Neonatal care and the reproductive success of purebred dogs: challenges and goals

Os cuidados neonatais e o sucesso reprodutivo dos cães de raça pura: desafios e objectivos

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ABSTRACT
There are over 400 dog breeds that differ in size, morphology, and fitness. The correct management of pure breed kennels is essential for reproductive success. This requires multiple approaches that help control risk factors both intrinsic and extrinsic to progenitors and pups. Essential stages precede conception. Additionally, the fetal-neonatal transition is a complex period requiring greater attention to the pups. Once these challenges have been overcome, the breeder and veterinarian must apply tools to reduce the morbidity and mortality of pups. These rates remain high, impacting animal welfare and breed conservation while also resulting in notable economic damage. In this review, we present risk factors and their impacts on the success of breeding and preserving purebred dogs. Moreover, we highlight the importance of monitoring pup health and growth throughout the neonatal period.

Keywords: newborn, welfare, growth, kennel, APGAR, pup.

RESUMO
Há mais de 400 raças de cães que diferem em tamanho, morfologia e aptidão física. A gestão correcta de canis de raça pura é essencial para o sucesso reprodutivo. Isto requer múltiplas abordagens que ajudam a controlar os factores de risco tanto intrínsecos como extrínsecos aos progenitores e cachorros. As fases essenciais precedem a concepção.

Além disso, a transição fetal-neonatal é um período complexo que requer maior atenção aos cachorros. Uma vez superados estes desafios, o criador e o veterinário devem aplicar ferramentas para reduzir a morbilidade e mortalidade dos cachorros. Estas taxas permanecem elevadas, com impacto no bem-estar animal e na conservação da raça, resultando ao mesmo tempo em prejuízos económicos notáveis. Nesta revisão, apresentamos os factores de risco e os seus impactos no sucesso da criação e preservação de cães de raça pura. Além disso, salientamos a importância de monitorizar a saúde e o crescimento dos cachorros ao longo do período neonatal.

Palavras-chave: recém-nascido, bem-estar, crescimento, canil, APGAR, cachorro.

1 INTRODUCTION

Responsible dog breeding requires overcoming the reproductive challenges of the species aided by canine obstetrics and neonatology. Advances in theriogenology have stimulated the research and development of methods to reduce mortality and morbidity during the prenatal, perinatal, and neonatal periods in canines. The mortality of pups remains elevated, causing important impacts for breeders, not only economically but also for animal welfare. Nonetheless, there are new techniques to support birth, comprehend the physiology and evaluate the vitality of neonates, as well as tools for early diagnostics. Reproductive management requires multiple strategies since it is influenced by complex factors both extrinsic and intrinsic to the pup. Appropriate monitoring of pups requires knowledge and specific skills that enable disease prevention, as well as identification of practices to preserve the life and welfare of the neonates. In this study, we reviewed the data pertaining to noninfectious causes of pup mortality and the monitoring processes that reduce mortality in neonatal canines.

Dogs originated from the divergence of the domestic canine from its ancestor. This resulted from an unintentional domestication process that possibly began over 36 thousand years ago, although the precise period remains unclear. Abundant genetic and archeological research has been focused on explaining the origin of the species. The process was likely accelerated by empirical artificial selection of canines for different morphological and behavioral characteristics that originated the species *Canis lupus familiaris* (domestic dog). This species has an important social role, performing multiple functions that require extraordinary variability in morphology and behavior. Recently, reproductive isolation and selection have resulted in over 400 dog breeds with distinct appearance and behavioral traits. The term breed in this review refers to genetically isolated canine populations displaying characteristic sets of physical and behavioral

features maintained under artificial selective pressure. Responsible dog breeding promotes pure breed preservation, contributing to the conservation of populations and their diversity. These breeds are registered in their origin throughout generations, forming closed populations (DIAS, 2019; SERPELL e DUFFY 2014).

The success in breeding purebred dogs is based on pillars of breeding excellence that guarantee adequate kennel management. These consider physiological, genetic, sanitary, nutritional, and environmental aspects integrating scientific and technical approaches to dog breeding. Implementing rigorous processes contributes to the control of risk factors, reducing mortality and assuring the welfare of mothers and pups during the pregnancy and neonatal periods (ROMAGNOLI, 2009; MUNNICH, 2008; DAVIDSON, 2003; MUNNICH E KUCHENMEISTER, 2014 BARTGES et al., 2012; DODAMANI et al., 2017; LUZ e FREITAS, 2019).

Dog breeding includes prenatal, perinatal, and neonatal losses for varying reasons related to breed, the progenitors, the environment, or intrinsic to the neonate. Intrinsic factors affect fetal viability and can result from gestational issues, litter size, gestational duration, fetal malformation, and maternal age, among others. Close monitoring during the prenatal, perinatal, and neonatal periods is necessary to control and mitigate these factors (SCHRANK et al., 2020; TESI et al., 2020; LUZ e FREITAS, 2019; GROPPETTI et al., 2015; MUNNICH E KUCHENMEISTER,2014; TONESSEM et al., 2012;). The impact of pup mortality and morbidity becomes greater when considering other aspects, including emotional distress, animal welfare, and breed conservation (MUGNIER et al., 2020; GROPPETTI et al., 2017; DODAMANI et al., 2017; VERONESI et al., 2009).

An appropriate breeding plan must consider consanguinity levels, hereditary conditions, and pathological and sanitary conditions of the progenitors. In particular, factors associated with the reproductive history of females dictate the amount of care required during the prenatal period. These factors include morphology, age, number of litters and interventions in previous gestations, frequency of stillborn pups and dystocia. Optimal nutritional and sanitary conditions as well as vaccination programs should be rigorously maintained during gestation to ensure the welfare and health of dams. Moreover, pharmacological interventions should be carefully evaluated to reduce teratogenic or other risks to the fetuses (ROMAGNOLI, 2009; SOMMERFELD-STUR, 2006).

Knowledge of the reproductive physiology of canines and prenatal exams facilitate the monitoring of fetal development and a more accurate prediction of the

delivery date. Obstetric evaluations include examining the birth canal and nipples, imaging (X-rays and pelvic ultrasound), and biochemical analysis (red blood cell count, hormonal levels). Knowledge of the breed in question also allows the implementation of appropriate obstetric conduct and interventions that will reduce perinatal and neonatal suffering. (FUSI et al., 2020, ROMAGNOLI, 2009, DAVIDSON, 2003; WEIJDEN e TAVERNE, 1994).

The term neonate is used to describe canine pups during the first weeks of life. Canine neonates are totally dependent on care, sensitive to environmental changes and susceptible to microbial infections. The fetal-neonatal transition is an important period requiring coordinated activation of multisystem adaptive processes. Prevention and control of physical, sanitary, and environmental risks reduce chance of suffering and the high rate of neonatal mortality and morbidity reported in purebred kennels. The morphological and physiological characteristics of the canine neonate hinder diagnostics and treatment. To overcome these challenges, the veterinarian requires skills and tools to implement the necessary care, which guarantees the survival of the pups (VERONESI, 2016; GRUNDY 2006; MUGNIER et al., 2020; MUNNICH, 2008)

2 RISK FACTORS AND THEIR IMPACT ON REPRODUCTIVE SUCCESS IN PUREBRED CANINES

Mila *et al.* (2017) emphasized the need to further understand the impacts of the gestational period on pup vitality at birth, instead of only monitoring birth. Dogs are multiparous, and labor can be prolonged for several reasons; periods can extend under normal conditions up to 12 h or 24 h in very large litters (INDEBRO et al., 2009). When monitoring labor, the dam's behavior should be observed as well as the interval between expulsions and the presence of productive contractions to identify complications and intervene to guarantee the well-being of the dam and pups. Physical, medical, or surgical interventions should occur in time to reduce risk and harm to the dam and neonates (ROMAGNOLI, 2009; DAVIDSON, 2003; WEIJDEN e TAVERNE, 1994).

Factors that increase the risk of neonatal mortality were reviewed by Ogbu *et al.* (2016), who emphasized race, the dam's age, number of pups, duration of labor, and litter size. The authors highlighted the importance of obstetric veterinary monitoring by recommending birth weight, placental assessments and other analyses capable of adding information to the empirical observations of breeders.

Dystocia is a change in the normal course of labor influenced by characteristics of the dam and of the pups (MUNNICH e KUCHENMEISTER, 2009). The condition increases the chance of hypoxemia (respiratory stress syndrome) as the neonate's cardiorespiratory homeostasis is easily altered, also resulting in an acid-base imbalance. After delivery, the activation of breathing is a critical moment for the survival of the neonate, affecting the respiratory and cardiovascular systems. (VERONESI et al., 2009; VERONESI et al., 2016; GRUNDY, 2006; MUNNICH AND KUCHENMEISTER, 2009; MUNNICH AND KUCHENMEISTER, 2014). Brum *et al.* (2021) reported mortality rates greater than 50% in pups born by cesarean section under dystocia conditions in a veterinary hospital in Brazil.

3 ASSESSMENT OF PUPPIES DURING THE EARLY NEONATAL PERIOD

After birth, monitoring the vitality of pups can contribute to the selection of measures to reduce neonatal mortality. Therefore, the modified Appearance, Pulse, Grimace, Activity, and Respiration (APGAR) test has been successfully adopted in veterinary medicine as an auxiliary protocol to identify neonates at immediate risk. Obtaining individual scores enables individualized support measures, focusing on the most vulnerable pups (VERONESI et al., 2009). The use of a score to assess neonatal vitality is noninvasive and allows rapid analysis of heart rate, respiratory rate, motility, irritability reflex and mucosal color. The scores provide an overview of the main vulnerabilities in the early neonatal period and can be used for all dog breeds or adapted for specific breeds or pups delivered via cesarean section. Neonates with scores between 0 and 3 are considered critical, those with scores between 4 and 6 are in moderate distress, and scores of 7 to 10 indicate normal neonates. The test identifies vulnerabilities in neonates, prompting immediate attention to the pups at greatest risk (scores of 0-6), thereby reducing early neonatal mortality (VERONESI, 2016; VERONESI et al., 2009). In a study carried out with the Chihuahua breed, Fusi *et al.* (2020) analyzed the scores obtained for 176 puppies born through elective cesarean section. The authors confirmed the utility of the APGAR test to predict the viability of neonates in the first 24 h after delivery. A study conducted by Vassalo *et al.* (2015) observed higher APGAR scores immediately after delivery in pups of different breeds born vaginally (49) than pups born by cesarean section (55), which were prostrated. This effect reflected fetal distress related to dystocia and anesthetic effects. After 60 min, the scores were similar between vaginally and cesarian section-delivered pups. Therefore, the study verified the effectiveness of the

interventions used for pup recovery, including clearing the upper airways, drying, cardiopulmonary resuscitation, oxygenation, fluid therapy, and intravenous medication when required. In addition to analyzing the APGAR scores, the authors also performed a clinical evaluation, measuring rectal temperature and reflexes in the early neonatal period. Both APGAR and reflex scores were higher in pups delivered vaginally. The authors consider both important parameters for identifying at-risk pups and evaluating the effectiveness of resuscitation actions. Nonetheless, APGAR and reflex scores were not considered useful as prognostic parameters. Intensive care for the neonate includes cardiorespiratory support, recovery from normothermia, care with passive immunity and blood glucose, which contribute to healthy neonatal vital functions, increasing the chances of survival by reducing the factors triggering neonatal diseases (VANUCCI and ABREU, 2017; MUNICH AND KUCHENMEISTER 2014).

Mila et al. (2017) recommend the assessment of pup vitality through the APGAR test combined with analysis of plasma glucose levels during the first 24 h to monitor and identify at-risk pups. In addition to conducting the APGAR test, morphometric assessments of neonates can help veterinarians and breeders identify vulnerable pups. Low birth weight neonates are at increased risk of mortality and morbidity. The authors reported that birth weight is inversely related to litter size and observed differences between breeds. (GROPETTI, 2017). However, the complex interactions between factors related to the fetus, the dam, and the environment should be further investigated in canines.

The identification of issues during delivery and in the neonatal period allows the quick establishment of corrective measures. Analysis of umbilical cord lactate levels can provide important information about respiratory stress (GROPETTI et al., 2010). In a study involving 68 healthy pups, Mc Michael *et al.* (2005) indicated that venous lactate levels in neonates up to 28 days are higher than those in adults. Additionally, in four-day-old pups, these values significantly exceeded those observed in 10- to 28-day-old pups. The lactate levels in umbilical vein blood samples showed less fetal distress in vaginally delivered pups born than in those delivered through nonelective cesarean section (KUTTAN et al., 2016). Antoriczyk *et al.* (2021) evaluated umbilical cord blood samples and APGAR scores from pups delivered by elective cesarean sections and reported mild respiratory acidosis. Puppies with low APGAR scores had high blood glucose and higher mortality than those with high scores. Considering this, bradycardia in the first 4 days of life should be considered a sign of hypoxemia (GRUNDY, 2006).

Low adipose tissue reserves at birth imply difficulties in meeting metabolic demands without nutritional inputs. Healthy canine neonates have a lower ability to generate glucose, mainly due to low glycogen stores and system immaturity. During the first 24 h of life, glycogen is stored and severely depleted, with systemic glucose production predominantly via glycogenolysis, followed by a combination of glycogenolysis and gluconeogenesis after 24 h. The rapid depletion of glycogen stores highlights the importance of regular eating. Changes in reserve carbohydrate metabolism, endotoxemia, septicemia, and the portosystemic shunt may also contribute to hypoglycemia. Signs such as lethargy, weakness, vocalization, or convulsions should be immediately considered, especially in small-breed neonates, which are more susceptible to hypoglycemia. (DAVIDSON, 2003; GRUNDY; KLIEGMAN, AND MORTON, 1987; MUNNICH AND KUCHENMEISTER 2014). Mila *et al.* (2017) emphasized that the ability to transition to extrauterine conditions and colostrum ingestion is fundamental for pup survival, while Munnich and Kuchenmeister (2014) highlighted the importance of physical examination to identify early pathological signs.

Neonates are predisposed to dehydration due to the high surface/volume ratio, which occurs because the skin is more permeable and due to renal function immaturity. The disparity between water losses and intake in neonates can be accentuated by extrinsic factors such as maternal behavior, agalactia and high environmental temperature. Prematurity and pathological processes such as pneumonia and diarrhea that magnify this discrepancy result in hypovolemia, hemorrhages, shock, and neonatal losses (MUNNICH AND KUCHENMEISTER, 2014).

The environment where neonates are kept after delivery until weaning is highly important since pups do not have a fully mature autonomic nervous system and are less able to respond to physiological stresses (GRUNDY, 2006). Davidson (2003) emphasized the importance of thermal comfort, highlighting that maturity in the thermoregulatory system of canines is only reached in four weeks. The environment should be at an appropriate temperature and free of irritant substances to prevent respiratory stress syndrome. This is one of the most worrisome noninfectious conditions in pups and is related to more than 60% of neonatal losses (MUNNICH, 2008). After birth, the dam and pups should remain under mild temperature conditions. Hypothermia is a postpartum protective physiological response affecting the normal physiology of several systems, negatively impacting immunity, digestion, and breastfeeding. Healthy pups had body temperatures between 35 and 36.5 °C 24 h after delivery. However, in the first six days

after birth, neonates require thermal comfort interventions to maintain body temperature regardless of whether they are kept with the mother, and exposure to low temperatures should be avoided. Adequate maintenance of metabolic homeostasis requires a stable body temperature, and very high ambient temperatures reduce respiratory capacity and promote dehydration. Furthermore, low ambient temperatures hinder suckling, leading to dehydration, cardiorespiratory failure, alteration in intestinal motility, and predisposing pups to infections. Body temperature should be raised gradually, and food should only be reestablished when normothermia is reached (LAWER, 2008; DAVIDSON, 2003; MUNNICH and KUCHENMEISTER, 2014).

4 MONITORING THE GROWTH OF PUPS DURING THE NEONATAL PERIOD

After adaptation to extra uterine life, pups face new challenges demanding attention and care. Often, neonatal losses after the first 24 h of life occur without an accurate diagnosis. Canine wasting syndrome is a colloquial term used to describe apparently healthy pups that perish after failing to maintain growth and development in the first two weeks of life. The causes of this syndrome can be environmental, genetic, or infectious, although descriptions included a grouped set of pathological signs of different origins. Alternatively, they can be classified into maternal, neonatal and management causes. In these circumstances, clinical signs are nonspecific but generally related to low birth weight, low weight gain, and reduced suckling reflex leading to the segregation of the pup by the dam (KAHM et al., 2009). Both the assessment of birth weight and daily weight gain from regular weighing can reveal the pups at severe risk (INDEBRO et al., 2007), contributing to the identification and correction of primary causes. Hedberg (2015) highlighted the main causes of insufficient weight gain or weight loss during the early neonatal period, including dehydration, hypoglycemia, inadequate management, environmental conditions interfering with the thermal balance of the pups, lack of milk, or maternal neglect. Weight loss in the early neonatal period due to physiological causes can reach 10%. Monitoring the daily variations in pup weight can contribute to the identification of risk situations. However, specific curves should be prepared to meet the peculiarities of the growth and development of each breed (BIGLIARDI et al., 2013).

Pup weight at birth, weight at 12 and 24 h after delivery, weight before and after feeding, daily weight gain, average weight and average litter weight gain are easily obtained, can be performed alone or with the breeder, and contribute to the daily

monitoring of newborns. Recording data and providing the developmental history of the pup and litter expand the information on colostrum intake, maternal ability, adverse conditions, pup nutrition, and presence of pathologies (DODAMAI *et al*., 2017). The risks of reducing pup survival with very low birth weight are recognized by both scientists and breeders, leading to the adoption of preventive and corrective measures, although interventions vary between kennels. Mugnier *et al.* (2021) identified the most common practices to manage low-birth-weight canine and feline pups by reviewing interventions by French breeders to reduce neonatal losses. Mila *et al.* (2015) highlighted the impact of birth weight and neonatal development on early neonatal mortality (first two days) and on that observed between the second and third weeks after delivery.

5 FINAL CONSIDERATIONS

Understanding the fragility of the neonate and the complexity of the measures adopted to manage the kennel, the progenitors, and the neonate are essential to reduce and control risks in the first days of life. These constitute an essential step to reduce neonatal mortality of purebred dogs. Sanitary, nutritional, and reproductive planning and management in kennel can reduce pup mortality. Additionally, prenatal care, birth supervision, and neonatal care through biochemical analyses, vitality tests, and pup growth monitoring reduce losses by increasing reproductive success with important economic and animal welfare impacts.

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