# Evaluation of 3 Milk Replacers for Hand-Rearing Indian Nilgai *(Boselaphus tragocamelus)*

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Hoofstock neonates are often hand-raised for multiple reasons. Feeding maternal milk is optimal, but is rarely available for hand-rearing. Therefore, suitable substitutes must be identified. Published nutrient composition of maternal milk is frequently used as a guide. In many instances, however, no information is available regarding the milk composition of a particular species. Nilgai have been successfully raised at the Wild Animal Park using several formulas. It has yet to be determined which formula(s) produce the best response. Eight nilgai (3 females, 5 males) were received for hand-rearing and were randomly assigned 1 of the following 3 formulas for a blind study: evaporated cows (EC) :nonfat cows (NFC) 2: 1, EC: Milk Matrix 30/55®:water 10: 3: 12, or EC:SPF-Iac® 2: 1. EC: NFC 2: 1, which has been used for several seasons, was designated as the control. The composition of EC:30/55:H2O 10:3: 12 is comparable to the published composition of eland milk, a species taxonomically related to nilgai. EC:SPF-Iac® 2: 1 has lipid and carbohydrate composition intermediate to the other formulas. Response parameters monitored include weight gain, stool consistency, feeding response, and overall body condition. Based on the results, Indian nilgai can be hand-reared successfully on any of the 3 milk replacers. Of the 3, however, the group fed EC:NFC 2: 1 were the heaviest at weaning and the most vigorous throughout the hand-rearing process.

Key words: ungulate, neonatal nutrition, husbandry, captive animal management

## INTRODUCTION

Protocols for hand-rearing are essential elements of captive animal management programs. Hand-raising those neonates that are maternally neglected or medically compromised reduces neonate mortality (Louden, 1985). Milk replacer formulation and selection can be the most important and difficult decisions of the hand-rearing process. In most zoological institutions, the use of nurse dams or the milking of tractable conspecifics is not possible. Subsequently, it becomes necessary to utilize a variety of commercially available milks (i.e., cows and goats) and milk replacers. Although macronutrient values for maternal milk composition have been published for a number of species and are frequently used as a guide for formulating milk replacers, very few comparative studies involving nondomestic species have been published (Murphy, 1960; Silver, 1961; and Robbins, 1975). The San Diego Wild Animal Park hand-raises approximately 100 ungulate neonates from many species each year. Many are "pulled" due to abandonment or health reasons, but some species are hand-reared for herd management purposes. This has allowed our facility the ability to make comparative evaluations of formulas and other techniques.

## METHODS

### Feeding Schedule

In September 1994, 8 nilgai *(Boselaphus tragocamelus)* were pulled to be hand- raised for herd management purposes and were randomly assigned to 1 of 3 milk replacers. Nine neonates were anticipated (3/group). However, an older dam, expected to twin, gave birth to a single calf. For the first 24 hr, the calves were fed domestic cows' colostrum. In the second 24 hr, the calves were gradually introduced to their formulas (50% colostrum, v/v). For an additional 3 wk, colostrum comprised 10% of the formula volume (v/v). On d 3, Vi-Sorbin® vitamin and iron supplement (0.33 cc/kg body wt) and Colosto-lac lactobacillus supplement were added to the bottles once daily and continued to weaning.

In amounts dictated by their appetite, the calves were fed 5 times during a 12 hr period (every 3 hr), until 21 d of age. Then, they were fed 4 times per 12 hr (every 4 hr) for an additional 20 d, at which time they were reduced to 3 times/day (every 5 hr). The volume of formula fed remained stable from d 48 to d 61 to aid in the transition from liquid to solid diet. The calves were weaned over the next mo. Solid foods were introduced on d 7 and fed *ad libitum.* Commercial sources of products can be found in table 1.

### Formulas

Indian nilgai milk has not yet been analyzed, nor has the milk of the four-horned antelope, also of the primitive tribe boselaphini. Literature indicates that milk composition is phylogenetically conserved (Oftedal, 1984). Therefore, milk of modern cattle, which arose from this tribe (Underwood, 1984), was used as the base milk of the 3 formulations of milk replacer. The final tribe of the subfamily bovinae, strepsicerotini, includes the eland, an African antelope of which the milk has been analyzed (Treus, 1 968). Although the eland is more distantly related to the nilgai, it was determined to be a suitable model due to similar dietary habits.

The control formula, evaporated cows: nonfat cows (EC: NFC) 2: 1 (formula “A”), was developed, like many formulas, through the trial-and-error method. In 1989, 9 nilgai were reared using evaporated cows milk and reconstituted powdered nonfat milk (9% dry matter) mixed in a 1:2 ratio. Of these 9, a single animal died from a twisted loop of intestine and was found to be anemic, with thinner bones and less adipose tissue than previously necropsied nilgai calves. Although it could not be directly correlated to the formula, the following year the formula was modified to a 2: 1 mixture of evaporated: nonfat cows milk. Nilgai calves raised on this formula demonstrated a better weight gain but were still experiencing a softer than ideal stools.

One of the experimental formulas, evaporated cows, Milk Matrix 30/55®, and water (EC:30/55:H2O) mixed in a ratio 10:3: 12 (formula "C"), was formulated to have the same lipid, carbohydrate, and protein concentrations as eland milk. Formula "C" and control, formula " A " , differ significantly in both fat and lactose concentrations as a percent of total solids. In formula "A", the fat content is much lower and, conversely, the lactose content is much higher than the experimental matrix formula, "C".

The second experimental formula, evaporated cows and SPF-Lac®, in a 2: 1 ratio (formula "B"), has a macronutrient breakdown intermediate to the other formulas. All were adjusted to be comparable for total solids, thus varying slightly in caloric density. The composition of each formula as well as the components is given in tables 2 and 3, respectively.

**Evaluation**

Because loose stools can be a symptom of formula indigestibility and/or incompatibility (Oftedal, 1980), during the first 3 wk, stools were monitored and recorded. Numerical values were assigned, based on the consistency of the stools:

1- diarrhea, foamy stools

2- extremely soft, badly formed/amorphous stools

3- cylindrical-shaped stools, tacky to touch, leaves mark when picked up

4- well-formed, cylindrical-shaped and pelleted stools, dry but not crumbly, easily picked up and leaves no mark

Weight gain is another important parameter for evaluating formula fitness. Long term survivability is higher in the larger neonates than their smaller conspecifics (Louden, 1985). Weights were recorded daily before the first bottle from birth until weaning. In addition, the neonates were observed for behavioral abnormalities and overall body condition, such as coat texture and signs of abdominal distension or bloat.

**RESULTS**

**Body Weight**

Weight gain is the most easily and frequently used indicator of a neonate's response to a hand-rearing protocol. In the first month, calves fed formula *"C"* weighed significantly more than calves in the other two groups ($p < 0.01$). In addition, the calves fed formula "B" weighed significantly more than those fed formula "A" ($p < 0.01$, table 4, figure 1). Weaning weights were comparable, but during the last 2 weeks of hand-rearing, daily weights of calves fed formulas "A" and "B" became significantly greater than calves fed formula "C" ($p < 0.01$, figure 2). When normalized to account for initial wt ($wt_o$) differences, nilgai calves fed formula " A " gained significantly more wt ($wt_n$/ $wt_o$) than formula "B" calves and, in turn, those calves gained significantly more than formula "C" calves ($p < 0.01$, figure 3). Average daily gain (ADG) is numerically but not statistically greater for formula "A" than for the other formulas. In all cases, regardless of milk replacer or method of analysis, body weight increased linearly with age (figures 1, 2, 3).

**Energy intake**

Formula consumption was greatest for the nilgai fed formula "A" in both total volume and as a percentage of body wt ($p < 0.01$, table 5, figure 4). Caloric intake was highest in the formula *"C"* group ($p < 0.01$). This was not unexpected as: a) formula "C" was the most calorically dense formula (Kcal/cc, table 2) and b) the calves' initial wt was greater (table 4). Intake was also greater, however, when expressed as a function of metabolic body weight (Kcal/Kgo.75, $p < 0.01$).

**Stool Consistency**

For the first 3 wk, calves reared on formula *"C"* exhibited the firmest, most desirable stools ($x = 3.69 \pm 0.13$). Although calves fed formula "C" had significantly firmer stools ($p<0.01$), the consistency was acceptable in all groups ("A", $x= 2.65 \pm 0.14$; "B", $x=2.66 \pm 0.16$). By one mo of age, all calves had stools with a rating of "4".

**Behavior**

Although specific behaviors were not quantified, nilgai calves fed formula "C" were observed to be far less active than those individuals fed the other replacers. Anecdotal, but "blind", observations report that formula "C" calves were sluggish in shifting between exhibit areas and frequently needed to be coaxed to approach the keeper for their bottles. Calves fed formula "A" were the most active, often observed exploring the enclosures. These neonates eagerly approached the keeper at feeding times and nursing bouts were strong. Formula "B" and formula "C" both caused a transient period of bloating not observed in those fed formula "A".

**DISCUSSION**

Formula consumption varied significantly between formulas "A" and "C".This was most likely due to the difference in the caloric density (Kcal/cc) between the 2 formulas. The lower caloric density of formula "A" necessitated an increased consumption to meet the metabolic demands of growth, shown by the significantly greater formula consumption of calves fed formula "A".The increased volume was inadequate to offset the difference in caloric intake, which may coincide with the physical limitations of the neonates' omasum.

In all cases, the caloric intake was greater than the estimated minimum requirement calculated for the calves, based upon body weight using Kleiber's formula for interspecific comparisons of BMR adjusted for neonates: $2(70*BW_{Kg}\ 0.75)$. From d 72, caloric intake provided by milk replacer "A" was below the estimated minimum requirement, yet during the last 2 wk prior to weaning, the calves weighed the greatest. Although dry feed intake was not measured, the calves must have been consuming a considerable amount of solid feed. The greater activity level of calves fed formula "A", in retrospect, may have been stimulated by the lower caloric intake from the formula. It apparently stimulated the calves to seek additional sources of energy (i.e., solid foods) and thus began consuming the offered foods sooner than the other treatment groups.
Stool consistency was softer, less formed during the first 3 wk for calves offered formulas "A" and "B". In the case of formula "A", it is possible that it was caused by the higher lactose concentration. Calves fed formula "B" also experienced bloating during this period, therefore, an digestive incompatibility of the milk replacer may be the cause of both problems.
The sluggish behavior and bloat demonstrated by calves fed formula "C" may be due to the consituent fatty acids in the milk replacer. Of those ruminant milk fats which have been analyzed, short-chain fatty acids are reported to be prevalent. In addition, species of the subfamily bovinae

exhibit a trend of 22.6%, 36.7%, and 40.8% of the fatty acids, by weight provided by C4-C15, C16, and C18, respectively (Glass, 1962). Milk Matrix 30/55® has considerably less fatty acids provided by the C4-C15 fatty acids (1.8%), with C16 and C18 providing 27.3% and 54.4%, by weight, respectively. The relative ease of digestion of the shorter chain fatty acids may be an important factor in the reduction of the conditions noted in the treatment group fed formula "C", which contained a high concentration of C16 and C18 fatty acids.

## CONCLUSIONS

A comparison of 3 milk replacers for hand-rearing Indian nilgai yielded the following conclusions:

1. Formula *"A",* evaporated cows milk and nonfat cows milk mixed in a 2:1 ratio, is preferable to either of the other 2 milk replacers. Absolute weight gain (as expressed in ADG) was comparable for all groups, but nilgai calves fed formula "A" exhibited the greatest gain with respect to initial weight (percent of original). While weight gain and stool consistency are important evaluational parameters, no parameter is all inclusive and several parameters should be evaluated concurrently. Calves offered formula "A" were also the most active, displayed the most vigorous nursing response, and did not exhibit the signs of bloating that were evident in the calves of the other 2 groups.

2. Although the eland may a species closely related to the nilgai, utilizing maternal milk nutrient composition of a related species is informative but must remain in context. Theoretically, formula "C" should have provided the best all-around response. When applied practically, however, it becomes apparent that knowledge of the complete nutritional composition of a species is important and that knowledge of the gross macronutrient composition may be insufficient to produce the ideal response.

3. In addition to percent of total solids, caloric density must be considered in dictating the choice of milk replacer. There exists a 22% difference in calories between the highest (EC:MM 30/55®:H2O, formula *"C")* and the lowest (EC:NFC, formula "A"). Further study is necessary to determine how much significance this difference caused in this experiment.

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**TABLE 1. Commercial sources of milk replacer components, supplements, and solid feed offered**

| PRODUCT | MANUFACTURER |
|---|---|
| Milk Matrix 30/55® | Zoologic Nutritional Components Pet-Ag, Inc., Elgin, IL 60120 |
| SPF-Lac® | Pet-Ag, Inc., Elgin, IL 60120 |
| Vi-Sorbin® | SmithKline Beecham Animal Health, West Chester, PA 19380 |
| Colosto-Lac | Dairy Goat Nutrition, Clatskanie, OR 97106 |
| Low fiber (ADF-16) herbivore pellet<br>High fiber (ADF-25) herbivore pellet<br>Rolled corn and barley<br>Rolled feed oats<br>Manamar starter and supplement pellets<br>Manamilk supplement<br>4 way stock feed | O.H. Kruse Grain and Milling, El Monte, CA 91734 |

TABLE 2. Selected Nutrient Composition of Eland Milk and Three Milk Replacers for Hand-Rearing Indian Nilgai *(Boselaphus tragocamelus)*

| MILK or MILK REPLACER | ELAND[a] | EVAPORATED COWS: NONFAT COWS 2:1 | EVAPORATED COWS: SPF-Lac® 2:1 | EVAPORATED COWS:MM 30/55® :WATER 10:3:12 |
|---|---|---|---|---|
| TOTAL SOLIDS, % (TS) | 21.9 | 20.4 | 22.4 | 21.8 |
| TOTAL FAT, % OF TS | 45.2 | 25.0 | 30.8 | 42.7 |
| TOTAL PROTEIN, % OF TS | 28.8 | 27.8 | 27.7 | 28.2 |
| TOTAL CARBOHYDRATES, % OF TS | 20.1 | 40.8 | 35.6 | 18.5 |
| Kcal/cc[b] | 1.32 | 1.02 | 1.19 | 1.24 |

[a]Treus, 1968.
[b]Gross energy calculated on the basis of 9, 4, 4 Kcal per gram of fat, protein, and carbohydrate, respectively

TABLE 3. Selected Nutrient Compostion of Milks/Milk Replacers used for Formulating Three Milk Replacers for Indian Nilgai *(Boselaphus tragocamelus)*

| | EVAPORATED COWS MILK[a] | NONFAT COWS MILK[a] | SPF-Lac® | MILK MATRIX 30/55® | COLOSTRUM, DOMESTIC COW[b] |
|---|---|---|---|---|---|
| TOTAL SOLIDS, % (TS) | 26.0 | 9.20 | 15.2 | 95.0 | 22.1 |
| TOTAL FAT, % OF TS | 29.1 | 2.0 | 36.6 | 55.0 | 16.3 |
| TOTAL PROTEIN, % OF TS | 26.2 | 37.1 | 33.0 | 30.0 | 64.7 |
| TOTAL LACTOSE, % OF TS | 38.7 | 52.7 | 24.8 | TRACE | 14.0 |
| Kcal/cc[c] | 1.36 | 0.34 | 0.85 | 5.84 | 1.02 |

[a] USDA, 1976
[b] Roy, 1969
[c]Gross energy calculated on the basis of 9, 4, 4, kcal per gram of fat, protein and lactose, respectively

**TABLE 4.** **A comparison of weights obtained hand-reared Indian nilgai *(Boselaphus tragocamelus)* fed three milk replacers (mean $\pm$ sem)**

| FORMULA | A | B | C |
|---|---|---|---|
| WEIGHT, Kg | | | |
| INITIAL | 6.5 $\pm$ 0.55 | 7.2 $\pm$ 0.43 | 7.9 $\pm$ 0.30 |
| DAY 30 | 15.8 $\pm$ 1.59 | 16.8 $\pm$ 0.73 | 17.0 $\pm$ 0.050 |
| WEANING (DAY 92) | 37.5 $\pm$ 2.50 | 37.5 $\pm$ 0.866 | 36.0 $\pm$ 0.050 |
| AVERAGE DAILY GAIN (ADG), (g/d) | 348 $\pm$ 47 | 336 $\pm$ 46 | 311 $\pm$ 56 |

"A" Evaporated cows:nonfat cows 2:1

"B" Evaporated cows:SPF-Lac 2:1

"C" Evaporated cows:MM 30/55:H20 10:3:12

**TABLE 5. Consumption of Indian nilgai calves fed three milk replacers from d 2 until the start of weaning (mean ± sem)**

| FORMULA | A | B | C |
|---|---|---|---|
| FORMULA INTAKE, cc/d | 1625 ± 59* | 1475 ± 49* | 1559 ± 49* |
| CALORIC INTAKE, Kcal/D | 1647 ± 55* | 1750 ± 56** | 1889 ± 55*,** |
| MILK INTAKE, % BW, cc/Kg | 10.72 ± 0.21*,** | 9.24 ± 0.26* | 9.52 ± 0.21** |
| CALORIC INTAKE, $kcal/BW_{kg}0.75$ | 210.14 ± 3.07* | 214.30 ± 4.57** | 227.33 ± 3.96*,** |

*,** SIGNIFICANT DIFFERENCE BETWEEN GROUPS WITH LIKE SYMBOLS, $P<0.01$.

**Figure 1. A comparison of weight gain of hand-reared Indian nilgai fed 3 milk replacers**

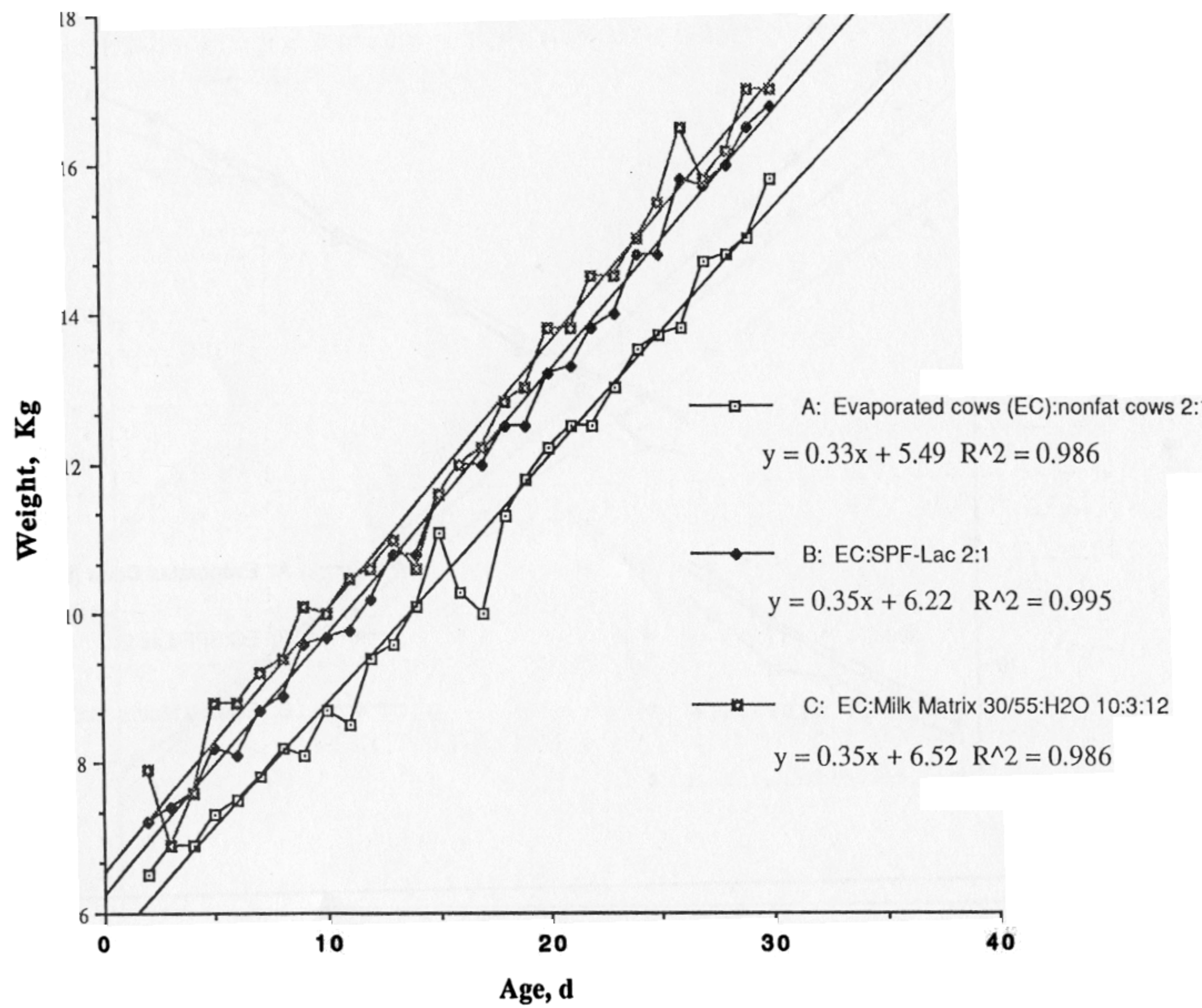

**Figure 2. Weight gain of hand-reared Indian nilgai calves fed 3 milk replacers.**

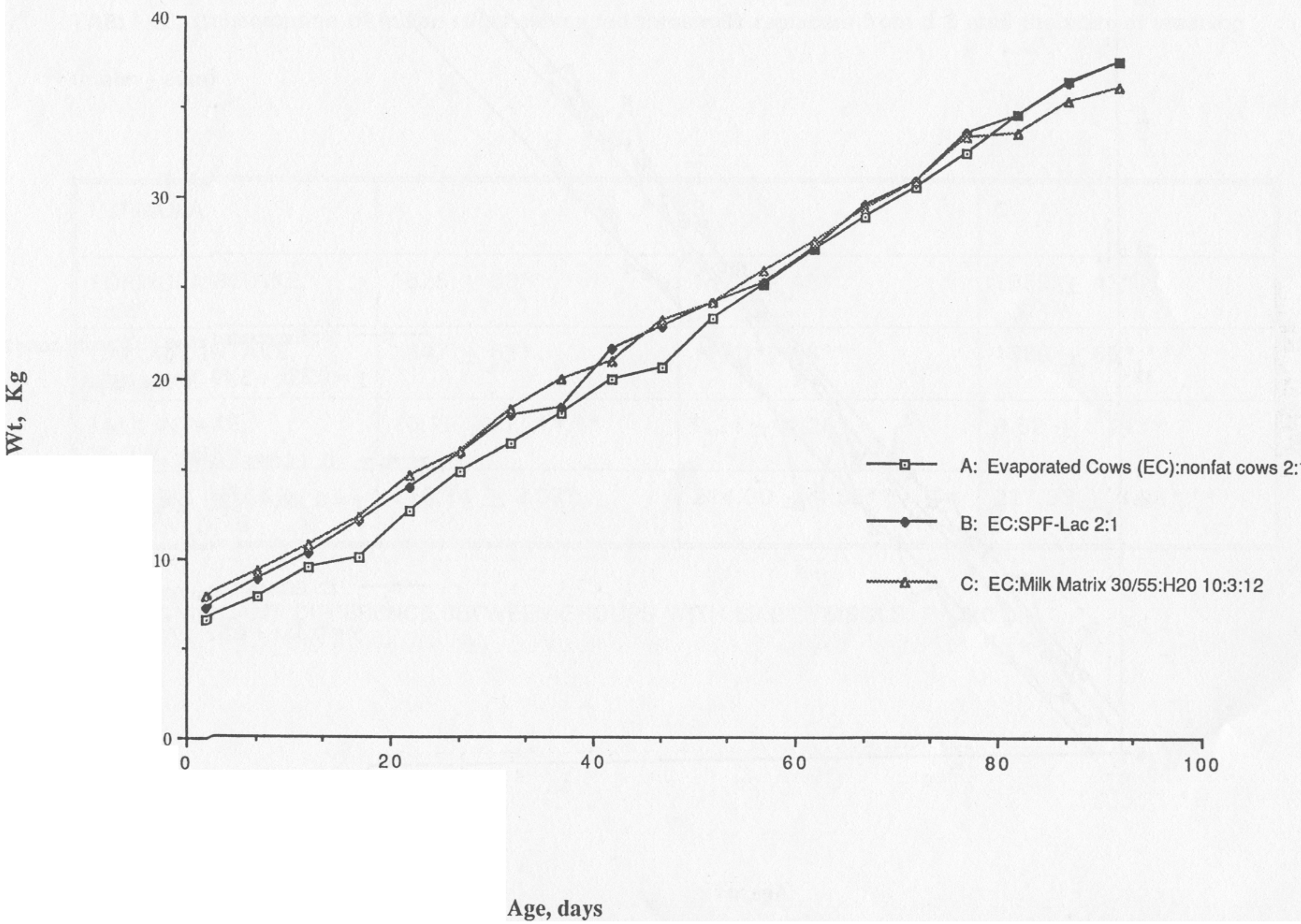

**Figure 3. Weight gain of Indian nilgai calves fed 3 milk replacers reflected as a percent of the original weight.**

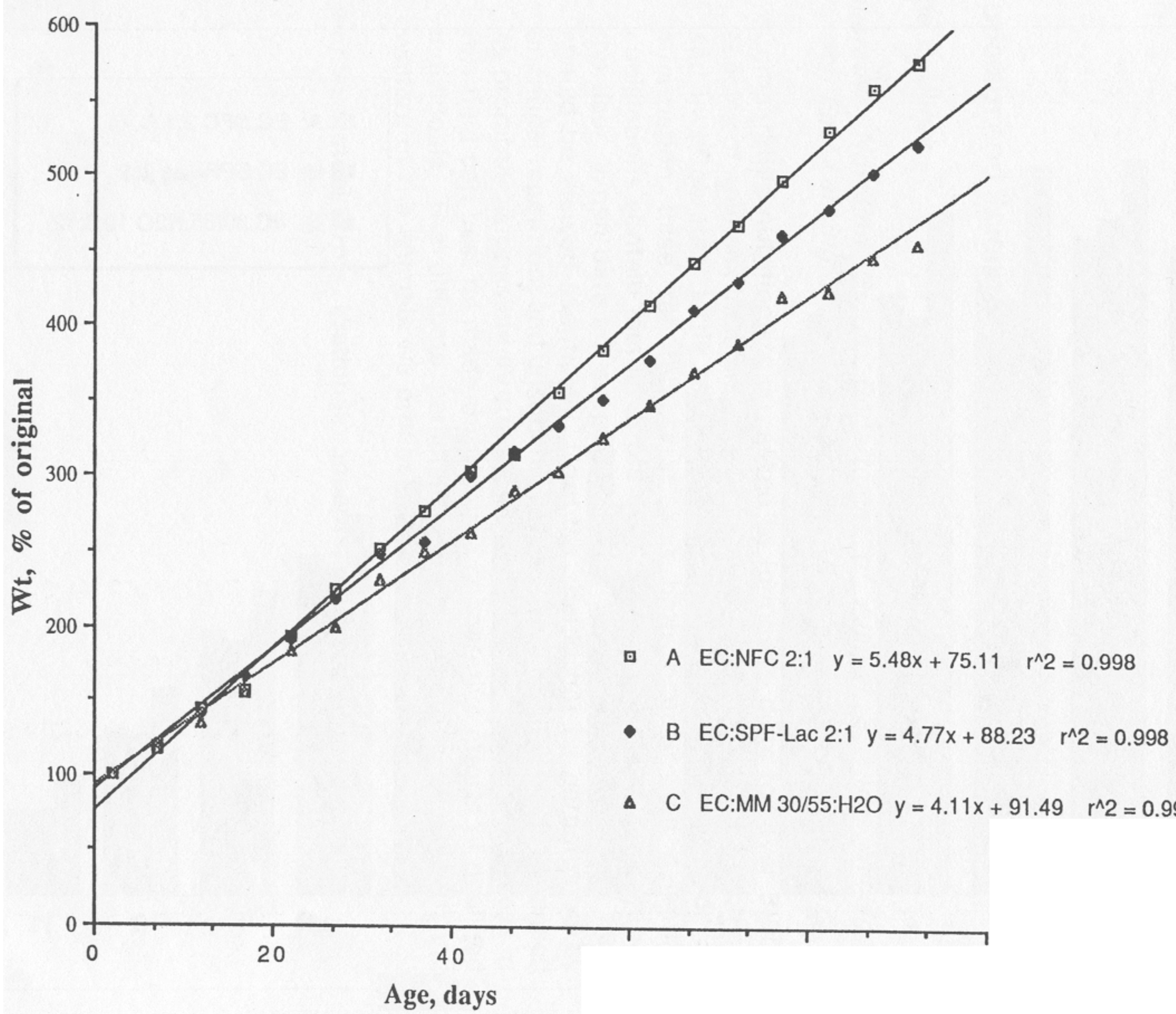

Figure 4. Mean weekly consumption of 3 nilgai milk replacers as percent body weight