Workshop I: The impact of heat stress on dairy cows fertility-The management point of view

Efficient cooling management and remedial hormonal treatment to alleviate the effect of heat stress on ovarian function in dairy cows

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Keywords: Heat stress, cooling management, hormonal treatments, reproduction

The impact of elevated temperature on the reproductive performance of dairy cows is becoming a worldwide problem, as a result of climate change and intensive genetic selection for high milk production. Reduced fertility is no longer confined to subtropical and tropical climates; adverse effects of elevated temperature have been reported in dairy farms located in cooler regions, such as Europe, and in temperate and Mediterranean climate zones. Furthermore, the effects of heat stress are not limited to the hot months: they carry over to the following cooler months, resulting in long-term effects throughout the year. Various heat-abatement strategies have been developed in the last four decades; these include providing shade to block direct solar radiation, ventilation, and indirect and/or direct cooling with water. The direct cooling approach is based on short-term spraying of water followed by its evaporation from the skin) constituting one cycle). Efficient cooling requires several cooling windows per day, each consisting of several cycles and lasting about 30–50 min. The efficiency of cooling on commercial farms can be conveniently compared by calculating the ratios between summer and winter milk production and conception rate. Calculations demonstrate that by using efficient cooling management, it is possible to maintain 98% of the winter milk production in summer; however, summer conception rate reaches only 68% of that in winter. Findings indicate that the reproductive system is highly susceptible to thermal stress and additional means are required to improve conception in the summer. Understanding the mechanism by which thermal stress impairs ovarian function led to the development of supporting hormonal treatment. The long-term effects of seasonal heat stress on the hypothalamus–pituitary–ovarian axis involve various impairments. These include alteration of the ovarian pool of follicles and their enclosed oocytes and impaired function of the corpus luteum, expressed by reduced plasma progesterone concentration. Induction of three consecutive 9-day follicular waves during the summer and fall improved conception rate (37 vs. 53% for control and treated cows, respectively) in primiparous cows. Treatment was more effective for multiparous cows with a high body condition score (BCS) and low somatic cell count. Administration of a controlled intravaginal progesterone-releasing device on day 5 ± 1 post-AI for 13 days was found beneficial for a subgroup of cows with low BCS at peak lactation compared to their control counterparts (53 vs. 27%, respectively) and for cows exhibiting both low BCS and postpartum reproductive disorders, compared to their control counterparts (58 vs. 14%, respectively). In summary, the reproductive tract, and in particular the ovarian components (i.e., follicles, oocytes, corpus luteum), are highly sensitive to elevated temperatures. Using an efficient cooling system to maintain normothermia in cows is a prerequisite for any additional remedial approach. Given that the effect of heat stress on fertility is multifactorial in nature, a combination of several treatment approaches might be most effective.

Embryo transfer- a promising tool for improving fertility during heat stress

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Keywords: embryo transfer, heat stress, cattle.

The major cause of infertility caused by heat stress is damage to the oocyte and early embryo by direct effects of elevated temperature and the physiological changes in the cow caused by heat stress. The developing embryo develops increased resistance to maternal hyperthermia by Day 3 of pregnancy. It is this characteristic of embryonic development that makes embryo transfer, typically performed at Days 6 to 8 after estrus, an effective tool to increase fertility during heat stress. Pregnancy rates following embryo transfer in the summer can be twice as high as pregnancy rates after artificial insemination. Moreover, differences in pregnancy rates between summer and winter are much less for embryo transfer than for artificial insemination. Coupling embryo transfer with an ovulation synchronization scheme like Ovsynch can make it possible to bypass effects of heat stress on estrus detection. The major limitation to the economic use of embryo transfer in commercial dairy and beef system is the cost of the procedure, which must be kept low to make implementation of an embryo transfer program economical.

Using thermoprotective factors to alleviate the effects of heat stress on the ovarian pool of oocytes: lessons from the lab bench to the field

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Keywords: antioxidant, anti-apoptotic, survival factors.

Growth and development of ovarian follicles and oocytes require a series of coordinated events leading to successful ovulation, oocyte maturation, fertilization and preimplantation embryonic development. In cattle, such events can be disrupted by high environmental temperature leading to heat stress. Adverse environmental temperatures observed during the hot months of the year in subtropical and tropical climates reduce fertility in lactating dairy cows. Heat stress compromises follicular development, hormonal secretion, endometrial and oviductal function, oocyte and preimplantation embryonic development. Oocyte susceptibility to heat stress has been demonstrated during the germinal vesicle (GV) and maturation periods. In vivo and in vitro studies indicated that exposure of bovine oocytes to elevated temperature affects the cellular and molecular machinery required for proper oocyte function. For example, heat stress increased mitochondrial production of reactive oxygen species (ROS) altering the oocyte balance between ROS accumulation and removal by intracellular antioxidants. Heat stress also compromised mitochondrial function, nuclear and cytoplasmic maturation, induced cytoskeleton disorganization and apoptosis. Many efforts have been employed to alleviate the low fertility associated with heat stress. Therefore, the objective of this work is to highlight basic and applied strategies to protect oocytes from heat stress. Recently, molecules such as insulin-like growth factor I, astaxanthin, melatonin, epigallocatechin gallate, caspase inhibitors and sphingosine-1-phosphate were identified as thermoprotective factors for bovine oocytes. These factors rescued several cellular functions damaged by heat stress enhancing the ability of the oocyte to be fertilized and reach the blastocyst stage. Moreover, in vivo administration of antioxidants improved reproductive performance in heat stressed animals. Therefore, manipulation of themoprotective molecules has the potential to mitigate the deleterious effects of heat stress on the bovine oocyte improving fertility during summer.

Adaptation to heat stress in sows: an unfinished business

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Keywords: animal welfare, heat stress, pigs.

Animal welfare and production efficiency are impaired by stress. Exposure to heat (measured by the Temperature Humidity Index) can lead to physiological and behavioral changes indicative of stress. According to recent predictions on climate change, severe heat events are forecasted to increase in intensity and frequency throughout the next decades, likely affecting animal production. This is of special interest in pig production as according to FAO, more than 50% of pig production occurs in warm climates, with predicted faster temperature growth than temperate areas. Heat stress response is a multisystemic adaptive mechanism triggered to cope with high environmental temperature. When heat exceeds the adaptation capacity of pigs, the body temperature increases, unbalancing homeostasis, which has negative consequences for production and welfare. Intensive breeding have led to a reduction of the adaptation capacity that confer a reduction in resilience towards environmental challenges. Pigs are particularly sensitive to heat because they lack functional sweat glands and the presence of a thick layer of subcutaneous adipose tissue that prevents heat dissipation. Besides the previous limitations, pigs kept in intensive conditions are prevented to perform most of natural behavior regulating body temperature, such as wallowing, which exacerbates the diminished adaptation capacity. The effects of heat stress in pigs are diverse, perturbing several body systems. Respiration rate increases to optimize the transpiration capacity and reduce body temperature. Activity decreases in order to reduce the metabolic source of heat due to muscle contraction. An increase in satiety during heat events alter feeding behavior and reduce the feed intake. Reproduction performance is linked to this reduction in feed intake, as lower access to nutrients leads to a loss of body condition and a negative energy balance, provoking reproductive problems associated with inadequate ovarian function. These effects are readily apparent on-farm, including anestrus, reduced farrowing rates, increased abortion rates, and reduced litter size. Heat is the environmental stressor that produces the highest (negative) impact on pig production, and it is likely that reproduction plays a major role.Strategies of heat stress mitigation can either focus on reducing the environmental challenge to which pigs are submitted or alleviating the consequences of the stress response on the organism. In the first approach, the reduction of ambient temperature (5–7°C) inside swine barns using evaporative cooling systems is the most extended strategy in intensive pig production. Alleviating the consequences of heat stress, stimulating feed intake using dietary strategies (i.e. additives) and feeding management are, to date, the most efficient strategies. Out of housing and management strategies, improving pig resilience to heat stress through breeding and epigenetic strategies are promising approaches addressing the fundamental root, which is adaptation.

Supported by Juan de la Cierva – Incorporación fellowship (IJCI-2016-30928).