DIFFERENCES IN THE COMPOSITION OF COLOSTRUM AND MILK IN EUTHERIANS REFLECT DIFFERENCES IN IMMUNOGLOBULIN TRANSFER

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Colostrum is a special type of milk produced in eutherian mammals during the end of pregnancy and during the 1st few days after birth. It supplies passive immunity to the offspring. The composition of colostrum and mature milk is compared in this study. In species with prenatal passive immunization (humans, baboons, and rabbits), immunoglobulin transfer via colostrum is of little importance and the difference in relative protein concentration between colostrum and mature milk can be small. In ungulates, on the other hand, colostrum has to supply the offspring postnatally with passive immunity and colostrum is relatively rich in immunoglobulin. Large differences between relative protein concentration in colostrum and milk can be observed in ungulates. Compositions of colostrum and milk thus reflect differences in immunoglobulin transfer.

Key words: carbohydrate, colostrum, fat, mature milk, passive immunity, protein

Newborn mammals encounter a microbially hostile environment. Response to this situation affords passive immunization either by prenatal transfer of immunoglobulins via placenta or yolk sac or by postnatal transport of immunoglobulin from mother to offspring via colostrum (Baintner 2007). Differences in protein transfer from mother to offspring among eutherian species are considerable (Vernier and Sire 1981). In hoofed mammals, transfer of immunoglobulins via the epitheliochorial placenta does not take place and the fetus acquires few or no antibodies across the placental barrier (Baintner 2007; Gaskin and Kelley 1995). This multicellular obstacle consists not only of layers of maternal endometrium, but also of fetal chorion. However, postnatally immunoglobulins are supplied by absorption from colostrum via the gut wall (Lascelles 1979). During the very 1st days after birth, the newborn ungulate is essentially devoid of circulating antibodies until absorption from the colostrum is possible. The animals are born in a "hypogammaglobulinaemic state" (Baintner 2007:159).

Colostrum is a special type of milk formed during the last days of pregnancy and in the 1st few days after birth. In some mammals, especially ungulates, colostrum is particularly rich in proteins. Protein contributes to the synthesis of cells and tissues and to the formation of enzymes and antibodies (immunoglobulin G [IgG], IgA, and IgM). Especially because of this latter function, protein cannot be replaced by fat and carbohydrate, which supply energy needed for metabolism.

A large part of the high protein percentage in colostrum "is due to the globulin contents that contain the antibodies" (Park 2006b:394). For example, in pigs (*Sus scrofa*) 55% of the total crude protein consists of immunoglobulins (Pluske et al. 1995). Although Lascelles (1979) states that concentrations of immunoglobulin in the colostrum of eutherian species are high compared with those detected in mature milk, this statement cannot be generalized. For example, in some species (e.g., in the orders Primates, Rodentia, Lagomorpha, and Proboscidea) protein represents <50% of the nutrients in their colostrum, whereas others (e.g., Cetacea and Artiodactyla—particularly Camelidae, Suidae, and many Ruminantia) show a high percentage of protein. On the other hand, mature milk of different eutherian species contains <50% protein, which is consistent with data published by Braun (1997).

Thus, in some species colostrum can contain higher concentrations of protein than mature milk, but in other species similar compositions exist in both liquids. Differences in the composition of colostrum and milk in eutherians may reflect different species-specific strategies for immunoglobulin transfer. This study examines this hypothesis using data compiled from the literature on protein, fat, and carbohydrate concentration in colostra and milks.

MATERIALS AND METHODS

This paper compares the composition of colostrum with that of mature milk. The comparison is based on data from the literature that were published between 1962 and 2006. In these

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TABLE 1.—Contents of nutrients (proteins, fats, and carbohydrates) in colostrum of 19 eutherian species. Units of measure and references are also given. Scientific names of species follow Wilson and Reeder (2005). Data with different units of measure are given in the literature for the pig (*Sus scrofa*). Therefore, 2 data sets are given for this species. In all other species means could be calculated because identical dimensions were given. These means are listed in the table.

| Species | | Colostrum nutrients | | | | |
		Protein	Fat	Carbohydrate (lactose)	Unit	Reference
Homo sapiens	Human	22.9	29.5	57.0	g/l	Documenta Geigy (1969)
Papio	Baboon	2.3	5.1	6.8	g/100 ml	Buss (1968)
Canis lupus	Dog	138.0	78.0	27.0	g/kg	Meyer and Kamphues (1990)
Felis catus	Cat	4.0	3.4	3.6	%	Keen et al. (1982)
Balaena mysticetus	Bowhead whale	86.6	4.9	6.3	%	Harms (1993)
Loxodonta africana	African elephant	21.0	56.0	61.8	g/kg	Osthoff et al. (2005)
Equus caballus	Horse	191.0	7.0	46.0	g/kg	Meyer and Kamphues (1990)
Sus scrofa	Pig	180.0	72.0	24.0	g/kg	Meyer and Kamphues (1990)
Sus scrofa	Pig	10.6	5.8	3.4	%	Park (2006a)
Pecari tajacu	Collared peccary	6.0	4.8	5.2	%	Sowls (1984)
Camelus dromedaries	Dromedary	13.0	1.5	3.6	%	Abu Lehia et al. (1989), El-Agamy (2006)
Camelus bactrianus	Bactrian camel	19.2	0.3	5.9	%	El-Agamy (2006)
Lama glama	Llama	16.5	1.0	6.3	%	Rosenberg (2006)
Mazama gouazoubira	Mazama deer	95.2	87.0	11.1	g/dl	Fernández et al. (1999)
Bos taurus	Cow	130.0	36.0	31.0	g/kg	Meyer and Kamphues (1990)
Bos grunniens	Yak	16.1	14.0	1.9	%	Silk et al. (2006)
Ovis aries	Sheep	130.0	124.0	34.0	g/kg	Meyer and Kamphues (1990)
Capra hircus	Goat	80.0	90.0	25.0	g/kg	Meyer and Kamphues (1990)
Rattus norvegicus	Rat	8.9	14.7	2.5	%	Keen et al. (1981)
Oryctolagus cuniculus	Rabbit	135.0	147.0	16.0	g/kg	Meyer and Kamphues (1990)

publications quantities of protein, fat, and carbohydrate are expressed in different dimensions, either in grams per weight, grams per volume, or percentages of total liquid volume. They can be pooled by considering their sum, independent of their original dimensions, as protein + fat + carbohydrate = 100%. When this is done both for colostrum and mature milk, the differences in protein, fat, and carbohydrate percentages between both liquids (percent colostrum − percent milk) can be determined for different eutherian species. When >1 measurement for either colostrum or mature milk per species was available, means were used. Originally, 36 measurements from 20 eutherian species were available for composition of colostrum, and 137 measurements from 60 species for composition of mature milk. Data were compiled as triangular (or ternary) diagrams, which present percentages of fats, proteins, and carbohydrates for colostrum and for mature milk. Raw data are not listed in this paper, but can be obtained from the author upon request.

Some authors, for example, El-Agamy (2006), supplied results of >1 measurement. These were not considered separately, but means are given for those measurements presented in identical dimensions. However, data for the colostrum of pigs (*S. scrofa*) and for mature milk of house cats (*Felis catus*) and pigs were sometimes presented in different dimensions and are therefore considered separately. Dimensions can either be grams per weight, grams per volume, or percentages of total liquid volume. They can be pooled by considering their sum, independent of their original dimensions, as protein + fat + carbohydrate = 100%. Comparisons of the composition of colostrum and mature milk were thus based on 19 eutherian species (Tables 1 and 2).

To characterize and compare the composition of colostrum and milk from eutherian species for which measurements of both were available, their concentrations of protein, fat, and carbohydrate were compiled from the literature. Assuming that immunoglobulin transfer from mother to offspring is an important factor influencing the composition of colostrum, only those species were considered where information on immunoglobulin transfer was clearly reported (Baintner 2007) or where "informed guesses," based on closely related species (see below), could be made. In many species, the carbohydrates in secretions of the mammary gland are primarily in the form of lactose (Karasov and Martínez del Rio 2007). When only data on lactose concentration were given in references, this was taken as representing the total concentration of carbohydrate in colostrum or milk.

Data on milk composition taken from the literature present a problem because mature milk can change in composition during the lactation period (Oftedal 1984). In most of the references "peak lactation" is the time when measurements were made, but in free-ranging wild mammals, such as *Balaena mysticetus* (bowhead whale), *Loxodonta africana* (African elephant), or *Pecari tajacu* (collared peccary), clear statements concerning the lactation stages were not made.

Colostrum changes in carbohydrate, fat, and protein composition during the 1st days of postnatal life (Baintner 2007), becoming more and more similar to mature milk. It was problematic to obtain unambiguous, well-defined data on colostrum for all eutherian species included in the analyses. Many data were taken from review volumes (e.g., Meyer and Kamphues 1990; Park 2006a) to base this survey on generally accepted information and to obtain comparable data for >1 eutherian

TABLE 2.—Contents of nutrients (proteins, fats, and carbohydrates) in mature milk of 19 eutherian species. Units of measure and references are also given. Scientific names of species follow Wilson and Reeder (2005). Data with different units of measure are given in the literature for the cat (*Felis catus*) and the pig (*Sus scrofa*). Therefore, 2 data sets are given for these species. In all other species means could be calculated because identical dimensions were given. These means are listed in the table.

Species		Mature milk nutrients				
		Protein	Fat	Carbohydrate (lactose)	Unit	Reference
Homo sapiens	Human	10.6	45.4	71.0	g/l	Documenta Geigy (1969)
Papio	Baboon	1.6	5.0	7.3	g/100 ml	Buss (1968)
Canis lupus	Dog	80.0	90.0	30.0	g/kg	Meyer and Kamphues (1990)
Felis catus	Cat	55.0	48.0	40.0	g/kg	Meyer and Kamphues (1990)
Felis catus	Cat	6.6	5.5	4.1	%	Keen et al. (1982)
Balaena mysticetus	Bowhead whale	9.4	19.4	0.0	%	Ben Shaul (1962)
Loxodonta africana	African elephant	25.0	76.0	18.9	g/kg	Osthoff et al. (2005)
Equus caballus	Horse	25.0	20.0	65.0	g/kg	Meyer and Kamphues (1990)
Sus scrofa	Pig	51.0	79.0	52.0	g/kg	Meyer and Kamphues (1990)
Sus scrofa	Pig	5.1	5.4	5.7	%	Park (2006a)
Pecari tajacu	Collared peccary	5.3	4.6	6.5	%	Sowls (1984), Lochmiller et al. (1985)
Camelus dromedarius	Dromedary	3.3	4.1	4.4	%	Abu Lehia et al. (1989), El-Agamy (2006)
Camelus bactrianus	Bactrian camel	4.2	5.3	4.9	%	El-Agamy (2006)
Lama glama	Llama	5.0	5.5	6.6	%	Rosenberg (2006)
Mazama gouazoubira	Mazama deer	65.0	48.2	55.3	g/dl	Fernández et al. (1999)
Bos taurus	Cow	33.0	38.0	50.0	g/kg	Meyer and Kamphues (1990)
Bos grunniens	Yak	5.3	7.0	4.6	%	Silk et al. (2006)
Ovis aries	Sheep	58.0	60.0	43.0	g/kg	Meyer and Kamphues (1990)
Capra hircus	Goat	30.0	34.0	45.0	g/kg	Meyer and Kamphues (1990)
Rattus norvegicus	Rat	12.1	12.2	2.5	%	Keen et al. (1981)
Oryctolagus cuniculus	Rabbit	127.0	148.0	9.0	g/kg	Meyer and Kamphues (1990)

species. In 3 species (cow [*Bos taurus*], sheep [*Ovis aries*], and goat [*Capra hircus*]) domestication produced races specialized either on milk, meat, wool, or multipurpose production. These breeds might produce colostrum and milk of various compositions, which were not taken into account in the present general survey. The present study is—to the knowledge of the author—the 1st that compares colostrum and milk under consideration of different strategies of passive immunization. Information determined under controlled and reproducible conditions could not be obtained for all eutherian species included in the analyses, but data of suboptimal quality can still produce valuable insights.

RESULTS

Concentrations of fats, protein, and carbohydrates varied considerably among species in both colostrum (Fig. 1a) and mature milk (Fig. 1b). Variation in the concentration of protein
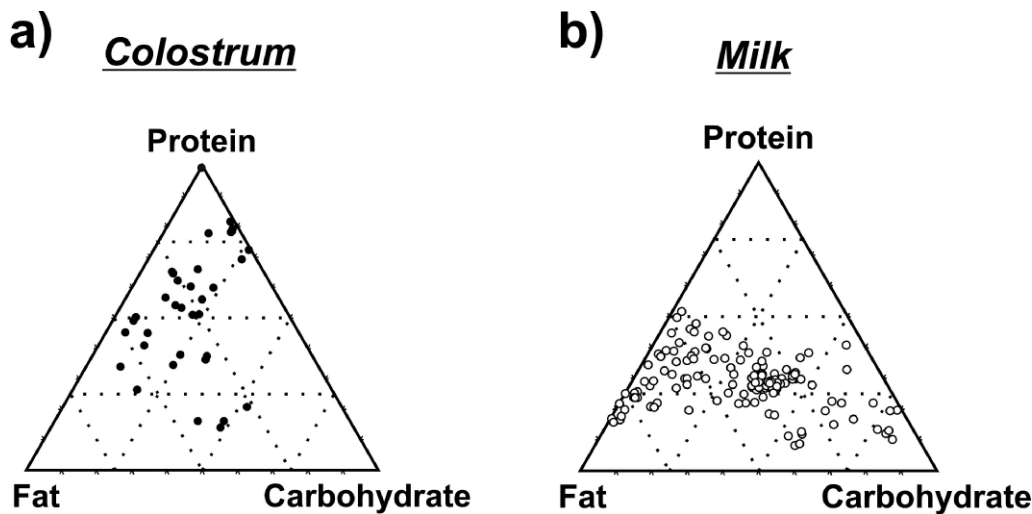

FIG. 1.—Two triangular or ternary diagrams representing composition of fats, proteins, and carbohydrates in a) colostrum and b) mature milk; 36 measurements from 20 eutherian species were available for colostrum and 137 measurements from 60 species for mature milk. The sum of protein plus fat plus carbohydrate is considered as 100%. The percentage of protein can be read from the bottom line of the triangle (0%) to the top corner (100%). The percentage of fat starts at the upper right (0%) and ends at the lower left corner (100%). The percentage of carbohydrate is read from top left to bottom right corner. Dotted lines mark 25%, 50%, and 75%.
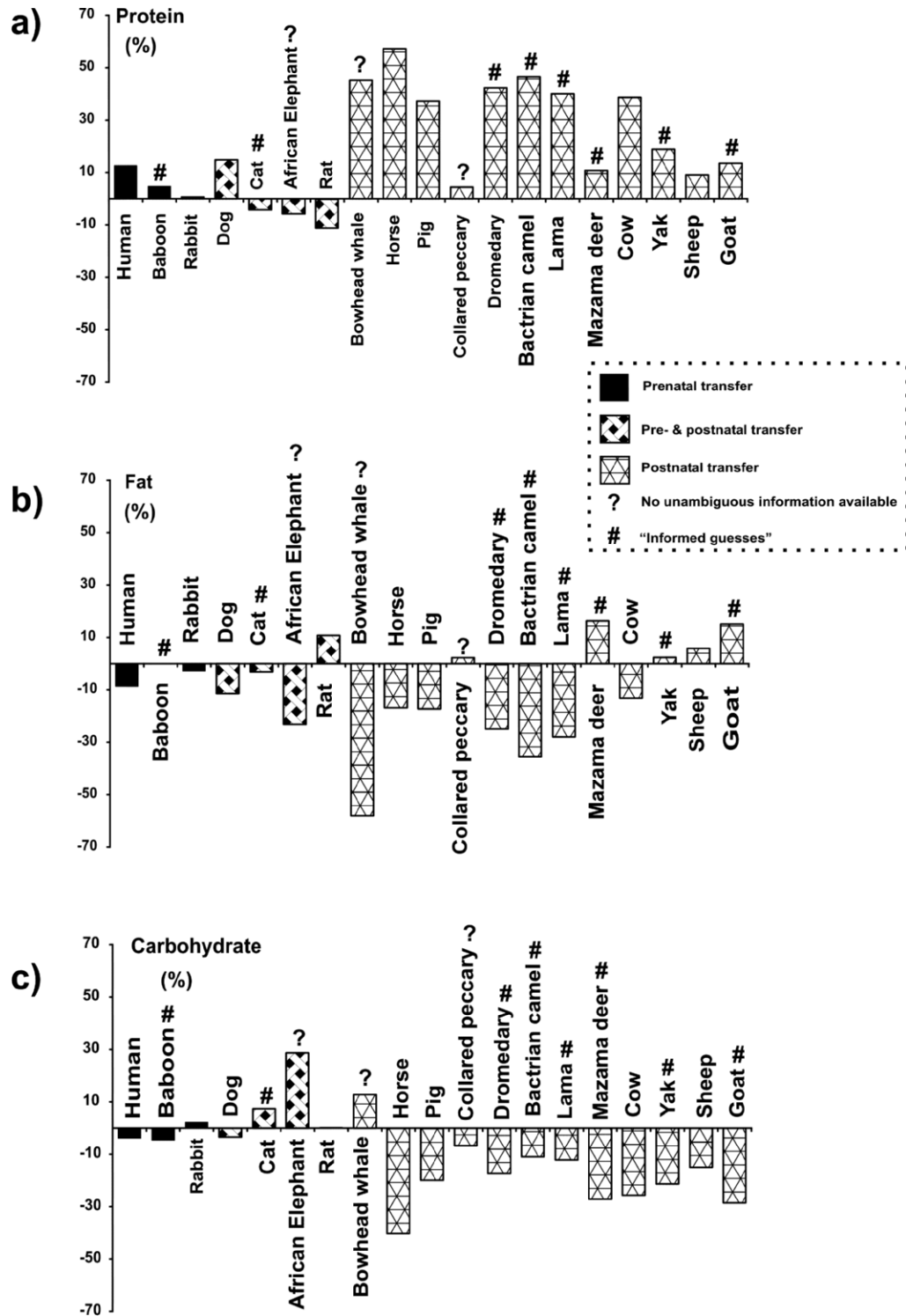
FIG. 2.—a) Differences between the relative concentration of proteins (expressed as percent of protein + fat + carbohydrate = 100%) in colostrum and mature milk for 19 eutherian species. Comparable diagrams are presented for b) fats and c) carbohydrates. Species names are provided in Tables 1 and 2. Positive values mean higher concentrations in colostrum than in mature milk. When concentrations in colostrum are smaller than in mature milk, the columns lie in the negative range. Three types of the maternal–fetal immunoglobulin transfer are indicated by different fill patterns. Question marks indicate taxa for which no unambiguous information on maternal–fetal transfer was available. Number signs (#) indicate taxa for which it is not clearly documented whether transfer happens pre- or postnatally. "Informed guesses" were extrapolated from information on closely related eutherian species, where transfer can be observed either prenatally via the placenta or the yolk-sac wall, or postnatally from colostrum via the small intestine. For example, Mazama deer have not been investigated in this respect, but in other artiodactyls immunoglobulins are supplied to the newborn postnatally (Baintner 2007; Lascelles 1979).

was particularly pronounced in the data examined for colostrum. For example, protein concentration in the colostrum (in g/kg) of horses (*Equus caballus*) and pigs was similar, but colostra of these species were highly different in concentrations of fat and carbohydrate. When milks of the 2 species are compared, protein and fat concentrations varied considerably between species. Differences in percentages of protein, fats, and carbohydrates between colostrum and mature milk (percent colostrum − percent milk) were calculated for the 19 eutherian species, and related to the pattern of postnatal transfer of antibodies (proteins) from mother to young (Fig. 2). In the figure, species with prenatal, with pre- as well as postnatal, and with postnatal transfer of immunoglobulin form 3 groups. In general, the colostrum of species with postnatal transfer of immunoglobulins has a much greater proportion of protein than the mature milk of those species (Fig. 2a).

Oftedal (1984) demonstrated that milk composition varies considerably over the course of the lactation period, but many of the data presented here are based on very few analyses and, because of this, have little information about the state of lactation when milk samples were taken (Park and Haenlein 2006). Data listed in Tables 1 and 2 represent ''averages'' taken from different sources and obtained from different authors with different methods. Thus, patterns are discussed qualitatively. An ideal comparison would consider colostrum and milk from the same mother during ontogeny of her young—data that were not available in the present study. A statistical comparison of few data from very different sources would suggest greater precision than can be offered by presently available data.

DISCUSSION

Differences in the composition of colostrum and milk in the 19 species of eutherians examined in this study reflected differences in immunoglobulin transfer. All newborn mammals, including humans (*Homo sapiens*), are exposed to an environment rich in antigens. Without passive transfer of antibodies from the mother, most ''trivial'' infections would be dangerous in this early phase of life (Braun 1997; Buschmann 1990). The offspring is dependent on the transmission of maternal antibodies (Malek 2003). In colostrum, a large proportion of the protein is globulin that contains antibodies (Park 2006b). Postnatally, proteins, fats, and carbohydrates together contribute to build up body mass and to differentiate tissues and cells. Proteins, fats, and carbohydrates combined represent >90% of solids in milk (Park and Haenlein 2006).

Before reaching full immunocompetence, newborn mammals are protected from infections by maternal antibodies that enable passive immunity. To accomplish this, 3 routes may be used (Baintner 2007; Butler 1974): transfer from mother to fetus through the chorioallantoic placenta may occur; transfer via the yolk-sac wall may occur; or IgG is absorbed from the colostrum via the intestinal wall, mainly the ileum (Baintner 2007). In this latter case, antibodies are not destroyed during the first 24 h of life of the newborn, but with increasing intensity of the digestive process most immunoglobulins are

digested in the offspring's gut. In newborn kittens, maximum IgG concentration in blood serum is reached on day 2 after parturition (Claus et al. 2006), which means that colostrum is ingested by the newborn before that day. In naturally suckling piglets, on the other hand, the period of production of colostrum seems to be longer, because they begin to synthesize their own IgG as late as 7 days of age (Rooke et al. 2003).

Prenatal transfer of immunity from mother to fetus via the placenta is mainly accomplished by immunoglobulins of the IgG class (Herrmann and Forstreuter 1967; Lin 1980; Vernier and Sire 1981), which provide the newborn with sufficient passive immunity against infectious pathogens until the neonatal immune system has matured (Malek 2003). On the other hand, Merad and Wild (1992) emphasized that the rabbit (*Oryctolagus cuniculus*) fetus acquires passive immunity not only in the form of maternal IgG, but also by maternal IgM. Both immunoglobulins are transported prenatally to the fetal blood.

Prenatal transfer of maternal antibodies depends on the architecture of the barrier between mother and fetus. IgG is a relatively small molecule suited for vesicular transport through the trophoblast barrier of the human hemochorial placenta (Kaufmann 1990; Mossman 1987). In this placental type, maternal immunoproteins can be transferred directly into the blood of the offspring, which enables passive immunological protection. In humans, immunoglobulins have to pass the placenta, which has only the syncytiotrophoblast as the important transport barrier (Lüllmann-Rauch 2003). Passage of IgG through this barrier takes place via transcytosis (Lüllmann-Rauch 2003; Welsch 2003), which requires immunoglobulin-binding proteins, the ''Fc receptors,'' involved in antibody transport (Jenkinson et al. 1976; Kacskovics 2004). As an effect of this, there is no significant postnatal immunoglobulin absorption from the gut of newborn humans (Baintner 2007).

In the representatives of rodents and lagomorphs examined to date (*Rattus*, *Mus*, and *Oryctolagus*), maternal γ-globulin is transferred to the fetal blood via the yolk-sac wall (Brambell et al. 1948; Brambell and Halliday 1956). Regardless of the route—yolk-sac wall or placenta—it is well established that immunoglobulin is transferred to the fetal circulation (Elson et al. 1975).

As can be seen in Fig. 2a, prenatal transfer of immunoglobulin in humans, baboons (*Papio*), and rabbits is related to relatively small differences in protein concentration between colostrum and mature milk. Concentrations of fats (Fig. 2b) and carbohydrates (Fig. 2c) in colostrum and milk also do not differ greatly. On the other hand, most ungulate species with postnatal globulin transfer produce colostrum that is much richer in protein than mature milk (Fig. 2a). In these cases, especially in ungulates, passive immunization of the offspring takes place immediately after birth via this rich colostrum.

The greater protein concentration in the colostrum than in milk of ungulates is related to the fact that ungulates produce precocial young that ''subsidize'' their mothers in the final phase of lactation by searching for and eating solid food (Langer 2008a, 2008b). In 4 species with postnatal immuno-

globulin transfer (collared peccaries, Mazama deer [*Mazama gouazoubira*], sheep, and goats) differences in protein concentration between colostrum and mature milk are relatively small. In the majority of ungulates, milk is richer in fats and carbohydrates than is colostrum (Figs. 2b and 2c); fats and carbohydrates both supply energy to the young offspring.

Recent research demonstrated that ''cetaceans are highly derived artiodactyls'' (Milinkovitch et al. 1998), a statement that is well accepted among mammalogists (Berta and Sumich 1999; Geisler and Luo 1998). Under these circumstances it is justified to assume that the time of immunoglobulin transfer takes place postnatally in cetaceans, although unambiguous information on this subject is not available. In the bowhead whale, carbohydrate concentration was higher in colostrum than in milk (Fig. 2c), which is different from the situation in Artiodactyla. On the other hand, the greater fat concentration in mature milk than colostrum of *Balaena mysticetus* might be due to metabolic needs of the growing cetacean offspring.

According to Baintner (2007), the rat (*Rattus norvegicus*; Rodentia) and the dog (*Canis lupus*; Carnivora) show immunoglobulin transfer pre- and postnatally. Stoffel et al. (2000) discuss transport of IgG via the placenta of female dogs. Relative protein concentration is higher in colostrum than in milk of dogs, whereas the milk of rats contains relatively more protein than does colostrum. The latter statement can also be made for the cat, a carnivoran. In his extensive study, Braun (1997) corroborates this observation. He stated that protein concentration increases from colostrum to mature milk in rodents and cats, and also in lagomorphs. In rabbits, which show exclusive prenatal transfer of protein from mother to offspring (Baintner 2007), the difference between relative protein concentration in colostrum and milk is minute, as are the differences in relative fat and carbohydrate concentrations. Because of prenatal transfer, young of rabbits do not need a colostrum that is considerably different from mature milk. Because they are born in a very altricial condition, it is important that the quality of the food supplied by the mother is high, the phase when milk is the only food ingested by the young animal is relatively long, and the time when milk and solid food are taken represents a relatively short time of transition to adult feeding conditions (Langer 2008b).

It is frustrating that the following question cannot be answered: Why is the percentage of protein in milks of cats, African elephants, and rats higher than in colostrum? At least for the data used here for domestic cats it is highly improbable that the colostrum produced immediately after birth was not clearly separated from the milk produced later. Very probably, the increase in protein percentage from colostrum to milk is not an artifact, because it was possible to calculate from data published by Day (2007) that absolute immunoglobulin content is considerably lower (8.3 mg/ml) in feline colostrum than in mature milk (19.1 mg/ml). Braun (1997) documented an increase in protein percentage from colostrum to milk, but a clear explanation for this deviation from other carnivores could not be given by that author. On the other hand, he mentions that colostrum is richer in protein than the milk in other species of Carnivora.

It is possible that the data listed for the African elephant in Table 1 may not really refer to colostrum. Osthoff et al. (2005) collected milk samples from an African elephant cow covering the period from the 4th day after birth onward. In addition, unambiguous information on immunoglobulin transfer in *L. africana* is not available.

The small differences between colostrum and mature milk in protein concentration in collared peccaries and Mazama deer could be due to ambiguous information in the literature, but no clear explanation for why these species differ quantitatively from the other ungulates examined can be given. Small differences in protein concentrations of colostrum and mature milk also were found for domestic sheep, although careful and controlled measurements (Meyer and Kamphues 1990) were possible in this species.

In future investigations the above-mentioned uncertainties could be resolved if colostrum and mature milk from the same mother during the same lactation period were evaluated in as many eutherian species as possible. In spite of the possible bias from suboptimal data that were available for some species in this study, 3 conclusions can be drawn about why colostrum and milk composition are different in some species (e.g., ungulates) and similar in others (primates, rodents, and lagomorphs).

Data for 3 species with prenatal immunoglobulin transfer were available in this study (humans, baboons, and rabbits). Prenatal transfer of immunoglobulins was associated with small differences between the relative concentration of proteins in colostrum and milk. Differences in percentages of fats and carbohydrates between colostrum and mature milk also were small. Because of prenatal passive immunization via the placenta in humans and baboons, or via the Fc-receptor in the everted yolk sac in rabbits (Baintner 2007), the postnatal transfer of protein from mother to offspring can be relatively low and a considerable change in composition from colostrum to milk is not necessary.

Two carnivores (dogs and cats) and 1 rodent (rats) examined in this study transfer immunoglobulins pre- and postnatally (Baintner 2007). In these 3 species, the differences in relative percentages of proteins, fats, and carbohydrates were low, that is, colostrum and milk did not differ considerably. The prenatal part of immunoglobulin transfer will, very probably, reduce the importance of postnatal transfer. More data should be available for species with pre- and postnatal phases of transfer to obtain a clear picture of the relationship between composition of colostrum and milk.

When prenatal maternal–fetal transfer of immunoglobulin is inhibited, such as in ungulates, colostrum has to boost immune protection of the newborn, which means that immunoglobulin has to be available postnatally in great quantities. In this situation, large differences can be observed between relative protein concentration of colostrum and mature milk. This has the consequence that the differences for fat and carbohydrate are also high in species with postnatal globulin transfer. In most of these species, fats and carbohydrates are relatively more important in mature milk than in colostrum. With increasing age and change from colostrum to mature milk, the young animal develops its own immune protection and the relative

amount of immunoglobulins and proteins in general decreases from colostrum to milk.

ZUSAMMENFASSUNG

Kolostrum ist ein besonderer Typ Milch, der von den Eutheria am Ende der Trächtigkeit und in den ersten Tagen nach der Geburt gebildet wird und passive Immunität gegen schädliche Keime vermittelt. Warum unterscheiden sich die relativen Proteingehalte von Kolostrum und Milch bei verschiedenen Arten? Die Rohdaten zur Beantwortung dieser Frage wurden für 19 Eutheria-Arten aus der Literatur zusammengestellt und der Proteingehalt für Kolostrum und Milch wird ausgedrückt als Prozent der Summe der Nährstoffe (Protein + Fett + Kohlenhydrat = 100%). Vor der Geburt wird beim Menschen, Pavian und Kaninchen Protein, welches zum großen Teil aus Immunglobulinen besteht, entweder über die Plazenta oder andererseits über die Wand des Dottersacks von der Mutter in den Blutkreislauf des Nachkommen transportiert. Bei Huftieren wird nach der Geburt Protein, und damit auch Immunglobulin, über das vom Jungtier aufgenommene Kolostrum durch die Darmwand resorbiert. Wenn passive Immunität vor der Geburt erzielt wird, ist der Transfer von Immunglobulinen über Kolostrum von geringer Bedeutung, was zur Folge hat, dass sich die relativen Proteingehalte von Kolostrum und reifer Milch nur wenig unterscheiden. Andererseits wird bei Huftieren nach der Geburt das Neugeborene über das Kolostrum mit reichlich Immunglobulinen versorgt und der Unterschied der Proteingehalte von Kolostrum und Milch ist groß. Die Befunde zeigen, dass die Differenzen in der Zusammensetzung von Kolostrum und Milch die Unterschiede im Zeitpunkt der passiven Immunisierung wiederspiegeln.

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