



### Growth and Development of a Hand-reared Rodriguez Fruit Bat, *Pteropus Rodricensis*

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**ABSTRACT**—A neonatal female Rodrigues fruit bat (*Pteropus rodricensis*) was hand-reared until 173 days of age, at which time she was reintroduced to her natal colony. Five milk formulations were fed in series in an attempt to mimic the proximate analysis of *P. rodricensis* milk sampled from individuals housed in a research colony throughout lactation. Milk composition varied from 10 to 18% solids (at 5 and 83 days of age, respectively); fat content increased from 3.6 to 8.3% (as-fed basis) over the same period, while protein increased from 1.5 to 4.1% (as-fed basis). The pup was weaned gradually over a 90-day period by decreasing the milk nutrient density and introducing solids. Daily gain in body mass (8.0 g/day) paralleled that measured in other hand-reared Rodrigues fruit bats (n=2) until approximately 140 days, at which time weight plateaued at 190 g. Major stages of development and husbandry are discussed.

Key words: Chiroptera, nutrition, neonate

#### INTRODUCTION

The Rodrigues fruit bat (*Pteropus rodricensis*) is a highly endangered species endemic to the island of Rodrigues in the Indian Ocean. Due to deforestation and periodic cyclones which have disturbed the habitat, numbers in the wild have varied from a

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population low of approximately 130 individuals to a current estimate of 600 (Mickleburgh et al., 1992). Because of their tenuous conservation status, Rodrigues fruit bats have been the focus of captive breeding programs throughout the international zoological community, with nine institutions holding approximately 264 individuals (Carroll, 1992).

*History*-A colony of *P. rodricensis* has been housed at the Wildlife Conservation Society's Bronx Zoo for 9 years, over which time the population has increased from 10 (4 males/6 females) to 73 (40 males/32 females/1 unknown) individuals. Young bats have been exclusively mother-reared. Previous neonates found off dams have not survived due to injury or hypothermia. In general, the decision to handrear an infant would only be reached if the parent was unable to rear it due to illness or abandonment. The young female in this report was discovered immediately after birth with umbilicus and placenta still attached; none of the adult female bats in the colony displayed any interest in this female pup. Since she was otherwise in good health, the decision was made to hand-rear this individual. The ability of the pup to reintegrate into the colony was a concern, as it is with any hand-raised animal, so every effort was made to raise her to be a fully functional adult.

Only a single report of hand-rearing *P. rodricensis* was found in the literature (Young, 1987). Additionally, published information on infant bat formulas includes no data for frugivorous bats. However, a summary of formulas and feeding schedules for various bat species was described by Barnard

(1994). Unpublished milk composition data supplied by T.H. Kunz (personal communication) from a colony of female Rodrigues fruit bats throughout lactation formed the basis of the milk formulas and alterations in composition developed in feeding this infant (see Table 1). Approximations of maternal milk composition (both captive and wild populations) for any species are a critical re-creation factor during the hand-rearing process for mammals (Ofstedal, 1980). While protocols may be refined with more information and multiple animals, this report describes husbandry details of hand-rearing, growth, development, and colony reintroduction of a female Rodrigues fruit bat housed at the Wildlife Conservation Society's Bronx Zoo.

## METHODS AND MATERIALS

*Housing*-The pup was initially housed in an infant incubator (Air Shields Inc., Hatboro, PA) measuring 67 x 40 x 38 cm (L x W x H) at a temperature range of 29-32° C and 85-90% humidity. A cotton stuffed stockinette (Carlisle Laboratories, Rockville Center, NY) 15 cm in length by 25 cm circumference was suspended from the top of the incubator as a "sock-mom". Wide pieces of cloth were also suspended around the "sock-mom" to drape around the baby to emulate wings. Ambient air temperature was approximately 23° C. Throughout most of the hand-rearing procedures, the room was darkened between 1800 and 0700 hr. During reintroduction adaptation, the room was dark from 1000 to 2200 hr. The light cycle was altered to simulate lighting in the exhibit to which she ultimately would be moved.

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*Formula Composition*-Five separate formulae were devised for feeding the neonate based upon unpublished data (T.H. Kunz, personal communication) on milk compositional changes throughout lactation in *P. rodricensis*. Recipes and calculated composition of these

milks are summarized in Table 1. Because fruit bats may be prone to excess iron deposition in the liver (Cranshaw et al., 1995), a low-iron primate milk substitute (Similac Low Iron; Abbott Laboratories, Columbus, OH 43215 USA) was selected as the basal formula to which additional fat and protein were added (Multi-Milk; Pet-Ag, Inc., Elgin, IL 60120 USA). Lactose was predigested with enzyme addition (Lactaid; distributed by McNeil Consumer Products, Inc., Ft. Washington, PA 19034 USA).

**Table 1** - Formulas and calculated composition milks (as-fed basis) fed to a hand-reared Rodrigues fruit bat (*Pteropus rodricensis*) at the Wildlife Conservation Society's Wildlife Conservation Park, Bronx, NY. All preparations contained Lactaid<sup>1</sup> following directions on product label.

Age (days)	Formula	Volume consumed per day (range in ml)	Total number of feedings per day
5 to 41	0 <sup>2</sup>	10 to 26	6 to 8
42 to 50	A <sup>3</sup>	26	6
51 to 58	B <sup>4</sup>	25 to 30	5 to 6
59 to 67	C <sup>5</sup>	30	5
68 to 82	D <sup>6</sup>	29 to 36	5
83 to 98	C	33 to 41	3 to 5
99 to 117	B	40 to 45	3
118 to 143	A	29 to 45	2 to 3
144 to 172	0	0 to 30	2

<sup>1</sup>Distributed by McNeil Consumer Products, Inc., Ft. Washington, PA 19034

<sup>2</sup>Formula 0 = Similac<sup>7</sup> (low iron)

<sup>3</sup>Formula A = 100 ml Similac + 2.5 g Multi-Milk<sup>8</sup>

<sup>4</sup>Formula B = 100ml Similac + 5.0 g Multi-Milk

<sup>5</sup>Formula C = 100 ml Similac + 7.5 g Multi-Milk

<sup>6</sup>Formula D = 100 ml Similac + 10.0 g Multi-Milk

<sup>7</sup>Abbott Laboratories, Columbus, OH 43215-1724

<sup>8</sup>Pet-Ag, Inc., Elgin, IL 60120

*Feeding Regimens*-Diet schedules and volumes of milk consumed are summarized in Table 2. The pup was originally fed every 2 hours between 0700 and 2300; the number of feedings decreased with maturity. The pup consumed 9.6% of body mass over a 24 hour period to a maximum of 25% at 141 days of age.

*Nursing Position*-Initially, when an artificial nipple (Latex H-1205; Fall River, MA 02722) introduced into the pup's mouth, she responded by clamping down on it in an effort to secure her position. This behavior has been observed in other captive Rodrigues pups with their mothers (Hill et al., 1984). The pup gradually grew out of this behavior as her nursing skills improved. The pup eventually nursed from several different homemade nipples which were attached to plastic syringes. Initially, the handlers positioned the nipple in

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the bat's mouth and then compressed it to release a small amount of formula. The plunger of the syringe was also gently depressed in conjunction with squeezing the nipple to further stimulate the sucking reflex. Over the course of two weeks, the bat's suckling reflex established itself. Various nursing positions were attempted, the most successful

being holding the pup by her feet, inverted, with her back resting against the handler. However, nursing with the pup's head positioned in line with her body caused some formula aspiration. Her previously mentioned behavior of clamping down on the nipple also contributed to this problem. Thereafter her head was rotated (ear touching shoulder) making it perpendicular to her

body. Adopting this new position resulted in fewer complications and increasing nursing success.

**Table 2** - Feeding schedule and amounts fed to a hand-reared Rodrigues fruit bat (*Pteropus rodricensis*) at the Wildlife Conservation Society's Wildlife Conservation Park, Bronx, NY. All Formulas contained Lactaid<sup>1</sup> following directions on product label.

Age (days)	Type of Solid	Amount consumed per day (g)	Presentation
53	Fruit baby food <sup>1</sup> (banana, apple)	6 g	Offered after each milk feeding
70	Cut fruit (banana, apple, blueberry, grape)	15	Offered after each milk feeding
84	Adult Fruit Bat Diet A <sup>2</sup>	25 g (1/6 tsp)	Offered after each milk feeding and in pan in incubator/cage
108	Adult Fruit Bat Diet A	30 g (1 tsp)	Two pans placed in cage in variable locations
158	Adult Fruit Bat Diet B <sup>3</sup>	60 g (2.5 tsp)	Two pans placed in cage in variable locations
204	Adult Fruit Bat Diet B	80 - 100 g (4 tsp)	Several feeding stations in colony enclosure

*Solid Food Introduction*-Solid food was introduced beginning at 53 days of age.

Details of solid foods offered and feeding schedules are summarized in Table 3.

Commercially prepared jarred pureed baby food and/or small pieces of blueberry, apple, banana, or grape were fed using a wooden stirrer (0.6 cm diameter) after each nursing session. The pup seemed to prefer whole blueberries and would take them directly from her handlers, chew the pulp and discard the skin. Adult fruit bat diet A was hand-fed to the pup after nursing sessions and was left in the cage for self-feeding.

The adult diet was readily consumed from bowls placed at various heights in the enclosure, including the floor.

<sup>1</sup>Beech-nut Nutrition Corporation, Canajoharie, NY 13317

<sup>2</sup>Adult Fruit Bat Diet A comprises 45% (as fed weight) bananas, 25% apples, 25% canned ZuPreem primate diet (Premium Nutritional Products, Topeka, KS), and 5% in house supplement powder (56% malt powder, 30% Superhydramin, 11% corn dextrin, 3% calcium carbonate, and 0.2% vitamin E).

<sup>3</sup>Adult Fruit Bat Diet B contained 45% bananas, 10% apples, 40% canned ZuPreem primate diet and other ingredients as above.



Adult fruit bat Diet B was more calorie-dense than Diet A created by increasing the volume of canned primate diet and proportionately decreasing the volume of apple. This change of diet was instituted when the pup appeared to reach a plateau in body mass (Day 158). Weaning began at age 157 days; formula was offered both from the bottle and in a bowl, along with adult fruit bat Diet B. The weaning process required approximately 15 days.

## RESULTS

*Growth and Development*-The pup was weighed daily at 0900, prior to the morning feeding. This individual pup weighed 47 g at birth. Average body weight for the species is 45 g which is 13-18% of the mother's body weight (West and Redshaw, 1987). At birth forearm length measurements were not taken, but in retrospect would have been useful as another means of growth comparison. Weekly growth in relation to two other hand-reared Rodrigues fruit bats (Young, 1987) is shown for comparison in Figure 1. While daily fluctuation was apparent, the pup gained approximately 8 g/day for 19 weeks, then reached a plateau starting at 140 days of age (week 20). Her peak body mass before weaning was reached at 181

days of age. Following reintroduction to the colony, body mass stabilized at approximately 200 g. This was considerably lower than the range for adult females in the colony at the Wildlife Conservation Society (243 to 334 g, n = 4) and the documented body masses for two other hand-raised female *Pteropus rodricensis* (Figure 1). Significant developmental events are recorded in Table 4. The pup required assistance nursing, as well as stimulation for urination and defecation, for the first 10 days of hand raising.

**Table 3** - Solid foods (types and amounts) offered to a hand-reared Rodrigues fruit bat (*Pteropus rodricensis*) at the Wildlife Conservation Society's Wildlife Conservation Park, Bronx, NY.

Formula	% Solids <sup>1</sup>	% Fat	% Protein	kcal/ml <sup>2</sup>
0 = Similac <sup>3</sup> (low iron)	9.8	3.6	1.5	0.67
A = 100 ml Similac + 2.5 g Multi-Milk <sup>4</sup>	11.9	4.9	2.2	0.84
B = 100 ml Similac + 5.0 g Multi-Milk	14.0	6.1	2.9	1.00
C = 100 ml Similac + 7.5 g Multi-Milk	15.9	7.2	3.5	1.16
D = 100 ml Similac + 10.0 g Multi-Milk	17.7	8.3	4.1	1.33

<sup>1</sup>Distributed by McNeil Consumer Products, Inc., Ft. Washington, PA 19034

<sup>2</sup>Calculated values based on proximate composition

<sup>3</sup>Abbott Laboratories, Columbus, OH 43215-1734

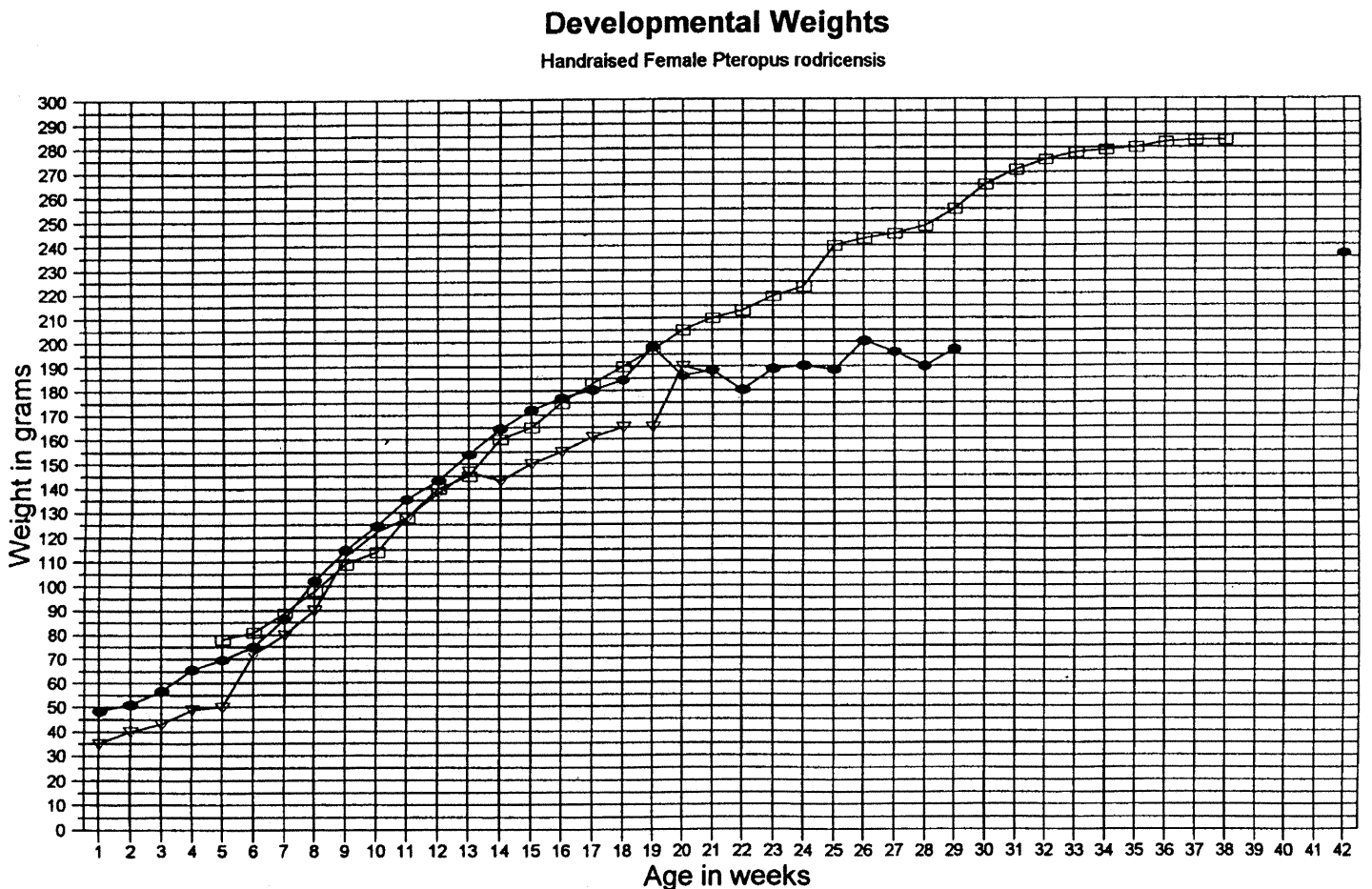
<sup>4</sup>Pet-Ag, Inc., Elgin, IL 60120

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**Colony Reintroduction**-The pup was hand-reared until 173 days of age, at which point she was reintroduced to her colony of origin. This re-introduction process consisted of two stages. First, she was housed inside her smaller cage which was placed within the larger colony exhibit. This provided visual and olfactory access to the colony. After 2 weeks in the smaller cage, she was allowed full access to the colony with the ability to retreat to the smaller cage. Additional feeding stations were added to the exhibit to help the pup acclimate and integrate successfully. She predominately remained in one area of the

exhibit near a feeding station and was observed flying infrequently. At 300 days of age, the pup was transferred to a large rain forest exhibit containing all female bats (from her natal colony) and mixed bird species at the Wildlife Conservation Society's Central Park Conservation Center. This exhibit contained female bats from her natal colony as well as mixed bird species. At the time of this publication, the pup appears to be fully integrated into the captive colony.

**Figure 1** - Growth of 3 hand-reared female Rodrigues fruit bats (*Pteropus rodricensis*), housed in Mauritius, Jersey Wildlife Preservation Trust (JWPT) and the Wildlife Conservation Society (WCS).





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**Table 4** - Significant developmental observations on a hand-reared Rodrigues fruit bat (*Pteropus rodricensis*) at the Wildlife Conservation Society's Wildlife Conservation Park, Bronx, NY.

Age (days)	Developmental Milestone
1	Pup removed from colony, housed in incubator
7	Handler & pup find comfortable nursing position <sup>†</sup>
11	Defecated alone; stopped stimulating to defecate and urinate
17	Vocalized within human hearing range
18	Exercised sternally on towel (by handlers)
19	Started to self-groom
34	Exercised more vigorously (wing flapping) while hanging from a branch
46	All adult teeth visibly erupted; "teething" slowing down
49	First well-formed feces
55	Righted self after hanging by thumbs to defecate and urinate
57	Flew from surrogate mother to handler
61	Began hanging from wood perching in incubator away from surrogate mother
82	First successful attempt at flying
89	Housing change-0800 to 1700 in wire mesh cage, 1700 to 0800 in incubator
99	Righted self after hanging by thumbs to defecate
108	Housing change - full time in wire mesh cage
120	All adult teeth fully emerged
144	Reversed light cycle initiated (off at 1000, on at 2200)
157	Milk consumed from bowl
173	Housing change - moved to small cage within larger colony enclosure
191	Full time unrestricted colony access
300	Transfer to new colony

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