



Newborn adaptations and healthcare throughout the first age of the foal

B.R. Curcio¹, C.E.W. Nogueira¹

¹Department of Veterinary Clinics, Veterinary College, Federal University of Pelotas, Pelotas, RS, Brazil

Abstract

This paper aims to present the events of physiological adaptation to external environment in newborn foal and their relationship with the healthcare provided in this phase. This process includes a detailed evaluation of the mare during pregnancy and foaling, as well as clinical observations of neurological reflexes from the neonatal foal, behavioral and laboratory tests to determine the degree of maturity and viability of the newborn.

Keywords: foaling, mare, maturity, newborn, perinatology.

Introduction

The population of racehorses in Brazil is estimated in 900,000 animals, and in recent years, the profile of Brazilian equestrian breeding is changing; the horse, as a domestic animal, has become a tool for entertainment, not merely production (Mendes, 2011). That shift, in conjunction with the economic status of the country, has contributed to the remarkable growth of embryo transfer (ET) in the equine industry. In 2003, Brazil was considered the second country in the world with respect to number of transferred embryos (Viana, 2005), and by 2006, an estimated average of 6,000 pregnancies a year were derived from ET (Losinno and Alvarenga, 2006). In 2010, Brazil was the first in the world, with 12,422 embryos transferred (Stroud, 2011). However, no information has been disclosed on birthrates of these pregnancies. In Brazil, the breeding through the application of biotechnologies, including the extensive use of ET, has resulted in an increasing concern with perinatal problems. This new market demand has encouraged the resumption of research in equine neonatology in the country. Such studies are being developed by a few groups that have expertise in the area, being located near large concentrations of Thoroughbred (TB) breeders. At birth, the foal undergoes a number of physiological adaptations to the external environment, assuming functions previously performed by the placenta, such as respiration, nutrition and excretion (Sangild *et al.*, 2000). This review aims to present the main events related to the early neonatal foal and their relationship with the healthcare provided during this phase.

Foaling and perinatal endocrine adaptations

The signals that trigger delivery start with hormones released by the hypothalamus-pituitary-

adrenal (HPA) axis of the fetus. Prior to 30 days before delivery (before 290 days of gestation), fetal HPA axis shows basal activity and is considered to be unable to respond to low levels stimulus of circulating ACTH. There is a large increase in the maternal levels of progesterone (P4) during the final weeks of pregnancy (nearly 310-330 days of gestation), resulting from stimulation of fetal adrenal gland by changes in the pattern and bioactivity of ACTH produced by the pituitary (Fowden *et al.*, 2012). When the fetal adrenal gland expresses enough of the enzyme 17 α -hydroxylase (P450c17), which transforms the P4 to cortisol, fetal cortisol elevation occurs, concomitant with a decrease in progesterone and an increase in estradiol-17 β in maternal circulation (Holtan *et al.*, 1991; Ousey *et al.*, 2004).

In the 24 h before delivery, there is a predominance of circulating estrogen, which increases the responsiveness of myometrial oxytocin receptors; this event is essential for the development of labor. The elevation of cortisol typically occurs in the last 5 days of gestation, continues for a few hours after birth and is considered to be essential for maturation of the organs of the newborn (Allen, 2000).

The knowledge of the history of fetal development period is fundamental to the evaluation process and outcome of neonates.

Initial adaptation to the extrauterine environment

The neonatal period is characterized as a transitional phase for physiological and metabolic organs and systems to meet the new challenges of extra-uterine environment (Rossdale, 2004).

Immediately after the expulsion of the foal, respiration begins; respiratory movements can typically be observed 30 sec after birth (Pierce, 2003). The establishment of pulmonary respiration in the neonate is triggered by chemical, thermal and tactile stimulation. The chemical factors are hypoxemia, hypercapnia and respiratory acidosis that occur during labor and that stimulate the respiratory center in the medulla. The decrease in O₂ pressure and blood pH, associated with an increased CO₂ pressure, are triggered by the start of placental separation and the occlusion of blood flow to the cord, restricting gas exchange (Acworth, 2003). Other important components that complete the sequence of stimuli (thermal and tactile) are the sharp drop in temperature in the external environment; the effects of gravity, reducing the circulatory resistance previously promoted by the placenta; and the chest compression suffered by the foal during the passage through birth

¹Corresponding author: curciobruna@hotmail.com

Phone: +55(53)3275-7506

Received: June 16, 2012

Accepted: July 25, 2012



canal, a stimulus that may be enhanced by massage performed after birth (Stoneham, 1991, Acworth, 2003).

When the first respiratory movement occurs, an air-liquid interface is formed in the alveoli. In the lung, surfactant produced by alveolar type II epithelial cells acts to reduce the surface tension and stabilize the alveoli (Lester, 2005). When the lung expands and the O₂ pressure increases, pulmonary vascular resistance declines rapidly, and pulmonary blood flow increases by approximately 10-fold. With the transition from placental circulation to systemic circulation of the foal, associated with alterations in the pulmonary circulation, there is a reduction of the inlet pressure in the right atrium and an increase in the volume of blood returning via the left atrium. When the left atrial pressure exceeds the right, the closure of the foramen ovale occurs. In this first phase, a portion of the blood returning from the lung via the left atrium is also pumped back into the right heart chamber via the ductus arteriosus, which is still open. The ductus arteriosus may remain open until the 4th day of life in equine neonate. The closure of this gap is mediated by increased O₂ tension and a reduction in the circulating and tissue levels of prostaglandins, although this mechanism is active only in mature neonates (Lombard, 1990).

The evaluation of the peripheral circulation can be performed by observing the mucous membranes. These membranes must have a pink color and a capillary refill time of 2 sec or less from the first minute of life. The initial parameters of the cardiac and respiratory rate should be 60-70 breaths/min and 60-120 beats/min, respectively (Koterba, 1990; Pierce, 2003). The maintenance of the body temperature by the neonate requires considerable energy. Thermogenesis may occur with increased involuntary muscle tremors or without the occurrence of tremors. In this situation, increased metabolic heat production and oxygen consumption can arise from brown adipose tissue. However, there is no evidence of the presence of brown adipose tissue in foals. Even with the ingestion of colostrum, the primary metabolic energy source of the foal is its endogenous glycogen stores. Weak and premature foals are susceptible to conditions such as hypothermia because of their weak body condition, which is characterized by reduced energy reserves, an apathetic attitude, low consumption of colostrum and hypoglycemia (Acworth, 2003; Morresey, 2005). The maintenance of a body temperature of 37.2 to 38.9°C is considered to be physiologically normal in foals up to 4 days old (Koterba, 1990).

The rupture of the umbilical cord should occur by the natural movement of the mare or foal. The umbilical remnant should be treated to reduce bacterial contamination until it is sealed. The most commonly used products are 0.5% chlorhexidine and 2-5% solutions of iodine (Acworth, 2003). The average time to rupture is 5-6 min (Pierce, 2003). It is important to choose the best location and to maintain a quiet

environment so that the horse remains in position for a few minutes to facilitate cord stenosis (Finger *et al.*, 2010). Examination of the placenta should be part of the monitoring protocol for foaling and newborn foal. Initially, the fetal membranes must be weighed; the total weight of the placenta should be close to 11% of the weight of the foal. For macroscopic evaluation, the placenta should be extended on a clean surface and in a well-lit area, in a "Y" or "F" shape (Schlafer, 2000). The integrity of the placental structures should be noted, with special attention paid to the ends of the uterine horns. The macroscopic changes that can be observed in the chorioallantois include lack of microvilli, thickening and tissue necrosis, presence of pus and other signs of inflammation (edema, fibrin, congestion or hemorrhage; Schlafer, 2004).

The histopathology of the placenta has been the focus of our research group for the last 3 yr, with a particular emphasis on the study of inflammatory and degenerative diseases of the placenta. The identification of inflammatory changes in the histopathology of the placenta, characterized by mixed cellular infiltrates and a predominantly histio-lymphocytic presence of some neutrophils, is related to low birth weight and associated with clinical and metabolic impairment in TB neonates (Finger *et al.*, 2011).

The concept of the prenatal origin of a neonatal foal's clinical condition was established by Rossdale (1972). The term dysmaturity, from the human literature, was used to describe maladjusted foals that are born at term (gestation >320 days), but with clinical and behavioral signs similar to those observed in premature foals (Rossdale, 1976), exhibiting the syndrome known as intrauterine growth retardation (IUGR; Rossdale and Ousey, 2002). Several studies have been performed to identify factors related to the deprivation of nutrients to the developing fetus as a result of placental or uterine defects (Rossdale and Ousey, 2002). Foals originated from pregnancies with these complications present signs of immaturity, which exemplifies the importance of pre-natal evaluation to identify potential problems of newborn foals.

Behavior of the equine neonate

The next adaptation stage of the newborn is the activation of neuromuscular reflexes and behavior, which are essential for the foal to remain standing and gain the energy to follow the footsteps of the mare, obeying his instincts to escape from predators, which are characteristic of the prey attitude of the equine (Rossdale, 2004).

The time intervals from birth to the manifestation of specific reflexes in foals are used as parameters for evaluating goals on health of the newborn. However, these values may vary according to breed (Stoneham, 2006), monitoring and degree of manipulation in foaling. For healthy foals, the following times are described: sternal recumbence, 5-10 min;



sucking reflex, 5-20 min; standing, up to 1 h; nursing from the mare, up to 2 h; and eliminating the meconium, 2 h (Koterba, 1990; Kurtz Filho *et al.*, 1997; Vaala, 2000; Pierce, 2003; Stoneham, 2006).

Table 1 describes the results obtained by our

research group over three reproductive seasons (2009-2011) regarding neuromuscular reflexes and behavioral signs observed in monitored foaling in Thoroughbred breeding farms in Southern Brazil (31°51'55" south; 54°10'02" west).

Table 1. Values of mean and standard deviation (SD) for neuromuscular reflexes and behavioral signs in monitored foaling in Thoroughbred breeding in the south of Brazil (31°51'55" south; 54°10'02" west).

	Sitting sternally (n = 273)	Sucking reflex (n = 278)	Time to stand (n = 278)	Time to suck (n = 274)	Time to eliminate meconium (n = 264)
Mean ± SD	4 ± 5 min	30 ± 11 min	34 ± 14 min	51 ± 18 min	63 ± 28

Neonates with musculoskeletal (flexural or angular changes, incomplete ossification), neurological (fasciculation and reduced muscle tone) or septic (joint distension and incomplete ossification) impairment tend to remain in one position for a longer time (Morressey, 2005). When the time to achieve sternal recumbence and a standing position exceed the expected values, the reasons for those changes should be investigated.

Performing feeding in the first 2 h is critical for a proper energy supply and for the absorption of immunoglobulins by the foal (Le Blanc, 1990).

In general, foals with little ability to remain standing and nurse within 2 h of life are considered to be potentially abnormal (Koterba, 1990). These events are essential for the maintenance of metabolic homeostasis and for establishing the bond between the foal and mare.

Most foals' passage of the meconium starts 2 h after birth, in certain cases demonstrating mild abdominal discomfort. The complete elimination can take 12-24 h (Koterba, 1990; Morressey, 2005). Colostrum has the ability to stimulate gastrointestinal motility in foals (Le Blanc, 1990), and the passage of the meconium typically starts 30 min after the colostrum intake of the newborn (Kurtz Filho *et al.*, 1997). Therefore, a foal that achieved adequate intake of colostrum does not require the administration of laxatives or enemas for the prophylaxis of meconium retention (Kurtz Filho *et al.*, 1997). However, the routine use of a commercial sodium phosphate-based enema in all animals after delivery is described in the literature (Pierce, 2003) and widely used in horse farms in Brazil.

The evaluation of parameters related to the urinary system is not routinely performed. The reduced flow of urine may be a result of low fluid intake, increased fluid losses by other mechanisms or impaired renal function (Morressey, 2005). The time for the first urination after delivery is 6 to 10 h in foals and fillies (Jeffcott, 1972). The rate of production of urine in the neonate is 6 ml/Kg/h (Brewer *et al.*, 1990). The blockage or rupture of a portion of the urinary tract, resulting in uroperitoneum, is a common occurrence in compromised foals or in cases of trauma during delivery (Morressey, 2005).

When all these steps have been completed, the

observation of the foal continues, with emphasis on adaptation of renal functions and a gradual increase in the demand for food.

Passive transfer of immunity

Macromolecules, such as immunoglobulins, that are present in the colostrum are absorbed by pinocytosis in the intestinal epithelium of the neonate without significant digestion. The uptake of immunoglobulins presents maximum absorption immediately after birth, declining to 22% of its capacity in the foal within 3 h of life (Jeffcott, 1971).

For the process of transfer of passive immunity through colostrum to occur efficiently, it is necessary to ensure that the foal ingests approximately 1 liter of good quality colostrum within the first 6 h of life (Sellon, 2006). Good quality colostrum has a viscous, yellowish aspect and a specific density ≥ 1060 (evaluated by a densimeter), which corresponds to a minimum concentration of IgG of 3,000 mg/dl. Upon delivery, the concentration of IgG in the colostrum of mares exceeds 9,000 mg/dl (Le Blanc, 1990). In the evaluation of colostrum, a portable refractometer unit is used to determine the Brix% and follows the following interpretation: Regular, 15-20% Brix and 28-50 g/dl IgG; Adequate, 50-80 g/dl Brix and 21-30% of IgG and Very good, >30% Brix and >80 g/dl IgG (Cash, 1999).

The indicated procedure during the monitoring of the delivery is to collect a sample for the evaluation of the colostrum before the foal begins the first feeding. If the mother does not have the appropriate concentration of IgG in the colostrum, colostrum from a wet stock of milk or frozen colostrum must be offered to the neonate.

Foals that fail to receive the transfer of passive immunity (if the IgG is less than 400 mg/dl) may be subjected to the transfusion of plasma to increase the concentration of serum IgG. The donor plasma must have a minimum concentration of 1,200 mg/dl IgG. An increase from 200 to 300 mg/dl is observed in the foal serum IgG after the administration of 1 liter of plasma.

In Brazil, horse farms often collect plasma from their own animals, which are donors with adequate sanitary control, instead of commercial equine plasma. This practice results in a lower cost and antibodies specific for the agents in the environment in which the foal lives.



Clinical pathology of the foal

Hematology

Erythrocytes

During the fetal period, the process of hematopoiesis occurs in the liver, and the bone marrow does not contribute to this process until the end of pregnancy. At birth, the foal has high levels of packed cell volume, red blood cell (RBC) and hemoglobin concentration (Harvey *et al.*, 1984). This increase is likely due to blood transferred from the placenta via the umbilical cord at birth. The hematocrit values decrease by approximately 10% within the first 12-24 h (Axon and Palmer, 2008). The RBC and hemoglobin values decline during the first 2 weeks and then remain low in proportion to reference values of adult horses (Harvey *et al.*, 1984).

Leukocytes

A significant increase in white blood cells is

observed in the first 12 h of the foal's life. This increase is due to the large increase in circulating neutrophils. The neutrophil/lymphocyte (N/T) ratio is 2.5:1 at birth, and after 3 h of life, it increases to 3.5-4:1 in response to the peak level of cortisol in the fetal circulation that occurs in this phase (Silver *et al.*, 1984). These events are important markers of adrenocortical activity and maturity of the newborn (Rossdale, 2004).

Eosinophils are not found in the fetus and neonate, first appearing in foals at 4 months of age. Monocytes and basophils are absent or reduced in number during the neonatal period and do not show significant changes during the first year of life (Harvey, 1990).

In Table 2, hematological data in Thoroughbred foals are described, accompanied by data obtained by our research group during the foaling season of 2011 (South Brazil). The means of the hematological values found in foals before suckling (the immediate postpartum period), during the first 12-24 h and in the first 7 days of life were compared by the Tukey's test.

Table 2. Hematological data found in Thoroughbred foals before suckling (immediate postpartum period), during the first 12-24 h and at the 7th day of life, in the south of Brazil (31°51'55" south; 54°10'02" west).

Trials	Immediate postpartum			12-24 h			7th day		
	N	Mean	SD	N	Mean	SD	N	Mean	SD
PCV (%)	88	46.47 ^a	3.80	89	40.98 ^b	4.94	78	36.30 ^c	5.07
TPP (g/dl)	88	6.40 ^a	0.74	89	7.53 ^b	0.90	78	7.55 ^b	0.78
FB (mg/dl)	88	312.5 ^{ab}	126.68	87	275.86 ^b	131.15	77	345.45 ^a	130.33
Leucocytes (x10 ³ /μl)	87	6.25 ^a	2.00	86	8.84 ^b	2.17	76	9.68 ^b	3.45

^{a,b,c}Different letters in the same row indicate differences ($P < 0.05$). Abbreviations: PCV: Packed cell volume; TPP: Total plasma proteins; FB: fibrinogen.

Blood biochemistry

The values related to blood chemistry are widely varied during the first 4 weeks in the equine neonate. In this review, we discuss plasma proteins, urea, creatinine, glucose and lactate. We do not discuss changes in enzymology and electrolytes; for more information on these topics, we recommend a review published by Axon and Palmer (2008).

Total plasma proteins

Foals are born with a wide variety of plasma proteins, including albumin and fibrinogen. Starting in the first 12-24 h of life, there is a gradual increase in the serum protein concentration due to the absorption of globulins from adequate intake of colostrum (Axon and Palmer, 2008).

Fibrinogen concentrations are low at birth (<200 mg/dl), increase progressively until the 5th month and then are reduced to near the default values of adult horses (Harvey *et al.*, 1984). Foals born with hyperfibrinogenemia, up to 2 days old, may have been subjected to septic or inflammatory stimuli in the uterus. In

the septic foal, hyperfibrinogenemia is associated with leukopenia and an N/L ratio of 1:1 (Morresey, 2005).

Creatinine and urea

Azotemia in neonatal foals up to 7 days old may be an indicator of pre-renal failure, acute kidney injury, obstruction, or congenital renal lesions of urine collection systems, coinciding with uroperitoneum. However, it is noteworthy that the concentration of creatinine and urea (BUN) is high in the first 24 h of life, with values of 15-30 mg/dl for urea and 2-4 mg/dl for creatinine (Harold, 2011). The creatinine may remain high in the first 36 h of life, after which it returns to values similar to those of reference for adult horses (Edwards *et al.*, 1990). The values of urea are generally reduced, being close to the lower limits found in adult horses in the first 24 h of a foal's life (Harold, 2011).

In this initial phase, the presence of a "spurious hypercreatininemia" may be a transient finding in asphyxiated foals or foals delivered by mares with placentitis (Chaney *et al.*, 2010). Neonatal foals with a spurious hypercreatininemia (>20 mg/dl) show normal serum electrolytes, indicating that renal function is



adequate. These foals show declines of 50% in the serum creatinine after 1 or 2 days with adequate fluid therapy (Chaney *et al.*, 2010, Harold, 2011).

Elevations in BUN have been related to negative energy balance, typically in critically ill foals and newborns that have suffered stress and catabolism during the fetal period (Axon and Palmer, 2008).

Glucose

The initial concentrations in newborns are related to maternal serum levels, with stabilization of blood glucose occurring after 2 h (108-109 mg/dl). This stabilization is due to the process of gluconeogenesis and enteral feeding started by the foal. In affected individuals, failures occur in these processes, resulting in hypoglycemia (Koterba *et al.*, 1984).

The blood glucose concentration increases in the first 48 h and remains at higher values in foals up to 6 months of age (120-210 mg/dl) compared with adult horses (Fowden *et al.*, 1982; Bauer, 1990).

Lactate

The lactate concentrations are high at birth, showing a marked reduction in the first 24 h. The values described in this period range from 3.0 ± 0.04 mmol/l to 4.9 ± 1.02 mmol/l. Increases in these values are associated with reduced perfusion frames with tissue hypoxia (Axon and Palmer, 2008). Hyperlactatemia has also been associated with increased metabolism in cases of inflammation and activation of protein catabolism, as in cases of sepsis. Thus, this value can be used as a prognostic marker in critically ill foals (Franklin, 2007; Henderson *et al.*, 2007).

Concluding remarks

The neonatal period can be defined as a process of physiological adaptations in the life of the foal. When the objective is to assess the maturity and viability of the newborn, one must consider a detailed evaluation of the mare during pregnancy and foaling and of the neonatal foal, including clinical observation of neurological reflexes, behavioral signs of reflexes and interpretation of endpoints related to endocrinology, hematology and biochemistry.

References

Acworth NRL. 2003. The health neonatal foal: routine examinations and preventative medicine. *Equine Vet Educ*, 15(suppl 6):45-49.

Allen WR. 2000. The physiology of later pregnancy in the mare. *In: Proceedings of the Annual Conference of the Society for Theriogenology*, 2000, San Antonio, TX. Montgomery, AL: SFT. pp. 3-15.

Axon JE, Palmer JE. 2008. Clinical pathology of the

foal. *Vet Clin Equine*, 24:357-385.

Bauer JE. 1990. Normal blood chemistry. *In: Koterba AM, Drummond WH, Kosch PC (Ed.). Equine Clinical Neonatology*. Philadelphia, USA: Lea & Febiger. pp. 602-614.

Brewer BD, Clement SF, Lotz WS, Gronwall R. 1990. A comparison of insulin, para-aminohippuric acid, and endogenous creatinine clearances as measures of renal function in neonatal foals. *J Vet Intern Med*, 4:301-305.

Cash RSG. 1999. Colostral quality determined by refractometry. *Equine Vet Educ*, 11:36-38.

Chaney KP, Holcombe SJ, Schott HC, Barr BS. 2010. Spurious hypercreatininemia: 28 neonatal foals (2000-2008). *J Vet Emerg Crit Care*, 20:244-249.

Edwards DJ, Brownlow MA, Hutchins DR. 1990. Indices of renal function: values in eight normal foals from birth to 56 days. *Aust Vet J*, 67:251-254.

Finger IS, Curcio BR, Lins LA, Frey Jr F, Nogueira CEW. 2010. Assistência ao parto em equinos. *Braz J Equine Med*, 5:32-35.

Finger IS, Lins LA, Frey Jr F, Kasinger S, Nogueira CEW. 2011. Clinical e metabolic evaluation of neonatal foals relates to the presence of inflammatory lesions of the placenta. *In: Resúmenes del II Congreso Argentino de Reproducción Equina*, 2011. Mendoza, Argentina. Rio Cuarto: Facultad de Agronomía y Veterinaria. pp. 605-608.

Fowden AL, Ellis L, Rossdale PD. 1982. Pancreatic B cell function in the neonatal foal. *J Reprod Fertil Suppl*, 32:529-535.

Fowden AL, Forhead AJ, Ousey JC. 2012. Endocrine adaptations in the foal over perinatal period. *Equine Vet J*, 44(suppl 41):130-139.

Franklin RP. 2007. Identification and treatment of the high-risk foal. *In: Proceedings of the 53th Annual Convention of the American Association of Equine Practitioners*, 2011, Orlando, FL. Lexington, KY: AAEP. pp. 320-328.

Harold CS. 2011. Review of azotemia in foals. *In: Proceedings of the 57th Annual Convention of the American Association of Equine Practitioners*, 2011, San Antonio, Texas. Lexington, KY: AAEP. pp. 328-334.

Harvey JW. 1990. Normal hematologic values: *In: Koterba AM, Drummond WH, Kosch PC (Ed.). Equine Clinical Neonatology*. Philadelphia, USA: Lea & Febiger. pp. 561-570.

Harvey RW, Asquith RL, McNulty PK. 1984. Haematology of foals up to one year old. *Equine Vet J*, 16:347-353.

Henderson RP, Wilkins PA, Boston RC. 2007. Association of hyperlactatemia with age, diagnosis, and survival in equine neonates. *In: Proceedings of the 53th Annual Convention of the American Association of Equine Practitioners*, 2011, Orlando, FL. Lexington, KY: AAEP. pp. 354-355. (abstract).

Holtan D, Houghton E, Silver M, Fowden AL, Ousey



- J, Rossdale PD.** 1991. Plasma progesterone in the mare, fetus e newborn foal. *J Reprod Fertil Suppl*, 44:517-528.
- Jeffcott L.** 1971. Duration of permeability of the intestine to macro-molecules in the new-born foal. *Vet Rec*, 88:340-341.
- Jeffcott L.** 1972. Observations on parturition in crossbred pony mares. *Equine Vet J*, 4:209-213.
- Koterba AM, Brewer BD, Tarplee FA.** 1984. Clinical and clinicopathological characteristics of the septicemic neonatal foal: review of 38 cases. *Equine Vet J*, 16:376-382.
- Koterba AM.** 1990. Physical examination: In: Koterba AM, Drummond WH, Kosch PC (Ed.). *Equine Clinical Neonatology*. Philadelphia, PA: Lea & Febiger. pp. 71-85.
- Kurtz Filho M, Deprá NM, Alda JL, Castro IN, Corte FD, Silva CAM.** 1997. Parâmetros fisiológicos e etológicos do potro recém-nascido, na raça puro-sangue de corrida. *Braz J Vet Res Anim Sci*, 34:103-108.
- LeBlanc MM.** 1990. Immunologic considerations: In: Koterba AM, Drummond WH, Kosch PC (Ed.). *Equine Clinical Neonatology*. Philadelphia, PA: Lea & Febiger. pp. 275-295.
- Lester GD.** 2005. Maturity of the neonatal foal. *Vet Clin Equine*, 21:333-335.
- Lombard CW.** 1990. Cardiovascular diseases: In: Koterba AM, Drummond WH, Kosch PC (Ed.). *Equine Clinical Neonatology*. Philadelphia, PA: Lea & Febiger. pp. 240-261.
- Losinno L, Alvarenga MA.** 2006. Fatores críticos em programas de transferência de embriões em equinos no Brasil e Argentina. *Acta Scient Vet*, 34(suppl 1):39-49.
- Mendes LH.** 2011. Mercado de cavalos de raça cresce no Brasil. Clipping Semanal, 99:47-48. Available on: http://www.esalq.usp.br/acom/clipping_semanal/2011/novembro/12_a_18/index.html#/47/zoomed. Accessed on: May 1th 2012.
- Morresey PR.** 2005. Prenatal and perinatal indicators of neonatal viability. *Clin Tech Equine Pract*, 4:238-249.
- Ousey JC, Rossdale PD, Fowden AL, Palmer L, Turnbull C, Allen WW.** 2004. The effects of manipulating intra-uterine growth on postnatal adrenocortical development and other parameters of maturity in neonatal foals. *Equine Vet J*, 36:616-621.
- Pierce SW.** 2003. Foal care from birth to 30 days: a practitioner's perspective. In: Proceedings of the 49th Annual Convention of the American Association of Equine Practitioners, 2003, New Orleans, LA. Lexington, KY: AAEP. pp. 13-21.
- Rossdale PD.** 1972. Modern concepts of neonatal disease in foals. *Equine Vet J*, 4:1-12.
- Rossdale PD.** 1976. A clinician's view of prematurity and dysmaturity in Thoroughbred foals. *Proc Roy Soc Med*, 69:27-28.
- Rossdale PD, Ousey JC.** 2002. Fetal programming for athletic performance in the horse: potential effects of IUGR. *Equine Vet Educ*, 14:98-112.
- Rossdale PD.** 2004. The maladjusted foal: influence of intrauterine growth retardation and birth trauma. In: Proceedings of the 50th Annual Convention of the American Association of Equine Practitioners, 2004, Denver, CO. Denver: AAEP. pp.75-126.
- Sangild PT, Fowden AL, Trahair JF.** 2000. How does the fetal gastrointestinal tract develop in preparation for enteral nutrition after birth? *Livest Prod Sci*, 66:141-150.
- Schlafer DH.** 2000. Gross examination of equine membranes: what's important - what' not! In: Proceedings of the Annual Conference of Society for Theriogenology, 2000, San Antonio, Texas. Montgomery, AL: SFT. pp.85-94.
- Schlafer DH.** 2004. Postmortem examination of the equine placenta, fetus, and neonate: methods and interpretation of findings. In: Proceedings of the 50th Annual Convention of the American Association of Equine Practitioners, 2004, Denver, CO. Lexington, KY: AAEP. pp. 144-161.
- Sellon DC.** 2006. Neonatal immunity. In: Paradis MR (Ed.). *Equine Neonatal Medicine*. Philadelphia, PA: Elsevier Saunders. pp. 31-38.
- Silver M, Ousey JC, Dudan FE, Fowden AL, Knox J, Cash RSG, Rossdale PD.** 1984. Studies on equine prematurity 2: post natal adrenocortical activity in relation to plasma adrenocorticotrophic hormone and catecholamine levels in term and premature foals. *Equine Vet J*, 16:278-286.
- Stoneham SJ.** 1991. Failure of passive transfer of colostral immunity in the foal. *Equine Vet Edu*, 3:43-44.
- Stoneham SJ.** 2006. Assessing the newborn foal. In: Paradis MR (Ed.). *Equine neonatal medicine*. Philadelphia, PA: Elsevier Saunders. pp. 1-10.
- Stroud B.** 2011. The year 2010 worldwide statistics of embryo transfer in domestic farm animals. *IETS Newslett*, 29:14-25.
- Vaala W.** 2000. How to stabilize a critical foal prior to and during referral. In: Proceedings of the 46th Annual Convention of the American Association of Equine Practitioners, 2000, San Antonio, Texas. Lexington, KY: AAEP. pp. 182-187.
- Viana JHM.** 2005. A TE no mundo: mudanças e tendências. *Embrião*, 2:4-5.
-