frontiers | Frontiers in Animal Science

TYPE Editorial
PUBLISHED 05 December 2023
DOI 10.3389/fanim.2023.1328894

OPEN ACCESS

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RECEIVED 27 October 2023
ACCEPTED 17 November 2023
PUBLISHED 05 December 2023

CITATION
McLean KJ, McFarlane Z and Alves MBR (2023) Editorial: Current state of male physiological research and the impacts of environment and fetal programming in livestock.
Front. Anim. Sci. 4:1328894.
doi: 10.3389/fanim.2023.1328894

Editorial: Current state of male physiological research and the impacts of environment and fetal programming in livestock

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KEYWORDS

sperm, semen, male contribution, paternal effect, epigenetics, cattle

Editorial on the Research Topic
Current state of male physiological research and the impacts of environment and fetal programming in livestock

Introduction

In livestock production, artificial insemination associated with refrigerated or cryopreserved semen is frequently used to improve the reproductive efficiency and the genetic gain. Since these biotechnologies make it possible to disseminate one ejaculate into several doses and inseminate several females instead of one, they greatly improve the male fertility potential. Thus, in this context, the impact of male fertility on production efficiency and reproduction rates is meaningful. Recently, in addition to reproductive efficiency, male fertility has become recognized for impacting the health of the progeny. Most evidence of the male's influence on progeny has been shown in mouse models since the methods to control environment and nutrition conditions are more feasible to apply. Additionally, and most importantly, the reproductive and life cycles are short.

In mice, it was already shown that males housed in enriched cages produced sperm with specific molecular content that could influence the cognitive features of the progeny (Benito et al., 2018). In the same way, evidence has shown that the paternal diet impacts the metabolism of the mice progeny (Chen et al., 2016; Sharma et al., 2016; Lismer et al., 2021). Finally, paternal stress was able to influence the stress reactivity of the progeny in mice (Rodgers et al., 2015). With all these points in mind, it is expected that in the context of livestock animals, offspring production is potentially affected by paternal welfare, nutrition, environment, and other factors. Further, with this knowledge, it will be possible to propose fetal programming protocols to produce healthy animals that produce better quality animal products.

Thus, in this Research Topic, we present 5 papers that address the following: techniques to evaluate the quality of sperm cells, explore the diet effects of the seminal plasma composition, and investigate reproductive efficiency and offspring features of progeny produced with sperm from males submitted to different challenges.

The first step to evaluating the paternal influence on fetal programming: the quality of the spermatozoa

Although male fertility relies on a host of factors, sperm quality is the most important among them. However, defining sperm quality is not straightforward and requires the investigation of different features of sperm cells. Sperm cells first need to be assessed on the structural features related to the formation of the head and flagellum (reviewed in Alves et al., 2020). Then, sperm cells must display morpho-functional features such as the ability to move (i.e., motility), the presence of healthy plasma and acrosome membranes, good quality DNA, and low production of reactive oxygen species (ROS), among other essential aspects to reach the fertilization site and fertilize the ovum (reviewed in Alves et al., 2020). Finally, the sperm cells require intrinsic factors such as specific organelles and molecules for functionality (reviewed in Alves et al., 2020). In this Research Topic, molecular (DAG1, SERPINA5, and CD9) and biochemical (e.g., Zinc signature) factors present in sperm were investigated regarding the potential to predict bull sperm fertility potential as presented in Zoca S. et al. and Zoca S. et al.

An important feature of improving spermatozoa function: seminal plasma composition

Seminal plasma comprises a major portion of the ejaculate; however, little focus has been given to the effects of seminal plasma on the female reproductive tract, pregnancy establishment, and subsequent offspring performance. Seminal plasma is important to sperm quality since it contains components that ensure the viability of sperm cells and also prevent sperm from passing through capacitation before the proper time (reviewed in Poiani, 2006). Since seminal plasma encompasses fluids from the epididymis and sexual accessory glands, it is frequently used as a biomarker of alterations in the male reproductive tract (Drabovich et al., 2014). Also, the seminal plasma effect in the female reproductive tract differs in accordance with seminal plasma composition (Robertson et al., 2009; Bromfield, 2014). In this Research Topic, the composition of seminal plasma was impacted after the alteration of diet in bulls by Harrison et al. These data suggest that seminal fluid composition will most likely influence the immune response in the female reproductive tract, which may have important downstream implications for the maintenance of pregnancy.

Shedding light on fetal programming in livestock: the role of animal welfare concerning the paternal environment

For many years, the goal of animal production was to produce more animals with high reproductive efficiency that also create high-quality products. Since the paternal environment can impact stress, metabolism, and cognitive aspects of the progeny (Rodgers et al., 2015; Chen et al., 2016; Sharma et al., 2016; Benito et al., 2018; Lismer et al., 2021), the chance of reaching this aim by improving the sires' living conditions is highly relevant. In livestock, poor evidence has been produced until now of how offspring performance could be modulated by the paternal environment. However, recent findings from Alves et al. (2021) and Silva et al. (2022) have shown that heat stress impacts the molecular content of sperm cells from Nellore and Holstein bulls, respectively. In addition, Wu et al. (2020) have shown that the age of the bull influences molecular sperm factors that influence embryo production. The long-term effects of these paternal changes on the offspring's postnatal health remain unknown. In this Research Topic, Sabei L. et al. and Sabei L. et al. show that semen produced by boars raised in an enriched environment resulted in more live-born piglets, and the offspring produced exhibited differential stress and emotional responses.

Conclusion

Even though the paternal effects on offspring performance are poorly investigated in livestock animals, evidence using mouse models indicates that sperm from males raised in different conditions can modulate progeny performance. With the advances regarding semen quality attributes, it is more evident that intrinsic factors related to sperm cells are likely determinants of improved embryo production, pregnancy viability, and could be initiating fetal programming. Also, the interaction of spermatozoa with seminal plasma components as well as the seminal plasma composition are likely important in fertility and the female response to copulation. In this context, this Research Topic brings new data regarding intrinsic factors of sperm cell physiology that are related to overall semen quality, effects of the male on subsequent progeny, and seminal plasma composition.

Author contributions

KM: Writing – original draft, Writing – review & editing. ZM: Writing – original draft, Writing – review & editing. MBRA: Writing – original draft, Writing – review & editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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