

The placenta of the Colobinae

Kurt Benirschke

University of California San Diego, Department of Pathology, USA
8457 Prestwick Drive La Jolla, CA 92037, USA <kbenirsc@ucsd.edu>

Key words: Colobinae, langurs, placenta, bilobed, hemochorial

Summary

Leaf-eating monkeys have a hemomonochorial placenta that is usually composed of two lobes and these are connected by large fetal vessels. In general, the placenta is similar to that of the rhesus monkey (*Macaca mulatta*) and, like that species, occasional placentas possess only a single lobe. This paper describes the structure, weights and cord lengths of all colobine monkeys examined by the author to date and it provides an overview of the placentation of langurs in general.

Nghiên cứu về nhau thai của nhóm khỉ ăn lá

Tóm tắt

Ở nhóm khỉ ăn lá (leaf-eating monkeys) nhau thai thường được tạo bởi hai thùy, và hai thùy này nối với nhau bởi những mạch máu lớn từ bào thai. Nhìn chung, cấu tạo nhau thai của nhóm này giống ở nhóm khỉ vàng (*Macaca mulatta*). Và cũng như ở khỉ vàng, thỉnh thoảng nhau thai chỉ có một thùy. Trong nghiên cứu này tác giả mô tả cấu tạo, cân nặng cũng như chiều dài nhau thai của các loài thuộc nhóm khỉ ăn lá. Qua đó cung cấp thông tin toàn diện về cấu tạo nhau thai của các loài khỉ ăn lá.

Introduction

Colobine monkeys have a placentation that is similar to that of other members of the Cercopithecidae. The placentas are usually bilobed, generally their cord insertion site is on the larger of the two lobes, and they have a hemomonochorial relationship to the maternal organism. In addition, there are no atrophied villi in the free membranes, presumably because of the paucity of a true decidua capsularis as well as their superficial endometrial implantation. This paper describes all known placental publications of the Colobinae and provides a summary of the placental weights and other physical characteristics of placentas examined by the author.

Materials and Methods

The placentas presented here come from the births of all Colobinae at the Zoological Society of San Diego and the Endangered Primate Research Center at Cuc Phuong National Park, Vietnam.

The following species were studied:

Delacour's langur *Trachypithecus delacouri*

Francois' langur *Trachypithecus francoisi*

Hatinh langur *Trachypithecus laotum hatinhensis*

Red-shanked douc langur	<i>Pygathrix nemaeus</i>
Grey-shanked douc langur	<i>Pygathrix cinerea</i>
Cat Ba langur	<i>Trachypithecus p. poliocephalus</i>
African Colobus monkey	<i>Colobus angolensis</i>
Hanuman langur	<i>Presbytis (Semnopithecus) entellus</i>

Some of these placentas were received fresh; others had been fixed in 10% formalin solution before examination. Although a bilobed placenta is typical of these species, as will be seen in Table 1, three placentas had only a single lobe despite being apparently complete specimens and, in addition, there were 3 of 20 Hanuman langurs (*Presbytis (Semnopithecus) entellus*) with single lobe. This has also been the case in some rhesus monkey placentas; they are described as having two disks in only about ~80% of term gestations (Myers, 1972; Chez et al., 1972). The real reason for this discrepancy is unknown at this time, but Chez et al. (1972) considered this to represent a hereditary phenomenon. In the closely related baboon, however, only a single placental disk is found. Similarly, in Hanuman langurs 3 of 20 placentas examined by me had only a single lobe (Benirschke, 2007). It is likely that some factors at early implantation are responsible for the discrepancy but no specific suggestions of what they are have been made.

Results

Langurs have a typical hemo-monochorial type of placenta. That is to say, only one trophoblastic layer separates the villous structures from the maternal intervillous blood. The villous structure is very similar to that found in the human placenta and it is shown next. Three to four fetal capillaries nearly fill the tertiary villi that are covered with a continuous layer of syncytiotrophoblast. This trophoblast with its microvillous surface is bathed by the maternal blood. The syncytium derives from the cytotrophoblast, but that is difficult to discern by light microscopy and becomes discontinuous as a layer with advancing gestation. In electronmicroscopic studies, however, it can always be identified and the cytotrophoblast can also be seen in very young langur placental light microscopic preparations (e.g. Burton, 1980). There are also a few connective tissue cells in the terminal villi while they and the fetal villous macrophages ("Hofbauer cells") are more common in secondary villi. The syncytium has a contiguous cytoplasm in which its diploid nuclei are dispersed. There is continuous growth of the syncytiotrophoblast during maturation and thus the formation of syncytial "knots" increases with age. The syncytial knots may detach and get swept away in the intervillous blood stream.

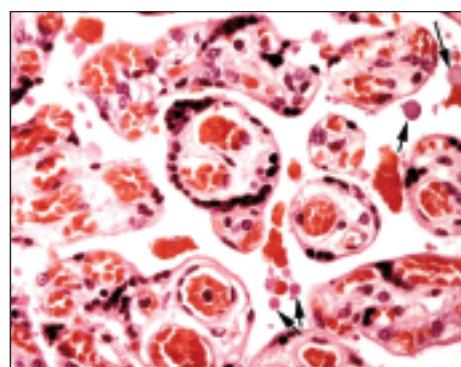


Fig. 1. Villi of mature langur placenta with syncytiotrophoblastic vesicles indicated at arrows.

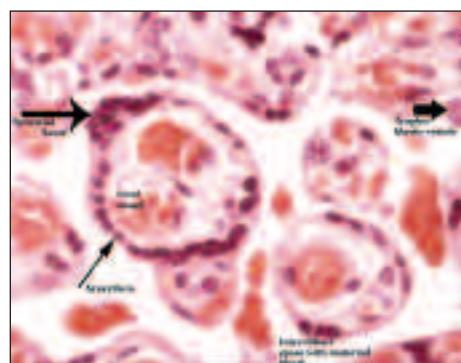


Fig. 2. Higher magnification of terminal mature villi and syncytial "knot".

They end up in the maternal lung and there they disintegrate because they do not have the capacity to reproduce. Additionally, numerous 'cytoplasmic vesicles' are found in the intervillous space that arise from the syncytial cytoplasm. These vesicles contain various enzymes and hormones (Fujikura & Mukai, 2006). The syncytiotrophoblast has a microvillous surface and is responsible for the nutrient and gaseous traffic across the placenta and for hormone production. It is essentially indistinguishable from human trophoblast when studied fine-structurally (Wynn et al. 1971).

The typical feto-maternal 'barrier' thus consists of fetal endothelium, and syncytiotrophoblast. The tertiary villi shown in Fig. 2 branch from larger stem villi which have their connective tissue connection to the chorionic membrane (Fig. 3).

The mature placenta also contains numerous foci of calcification. They occur both, in fibrinoid and in the more sclerotic villi. Such a degenerated 'intermediate' villus with calcification is shown next (Fig. 4).

The variability of the length of the umbilical cord shown in Table 1 is surely the result of inadequate removal at birth or because of incomplete submission to the pathologist. In general, the umbilical cord must be about 25-30 cm long; it possesses two arteries and one vein (Fig. 5). No ducts are present in most umbilical cords and the surface is covered with a single layer of squamous amniotic epithelium. There are few twists of the cord, but when they are present, the twisting is found to occur in both directions.

Many langur placentas have small regions of complete infarction, yellow areas that have become necrotic; most of these are located at the margins. As is true of human placentas with infarcts, these areas merely atrophy and do not become 'organized' by replacement with a scar; and they also do not elicit an inflammatory reaction. More importantly, the mechanism that leads to these frequent infarcts in cercopithecine placentas is unclear. Unlike the findings in human gestations, in which maternal decidua vascular occlusions or 'atherosis' (in preeclampsia) may be held responsible for the infarcts, such changes have not been demonstrated in langurs.

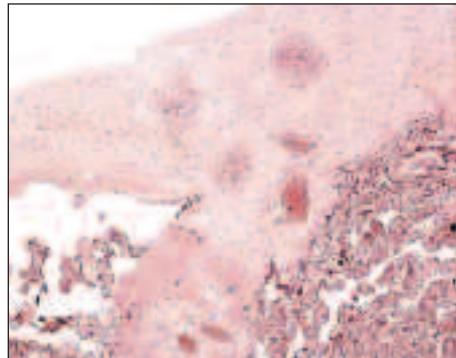


Fig. 3. Fetal surface of placenta with main stem villus arising from the chorionic membrane.

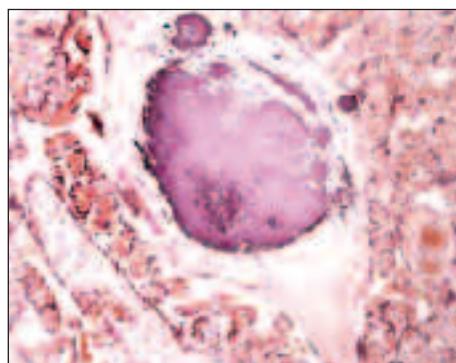


Fig. 4. Calcification (blue) within a degenerated villus.



Fig. 5. Cross section of the umbilical cord. The two umbilical arteries are at the top, the vein is below.

Table 1. The weights of placentas, lengths of umbilical cords and fetal weights (when available) are listed sequentially.

SPECIES	WEIGHT	CORD	LOBES	FETAL WEIGHT
	[g]	[cm]		[g]
Delacour's langur	145 g	26 cm	2	
	82 g	21 cm	2	
Hatinh langur	150 g	13 cm	1	
	87 g	?	2	
Francois' langur	141 g	20 cm	2	
	119 g	16 cm	2	
	70 g	8 cm	2	
Grey-shanked douc langur	118 g	5 cm	2	
Red-shanked douc langur	68 g	14 cm	2 stillborn	465 g
	145 g	19.7cm	2	
	95 g	33 cm	2	
	150 g	31.5cm	2	
	100 g	0	2	367 g
	72 g	18 cm	1	
	130 g	23 cm	2	510 g
	133 g	30 cm	2	577 g
	100 g	24 cm	2	475 g
	87.5 g	31 cm	2	304 g
	68.4 g	32 cm	2 stillborn	475 g
	195 g	21 cm	2 stillborn	
	110 g	24 cm	2	
Cat Ba langur	65 g	16 cm	2	
African Colobus monkey	120 g	21 cm	2	
	135 g	?	2	
	105 g	10 cm	2	
	129 g	3.5cm	2	750 g
	112 g	23 cm	2	272 g
	31 g	15 cm	1	
Hanuman langur	20 placentas are shown in tabular form by Benirschke (2007).			

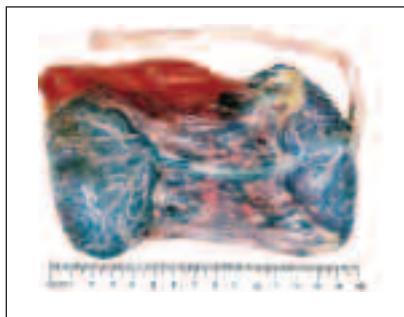


Fig. 6. Delacour's langur placenta with two lobes, cord insertion on larger lobe and connecting vessels between the two lobes. Photo: T. Nadler.

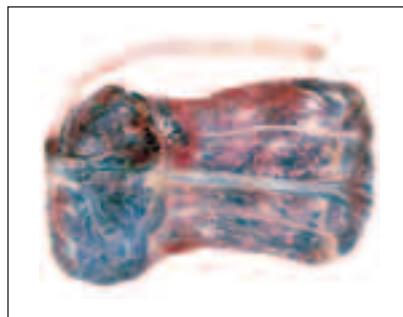


Fig. 7. Maternal surface of the same placenta as in Fig. 6. Photo: T. Nadler.

The membranes are composed of an inner layer of amnionic epithelium that sits on a thin layer of avascular connective tissue. While the amnion is compressed against the chorionic membrane, it can always be detached since it is not physically fused with the chorion. In the free membranes between the two lobes and those making up the gestational sac there are the large blood vessels that connect the two placental lobes (Fig. 6,7). A thin layer of trophoblast and some small quantity of decidua 'capsularis' form the outer surface of the free membranes (Fig. 8). In contrast to human placentas, however, the free membranes contain no atrophic villi. While they are characteristically found in the decidua capsularis of human placental membranes, they are absent in langurs, marmosets, rhesus monkey and most other primates studied in sufficient detail.



Fig. 8. Free membranes with amnion above, followed by a potential space, the chorion, trophoblast and decidua capsularis.



Fig. 9. Maternal surface of the placenta with the shell of extravillous trophoblast and peripheral decidua basalis. One of the large connecting blood vessels is carried in the chorion.

Another feature that distinguishes the langur placenta from that of human gestations is the nature of the maternal floor. The langurs have a relatively smooth outer surface on their disks. Peripheral to the villous tissue is a nearly smooth shell of extravillous trophoblast, cells that represent the invasive, implanting elements, and then follows a layer of less modified decidua basalis (compared to that seen in human term placentas) in which the placenta separates by shearing. It does not appear to be infiltrated by trophoblast very deeply (Fig. 9).

Discussion

The findings of different species of leaf-eating monkey's placentas show great similarities in their macroscopic and histological appearance. While most are bilobed, a smaller number has no secondary lobe despite being associated with the development of a normal offspring. Thus, these placentas resemble closely those of the better studied placentas of rhesus monkeys and baboon (Ramsey, 1982; Mossman, 1987), including the occasional unilobar structure. In addition, it is striking that none of these species possesses the numerous atrophic villi on the free membranes that are so characteristic of human placentation. Thus, there must be a sufficient difference in the early implantational relationship between trophoblast and endometrium. Unfortunately, the only early langur implantation sites described are restricted to two young implantations in dusky leaf monkeys (*Trachypithecus obscurus*) by Burton (1980). He found a number of significant differences from early human implantations. First, he suggested that there was little typical 'decidual' change in the endometrium. Remarkably though, the detachment of placentas from the uterus at term suggests that some decidualization must exist at the base. Also, some maternal endometrial tissue is found on the membranes and that tissue as well as that on the placental base is similar to endometrial stroma. It may not show the histological increase of glycogen content and the compaction of endometrial stromal cells may be different, but it must serve similar function. But then, the formation of the decidua is very complex, as was so well delineated in Kliman's review (2000); differences surely exist amongst primates. Burton (1980) also described the invasion of maternal blood vessels by extravillous trophoblast that is similar to human placentation without, however, causing the typical vascular modification of spiral arterioles to takes place in human implantation.

Most importantly though, Burton (1980) depicts the very large and superficial nature of the implanting trophoblast. In his second specimen, typical villous formation is shown, while there is apparently no evidence of the development of a secondary disk at those stages. As far as the pattern of fetal blood vessels is concerned, the majority show the 'magistral' type, as was true of baboon placentas (Houston & Hendrickx, 1968). Regrettably, no studies were conducted to ascertain the possible absence of the transverse umbilical arterial anastomosis ('Hyrtl anastomosis'). This is a definite need for future investigations.

Acknowledgements

The placentas from the Zoological Society of San Diego were kindly made available by April Gorow and the zoo's pathology department; those from the Endangered Primate Research Center, Vietnam come through the courtesy of Ulrike Streicher and Tilo Nadler. Helena Fitch-Snyder was very helpful in other respects.

References

- Benirschke K** (1982): Anatomical and functional differences in the placenta of primates. *Biol. Reprod.* 26,29-53.
- Benirschke K** (2007): Comparative Placentation. <http://medicine.ucsd.edu/cpa>.
- Benirschke K, Streicher U & Nadler T** (2004): The placenta of leaf monkeys. In: Nadler, Streicher & Ha Thang Long (eds.): Conservation of Primates in Vietnam; pp. 144-146. Frankfurt Zoological Society, Hanoi.
- Burton GJ** (1980): Early placentation in the dusky leaf monkey (*Presbytis obscura*). *Placenta* 1,187-195.
- Chez RA, Schlesselman JJ, Salazar H & Fox R** (1972): Single placentas in the Rhesus Monkey. *J. med. Primatol.* 1, 230-240.
- Fujikura T & Mukai M** (2006): Syncytiotrophoblastic vesicles in placental intervillous space. *Am. J. Obstet. Gynecol.* 195:304-307.

- Houston ML & Hendrickx AG**: (1968) Observations on the vasculature of the baboon placenta (*Papio* sp.) with special reference to the transverse communicating artery. *Folia Primatol.* 9, 68-77.
- Kliman HJ** (2000): Uteroplacental blood flow. The story of decidualization, menstruation, and trophoblast invasion. *Am. J. Pathol.* 157, 1759-1768.
- Mossman HW** (1987): Vertebrate Fetal Membranes. MacMillan, Houndsills.
- Myers RE** (1972): The pathology of the rhesus monkey placenta. In: Symposium on the Use of Non-human Primates for Research on Problems of Human Reproduction; pp. 221-260. Sukhumi, 1971. WHO Research & Training Centre on Human Reproduction, Karolinska, Sweden.
- Ramsey EM** (1982): The Placenta. Human and Animal. Praeger Publishers, New York.
- Resnik R, Robinson PT, Lasley B & Benirschke K** (1978): Intrauterine fetal demise associated with consumption coagulopathy in a Douc langur monkey (*Pygathrix nemaeus nemaeus*). *J. med. Primatol.* 7, 249-253.
- Wynn R, Panigel M & MacLennan AH** (1971): Fine structure of the placenta and fetal membranes of the baboon. *Am. J. Obstet. Gynecol.* 109, 638-648.