>
<td>2×/day: 1.0 (2)</td>
<td>1×/day: 2.75 (2.75)</td>
<td>4×/day: 0.05 + 0.15 + 0.2 + 0.25 (0.65)</td>
<td>5×/day</td>
</tr>
<tr>
<td><strong>D3</strong></td>
<td>6×/day: 0.75 (4.5)</td>
<td>2×/day: 1.0 (2)</td>
<td>2×/day: 2.0 (4.0)</td>
<td>4×/day: 1.0 (4.0)</td>
<td>4×/day (3.44)</td>
</tr>
<tr>
<td><strong>D4</strong></td>
<td>6×/day: 0.75 (4.5)</td>
<td>4×/day: 1.0 (4.0)</td>
<td>1×/day: 2.0 (2.0)</td>
<td>4×/day: 1.0 (4.0)</td>
<td>4×/day (4–10: Amount increasing but variable)</td>
</tr>
<tr>
<td><strong>D5</strong></td>
<td>6×/day: 0.75 (4.5)</td>
<td>4×/day: 1.5 (6.0)</td>
<td>3×/day: 0.5 + 0.3 + 0.4 (1.2)</td>
<td>4×/day: 1.2 (4.8)</td>
<td>4×/day (4–10)</td>
</tr>
<tr>
<td><strong>W1–2</strong></td>
<td>5×/day: 1.0 (5.0)</td>
<td>4×/day: 2.1 (8.4)</td>
<td>4×/day: 2.0–4.0 (2.3–8.0)</td>
<td>4×/day: 1.3 (5.2)</td>
<td>4×/day (4–10)</td>
</tr>
<tr>
<td><strong>W2–3</strong></td>
<td>5×/day: 1.3 (6.5)</td>
<td>4×/day: 2.4 (9.6)</td>
<td>4×/day: 2.0–4.0 (2.3–8.0)</td>
<td>4×/day: 1.5 (6.0)</td>
<td>4×/day (4–10)</td>
</tr>
<tr>
<td><strong>W3–4</strong></td>
<td>5×/day: 1.6 (8)</td>
<td>4×/day: 2.4 (9.6)</td>
<td>3×/day: 2.0–4.0 (5.1–9.1)</td>
<td>4×/day: 1.6 (6.6)</td>
<td>4×/day (4–10)</td>
</tr>
<tr>
<td><strong>W4–5</strong></td>
<td>4×/day: 1.8 (7.2)</td>
<td>4×/day: 2.7 (10.8)</td>
<td>3×/day: 2.0–4.0 (5.1–9.1)</td>
<td>4×/day: 1.8 (7.2)</td>
<td>4×/day (4–10)</td>
</tr>
<tr>
<td><strong>W5–8</strong></td>
<td>4×/day: 3.0 (first + last feeding) + 2.7 (middle feedings) (11.4)</td>
<td>3×/day: 2.0–4.0 (5.1–9.1)</td>
<td>4×/day: 2.0 (8.0)</td>
<td>4×/day (4–10)</td>
<td></td>
</tr>
<tr>
<td><strong>M2–3</strong></td>
<td>4×/day: 1.8 (7.2)</td>
<td>4×/day: 3.2 (first + last feeding) + 2.7 (middle feedings) (11.8)</td>
<td>3×/day: 2.0–4.0 (5.1–9.1)</td>
<td>3×/day: 3.0 (9.0)</td>
<td>4×/day (4–10)</td>
</tr>
<tr>
<td><strong>M3–4</strong></td>
<td>4×/day: 1.8 (7.2)</td>
<td>4×/day: 3.2 (first + last feeding) + 2.7 (middle feedings) (11.8)</td>
<td>2×/day: 4.0–5.0 (3.9–10.0)</td>
<td>2×/day: 4.0 (8.0)</td>
<td>3×/day (8–11)</td>
</tr>
<tr>
<td><strong>M4–6</strong></td>
<td>3×/day: 1.6 (4.8)</td>
<td>4×/day: 3.2 (first + last feeding) + 2.7 (middle feedings) (11.8)</td>
<td>2×/day: 6.0 (up to 11.4)</td>
<td>2×/day: 4.0 (8.0)</td>
<td>3×/day (8–11)</td>
</tr>
<tr>
<td><strong>M5–6</strong></td>
<td>2×/day: 1.6 (3.2)</td>
<td>3×/day: 3.2 (9.6)</td>
<td>4.5 M: 1×/day: 6.0 (6.0)</td>
<td>5 M: 1×/day: decreasing from 4.0 to 3.0 to 2.0</td>
<td></td>
</tr>
<tr>
<td><strong>M7–8</strong></td>
<td>2×/day: 1.6 (3.2)</td>
<td>1×/day: 3.2 (3.2)</td>
<td>1×/day: 6.0 (6.0)</td>
<td>1×/day: 1.0 (1.0)</td>
<td>3×/day (8–11)</td>
</tr>
<tr>
<td><strong>M7–8</strong></td>
<td>2×/day: 1.6 (3.2)</td>
<td>1×/day: 3.2 (3.2)</td>
<td>1×/day: 6.0 (6.0)</td>
<td>2×/day (decreasing from 9.0 to 8.0 to 7.0)</td>
<td></td>
</tr>
<tr>
<td><strong>M8–8.5</strong></td>
<td>1×/day: 1.6 (1.6)</td>
<td>1×/day: 3.2 (3.2)</td>
<td>1×/day: 6.0 (6.0)</td>
<td>2×/day (6)</td>
<td></td>
</tr>
<tr>
<td><strong>M8.5–9</strong></td>
<td>2×/day: 1.6 (3.2)</td>
<td>2×/day (5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>M9–9</strong></td>
<td>2×/day (4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>M10–10.5</strong></td>
<td>2×/day (2–3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>M10.5–11</strong></td>
<td>1×/day (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>M11–11.5</strong></td>
<td>1×/day (0.5)</td>
<td></td>
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</tbody>
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* D = day, W = week, M = month.
* Tube feeding.
* Offered volume.
* Actual intake.
the dam towards her offspring during its attempts to stand is the most common reason for hand-rearing, and was also the case with C1, C3, and C5. This behavior is primarily seen in primiparous females, as the mothers of C3 and C5. These females will usually exhibit it on consecutive occasions as well, as seen with C1. Sedation of the dam, although suggested to facilitate acceptance of the offspring, has not always been successful in practice, and was therefore not practiced here. Other dams may show normal maternal behavior but disallow the calf to suckle (C4), ignore it completely (C2), or suffer from agalactia. A single calf has been documented to be assisted with suckling the dam until it was strong enough to reach for the udder on its own. In most settings, no other dam is available to adopt the calf, but allonursing is very common in giraffes and one giraffe has been documented to have reared two calves at a time successfully.

The acceptance of bottle feeding, adequate colostrum quantity, and tolerance of milk replacer are critical steps. Because adequate colostrum quantity during the first days is essential, tube feeding, although stressful, is advised if the newborn refuses to suckle. C1 and C5 accepted the bottle during the first day, but C2 and C3 needed tube feeding for up to 4 days. Successfully used teats include the standard red rubber calf teat (C5), a soft yellow calf teat (C1), a smaller calf teat (C3), and lamb teats (C5). C4 was trained to consume milk from a trough, as was practiced in an unrelated case. A calf born in the wild and orphaned at a few months old started consuming milk from a bucket that was floated in a water trough (Tracy, pers. comm.). To avoid bonding with one person, all calves in this study were fed by at least two keepers.
Because intestinal absorption of immunoglobulin is not species-specific in ungulates, bovine colostrum is advised for all artiodactyls, including giraffes. This was administered in all calves reared from birth (C1–C6 and Table 4). In C4, maternal colostrum was added to bovine colostrum.

**Figure 2.** Measurements of the total height of three hand-reared (C1: --○--, C4: --○--, C5: -●-) and of two mother-raised Rothschild giraffe *Giraffa camelopardalis rothschildi* calves (C7: – – , C8: –△–), with δδ shown in a continuous line and χχ shown in a dashed line.

**Diet composition and nutrient intake**

**Figure 3.** Measurements of height of withers of three hand-reared (C1: --○--, C4: --○--, C5: -●-) and of two mother-raised Rothschild giraffe *Giraffa camelopardalis rothschildi* calves (C7: – – , C8: –△–), with δδ shown in a continuous line and χχ shown in a dashed line.
Cow’s milk and calf milk replacers were successfully used for rearing giraffes,\textsuperscript{2,3,13,22,38} including all giraffes in this study (C1–C6), despite the differences in content (Tables 1 and 4). Higher lactose concentration in cow’s milk was suggested as possible cause for gastrointestinal problems seen in hand-reared giraffes,\textsuperscript{3} especially when feeding large quantities, as described for other species.\textsuperscript{36} Recent analysis of early lactation giraffes’ milk, however, found lactose concentrations even higher than those of Holstein milk (Table 1).\textsuperscript{32} Lactase enzymes (Lactaid\textsuperscript{t}, Johnson \\& Johnson Inc., Guelp, Ontario N1K1A5, Canada) (C4, C5) and probiotics (Probios\textsuperscript{t}, Vets Plus, Inc., Menomonie, WI 54751, USA) (C2), which proved to be effective in diarrhea prevention in hand-reared cattle,\textsuperscript{40} were added to the milk in this study. None of these calves showed signs of gastrointestinal problems. C1 received Holstein cow’s milk supplemented with 10\% of bovine colostrum until 4 mo old, as suggested for giraffe calves.\textsuperscript{17} Besides higher fat and protein levels of this diet if compared to cow’s milk only (Table 1), this provides local lactogenic immunity against gastrointestinal infections.\textsuperscript{12} Jersey and Guernsey milk (Gold Top\textsuperscript{t}, Graham’s Family Dairy, Stirling FK94RW, UK) with higher fat and protein than Holstein milk (Table 1), was used in C3. Sheep’s milk, despite fat and protein concentrations comparable to giraffes’ milk and the highest energy amount if compared to the used milk formulas (Table 1), has not been reported for use in giraffes. It was considered as formula for C1 but not used because of low availability. Other institutions added Protifar\textsuperscript{t} (protein-rich powder of concentrated cow’s milk protein; Nutricia Advanced Medical Nutrition, 2719 EP Zoetermeer, The Netherlands; Safaripark Beekse Bergen, pers. comm.), Kalbi-Phosphoral\textsuperscript{t}2000 (vitamins, minerals and probiotics; H. Wilhelm Schaumann GmbH, 25421 Pinneberg/Hamburg, Germany)\textsuperscript{4} or evaporated milk,\textsuperscript{41} mixed cow’s milk with calf milk replacer (NantaMilk Bronze\textsuperscript{t}; Nanta SA, Tres Cantos, Madrid 28760, Spain)\textsuperscript{3} or used a calf milk replacer only (Denkovit\textsuperscript{t}; Murray Goulburn Cooperative Footscray, Victoria 3006, Australia. This product is no longer manufactured.).\textsuperscript{2} For neonatal mammals in general, feeding 10–15\% of the animal’s body weight per day is recommended.\textsuperscript{17} However, large amounts per feeding (>2 L) or per day (>9 L) were suspected to predispose giraffe calves for diarrhea.\textsuperscript{3} Giraffes produce up to 10 L milk daily\textsuperscript{b} but milk capacity of the udder (0.5–2 L)\textsuperscript{18} probably restricts the amount per feeding in mother-reared calves. Nevertheless, hand-reared calves took amounts of up to 6 L per feeding (C3) and of >10 L per day (C2, C5)\textsuperscript{3} without problems (Table 3).

In accordance with published guidelines\textsuperscript{11,17,20} most calves received 4–6 feedings daily in their first weeks (C1–C6)\textsuperscript{2,3,13,41} and 3–4 feedings until 5–6 mo (C1, C2, C5),\textsuperscript{41} with the exception of a calf reared at Sri Chamarajendra Zoological gardens, India, which was fed six times daily until 5 mo.\textsuperscript{22} In contrast, C3 and C4 were only fed twice daily before 3 mo old, but were receiving the same total amount as the mentioned calf in India. This was because of reducing handling and labor (C3) and inconsistent drinking (C4). Hand-reared calves showed interest for solid food within the first month (C1–C6).\textsuperscript{2,3,22,42}

![Figure 4. Measurements of chest girth (cm) in relation to age in a hand-reared \( \delta \) Rothschild giraffe \emph{Giraffa camelopardalis rothschildi} (C1).](https://complete.bioone.org/journals/Journal-of-Zoo-and-Wildlife-Medicine/0022-451X/10/1/213/full/82516f849c0b583a2ed528123e77848e)

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\textsuperscript{b}Terms of Use: https://complete.bioone.org/terms-of-use
Health monitoring and support

Insufficient passive immunity has been associated with health issues in young giraffes. Transfer of passive immunity from colostrum was therefore assessed by measurements of serum antibody levels with tests (protein electrophoresis; radial immunodiffusion) used for domestic large animals, also validated for giraffes in C1 and C5 (Table 2). Values were compared with bovine and giraffe reference data. Correction of an immunity deficit in a neonatal animal by a plasma transfusion is recommended. Plasma collected from an available adult giraffe was transferred to C4 as a precaution and serum antibody levels after transfusion showed sufficient immunity (values N/A). However, commercially available equine or bovine plasma for transfusion at the same dosage as for a newborn foal or calf has been used with success in giraffes with failure of passive immunity. Pretreatment of transfusion cases with diphenhydramine and/or a short-acting glucocorticoid for prevention of possible hypersensitivity reactions is then indicated (Miller, pers. comm.).

Stimulation of urination and defecation, although sometimes recommended for neonatal ungulates, was ineffective in giraffes and not necessary in C1–C4, as they urinated and defecated without problems. C5 on the contrary, experienced constipation during the first 5 days and was repeatedly treated with rectal enemas of 50 mL (50% water + 50% lubricating jelly) until problems...
resolved on the sixth day. Rectal temperature, ideally 37.8–38.3°C (100–101°F), was regularly measured in C1, C3, and C4, as rejected neonates may present hypothermia,¹⁷ as observed in C3.

Vitamin E supplementation, as advised in neonatal calves,¹⁷ was implemented in C1, C2, C4, and C5 (Table 2). Preventive antibiotics, although used in some neonatal calves (C3 and C4),³,⁴¹ might be contraindicated because of possible gastrointestinal disturbances, as seen in some neonatal giraffes (Miller, pers. comm.).

Diarrhea, reported in calves within the first month, might be of nutritional origin³ or caused by infectious diseases associated with diarrhea in domestic ruminants, like rotavirus, coronavirus, *Escherichia coli*, *Salmonella* spp., *Clostridium perfringens*, *Cryptosporidium* sp., *Giardia* sp., and coccidiosis.⁴ C3 developed diarrhea at 3 wk of age and tested positive for *E. coli*, which was successfully treated with antibiotics (Table 2). In other calves with gastrointestinal problems, transfaunation from adult giraffe feces mixed and filtered into the milk formula has been practiced (Miller, pers. comm.).

**Growth parameters**

Limited data on measurements and estimations of total height in captive and wild giraffes are available.⁶,³⁶ In the wild, average birth weight was 102 kg (n = 4) with withers’ height of approximately 1.5 m⁶ and a total height around 1.9 m. In captivity, heights between 1.34 and 2.14 m and weights between 31 and 81 kg were reported.²,³,⁸,¹³,²²,²⁴,³⁸,⁴¹ The calculated average weight at birth of calves of this study and published cases²,³,⁸,⁹,¹³,²²,²⁴,³⁸,⁴¹ was 58.51 ± 12.62 kg (n = 30). Mother-raised calves at Disney Animal Kingdom had an average birth weight of 64.64 ± 7.41 kg (n = 19), with males weighing 65.83 ± 7.34 kg (n = 11) and females weighing 63.0 ± 7.68 kg (n = 8). By 1 yr of age, these calves weighed 382 ± 28.83 kg (n = 17).²⁴ The average birth weight of calves in this study and the other published cases²,³,⁸,⁹,¹³,²²,²⁴,³⁸,⁴¹ was 59.4 ± 7.87 kg for females (n = 7), 58.46 ± 13.32 kg for males (n = 14), 56.47 ± 8.38 kg for reticulated giraffes (n = 6), and 56.78 ± 12.62 kg for Rothchild’s giraffe (n = 9). R statistical program was used for the data analysis (R Foundation for Statistical Computing, Vienna, Austria; https://www.R-project.org/). No significant difference between gender or subspecies was found (P > 0.05) by comparing the means of these groups with the t-test. Feeding, body condition of the dam, genetics, gestation time, and parity might be contributing factors to the difference in birth weights. However, although the smallest calf was born to a primiparous cow (31 kg),² birth weight of another cow’s first calf was higher than of the following two.¹⁸

Manipulation of giraffes for routine height and weight measurements is complicated by their nervous character and their size. Some hand-reared calves, including C1, C2, C4, C5, and C5, were measured regularly¹,³,²²,³⁸ (initially daily to weekly and occasionally afterwards; Figs. 1–4) to evaluate growth, health, and efficiency of the formula.²¹ In C2 measurements were discontinued when measuring became increasingly difficult because of the lack of an appropriate-sized scale, but C1, C4, and C5 were trained to walk on a scale using the milk as a motivator.

Weight measurements of eight hand-reared calves, including C1, C2, C4, C5, C6,³,⁴¹ and two dam-raised calves (C7, C8) are provided here (Fig. 1). The growth curve was linear in all cases, although a difference in body weight of 85 kg at 5 mo of age was found between C1 (218 kg) and a calf reared in Miami Zoo (133 kg). Usually measurements were not taken long enough to detect when growth attenuated. A slight decrease in average daily growth (ADG) between 7 and 8 mo occurred in C1, C4, and C5. In recent research at Prague Zoo, males had a significant higher weight than females as late as after 1 yr of age, grew longer, and had a higher daily weight gain.¹⁵ No difference in ADG between male and female and hand-raised versus mother-reared calves, as seen in bovine calves,¹³ was found (P ≥ 0.05) by comparing the means of these groups with the t-test. The ADG calculated for the dam-reared calves in Disney Animal Kingdom²⁴ from birth to 1 yr of age was approximately 0.87 g/day, and could serve as a guideline. ADG for calves in the current study and in earlier published cases (Table 4), was calculated until the last measurement before weaning and until approximately 2 mo of age for better comparability. ADG was higher during the first 2 mo, except for one calf raised at Biopark Valencia,³ which suffered from gastrointestinal problems and compensated growth later (Casares, pers. comm.). This calf gained 25% of its birth weight only,³ whereas C2 earned 140% of its birth weight, resulting in differences of up to nearly 60 kg within this time span. The other calves gained 80–100% of their birthweight (calf at Leipzig Zoo,³ C1, C4, C5, C6, C8). Differences in milk composition and amount per day are probably main reasons for variations in growth rates (g/day). C2 received Holstein milk at an amount of approximately 10% of its body weight (9.6–11.4 L/
day from 2 to 8 wk), resulting in the highest energy intake (24,000–34,000 kcal/day) if compared to the other calves (Table 1). Additionally, the milk was enriched with probiotics (Probios\textsuperscript{®}, Vets Plus, Inc., Menomonie, WI 54751, USA) which proved to promote growth and gastro-intestinal health in bovine calves.\textsuperscript{40} The ADG in this calf (1,239 g/day until 2 mo) was higher than in the other hand-reared (C1, C4, C5)\textsuperscript{2,3,41} and mother-raised calves (C7, C8).\textsuperscript{24} In the same time span, C1 consumed only 7.2 L of milk enriched with 10\% of bovine colostrum, resulting in 23,000–25,000 kcal/day. ADG in this calf (923 g/day) was higher than in calves receiving Holstein cow’s milk only (C4–C6, 18,940–21,600 kcal/day), and comparable to the mother-reared calves (Table 4). When C1’s amount of milk per day was decreased (17,140 kcal/day) at 4 mo old, a decrease in ADG was noticed. A comparison of individual energy intakes and ADG of each calf at 2-wk intervals, resulted in the conclusion that diets with 19,000–25,000 kcal/day during the first 4–5 mo will realize growth rates comparable to that of mother-raised calves (C7, C8).\textsuperscript{24} Formulas with a significantly lower energy amount (9,200–17,800 kcal/day) during this time resulted in considerably lower ADG (445 g/day,\textsuperscript{41} 529 g/day\textsuperscript{41}).

A rapid increase in height during the first year and a decrease in growth rate during subsequent years has been described.\textsuperscript{8} Calves grew up to 100 cm until 6 mo in captivity. In the wild, calves grow approximately 75 cm in total height until 6 mo and 110 cm until 12 mo.\textsuperscript{8} The increase in neck length was found to be faster than the increase in body mass.\textsuperscript{29} In this study, calves had a total height at birth between 170 cm (C4) and 188 cm (mother-reared male), withers of 117–136 cm (Figs. 2, 3), and achieved a 5.7–11.7\% growth of their height at birth during the first month. C1, C4, C5 and two mother-reared calves gained 40\%, 29\%, 63\%, 56\%, and 44\% of the total growth, respectively, in the neck during the first month. Small differences in neck position result in deviation of centimeters in total height and might explain the variation. C5 had a total height of 237 cm at 4 mo and 335 cm at 2 yr, and gained almost 50 and 60\%, respectively, in the neck.

Correlation between chest girth and body weight was proved for several ungulate species.\textsuperscript{28} If also true for giraffes, chest girth would be a useful parameter to predict body weight in wild animals. C1’s chest girth was measured occasionally and increased with an average of 12.5 cm per month until 4 mo (Fig. 4). A correlation between chest girth and weight during this period was not demonstrated (\(P \leq 0.05\)) by using the Spearman correlation test.

**Weaning**

In the wild, calves are weaned between 6 and 12 mo of age.\textsuperscript{4} Weaning of hand-reared calves at 1 yr of age has been recommended,\textsuperscript{3} as was practiced in C5. Others successfully weaned at 6 (C4), 6.5,\textsuperscript{7,24} 8 (C1, C2, C3),\textsuperscript{17} 9,\textsuperscript{22} and 9.5 mo,\textsuperscript{42} with recorded weights of 142–303 kg (Table 4). Weaning should follow a gradual decrease in numbers of feedings and milk volume, and be implemented when solid food uptake is sufficient to assure steady growth,\textsuperscript{20} which might be difficult for group-housed calves. Weight gain is a useful parameter to determine success of weaning, as no significant loss of weight or decrease of ADG should be noticed postweaning if the animal’s energy intake via solid food is sufficient. Earlier weaning spares labor, time, and money, and shortens the period of intensive interaction between calf and humans, as it is ideal to retain as much natural behavior as possible. It was practiced in C4, which had been inconsistent in taking the amount of milk offered and adequately consumed solid food from 5 mo, when the weaning process was initiated (Table 3). This calf had a considerably lower weight at weaning (142 kg) than the other calves in this study (258–303 kg), which were weaned later with comparable weights at weaning (Table 4).

**Socialization and reintroduction**

Most hand-reared giraffes, including C1, C2, C3, and C5, were initially housed individually but with visual, auditory, and olfactory stimulation from other giraffes, which seemed to facilitate future integration into the herd.\textsuperscript{3,41} Calves not separated for aggression of the dam, were housed with her (C4).\textsuperscript{14} A progressive, supervised introduction into the herd is advised to allow intervention.\textsuperscript{20} Some calves were initially mixed with females (C3–C5)\textsuperscript{14,41} or introduced temporarily during daytime in an outdoor enclosure (C1, C2, C5, C6). In general, few complications occur (C1–C6),\textsuperscript{3,14} an important finding, as adequate socialization is essential for the animal to express normal behavior towards conspecifics and be able to reproduce. A giraffe hand-reared in India also rejected her own calves,\textsuperscript{22} whereas C2 is currently rearing her first calf born in July 2018. The concern that hand-raised animals might be a higher risk towards humans was not confirmed in any of the other cases. If anything, the calves...
became easy tractable (C1, C2, C4). C2 even allowed prepartum rectal examinations.

CONCLUSION

Hand-rearing of giraffes involves some challenges, such as time, space, and acceptance of the bottle and milk formula. Nevertheless, a variety of feeding schemes have been used in practice. Additionally, cow’s milk and colostrum are an easily accessible and cost-effective alternative, and were successfully used to raise giraffes from birth and are recommended here. Therefore, rearing this species appears less difficult if compared to some other megaherbivores that rely on special formulations. The authors advise daily milk intake of 7–10% of the body weight (19,000–25,000 kcal/day) until solid food is consumed regularly. Moreover, growth should be monitored to evaluate the diet as well as the health of each individual calf. An average daily growth between 800 and 900 g/dL until 1 yr of age is recommended. Weaning should follow a gradual decrease in number of feedings and amount of milk per day and when solid food intake is adequate, which was achieved at 7–9 mo with a weight of 250–300 kg for most cases. Measurements of additional calves are required for better comparability and to establish guidelines on optimal weaning age and weight.

Acknowledgments: The authors thank the animal keeping staff at Bellewaerde Park, African Lion Safari, Africa Alive Suffolk, and Alburquerque Biopark for their cooperation and assistance. Special thanks to Koen Dedeurwaarder (head animal keeper, Bellewaerde Park, Belgium), Paul Huang (head giraffe keeper, Alburquerque Biopark, USA), Sara Goatcher (research coordinator, Africa Alive Suffolk, UK), and Terry Hornsey (animal manager, Africa Alive Suffolk, UK). Many thanks to Prof. Dr. Michele Miller, Colette Tracy (Tracy and Du Plessis Game Capture, South Africa), Miguel Casares (former veterinarian at Bioparc Valencia, Spain), and Terry Webb (curator of mammals, Miami Zoo, USA) for their cooperation and data providing. Special thanks and appreciation are extended to Dr. Jenne de Koster for assistance with the statistics and to Dr. Laura Rosen for comments and suggestions on earlier versions of this manuscript.

LITERATURE CITED

16. Gloneková M, Brandlová K, Žižková M, Dobiásová B, Pechrová K, Šimek J. The weight of Rothschild...

Accepted for publication 13 November 2018