

THE MILK REPOSITORY AT SMITHSONIAN'S NATIONAL ZOOLOGICAL PARK

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Introduction

Lactation, the exocrine secretion of milk from mammary glands for the nourishment of young, is a defining characteristic of mammals. All female mammals produce milk, and milk is the first food of all neonatal mammals. The diversity of the mammalian radiation is reflected in the diversity of lactation strategies that have evolved. This in turn is reflected in differences in milk composition among mammals. Lactation is an ancient mammalian adaptation that predates live birth. The egg-laying monotremes lactate, though they do not have nipples.

The production of nourishment for newborns from glandular tissue is not unique to mammals, however. For example, several avian species (e.g. pigeons, doves, flamingoes, and penguins) produce a holocrine crop secretion, termed crop milk, which they regurgitate for their chicks.⁴ The provisioning of offspring by substances produced by the adults is a fascinating adaptation that is important for nutritionists that might need to hand rear neonates of such species to understand. The composition of these substances has only begun to be investigated.

All milks contain the necessary nutrients for existence; however proportions vary widely. Milk fat content can differ widely between species. For example, milks of equids and rhinos typically have less than 1% milk fat, while many marine mammals have milk fat concentrations above 40%.⁶ Milk fat concentration can vary substantially even among individuals within a species. The fat concentration of common marmoset (*Callithrix jacchus*) and rhesus macaque (*Macaca mulatta*) milk samples generally range between 2 and 4%; however, samples with more than 10% milk fat have been collected from both species.^{3,7} In contrast, there was little variation in milk fat content in ring-tailed (*Lemur catta*) and red fronted lemurs (*Eulemur rufifrons*).⁹

Milk is a complex biological fluid. Its study is an important, but relatively neglected component for understanding the evolution of animals. The milk collection at the Smithsonian National Zoological Park (SINZP) represents a unique research resource, originally conceived by Dr. Olav Oftedal upon his tenure at the SINZP. The Nutrition Laboratory at SINZP has extensive experience in assaying milks; milks from over 200 species have been assayed. Validated techniques for accurately measuring the proximate nutrient composition of milk (dry matter, fat, protein, sugar, minerals, and energy) have been established in the lab. Proximate analysis with calculated gross energy content (GE) can be accomplished on as little as 0.5 ml of primate milk. In rhesus macaque milk we have shown that calculated GE values are not different from measured GE values using adiabatic bomb calorimetry.³

The Milk Repository

A large number of milk samples from a wide variety of mammals (Table 1), as well as a smaller collection of crop milks from avians, are stored frozen. New samples continue to be collected from zoos, research colonies, and wild animals. In addition, published data from previously assayed samples are available in summary form, as well as some unpublished data. Three doctoral dissertations on primate lactation have been facilitated by the laboratory and the milk collection so far.^{2,5,8}

Current projects include longitudinal assessments of milk composition in a number of species. Milk composition in some species (e.g. common marmosets and ring tailed lemurs) appears to be relatively invariant over lactation.^{7,9} In other species (e.g. Asian elephants; *Elephas maximus*) the composition of the milk changes considerably over the calf's first year of life.¹ An example of an ongoing project is weekly milk samples being collected from a lactating SINZP lowland gorilla (*Gorilla gorilla*). This female has been trained to present for medical and physical evaluation, enabling minimally invasive milk sample collection.

Collaborative Projects

We are actively seeking collaborative projects to continue our investigations of milk composition and lactation strategies, as well as expanding our investigations of nutritive secretions of non-mammalian species. We can provide guidance on sampling techniques and project design, or simply analyze samples that are part of existing studies. We are interested in increasing the milk collection both in terms of increasing the number of taxa represented; but also to collect more samples from taxa already present that will increase the representation of maternal age, maternal condition, and stage of lactation within the taxa or specific species.

We also welcome suggestions for additional scientific analyses that could be performed on our existing samples (e.g. genetic analyses; proteomics) and the inclusion of these samples to strengthen outside research projects. The samples currently in the collection range from opportunistic single samples from single animals to samples collected chronologically through entire lactation periods, and everything in between. Samples are paired with as much quantitative and qualitative information as available, and we have a specific set of information suggested for any samples collected for inclusion in the Repository from this point forward.

Samples included in this collection will not only be helpful in answering pressing hand-rearing related issues for specific animals at specific institutions (i.e. analysis of snow leopard (*Unica unica*) milk in early lactation to adjust formula for a cub being hand-reared at the time) to answering a myriad of larger questions related to nutritional and lactation physiology. The utility of this collection goes far beyond the walls of Smithsonian as part of our overall mission to "increase and disseminate knowledge." We welcome inquiries and discussion.

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Table 1. A partial list of milk samples stored frozen in the SINZP milk collection.

Milk Collection Inventory	
Taxonomic designation	Number of Species
Artiodactyla	33
Carnivora	16
Cetacea	5
Chiroptera	14
Edentata	2
Lagomorpha	1
Marsupialia	4
Perissodactyla	10
Pinnipedia	14
Primates	35
Proboscidea	2
Rodentia	9
Scandentia	2
Sirenia	1
Tubulidentata	1
Pigeons and doves (crop milk)	7