APPLIED VETERINARY RESEARCH

REVIEW ARTICLE
Published Online: April 15, 2023
https://doi.org/10.31893/avr.2023010

Climate change, nutrigenomics, immune function and diseases and production in dairy cattle: a comprehensive review

Hassan H. Musa[a] | Joram M. Mwacharo[b] | Saber Y. Adam[c] | Demin Cai[d] | Abdelkareem A. Ahmed[aef]

[a]Biomedical Research Institute, Darfur University College, Nyala, Sudan.
[b]Department of Genetics, International Center for Agricultural Research in the Dry Areas, Addis Ababa, Ethiopia.
[c]Department of One Health, Medical and Cancer Research Institute, Nyala, Sudan; Animal Welfare Center, Nyala, Sudan.
[d]College of Animal Science and Technology, Yangzhou University, Yangzhou 225009, PR China.
[e]Department of Veterinary Sciences, Faculty of Animal and Veterinary Sciences, Botswana University of Agriculture and Natural Resources, Private, Bag 0027, Gaborone, Botswana.
[f]Department of Physiology and Biochemistry, Faculty of Veterinary Science, University of Nyala, Nyala, Sudan.

Abstract Climate change is considered a main factor that negatively impacts agriculture and animal production. In addition, it also influences the animal's immune functions and diet intake, making it susceptible to infectious diseases. Recent nutritional research involving genomics proposes a rational ability to prevent disease occurrences. Scientific evidence in genomic sequencing discloses opportunities for discovering diet health associations and prospective for individual phenotypes and genotypes based on dietary suggestions. This review covers climate change, nutrition, and immune function on dairy cows' health and diseases. Strategies to increase dairy cow milk productive yield through nutritional interventions offer the prospect of improving their milk production performances and animal welfare. This review also addresses how such nutrition manipulations can enhance dairy cows' immune function and productivity. The principal competencies covered in this review are the evolutionary impacts of climate change on animals, climate change on livestock diseases, nutrition and clinical practice in dairy cows, and the influences of malnutrition on dairy cow diseases. In addition, the article discussed a common origin for immunity and digestion, the evolution of transgenerational immunity, nutrition, and immune function, and their impact on cattle. Moreover, the review covered the interaction between nutrition and immune function and their influence on the health problems of dairy cows. Finally, the review discussed the application of nutrigenomics and nutrigenetics in milk production in dairy cows and strategies for preventing disease during early lactation.

Keywords: climate change, dairy cow, immune function, nutrition

1. Introduction

Changing climatic conditions, directly and indirectly, impact biotic and abiotic processes and represent a robust basis for novel selection pressures for adaptive evolution (Merilä and Hoffmann 2016). In addition, climate change can affect development by altering the patterns of hybridization (Sanchez-Guillen et al 2013; Canestrelli et al 2017), changing population size (Knape and de Valpine 2011), and shifting patterns of gene flow in landscapes (Sork 2016). Known that the scientific evidence for rapid evolutionary adaptation to the spatial variation (Liu et al 2014) both in biotic and abiotic ecological conditions corresponding to that shown in modifications brought by climatic change is ubiquitous, continuing climate change is predicted to have large and extensive evolutionary impacts on animal biodiversity (Bellard et al 2012). Therefore, rapid evolution changes species in real-time. However, phenotypic plasticity (Vedder et al 2013; Merila and Hendry 2014), migration (Seebacher and Post 2015), and different kinds of ecological and genetically constraints (Franks and Hoffmann 2012) can prevent the animal from developing much in response to the climate change, and a generalization about the rates and magnitudes of expected responses seem to be challenging to make for several reasons (Hetem et al 2014; York et al 2017).

The impact of animal microevolutionary responses to climate change is a hot area of investigation (Boutin and Lane 2014). In contrast, interest in the evolutionary impacts of climate change goes back to early paleontological (macroevolutionary) studies focused on prehistoric climate changes and microevolutionary research that started only in the late 1980s (Gibbons 2010). The microevolutionary discipline has attracted the actual attention of scientists in the 2000s after the fundamental concept of climate change became essential to the universal public and funding organizations (Biedenkopf 2017). However, to date, no scientific conclusion has yet emerged. In addition, the complication of biotic changes has been

 Received: December 20, 2022 | Accepted: March 2, 2023

activated by novel climatic conditions, submitting predictions on strength and patterns of natural selection. Moreover, predictions are complicated due to the expression of genetic variability in traits of environmental consequence varying with ecological situations, influencing and expected responses toward climate-mediated selection (Weed et al 2013).

This review covers climate change, nutrition, and immune function on dairy cows' health and diseases. Strategies to increase dairy cow milk productive yield through nutritional interventions offer the prospect of improving their milk production performances and animal welfare. This review also addresses how such nutrition manipulations can enhance dairy cows' immune function and productivity.

2. Heat stress

All living organisms have a thermal comfort range that is a range of surrounding environmental temperatures. These temperatures are optimal for biological functions. Throughout the day, ruminants keep their body temperature within a range of ± 0.5 degrees centigrade (Henry et al 2012). Once body temperature increases more to the critical temperature of the normal range, the animals start to suffer from heat stress (Belhadj Slimen et al 2016). Then the animals developed a physical and phenotypic response to the source of stress, for example, heat, called acclimation. It has been reported that exposure to ambient temperature decreased feed intake (Pearce et al 2014), water intake (Bruno et al 2011), reduced productive and reproductive performance (Das et al 2016), and affected respiratory system function (Polsky and von Keyserlingk 2017). The influences of heat stress on livestock are dependent on temperature, humidity (Robert et al 2014), genetic potential (Das et al 2016), species, life stage, and nutritional status (Krishnan et al 2017). It is known that livestock in higher latitudes are less influenced by the increase in temperatures while livestock reared in lower latitudes are more subjected to heat stress (Kielland et al 2010) because animals in lower latitudes are habitually better acclimatized to high heat stress and droughts (Thornton et al 2009). Closed systems of livestock production are found to have more control of conditions over climate exposure (Flamenbaum and Galon 2010). Heat stress reduces diet intake (Das et al 2016), milk production (Yano et al 2014), feed conversion efficiency (Quinteiro-Filho et al 2010), and reproductive performance (Boni et al 2014). Humid and warm conditions cause heat stress (Gao et al 2017), which affects animal behavior (Allen et al 2015) and metabolic rates in livestock (Belhadj Slimen et al 2016) or even mortality (Bishop-Williams et al 2015). In the overall process, the impacts of heat stress on dairy cows include feed intake, feed nutrient utilization, production, reproduction performance, health, and mortality.

3. Heat stress and milk production

Heat stress is one of the main factors that cause production capacity reduction in the dairy and beef industry (Bernabucci et al 2014; Das et al 2016) and economic losses (St-Pierre et al 2003). High-yielding dairy cows produce more metabolic heat than low-yielding dairy cows (Moallem et al 2010; Garner et al 2016). Consequently, the high-yielding dairy cows are more sensitive to heat stress than zebu cattle (Hansen 2004; Berman 2011). Therefore, the increased metabolic heat production, and the increased heat stress, are accompanied by declined milk production (Reyad et al 2016). Heat stress also has negative impacts on sheep (Sevi and Caroprese 2012), goat (Mabjeesh et al 2013), and buffalo (Kapila et al 2016) milk production. Heat stress also negatively impacts milk composition and amount (Liu et al 2017).

The mechanism underlying the reduction of milk production by the heat stress is that dairy cows mainly depend on glucose for energy requirements; therefore, during the milk production period, less glucose is directed to the mammary glands, and this process will decline in milk production. Negative energy balance during lactation is associated with several metabolic alterations implemented to maintain the dominant physiological status of lactation (Fatima et al 2014). Apparent changes in glucose and lipid metabolisms ensure the partitioning of dietary constituents and tissues that originate nutrients to the mammary gland (Wheelock et al 2010; Tian et al 2016). Many of these metabolic alterations are mediated via endogenous reproductive hormones, which are usually hormones, throughout the periods of negative balance due to heat stress (Hansen 2009; Takahashi 2012; Dash et al 2016; Roth 2017). The milk constituents are also greatly influenced by heat stress (Tian et al 2016; Liu et al 2017). In addition, the studies on breed differences of ruminant species regarding their response to heat stress will provide an essential new window in the next quarter-century and, therefore, will allow dairy cattle selection based on resistance to heat stress as global warming continue (Matthews et al 2017; Rojas-Downing et al 2017).

4. Impact of heat stress Impact on the endocrine and reproductive system of dairy cow

Heat stress has adverse effects on reproductive capacity through negative energy imbalance and alterations in dairy cows' reproductive hormone concentrations (Figure 1) (Liu et al 2017). Various studies confirmed that heat stress negatively affects the fertility and reproductive performance of livestock via compromising the reproductive physiology system (O'Doherty et al 2014) through the imbalance of reproductive hormones (De Rensis et al 2017), reduced quality of oocytes (Al-Katanani et al 2002; Ferreira et al 2011), decreased semen quality (Hamilton et al 2016) (Al-Kanaan et al 2015), and decreased embryo development (Sakatani 2017) and survival (Silva et al 2013). Heat stress reduces the secretion of luteinizing hormone (Vanselow et al 2016) and estradiol (Bridges et al 2005), resulting in decreased length and intensity of the estrus cycle (Schüller et al 2017), an increased incidence of anoestrus (Das and Khan 2010) and silent heat in farm animals (Kadokawa et al 2012;

Dash et al 2016). Thermal stressed oocytes lose their fertilization competence (Silva et al 2013) and development (Hansen 2013) into the blastocyst stage (Lawrence et al 2004; Wang et al 2009), which in turn results in reduced fertility (Jordan 2003; Whitfield 2016) due to the poor quality oocytes (Satrapa et al 2011) and thus the embryos (Sakatani et al 2012; Sakatani 2017). In addition, low progesterone concentrations (De Rensis and Scaramuzzi 2003) limit the functions of endometrial (Kobayashi et al 2013), and consequently embryo development (Silva et al 2013). Moreover, the high concentration of endometrial prostaglandin F2-α during heat stress threatens the continuance of pregnancy (Kobayashi et al 2013). It was found that the increase in each unit of the temperature-humidity index over 70 decreased the percentage of conception rate by 4.6 (Nabenishi et al 2011). Heat stress during pregnancy also retarded fetal growth (Tao and Dahl 2013) and results in low birth weight (Tao et al 2012). The negative influence of heat stress on livestock health and production can be reduced through adapting appropriate scientific strategies, including management, modification optimization of environmental conditions, genetic development, and nutritional management. In addition, the applications of advanced technologies in reproductive science can be countered by including timed artificial insemination, hormonal treatments, and embryo transfer, that ultimately can increase the choices for establishing pregnancy in dairy cow.

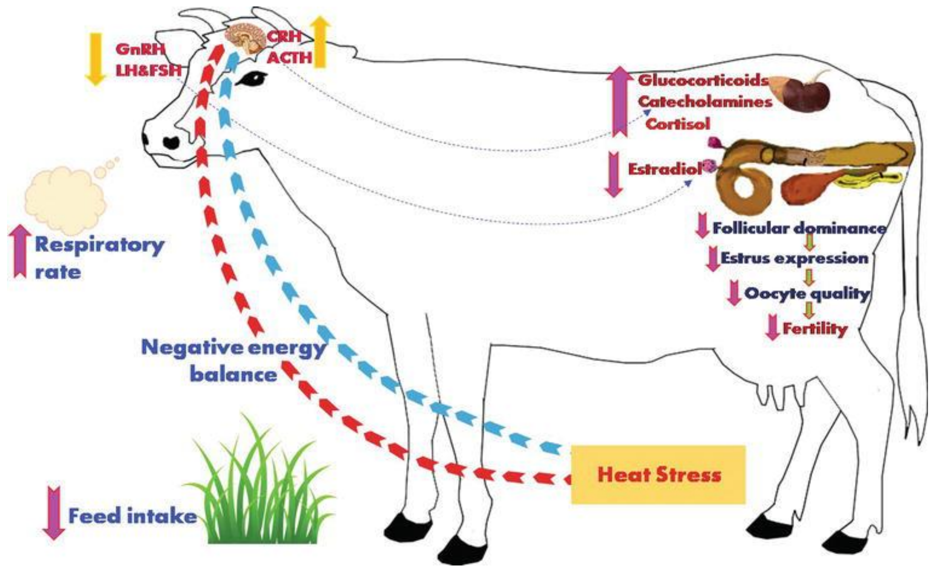

Figure 1 Effects of heat stress on reproductive performance in dairy cow. *Source:* Liu et al (2017).

5. Climate change and livestock diseases

Increasing greenhouse gas (GHG) emissions have been rising over the last century due to the increase in the planet's mean air and ocean temperatures (O'Reilly et al 2012; Drijfhout et al 2015; Ji et al 2016). These changes substantially impact the epidemiology of infectious diseases in livestock (Bett et al 2017). These effects can be direct and indirect progressions associated with climate change and livestock infectious diseases (Koneswaran and Nierenberg 2008). A few previous studies show a positive link between temperature and spreading out of the geographical arrays of arthropod vectors (Negev et al 2015; Flahault et al 2016). In contrast, most of the studies illustrated an opposite impact of climate change on the prevalence of infectious diseases (Kurane 2010; Ramasamy and Surendran 2012). Temperature (Ju et al 2015) and humidity (Jaworski and Hilszczański 2013) increases the rate of insects development (Ju et al 2011; Savopoulou-Soultani et al 2012), survival (Kreppel et al 2016) and production (Norhisham et al 2013). Thus increasing the incidence and prevalence of various diseases (Gray et al 2009; Dantas-Torres 2015; Robinson et al 2015). Higher temperatures may also motivate an infected host species to stay winter in larger populations (Aliabadi et al 2011), enlarge the population size and increase their habitat range (Negev et al 2015). Yet, the impact of these alterations on cattle disease in the Arctic has not been fully understood. In addition, whether these alterations can be transmitted to the offspring remain unknown. The roles of climate change on the incidence of infectious diseases are summarized in table 1.

6. Climate and mortality rate

Humid, warm climate conditions can cause heat stress that increases livestock mortality. They recommend sprinklers, shade, or similar management practices to cool the animals as a mitigation measure. Sirohi and Michaelowa (2007) linked livestock mortality to several heat waves between 1994 and 2006 in the United States and northern Europe. More information is needed concerning how heat stress affects feed nutrient utilization and feed intake, animal production, reproduction, and health. With more excellent knowledge related to livestock's nutritional and metabolism processes, management practices could be adapted to increase animal performance.

7. Nutrition and clinical practice

The impact of climate (Koluman Darcan and Silanikove 2017), nutrition (Ingvartsen and Moyes 2013) on animal health (Feleke et al 2016), immunity, disease (Rahal et al 2014), and reproductive capacity (Manjunathareddy et al 2017) has long been the issue of investigation, from its influences on animal evolution during the Paleolithic period to be the critical factor in causing several diseases (Barnosky and Kraatz 2007; Merilä and Hoffmann 2016). Recent scientific evidence in the genomic field has explored climate-nutrition-health interaction revealing the potential for genotype-based nutrition references (Rauw and Gomez-Raya 2015). However, double edging in nutritional field research and genomics disclose evidence preventing livestock diseases and supporting optimal health (Baye et al 2011). These issues have not been actively utilized nor given critical importance throughout ruminants health, production, nutrition, and disease control conferences (McNamara 2012). New window in biotechnology applications shows new approaches for advance climate, immunity, and nutritional genomics tools for analyzing biological mechanisms underlying in animal diseases. As climate change and nutrition are an important environmental factor that ultimately predispose animal disease, immunity based nutrition can potentially improve overall animal health (Asmare 2014). Through nutritional strategy based on animal genotype (James 2009), we will then outfitted to enhance animal immunity and prevent and control animal disease based on nutrition and climate change.

Table 1 Effects of climate change on the incidence of infectious diseases.

Environmental change	Disease example	Animal Species	Reference
Dams	Schistosomasis	Bovine, Humans	(Li et al 2007)
Canals	Schistosomasis	Bovine, Humans	(Colley et al 2014)
River	Rift Valley fever	Bovine	(Drake et al 2013)
Weather	Foot and Mouth Disease	Bovine	(Dong et al 2016)
Management	Milk fever	Bovine	(Thilsing-Hansen et al 2002)
Irrigation	Fasciolosis	Bovine	(Suon et al 2006)
Migration& Globalization	Tuberculosis	Bovine	(Humblet et al 2009)
Global warming	Trypanosomiasis	Bovine	(Moore et al 2012)
Drought	Johne's disease	Ovine	(Bush et al 2006)
Wildlife	Anthrax	Bovine, Caprine, Ovine	(Miller et al 2013)
Global Warming	*Cryptococcus neoformans*	Mammals	(Garcia-Solache and Casadevall 2010)
Seasonal changes	Bluetongue	Bovine, Caprine, Ovine	(Samy and Peterson 2016)
Land use	Pasteurellosis	Bovine, Caprine, Ovine	(Wilson and Ho 2013)
Depopulation	Corynebacterium	Bovine, Caprine, Ovine	(Spier and Azevedo 2017)
Evaporative cooling	Mastitis	Bovine	(Arcaro et al 2013)
High humidity	Rinderpest	Bovine	(Morand 2015)
Grazing system, land cover	Lumpy Skin Disease	Bovine	(Alkhamis and VanderWaal 2016)

With modern progress in the field of nutritional genomics (Loor et al 2013), environmental genomics (Shafer et al 2016), immunological genomics (Shen et al 2013; Raszek et al 2016), and the promotion of customized, genotype-based diets (Ferrell et al 2006; Seo et al 2013), management for optimal animal health is more common in developed countries veterinary medicine. However, these opportunities are missing in underdeveloped countries (Bayne et al 2015), particularly in Africa. Nevertheless, these approaches also correspond with animal welfare philosophy lobes in Eastern developed countries, which pressure their governments toward improving animal welfare (Szucs et al 2012). Several nutritional concepts in animal production and disease control have generally not been adopted by ministries of veterinary worldwide (Perry and Grace 2009; Thornton 2010). However, as both developing and developed countries (Thompson 2010; Cornish et al 2016) possess different weaknesses and strengths concerning biotechnology applications (De Simone and Serratosa 2005), as well an analysis of an integrated approach to animal immunity and nutrition (Warne 2014) therefore, could be accomplished by selecting the advantages of both approaches based on the knowledge and practice. Combining both approaches may thus create a comprehensive, all-inclusive concept of veterinary medicine, providing holistic systems and improved animal welfare from both systems.

8. Malnutrition and dairy cattle diseases

Malnutrition and infection have constantly been intricately associated (Katona and Katona-Apte 2008). It is considered the main factor which causes immunodeficiency worldwide (Duggal et al 2012), and scientists are searching more and more to understand the pathogenesis of this relationship. Deficiencies of both micronutrients and macronutrients have apparent effects on immune function (Banos et al 2013), susceptibility to infectious diseases (França et al 2009), decreases in milk production (Raboisson et al 2015), abortion, dystocia (Hickson et al 2006), and fetal growth retardation (Long et al 2012), congenital fetal diseases (Hill et al 2009), skeletal abnormalities (Dittmer and Thompson 2015) and increased mortality rate (Whiting et al 2012). It is well known that parasitic infestation causes malnutrition, particularly the cestodes (Kumar et al 2013). However, exactly which malnutrition increased parasitic infestation is not well documented; therefore, this issue must be addressed. Nutritional deficiencies during pregnancy are associated with decreased immune defense against infectious diseases (Katona and Katona-Apte 2008; Cunningham-Rundles et al 2009) since colostrums may partially compensate for this immune dysfunction; the best way to protect calves from infection diseases (Yang et al 2015; Ontsouka et al 2016). Malnutrition (Müller and Krawinkel 2005) and nutritional alterations (Joy et al 2014), a major complications of both human and animal problems in developing countries (Jin and Iannotti 2014; Mosites et al 2016; Kaur et al 2017). However, the disease-specific nutrition formula to improve the nutritional condition and functional reproductive performance in dairy cows remain scarce. Therefore, here we recommend further studies to address the disease specific nutrition formula in the field of livestock production particularly in dairy cattle.

9. A Common Origin for Immunity and Digestion

From an evolutionary view, scientific evidence on relationships between immunity and nutrition has shown an ancient connection in embryonic development and function (Broderick 2015; van Niekerk and Engelbrecht 2015). Historically, the immune and digestive systems have been observed and analyzed as separate entities. However, recent scientific evidence revealed that both systems shared vital similarities and common join functions, both in nutrient gaining and host defense and the origins common to both organs (Round and Mazmanian 2009; Sotolongo et al 2012). This concept provides a new and possibly novel method to visualize the emergence and evolution of host defense mechanisms (Broderick 2015). Unicellular organisms are known to phagocytose for gaining food (Esteban et al 2015) and defense (Oczypok et al 2013), and the phagocytosis process represents the main ancient and ubiquitous form of food acquisition and protection against foreign insult (Sanjuan and Green 2008). Multicellular vertebrates and invertebrates possess special phagocytic cells that function for defense and have evolved more complex processes (Morella and Koskella 2017) attributed to immunological defense cells, which became specialized for carrying out humoral immune and cellular responses (Buchmann 2014). From the oral cavity to the end of the intestine, the tubular gastrointestinal tract is well equipped and adapted with specialized cells, tissues, and organs that coevolved to remain forever together (Van den Abbeele et al 2011).

Host response against invading pathogens is an essential physiological reaction in all living organisms (Govers et al 2017). Since the development of the first eukaryotic cells, several defense mechanisms (Kono and Rock 2008; McGhee and Fujihashi 2012) have evolved to protect cellular integrity (Randow et al 2013), homeostasis (Marques et al 2016), and host survival (Nakad and Schumacher 2016). Invertebrate organisms from the protozoans to metazoans contain cellular receptors (Price et al 2016) that bind to antigens (Klose et al 2016) and consequently discriminate self from non-self (Chaplin 2010). In multicellular animals, this rudimentary capability is associated with phagocytes, known by different names (e.g., coelomocytes, hemocytes, amebocytes) in different group's species of organisms such as sponges (Dzik 2010), round worms, cnidarians (Davy et al 2012), mollusks (Terahara and Takahashi 2008), crustaceans (Vazquez et al 2009), chelicerates (Buchmann 2014), insects (Browne et al 2013), annelid worms and echinoderms (Hirano 2016). The macrophage-like cells, function, and related repair are most important even at the earliest evolutionary stage (Sunyer 2012). They have well-conserved molecular structures such as pathogen-recognizing receptors (Moretti and Blander 2014) and pathogen-related molecular patterns (Santoni et al 2015). However, the impact of climate change on livestock adaptation with the dynamics of parasitic, bacterial, and viral infections is missing. In addition, whether the global climate change will modify the fundamental animal immune reactivity for prenatal and postnatal needs to be investigated.

10. Evolution of transgenerational immunity

The discovery of transgenerational immunity in invertebrates changed an existing paradigm on the lack of sophistication of their immune system (Pigeault et al 2016). However, the incidence of this paradigm and the environmental factors motivating its evolution in invertebrates remain less understood. Invertebrate immunity was commonly assumed over a decade ago due to the lack of the most complicated components of the vertebrate immune system (Loker et al 2004; Rowley and Powell 2007). The ability of invertebrate's immunity to mount an acquired response (Cooper and Eleftherianos 2017) where memory effectors produced during an infection protects the offspring (transgenerational) (Little et al 2003) or individual (within-generational) (Jokela 2010) against later infections. Yet, recent investigations have shown that invertebrates possess spectacularly plastic immune effectors, which can produce accurate novelty and functional immune responses after exposure to pathogens (Armitage et al 2015). Scientific shreds of evidence of within-generational immune confirmation in invertebrates have been documented considerably in the last decade (Schmid-Hempel 2005). It has been reported that a variety of invertebrates species including Hymenoptera (Sadd and Schmid-Hempel 2006), Decapoda (Witteveldt et al 2004), Diptera (Rodrigues et al 2010), Lepidoptera (Tidbury et al 2011) , Branchiopoda (McTaggart et al 2012), Coleoptera (Roth et al 2009). Interestingly, transgenerational immunity has been therefore far reported in a wide range of invertebrate species (Figure 2) (Milutinovic and Kurtz 2016; Huang and Song 1999; Little et al 2003; Sadd et al 2005). However, relevant information on mammals generally and ruminants is missing. In addition, the mechanisms underlying the transgenerational immune protection in dairy cows remain unknown. Thus, this review strongly recommends the research work in such a direction.

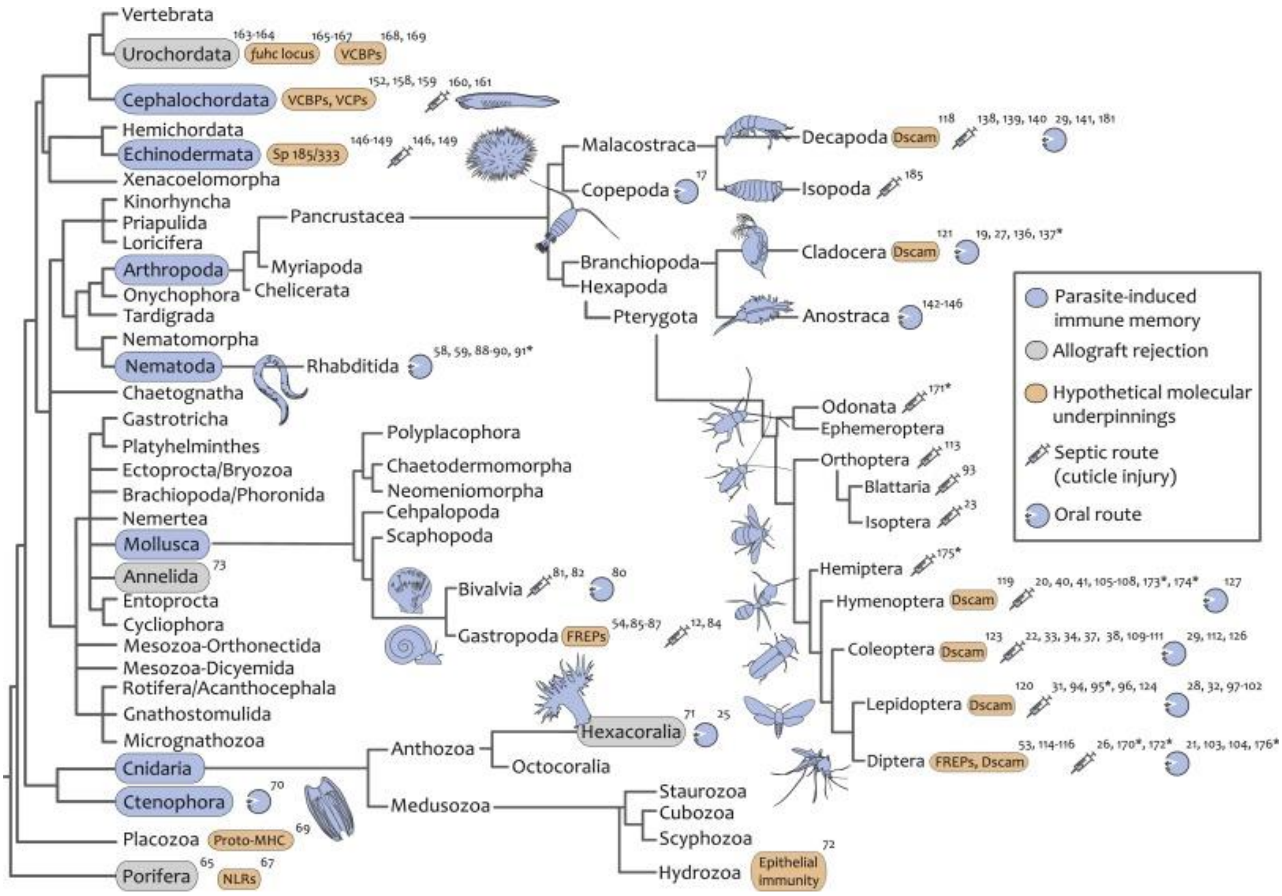

Figure 2 Transgenerational immunity invertebrate species. *Source:* Milutinović and Kurtz (2016)

11. Nutrition and immune function in livestock model: the cattle

Studies in animal nutrition analysis and animal immunity, especially in invertebrates, have been extensively investigated, given newer discoveries and insights (Ponton et al 2011; Valtonen et al 2011; Pigeault et al 2016). Increased milk production and the structural changes in the dairy technology are the main factors that caused significant problems and alterations in feeding (Thanh and Suksombat 2015), housing (Popescu et al 2013), management (Das et al 2016) and behavior of the dairy cattle and buffalos (Seerapu et al 2015; Polsky and von Keyserlingk 2017). However, as better improvements have occurred in animal production and efficiency (VandeHaar et al 2016), the disease prevalence, based on veterinary reports, does not improve (Ducrot et al 2011; Peiso et al 2011; Awan et al 2014; Brugere et al 2017). Previous review articles have enclosed critical periods, for instance, the transition period in the dairy cow and its impact on health and immune function (Ingvartsen and Moyes 2013), the interaction between the immune system, endocrine system and nutrition and immune function (Ingvartsen and Moyes 2013). Well, scientific establishment on these issues is fundamental for our understanding of animal disease risk and our attempt to expand animal health and welfare-improving approaches, including practical management for preventing infectious diseases and decreasing the severity of diseases. The health problems during the periparturient period signal the dairy cows' complexity in adapting to the nutrient requirements for lactation (Sun et al 2016; Ruiz et al 2017). This may result in physiological imbalance (Moyes et al 2013). In this situation, the regulatory mechanisms are inadequate for the cow to function optimally, resulting in a high risk of complex digestive (Abdela 2016), metabolic (Sundrum 2015) and infectious problems (Moosavi et al 2014). The compromised immune status increases the risk of infectious diseases in the animal (Ingvartsen and Moyes 2013). It is well recognized that nutrition status plays a critical role in the organism's immune response (Pae et al 2012), and the influence of nutrition can be directly through nutrients (Sordillo et al 2009; Ponton et al 2011) or indirectly via metabolites (Sordillo 2016), for example, in situations of physiological imbalance (Ingvartsen and Moyes 2013). Yet, these complex associations between immune function and metabolic status and the interactions enhance the risk of diseases during the lactation period. Therefore, special care should be taken into account on the vital energetic supplements which presently known to be used by immune cells, such as non-esterified fatty acids (Ster et al 2012), glucose, beta-hydroxybutyrate (Hillreiner et al 2016), and glutamine (de Oliveira et al., 2016). In addition, how specific metabolic states, for example the degree of negative energy balance and risk of physiological imbalance, contribute to immunosuppression during the periparturient period is critical, and therefore, it should give special attention.

12. Nutrition, immune function, and health problems of dairy cattle

The most common health problems in the dairy cow occur during the parturition period (Villarroel and Lane 2010; Palombi et al 2013). Previous reviews have discussed that decreased immune competence and physiological imbalance are the main predisposing and risk factors for disease rather than milk production (Ingvartsen and Moyes 2013). Several outstanding previous articles have enclosed critical periods, for instance, the transition period in dairy cows and its impact on animal health and immune function (Mulligan et al 2006; Mulligan and Doherty 2008), the interaction between the endocrine system and immune function (Burdick et al 2011; Banos et al 2013), nutrition and immune function (Sordillo 2016). The period of periparturient (Trevisi et al 2012) and particularly the transition period of dairy cattle are distinguished by dramatic alteration in metabolism (Sundrum 2015) and host defense mechanisms which are found to be associated with an increased risk of disease (Mordak and Anthony 2015). Predominantly, the transition period is the most demanding (Gross et al 2011) for the majority of mammals that may intimidate both animal health and animal welfare (Beggs et al 2015) if the challenges go beyond the coping mechanisms of the animal (Aitken et al 2009; Sordillo 2013; Aleri et al 2016). Both periods are found to be associated with an increased incidence of metabolic (Mordak and Anthony 2015) and other non-infectious (Sundrum 2015) and infectious diseases (Eckel and Ametaj 2016) such as fatty liver (White 2015), milk fever (Thilsing-Hansen et al 2002), retained placenta (Beagley et al 2010), metritis (Sheldon et al 2008), ketosis, left-displaced abomasums (Sexton et al 2007; Mueller 2011), lameness (Randall et al 2016) and clinical mastitis (Lundberg et al 2016). During the early lactation period, ruminants remobilize large amounts of nutrient reserves, mainly lipid from adipose tissue, to support milk production. Demobilization of lipids is a common physiological adaptation mechanism in mammals to counter those physiological conditions, such as in the periparturient period, but excessive demobilization of lipids has been associated with an increased risk of diseases (Vernon 2005; Contreras and Sordillo 2011).

The nutrient requirements increase significantly during late pregnancy and mainly in early lactation (Dunlap et al 2015). In late pregnancy, the nutrient demand is found to increase as a result of fetal development (Bell et al 1995; Dunlap et al 2015), which remarkably increases glucose (Brett et al 2014) and amino acids (Dunlap et al 2015; Tedeschi et al 2015). The extensive milk production acceleration, seen particularly in the last week of *prepartum* and in the first 2 weeks of lactation, mirrors the spectacular increase in nutrients requires at the onset of lactation. A dairy cow with a milk yield of 50 kg was found to secrete approximately 2 kg of milk fat per day, 2.5 kg of lactose, 1.6 kg of milk protein, 50 g of P, 65 g of Ca, and 8 g of Mg. All of these nutrients ultimately increase requirements for energy (Mair et al 2016), protein (Imaizumi et al 2010) and minerals (Bhanderi et al 2016). In the late stage of pregnancy, the nutrient demand and particularly the nutrient requirements for lactation induce a coordination mechanism of the biological processes in different tissues, resulting in metabolic alterations that ensure that dairy cows reach their highest genetic potentiality for milk yield.

Physiological imbalances in dairy cows have been known as cows whose parameters deviate from routine and thus have an elevated risk of developing production diseases and decreased reproduction and production capacity (Moyes et al 2013) A well-known example of physiological disturbances would be the extreme mobilization, due to over malnutrition or conditioning, in other cases, for extended periods in early lactation (Elizondo Salazar et al 2013; Sun et al 2016). During excessive mobilization of lipids, lipogenesis rates undergo very low (Contreras et al 2017), while lipolysis rates become very high (Humer et al 2016), resultant in high plasma non-esterified fatty acids (NEFA) concentrations (Adewuyi et al 2005; Contreras et al 2010) and glycerol (Melendez et al 2017). The interaction of these processes increased NEFA, which in turn reduces dry matter intake (Allen et al 2009) and, therefore, the low plasma glucose concentration with increased ketogenesis (Vicente et al 2014) and consequently elevated plasma ketone body levels (Enjalbert et al 2001). These metabolic changes associated with excessive lipid mobilization definitely serve as secondary factors to diseases, such as stress, displaced abomasum, and lameness (Gellrich et al 2015). The information mentioned above illustrates that, in general, more metabolic parameters are influenced by excessive lipid mobilization, stress, pain and disease (Goff 2006) (Figure 3).

13. Nutrigenomics and nutrigenetics in animal health and production

Traditional research work regarding animal nutrition mostly deals with either excess or deficiency of the specific nutrient, which causes a reduction in animal production or may cause health problems. Nutrigenomics (Ferguson 2009) and nutrigenetics (Raqib and Cravioto 2009) are new disciplines in the improvement of milk production in ruminant species (Table 2), which concern the influence of food at the genetic level (Martin and Król 2017). Nutrigenomics studies how bioactive components of foods and their supplements influence animal metabolism by changing gene expression (Bouchard-Mercier et al 2013) and connects various fields: nutrition (Ferguson 2015), bioinformatics (Malkaram et al 2012), molecular biology, genomics (Doo and Kim 2015), functional genomics (Hocquette et al 2007), epidemiology (Boeing 2013), and epigenomics (Bishop and Ferguson 2015; Carlberg et al 2016). Multi-disciplinary tool utilization provides new windows to explore the complex interactions between the genome and the diet. These new approaches emphasize the appropriate role of nutrition-genetics interactions on various physiological and metabolic processes with a high influence on economically associated traits such as milk and meat quality. Thus, multidisciplinary studies interest is essential to face these new complicated issues. However, the studies on basic concepts and technologies involved in nutrigenomics and nutrigenetics research in the diary field are lacking. In addition, research on how nutrition affects genes expression involved in lipid metabolism before parturition and during lactation period needed to investigate.

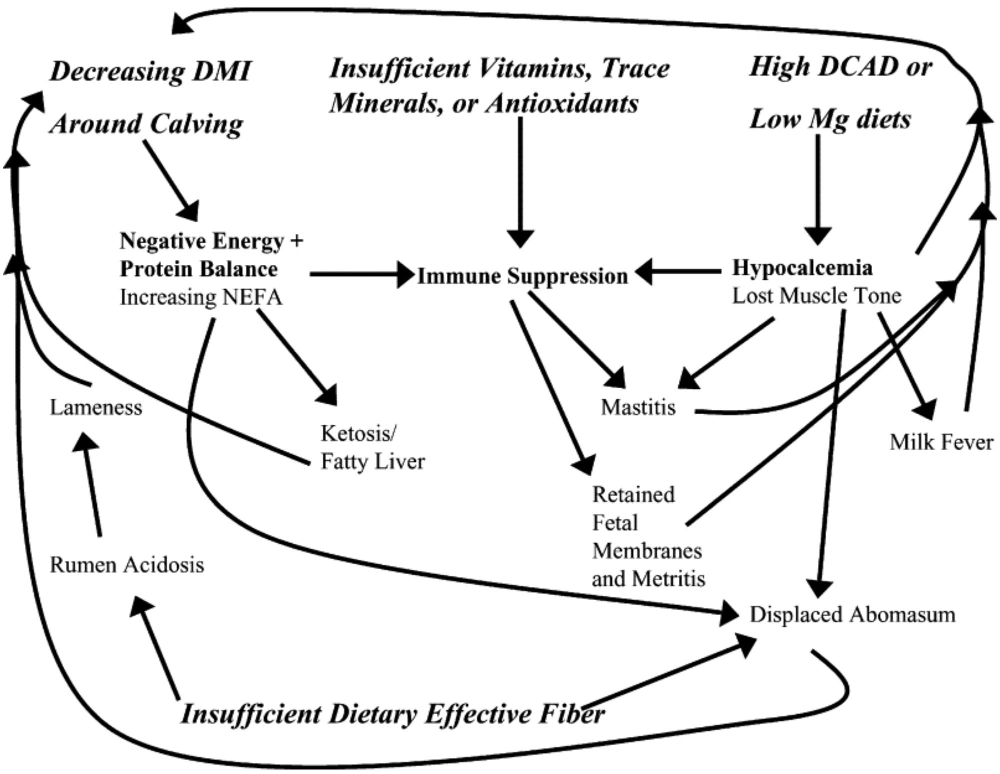

Figure 3 Metabolic pathways in the situation of excessive lipid mobilization, stress, pain and related disorders. *Source:* Goff et al (2006).

14. Strategies for preventing disease in the dairy cow during early lactation

The transition from late gestation to early lactation is the main metabolically demanding stage in the lactation cycle of a dairy cow (Sundrum 2015). There is growing evidence associates the degrees of nutrient balance with immunity function and risk of both infectious and non-infectious diseases (Lacasse et al 2017), minimizing the severity and period of negative nutrient balance during the periparturient period (García et al 2011), which is very important for improving animal health (Abuelo et al., 2015) and welfare and decreasing economic losses to farmers (de Ondarza and Tricarico 2017). In this review, it is not difficult to discuss all of these factors that affect the levels of nutrient balance, their quality, management, environmental factors, and risk factors of disease during early lactation in the dairy cow. Here we will cover the significant strategies of management that have been applied previously and are currently being established, focusing on the improvement of transition in dairy cows.

Dairy cows experience temporary decreases in dry matter intake before parturition, further aggravating the imbalance between energy requirements (Grummer et al 2004) and energy supply (Buhler et al 2017). Intake of dry matter usually decreases up to 32% before 3 weeks of parturition, and about 89% of these reductions occur throughout the last week before the calving (Hayirli et al 2002). Greater immersion in intake of dry matter at this time has been linked with elevated blood NEFA (Imhasly et al 2015) and ketone bodies, particularly BHBA (Imhasly et al 2015) and accumulation of liver triglycerides during early lactation (Sejersen et al 2012), thus increasing the risk factor of both infectious and non-infectious diseases (Janovick et al 2011). The strategies designed to minimize this natural fall in dry matter intake have revealed improvements in metabolic profiles, including the decreases in blood NEFA, ketone bodies and decreases in liver triglycerides accumulation. In addition, it has shown a decreased incidence of metabolic disorders in the dairy cow during the early lactation period.

Recent research work has shown the association between overconsumption during the dry period and the severity of energy balance (Smith et al 2017), decreased liver functions (Roche et al 2017) and increased the incidence of metabolic diseases throughout early lactation (Dann et al 2006; Sundrum 2015; Sun et al 2016). Previous nutritional strategies application showed significant changes in dry matter intake and energy balance, reduced the magnitude of body condition scoring modifications and decreased blood NEFA and BHBA levels and triglycerides accumulation in the liver. However, recent scientific evidence indicates that restriction of energy intake prepartum did not negatively impact primiparous dairy cows (Janovick et al 2011). Therefore, we here suggest future studies are needed to clarify if comparable responses are obvious in other cattle breeds, particularly Jerseys.

Table 2 Applications of nutrigenomics and nutrigenetics technology in ruminants.

Species	Type of Application	Tissue	Title of the study	Reference
Bovine	Gene expression	Muscle	Effect of the feeding system on the fatty acid composition, expression of the Δ9-desaturase, Peroxisome Proliferator-Activated Receptor Alpha, Gamma, and Sterol Regulatory Element Binding Protein 1 genes in the semitendinous muscle of light lambs of the Rasa Aragonesa breed	(Dervishi et al 2010)
Bovine	Gene expression	Muscle	Estimates different levels of protein supplementary diet on gene expressions related to intramuscular deposition in early-weaned yaks	(Zhang et al 2014)
Caprine	Gene expression	Mammary gland	Negative effects of long-term feeding of high-grain diets to lactating goats on milk fat production and composition by regulating gene expression and DNA methylation in the mammary gland	(Tian et al 2017)
Caprine	Gene expression	Muscle	Selection of Reference Genes for Gene Expression Studies Related to Intramuscular Fat Deposition in Capra hircus Skeletal Muscle	(Zhu et al 2015)
Caprine	Gene expression	Mammary gland	Effects of different model diets on milk composition and expression of genes related to fatty acid synthesis in the mammary gland of lactating dairy goats.	(Zhang et al 2015a)
Caprine	Gene expression	Liver	Long-term effects of subacute ruminal acidosis (SARA) on milk quality and hepatic gene expression in lactating goats fed a high-concentrate diet.	(Dong et al 2013)
Bovine	Gene expression	Muscle	Effects of different levels of protein supplementary diet on gene expressions related to intramuscular deposition in early-weaned yaks	(Zhang et al 2014)
Bovine	Gene expression	Adipose tissue	Effects of dietary energy level on lipid metabolism-related gene expression in subcutaneous adipose tissue of Yellow breed × Simmental cattle	(Zhang et al 2015b)
Caprine	Gene expression	Mammary gland	Feeding a High Concentrate Diet Down-Regulates Expression of ACACA, LPL and SCD and Modifies Milk Composition in Lactating Goats.	(Tao et al 2015)
Bovine	Gene expression	Muscle	Dietary conjugated linoleic acids increase intramuscular fat deposition and decrease subcutaneous fat deposition in Yellow Breed × Simmental cattle	(Zhang et al 2016)
Bovine	Gene expression	Cells	Neuronal Nicotinic Acetylcholine Receptors on Bovine Chromaffin Cells: Cloning, depression, and Genomic Organization of Receptor Subunits	(Campos-Caro et al 1997)
Bovine	Gene expression	Adipose tissue	Effects of dietary energy level on lipid metabolism-related gene expression in subcutaneous adipose tissue of Yellow breed x Simmental cattle.	(Zhang et al 2015b)
Bovine	Gene expression	Mammary glands	Conjugated linoleic acid-induced milk fat reduction associated with depressed expression of lipogenic genes in lactating Holstein mammary glands	(Han et al 2012)
Bovine	Gene expression	Mammary glands	Expression and nutritional regulation of lipogenic genes in the ruminant lactating mammary gland	(Bernard et al 2008)
Bovine	Gene expression	Liver	Dietary supplementation of selenium in inorganic and organic forms differentially and commonly alters blood and liver selenium concentrations and liver gene expression profiles of growing beef heifers	(Liao et al 2011)

Bovine	Transcriptome	Liver	Hepatic transcriptome profiles differ among maturing beef heifers supplemented with inorganic, organic, or mixed (50% inorganic:50% organic) forms of dietary selenium.	(Matthews et al 2014)
Bovine	Gene expression	Adipose tissue	Effect of Diet Supplementation on the Expression of Bovine Genes Associated with Fatty Acid Synthesis and Metabolism	(Joseph et al 2010)
Caprine	Gene expression	Mammary gland	Effects of different model diets on milk composition and expression of genes related to fatty acid synthesis in the mammary gland of lactating dairy goats	(Zhang et al 2015a)
Ovine	Gene expression	Mammary gland	Sheep and goats differences in CLA and fatty acids milk fat content in relation with mRNA stearoyl-CoA desaturase and lipogenic genes expression in their mammary gland.	(Tsiplakou et al 2009)
Bovine	Gene expression	Liver	Lipopolysaccharide derived from the rumen down-regulates stearoyl-CoA desaturase 1 expression and alters fatty acid composition in the liver of dairy cows fed a high-concentrate diet.	(Xu et al 2015)
Bovine	Gene expression	Muscle	Expression of genes involved in lipid metabolism in the muscle of beef cattle fed soybean or rumen-protected fat, with or without monensin supplementation	(Oliveira et al 2014)
Ovine	Gene expression	Ruminal epithelial cells	Conjugated linoleic acids influence fatty acid metabolism in ovine ruminal epithelial cells.	(Masur et al 2016)
Ovine	Gene expression	Muscle	The effect of feeding system in the expression of genes related with fat metabolism in semitendinous muscle in sheep	(Dervishi et al 2011)
Ovine	Gene expression	Muscle	Effect of vitamin E supplementation or alfalfa grazing on fatty acid composition and expression of genes related to lipid metabolism in lambs.	(Gonzalez-Calvo et al 2015)
Bovine	Gene expression	Mammary gland	Bovine Mammary Gene Expression Profiling during the Onset of Lactation	
Bovine	Gene expression	Milk	Differential expression of genes in milk of dairy cattle during lactation	(Yang et al 2016)
Bovine	Transcription	Mammary gland	Transcriptional profiling of mammary gland in Holstein cows with extremely different milk protein and fat percentage using RNA sequencing.	(Cui et al 2014)
Caprine	Transcriptome	Mammary gland	Transcriptome analysis of the mammary gland from GH transgenic goats during involution.	(Lin et al 2015)
Bovine	Transcription	Whole blood	Whole blood transcriptional profiling comparison between different milk yields of Chinese Holstein cows using RNA-seq data.	(Bai et al 2016)
Bovine	Gene expression	Mammary gland	Deep sequencing shows microRNA involvement in bovine mammary gland adaptation to diets supplemented with linseed oil or safflower oil.	(Li et al 2015)
Bovine	Gene expression	Mammary gland	Targeted imputation of sequence variants and gene expression profiling identifies twelve candidate genes associated with lactation volume, composition and calving interval in dairy cattle.	(Raven et al 2016)
Bovine	SNP	Milk	Genome-wide association study for endocrine fertility traits using single nucleotide polymorphism arrays and sequence variants in dairy cattle.	(Tenghe et al 2016)
Bovine	Gene expression	Mammary gland	Expression variants of the lipogenic AGPAT6 gene affect diverse milk composition phenotypes in Bos taurus.	(Littlejohn et al 2014)
Bovine	GWS		Multibreed genome wide association can improve precision of mapping causative variants underlying milk production in dairy cattle.	(Raven et al 2014)
Bovine	Gene expression	Mammary gland	Function of SREBP1 in the milk fat synthesis of dairy cow mammary epithelial cells.	(Li et al 2014)
Caprine	Gene expression	Mammary gland	Overexpression of SREBP1 (sterol regulatory element binding protein 1) promotes de novo fatty acid synthesis and triacylglycerol accumulation in goat mammary epithelial cells.	(Xu et al 2016)

Caprine	Gene expression	Mammary gland	Peroxisome proliferator-activated receptor delta facilitates lipid secretion and catabolism of fatty acids in dairy goat mammary epithelial cells.	(Shi et al 2017)
Caprine	Gene expression	Mammary gland	SCD1 Alters Long-Chain Fatty Acid (LCFA) Composition and Its Expression Is Directly Regulated by SREBP-1 and PPARγ 1 in Dairy Goat Mammary Cells.	(Yao et al 2017)
Caprine	MicroRNA	Mammary gland	MicroRNA-24 can control triacylglycerol synthesis in goat mammary epithelial cells by targeting the fatty acid synthase gene.	(Wang et al 2015)
Bovine	Transcription	Review paper	TRIENNIAL LACTATION SYMPOSIUM: Nutrigenomics in dairy cows: Nutrients, transcription factors, and techniques.	(Bionaz et al 2015)
Caprine	Gene expression	Mammary gland	Peroxisome proliferator-activated receptor γ1 and γ2 isoforms alter lipogenic gene networks in goat mammary epithelial cells to different extents.	(Shi et al 2014)
Caprine	Gene expression	Mammary gland	Overexpression of SREBP1 (sterol regulatory element binding protein 1) promotes de novo fatty acid synthesis and triacylglycerol accumulation in goat mammary epithelial cells.	(Xu et al 2016)
Bovine	Gene expression	Liver	Rumen-protected conjugated linoleic acid supplementation to dairy cows in late pregnancy and early lactation: effects on milk composition, milk yield, blood metabolites and gene expression in liver.	(Sigl et al 2010)
Bovine	Gene expression	Mammary gland	A commonly used rumen-protected conjugated linoleic acid supplement marginally affects fatty acid distribution of body tissues and gene expression of mammary gland in heifers during early lactation.	(Kramer et al 2013)

15. Final considerations

Climatic factors, for example, humidity, temperature and rainfall, are well known to influence the insect's population dynamics and transmission of disease potentiality. Shifting from the specific climatic condition is known to cause compromised health, immune functions and productivity in livestock. Climatic changes affect disease incidences in livestock breeds by influencing their heat stress which affects diet intake, metabolism, immune function, the virulence of pathogens, and increases transmission methods. Due to climate change, elevated temperature leads to increased infectious agents' development rates. Severe dehydration and heat stress ultimately affect the immune dysfunction in dairy cows due to climate changes. Most fitness problems in dairy cows occur around parturition, related to dairy cows facing difficulty in adapting nutrient requirements for milk production. Complex associations between immune function, nutrition and metabolic status have potentially affected disease risk. These disturbances decrease immune competence and increase the risk for the disease since metabolites and nutrients can affect numerous vital aspects of immune response and thus potentially resistance to diseases. Feeding strategies should avoid the physiological imbalance in dairy cows to improve immune function, thus disease resistance and health promotion.

Acknowledgments

The authors thank the International Center for Agricultural Research in the Dry Areas for providing us with free internet and an office.

Ethical Considerations

Not applicable.

Conflict of Interest

There was no conflict of interest.

Funding

The current work had no financial support.

References

Abdela N (2016) Sub-acute Ruminal Acidosis (SARA) and its Consequence in Dairy Cattle: A Review of Past and Recent Research at Global Prospective. Achievements in the Life Sciences 10:187-196.

Abuelo A, Hernández J, Benedito JL, Castillo C (2015) The importance of the oxidative status of dairy cattle in the periparturient period: revisiting antioxidant supplementation. Journal of animal physiology and animal nutrition 99:1003-1016.

Adewuyi AA, Gruys E, van Eerdenburg FJ 2005 Non esterified fatty acids (NEFA) in dairy cattle. A review. The Veterinary quarterly 27:117-126.

Aitken SL, Karcher EL, Rezamand P, Gandy JC, VandeHaar MJ, Capuco AV, Sordillo LM (2009) Evaluation of antioxidant and proinflammatory gene expression in bovine mammary tissue during the periparturient period. Journal of dairy science 92:589-598.

Al-Kanaan A, König S, Brügemann K (2015) Effects of heat stress on semen characteristics of Holstein bulls estimated on a continuous phenotypic and genetic scale. Livestock Science 177:15-24.

Al-Katanani YM, Paula-Lopes FF, Hansen PJ (2002) Effect of season and exposure to heat stress on oocyte competence in Holstein cows. Journal of dairy science 85:390-396.

Aleri JW, Hine BC, Pyman MF, Mansell PD, Wales WJ, Mallard B, Fisher AD (2016) Periparturient immunosuppression and strategies to improve dairy cow health during the periparturient period. Research in veterinary science 108:8-17.

Aliabadi AA, Rogak SN, Bartlett KH, Green SI (2011) Preventing Airborne Disease Transmission: Review of Methods for Ventilation Design in Health Care Facilities. Advances in Preventive Medicine 21.

Alkhamis MA, VanderWaal K (2016) Spatial and Temporal Epidemiology of Lumpy Skin Disease in the Middle East, 2012–2015. Frontiers in Veterinary Science 3:19.

Allen JD, Hall LW, Collier RJ, Smith JF (2015) Effect of core body temperature, time of day, and climate conditions on behavioral patterns of lactating dairy cows experiencing mild to moderate heat stress. Journal of dairy science 98:118-127.

Allen MS, Bradford BJ, Oba M (2009) Board Invited Review: The hepatic oxidation theory of the control of feed intake and its application to ruminants. Journal of animal science 87:3317-3334.

Arcaro JRP, Matarazzo SV, Pozzi CR, Arcaro Junior I, Toledo LMd, Costa EO, Miranda MSd (2013) Effects of environmental modification on mastitis occurrence and hormonal changes in Holstein cows. Pesquisa Veterinária Brasileira 33:826-830.

Armitage SA, Peuss R, Kurtz J (2015) Dscam and pancrustacean immune memory - a review of the evidence. Developmental and comparative immunology 48:315-323.

Asmare B (2014) Biotechnological Advances for Animal Nutrition and Feed Improvement. World Journal of Agricultural Research 2:115-118.

Awan F, Ali MM, Iqbal U, Khattak I, Mushtaq MH (2014) Some challenges in progressive control of livestock originated zoonotic diseases in Pakistan–a pilot survey. Asian Pacific Journal of Tropical Biomedicine 4:821-824.

Bai X, Zheng Z, Liu B, Ji X, Bai Y, Zhang W (2016) Whole blood transcriptional profiling comparison between different milk yield of Chinese Holstein cows using RNA-seq data. BMC Genomics 17:512.

Banos G, Wall E, Coffey MP, Bagnall A, Gillespie S, Russell GC, McNeilly TN (2013) Identification of Immune Traits Correlated with Dairy Cow Health, Reproduction and Productivity. PloS one 8:e65766.

Barnosky AD, Kraatz BP (2007) The Role of Climatic Change in the Evolution of Mammals. BioScience 57:523-532.

Baye TM, Abebe T, Wilke RA (2011) Genotype–environment interactions and their translational implications. Personalized medicine 8:59-70.

Bayne K, Ramachandra GS, Rivera EA, Wang J (2015) The Evolution of Animal Welfare and the 3Rs in Brazil, China, and India. Journal of the American Association for Laboratory Animal Science 54:181-191.

Beagley JC, Whitman KJ, Baptiste KE, Scherzer J (2010) Physiology and treatment of retained fetal membranes in cattle. J Vet intern Med 24.

Beggs DS, Fisher AD, Jongman EC, Hemsworth PH (2015) A survey of Australian dairy farmers to investigate animal welfare risks associated with increasing scale of production. Journal of dairy science 98:5330-5338.

Belhadj Slimen I, Najar T, Ghram A, Abdrrabba M (2016) Heat stress effects on livestock: molecular, cellular and metabolic aspects, a review. Journal of animal physiology and animal nutrition 100:401-412.

Bell AW, Slepetis R, Ehrhardt UA (1995) Growth and Accretion of Energy and Protein in the Gravid Uterus During Late Pregnancy in Holstein Cows1. Journal of dairy science 78:1954-1961.

Bellard C, Bertelsmeier C, Leadley P, Thuiller W, Courchamp F (2012) Impacts of climate change on the future of biodiversity. Ecology letters 15:365-377.

Berman A (2011) Invited review: Are adaptations present to support dairy cattle productivity in warm climates? Journal of dairy science 94:2147-2158.

Bernabucci U, Biffani S, Buggiotti L, Vitali A, Lacetera N, Nardone A (2014) The effects of heat stress in Italian Holstein dairy cattle. Journal of dairy science 97:71-486.

Bernard L, Leroux C, Chilliard Y (2008) Expression and Nutritional Regulation of Lipogenic Genes in the Ruminant Lactating Mammary Gland, in: Bösze, Z. (Ed.), Bioactive Components of Milk, Springer New York, New York, NY, pp. 67-108.

Bett B, Kiung P, Gachohi J, Sindato C, Mbotha D, Robinson T, Lindahl J, Grace D (2017) Effects of climate change on the occurrence and distribution of livestock diseases. Preventive veterinary medicine 137:119-129.

Bhanderi BM, Goswami A, Garg MR, Samanta S (2016) Study on minerals status of dairy cows and their supplementation through area specific mineral mixture in the state of Jharkhand. Journal of Animal Science and Technology 58:42.

Biedenkopf K (2017) Relations Between International Organisations in Combating Climate Change, in: Koops JA, Biermann R (2017) Palgrave Handbook of Inter-Organizational Relations in World Politics, Palgrave Macmillan UK, London, pp. 649-676.

Bionaz M, Osorio J, Loor JJ (2015) TRIENNIAL LACTATION SYMPOSIUM: Nutrigenomics in dairy cows: Nutrients, transcription factors, and techniques. Journal of animal science 93:5531-5553.

Bishop-Williams KE, Berke O, Pearl DL, Hand K, Kelton DF (2015) Heat stress related dairy cow mortality during heat waves and control periods in rural Southern Ontario from 2010–2012. BMC veterinary research 11:291.

Bishop KS, Ferguson LR (2015) The Interaction between Epigenetics, Nutrition and the Development of Cancer. Nutrients 7:922-947.

Boeing H (2013) Nutritional epidemiology: New perspectives for understanding the diet-disease relationship? European Journal Of Clinical Nutrition 67:424.

Boni R, Perrone LL, Cecchini S (2014) Heat stress affects reproductive performance of high producing dairy cows bred in an area of southern Apennines. Livestock Science 160:172-177.

Bouchard-Mercier A, Paradis A-M, Rudkowska I, Lemieux S, Couture P, Vohl M-C (2013) Associations between dietary patterns and gene expression profiles of healthy men and women: a cross-sectional study. Nutrition Journal 12:24.

Boutin S, Lane JE (2014) Climate change and mammals: evolutionary versus plastic responses. Evolutionary applications 7:29-41.

Brett KE, Ferraro ZM, Yockell-Lelievre J, Gruslin A, Adamo KB (2014) Maternal–Fetal Nutrient Transport in Pregnancy Pathologies: The Role of the Placenta. International Journal of Molecular Sciences 15:16153-16185.

Bridges PJ, Brusie MA, Fortune JE (2005) Elevated temperature (heat stress) in vitro reduces androstenedione and estradiol and increases progesterone secretion by follicular cells from bovine dominant follicles. Domestic animal endocrinology 29:508-522.

Broderick NA (2015) A common origin for immunity and digestion. Frontiers in immunology 6:72.

Browne N, Heelan M, Kavanagh K (2013) An analysis of the structural and functional similarities of insect hemocytes and mammalian phagocytes. Virulence 4:597-603.

Brugere C, Onuigbo DM, Morgan KL (2017) People matter in animal disease surveillance: Challenges and opportunities for the aquaculture sector. Aquaculture 467:158-169.

Bruno L, Maiorka A, Macari M, Furlan R, Givisiez P (2011) Water intake behavior of broiler chickens exposed to heat stress and drinking from bell or and nipple drinkers. Revista Brasileira de Ciência Avícola 13:147-152.

Buchmann K (2014) Evolution of Innate Immunity: Clues from Invertebrates via Fish to Mammals. Frontiers in immunology 5:459.

Buhler S, Frahm J, Liermann W, Tienken R, Kersten S, Meyer U, Huber K, Danicke S (2017) Effects of energy supply and nicotinic acid supplementation on phagocytosis and ROS production of blood immune cells of periparturient primi- and pluriparous dairy cows. Research in veterinary science.

Burdick NC, Randel RD, Carroll JA, Welsh TH (2011) Interactions between Temperament, Stress, and Immune Function in Cattle. International Journal of Zoology.

Bush RD, Toribio JA, Windsor PA (2006) The impact of malnutrition and other causes of losses of adult sheep in 12 flocks during drought. Australian veterinary journal 84:254-260.

Campos-Caro A, Smillie FI, Domínguez del Toro E, Rovira JC, Vicente-Agulló F, Chapuli J, Juíz JM, Sala S, Sala F, Ballesta JJ, Criado M (1997) Neuronal Nicotinic Acetylcholine Receptors on Bovine Chromaffin Cells: Cloning, Expression, and Genomic Organization of Receptor Subunits. Journal of Neurochemistry 68:488-497.

Canestrelli D, Bisconti R, Chiocchio A, Maiorano L, Zampiglia M, Nascetti G (2017) Climate change promotes hybridisation between deeply divergent species. PeerJ 5:e3072.

Carlberg C, Ulven SM, Molnár F (2016) Nutritional Epigenomics, in: Carlberg C, Ulven SM, Molnár F (Eds.), Nutrigenomics, Springer International Publishing, Cham, pp. 87-104.

Chaplin DD (2010) Overview of the Immune Response. The Journal of allergy and clinical immunology 125:S3-23.

Colley DG, Bustinduy AL, Secor WE, King CH (2014) Human schistosomiasis. Lancet (London, England) 383:2253-2264.

Contreras GA, O'Boyle NJ, Herdt TH, Sordillo LM (2010) Lipomobilization in periparturient dairy cows influences the composition of plasma nonesterified fatty acids and leukocyte phospholipid fatty acids. Journal of dairy science 93:2508-2516.

Contreras GA, Sordillo LM (2011) Lipid mobilization and inflammatory responses during the transition period of dairy cows. Comparative Immunology, Microbiology and Infectious Diseases 34:281-289.

Contreras GA, Strieder-Barboza C, Raphael W (2017) Adipose tissue lipolysis and remodeling during the transition period of dairy cows. Journal of Animal Science and Biotechnology 8:41.

Cooper D, Eleftherianos I (2017) Memory and Specificity in the Insect Immune System: Current Perspectives and Future Challenges. Frontiers in immunology 8:539.

Cornish A, Raubenheimer D, McGreevy P (2016) What We Know about the Public's Level of Concern for Farm Animal Welfare in Food Production in Developed Countries. Animals 6:74.

Cui X, Hou Y, Yang S, Xie Y, Zhang S, Zhang Y, Zhang Q, Lu X, Liu GE, Sun D (2014) Transcriptional profiling of mammary gland in Holstein cows with extremely different milk protein and fat percentage using RNA sequencing. BMC Genomics 15:226.

Cunningham-Rundles S, Lin H, Ho-Lin D, Dnistrian A, Cassileth BR, Perlman JM (2009) Role of nutrients in the development of neonatal immune response. Nutrition reviews 67:S152-S163.

Dann HM, Litherland NB, Underwood JP, Bionaz M, D'Angelo A, McFadden JW, Drackley JK (2006) Diets during far-off and close-up dry periods affect periparturient metabolism and lactation in multiparous cows. Journal of dairy science 89:3563-3577.

Dantas-Torres F (2015) Climate change, biodiversity, ticks and tick-borne diseases: The butterfly effect. International Journal for Parasitology: Parasites and Wildlife 4:452-461.

Das GK, Khan FA (2010) Summer Anoestrus in Buffalo – A Review. Reproduction in Domestic Animals 45:e483-e494.

Das R, Sailo L, Verma N, Bharti P, Saikia J, Imtiwati Kumar R (2016) Impact of heat stress on health and performance of dairy animals: A review. Veterinary World 9:260-268.

Dash S, Chakravarty AK, Singh A, Upadhyay A, Singh M, Yousuf S (2016) Effect of heat stress on reproductive performances of dairy cattle and buffaloes: A review. Veterinary World 9:235-244.

Davy SK, Allemand D, Weis VM (2012) Cell Biology of Cnidarian-Dinoflagellate Symbiosis. Microbiology and Molecular Biology Reviews 76:229-261.

de Oliveira DC, da Silva Lima F, Sartori T, Santos ACA, Rogero MM, Fock RA (2016) Glutamine metabolism and its effects on immune response: molecular mechanism and gene expression. Nutrire 41:14.

de Ondarza MB, Tricarico JM (2017) Review: Advantages and limitations of dairy efficiency measures and the effects of nutrition and feeding management interventions. The Professional Animal Scientist 33:393-400.

De Rensis F, Lopez-Gatius F, Garcia-Ispierto I, Morini G, Scaramuzzi RJ (2017) Causes of declining fertility in dairy cows during the warm season. Theriogenology 91:145-153.

De Rensis F, Scaramuzzi RJ (2003) Heat stress and seasonal effects on reproduction in the dairy cow--a review. Theriogenology 60:1139-1151.

De Simone FI, Serratosa J (2005) Biotechnology, animal health and animal welfare within the framework of European Union legislation. Revue scientifique et technique 24:89-99.

Dervishi E, Serrano C, Joy M, Serrano M, Rodellar C, Calvo JH (2010) Effect of the feeding system on the fatty acid composition, expression of the Δ(9)-desaturase, Peroxisome Proliferator-Activated Receptor Alpha, Gamma, and Sterol Regulatory Element Binding Protein 1 genes in the semitendinous muscle of light lambs of the Rasa Aragonesa breed. BMC veterinary research 6:40-40.

Dervishi E, Serrano C, Joy M, Serrano M, Rodellar C, Calvo JH (2011) The effect of feeding system in the expression of genes related with fat metabolism in semitendinous muscle in sheep. Meat science 89:91-97.

Dittmer KE, Thompson KG (2015). Approach to Investigating Congenital Skeletal Abnormalities in Livestock. Veterinary pathology 52:851-861.

Dong H, Wang S, Jia Y, Ni Y, Zhang Y, Zhuang S, Shen X, Zhao R (2013) Long-Term Effects of Subacute Ruminal Acidosis (SARA) on Milk Quality and Hepatic Gene Expression in Lactating Goats Fed a High-Concentrate Diet. PloS one 8:e82850.

Dong W, Li Xe, Yang P, Liao H, Wang X, Wang Q (2016) The Effects of Weather Factors on Hand, Foot and Mouth Disease in Beijing. Scientific reports 6:19247.

Doo M, Kim Y (2015) Obesity: Interactions of Genome and Nutrients Intake. Preventive Nutrition and Food Science 20:1-7.

Drake JM, Hassan AN, Beier JC, (2013) A statistical model of Rift Valley fever activity in Egypt. Journal of vector ecology : journal of the Society for Vector Ecology 38:251-259.

Drijfhout S, Bathiany S, Beaulieu C, Brovkin V, Claussen M, Huntingford C, Scheffer M, Sgubin G, Swingedouw D (2015) Catalogue of abrupt shifts in Intergovernmental Panel on Climate Change climate models. Proceedings of the National Academy of Sciences of the United States of America 112:E5777-5786.

Ducrot C, Bed'hom B, Beringue V, Coulon JB, Fourichon C, Guerin JL, Krebs S, Rainard P, Schwartz-Cornil I, Torny D, Vayssier-Taussat M, Zientara S, Zundel E, Pineau T (2011) Issues and special features of animal health research. Veterinary research 42:96.

Duggal S, Chugh TD, Duggal AK (2012) HIV and Malnutrition: Effects on Immune System. Clinical and Developmental Immunology 8.

Dunlap KA, Brown JD, Keith AB, Satterfield MC (2015) Factors controlling nutrient availability to the developing fetus in ruminants. Journal of Animal Science and Biotechnology 6:16.

Dzik JM (2010) The ancestry and cumulative evolution of immune reactions. Acta biochimica Polonica 57:443-466.

Eckel EF, Ametaj BN (2016). Invited review: Role of bacterial endotoxins in the etiopathogenesis of periparturient diseases of transition dairy cows. Journal of dairy science 99:5967-5990.

Elizondo Salazar JA, Ferguson JD, Beegle DB, Remsburg DW, Wu Z (2013) Body phosphorus mobilization and deposition during lactation in dairy cows. Journal of animal physiology and animal nutrition 97:502-514.

Enjalbert F, Nicot MC, Bayourthe C, Moncoulon R (2001) Ketone Bodies in Milk and Blood of Dairy Cows: Relationship between Concentrations and Utilization for Detection of Subclinical Ketosis. Journal of dairy science 84:583-589.

Esteban MÁ, Cuesta A, Chaves-Pozo E, Meseguer J (2015) Phagocytosis in Teleosts. Implications of the New Cells Involved. Biology 4:907-922.

Fatima A, Waters S, O'Boyle P, Seoighe C, Morris DG (2014) Alterations in hepatic miRNA expression during negative energy balance in postpartum dairy cattle. BMC Genomics 15:28-28.

Feleke FB, Berhe M, Gebru G, Hoag D (2016) Determinants of adaptation choices to climate change by sheep and goat farmers in Northern Ethiopia: the case of Southern and Central Tigray, Ethiopia. SpringerPlus 5:1692.

Ferguson LR (2009) Nutrigenomics Approaches to Functional Foods. Journal of the American Dietetic Association 109: 452-458.

Ferguson LR (2015) Nutritional Modulation of Gene Expression: Might This be of Benefit to Individuals with Crohn's Disease? Frontiers in immunology 6.

Ferreira RM, Ayres H, Chiaratti MR, Ferraz ML, Araújo AB, Rodrigues CA, Watanabe YF, Vireque AA, Joaquim DC, Smith LC, Meirelles FV, Baruselli PS (2011) The low fertility of repeat-breeder cows during summer heat stress is related to a low oocyte competence to develop into blastocysts. Journal of dairy science 94:2383-2392.

Ferrell CL, Berry ED, Freetly HC, Miller DN (2006) Influence of genotype and diet on steer performance, manure odor, and carriage of pathogenic and other fecal bacteria. I. Animal performance. Journal of animal science 84:2515-2522.

Flahault A, de Castaneda RR, Bolon I (2016) Climate change and infectious diseases. Public Health Reviews 37:21.

Flamenbaum I, Galon N (2010) Management of heat stress to improve fertility in dairy cows in Israel. The Journal of reproduction and development 56:S36-41.

França T, Ishikawa L, Zorzella-Pezavento S, Chiuso-Minicucci F, da Cunha M, Sartori A (2009) Impact of malnutrition on immunity and infection. Journal of Venomous Animals and Toxins including Tropical Diseases 15:374-390.

Franks SJ, Hoffmann AA (2012) Genetics of climate change adaptation. Annual review of genetics 46:185-208.

Gao C, Kuklane K, Ostergren PO, Kjellstrom T (2017) Occupational heat stress assessment and protective strategies in the context of climate change. International journal of biometeorology.

Garcia-Solache MA, Casadevall A (2010) Global warming will bring new fungal diseases for mammals. mBio 1.

García AMB, Cardoso FC, Campos R, Thedy DX, González FHD (2011) Metabolic evaluation of dairy cows submitted to three different strategies to decrease the effects of negative energy balance in early postpartum. Pesquisa Veterinária Brasileira 31:11-17.

Garner JB, Douglas ML, Williams SRO, Wales WJ, Marett LC, Nguyen TTT, Reich CM, Hayes BJ (2016) Genomic Selection Improves Heat Tolerance in Dairy Cattle. Scientific reports 6:34114.

Gellrich K, Sigl T, Meyer HHD, Wiedemann S (2015) Cortisol levels in skimmed milk during the first 22 weeks of lactation and response to short-term metabolic stress and lameness in dairy cows. Journal of Animal Science and Biotechnology 6:31.

Gibbons A (2010) Society of Vertebrate Paleontology. Going back to the future to understand climate change. Science 330:582.

Goff JP (2006) Major Advances in Our Understanding of Nutritional Influences on Bovine Health. Journal of dairy science 89:1292-1301.

Gonzalez-Calvo L, Joy M, Blanco M, Dervishi E, Molino F, Sarto P, Ripoll G, Serrano M, Calvo JH (2015) Effect of vitamin E supplementation or alfalfa grazing on fatty acid composition and expression of genes related to lipid metabolism in lambs. Journal of animal science 93:3044-3054.

Govers C, Berkel Kasikci M, van der Sluis AA, Mes JJ (2017) Review of the health effects of berries and their phytochemicals on the digestive and immune systems. Nutrition reviews.

Gray JS, Dautel H, Estrada-Pe A, Kahl O, Lindgren E (2009). Effects of Climate Change on Ticks and Tick-Borne Diseases in Europe. Interdisciplinary Perspectives on Infectious Diseases.

Gross J, van Dorland HA, Bruckmaier RM, Schwarz FJ (2011) Performance and metabolic profile of dairy cows during a lactational and deliberately induced negative energy balance with subsequent realimentation. Journal of dairy science 94:1820-1830.

Grummer RR, Mashek DG, Hayirli A (2004) Dry matter intake and energy balance in the transition period. The Veterinary clinics of North America. Food animal practice 20:447-470.

Hamilton TRdS, Mendes CM, Castro L, S, Assis P, M, Siqueira AFP, Delgado JdC, Goissis MD, Mui, Blanco T, Cebri P, J, lvaro Nichi M, lio, Visintin J, Antonio, Assump, MEOD (2016) Evaluation of Lasting Effects of Heat Stress on Sperm Profile and Oxidative Status of Ram Semen and Epididymal Sperm. Oxidative Medicine and Cellular Longevity 12.

Han LQ, Pang K, Li HJ, Zhu SB, Wang LF, Wang YB, Yang GQ, Yang GY (2012) Conjugated linoleic acid-induced milk fat reduction associated with depressed expression of lipogenic genes in lactating Holstein mammary glands. Genetics and molecular research 11:4754-4764.

Hansen PJ (2004) Physiological and cellular adaptations of zebu cattle to thermal stress. Animal reproduction science 82-83:349-360.

Hansen PJ (2009) Effects of heat stress on mammalian reproduction. Philosophical Transactions of the Royal Society B: Biological Sciences 364:3341-3350.

Hansen PJ (2013) Antecedents of mammalian fertility: Lessons from the heat-stressed cow regarding the importance of oocyte competence for fertilization and embryonic development. Animal Frontiers 3:34-39.

Hayirli A, Grummer RR, Nordheim EV, Crump PM (2002) Animal and dietary factors affecting feed intake during the prefresh transition period in Holsteins. Journal of dairy science 85:3430-3443.

Henry B, Charmley E, Eckard R, Gaughan, JB, Hegarty R (2012) Livestock production in a changing climate: adaptation and mitigation research in Australia. Crop and Pasture Science 63:191-202.

Hetem RS, Fuller A, Maloney SK, Mitchell D (2014) Responses of large mammals to climate change. Temperature: Multidisciplinary Biomedical Journal 1:115-127.

Hickson RE, Morris ST, Kenyon,PR, Lopez-Villalobos N (2006) Dystocia in beef heifers: A review of genetic and nutritional influences. New Zealand veterinary journal 54:256-264.

Hill BD, Holroyd RG, Sullivan M (2009) Clinical and pathological findings associated with congenital hypovitaminosis A in extensively grazed beef cattle. Australian veterinary journal 87:94-98.

Hillreiner M, Flinspach C, Pfaffl MW, Kliem H (2016) Effect of the Ketone Body Beta-Hydroxybutyrate on the Innate Defense Capability of Primary Bovine Mammary Epithelial Cells. PloS one 11:e0157774.

Hirano M (2016) Echinoderm immunity: is the larval immune system immature? Immunology and cell biology 94:809-811.

Hocquette JF, Lehnert S, Barendse W, Cassar-Malek I, Picard B (2007) Recent advances in cattle functional genomics and their application to beef quality. Animal : an international journal of animal bioscience 1:159-173.

Huang CC, Song YL (1999) Maternal transmission of immunity to white spot syndrome associated virus (WSSV) in shrimp (Penaeus monodon). Developmental and comparative immunology 23:545-552.

Humblet M-F, Boschiroli ML, Saegerman C (2009) Classification of worldwide bovine tuberculosis risk factors in cattle: a stratified approach. Veterinary research 40:50.

Humer E, Khol-Parisini A, Metzler-Zebeli BU, Gruber L, Zebeli Q (2016) Alterations of the Lipid Metabolome in Dairy Cows Experiencing Excessive Lipolysis Early Postpartum. PloS one 11:e0158633.

Imaizumi H, Santos FAP, Bittar CMM, Correia PS, Martinez JC (2010) Diet crude protein content and sources for lactating dairy cattle. Scientia Agricola 67:16-22.

Imhasly S, Bieli C, Naegeli H, Nystrom L, Ruetten M, Gerspach C (2015) Blood plasma lipidome profile of dairy cows during the transition period. BMC veterinary research 11:252.

Ingvartsen KL, Moyes K (2013) Nutrition, immune function and health of dairy cattle. Animal : an international journal of animal bioscience 1:112-122.

James JW (2009) Genotype by Environment Interaction in Farm Animals, in: van der Werf J, Graser H-U, Frankham R, Gondro C (Eds.) Adaptation and Fitness in Animal Populations: Evolutionary and Breeding Perspectives on Genetic Resource Management, Springer Netherlands, Dordrecht, pp. 151-167.

Janovick NA, Boisclair YR, Drackley JK (2011) Prepartum dietary energy intake affects metabolism and health during the periparturient period in primiparous and multiparous Holstein cows. Journal of dairy science 94:1385-1400.

Jaworski T, Hilszczański J (2013) The effect of temperature and humidity changes on insects development their impact on forest ecosystems in the expected climate change, Forest Research Papers, p. 345.

Ji C, Cao W, Chen Y, Yang H (2016) Carbon Balance and Contribution of Harvested Wood Products in China Based on the Production Approach of the Intergovernmental Panel on Climate Change. International journal of environmental research and public health 13.

Jin M, Iannotti LL (2014) Livestock production, animal source food intake, and young child growth: The role of gender for ensuring nutrition impacts. Social Science & Medicine 105:16-21.

Jokela J (2010) Transgenerational immune priming as cryptic parental care. Journal of Animal Ecology 79:305-307.

Jordan ER (2003) Effects of Heat Stress on Reproduction. Journal of dairy science 86:E104-E114.

Joseph SJ, Robbins KR, Pavan E, Pratt SL, Duckett SK, Rekaya R (2010) Effect of Diet Supplementation on the Expression of Bovine Genes Associated with Fatty Acid Synthesis and Metabolism. Bioinformatics and Biology Insights 4:19-31.

Joy EJM, Ander EL, Young SD, Black, CR, Watts MJ, Chilimba ADC, Chilima B, Siyame EWP, Kalimbira AA, Hurst R, Fairweather-Tait SJ, Stein AJ, Gibson RS, White PJ, Broadley MR (2014) Dietary mineral supplies in Africa. Physiologia Plantarum 151:208-229.

Ju R-T, Wang F, Li B (2011) Effects of Temperature on the Development and Population Growth of the Sycamore Lace Bug, Corythucha ciliata. Journal of Insect Science 11:16.

Ju R-T, Zhu H-Y, Gao L, Zhou X-H, Li B (2015) Increases in both temperature means and extremes likely facilitate invasive herbivore outbreaks. Scientific reports 5:15715.

Kadokawa H, Sakatani M, Hansen PJ (2012) Perspectives on improvement of reproduction in cattle during heat stress in a future Japan. Animal Science Journal 83:439-445.

Kapila N, Sharma A, Kishore A, Sodhi M, Tripathi PK, Mohanty AK, Mukesh M (2016) Impact of Heat Stress on Cellular and Transcriptional Adaptation of Mammary Epithelial Cells in Riverine Buffalo (Bubalus Bubalis). PloS one 11:e0157237.

Katona P, Katona-Apte J (2008) The Interaction between Nutrition and Infection. Clinical Infectious Diseases 46:1582-1588.

Kaur M, Graham JP, Eisenberg JNS (2017) Livestock Ownership Among Rural Households and Child Morbidity and Mortality: An Analysis of Demographic Health Survey Data from 30 Sub-Saharan African Countries (2005–2015). The American journal of tropical medicine and hygiene 96:741-748.

Kielland C, Skjerve E, Osteras O, Zanella AJ (2010) Dairy farmer attitudes and empathy toward animals are associated with animal welfare indicators. Journal of dairy science 93:2998-3006.

Klose D, Saunders U, Barth S, Fischer R, Jacobi AM, Nachreiner T (2016) Novel fusion proteins for the antigen-specific staining and elimination of B cell receptor-positive cell populations demonstrated by a tetanus toxoid fragment C (TTC) model antigen. BMC Biotechnology 16:18.

Knape J, de Valpine P (2011) Effects of weather and climate on the dynamics of animal population time series. Proceedings. Biological sciences 278:985-992.

Kobayashi Y, Wakamiya K, Kohka M, Yamamoto Y, Okuda K (2013) Summer heat stress affects prostaglandin synthesis in the bovine oviduct. Reproduction 146:103-110.

Koluman Darcan N, Silanikove N (2017) The advantages of goats for future adaptation to Climate Change: A conceptual overview. Small Ruminant Research.

Koneswaran G, Nierenberg D (2008) Global Farm Animal Production and Global Warming: Impacting and Mitigating Climate Change. Environmental Health Perspectives 116:578-582.

Kono H, Rock KL (2008) How dying cells alert the immune system to danger. Nature reviews. Immunology 8:279-289.

Kramer R, Wolf S, Petri T, von Soosten D, Dänicke S, Weber E-M, Zimmer R, Rehage J, Jahreis G (2013) A commonly used rumen-protected conjugated linoleic acid supplement marginally affects fatty acid distribution of body tissues and gene expression of mammary gland in heifers during early lactation. Lipids in Health and Disease 12:96-96.

Kreppel KS, Telfer S, Rajerison M, Morse A, Baylis M (2016) Effect of temperature and relative humidity on the development times and survival of Synopsyllus fonquerniei and Xenopsylla cheopis, the flea vectors of plague in Madagascar. Parasites & vectors 9:82.

Krishnan G, Bagath M, Pragna P, Vidya MK, Aleena J, Archana PR, Sejian V, Bhatta R (2017) Mitigation of the Heat Stress Impact in Livestock Reproduction, in: Carreira, R.P. (Ed.), Theriogenology, InTech, Rijeka, p. Ch. 04.

Kumar N, Rao TKS, Varghese A, Rathor VS (2013) Internal parasite management in grazing livestock. Journal of Parasitic Diseases: Official Organ of the Indian Society for Parasitology 37:151-157.

Kurane I (2010) The Effect of Global Warming on Infectious Diseases. Osong Public Health and Research Perspectives 1:4-9.

Lacasse P, Vanacker N, Ollier S, Ster C (2017) Innovative dairy cow management to improve resistance to metabolic and infectious diseases during the transition period. Research in veterinary science.

Lawrence JL, Payton RR, Godkin, JD, Saxton AM, Schrick FN, Edwards JL (2004) Retinol improves development of bovine oocytes compromised by heat stress during maturation. Journal of dairy science 87:2449-2454.

Li N, Zhao F, Wei C, Liang M, Zhang N, Wang C, Li QZ, Gao XJ (2014) Function of SREBP1 in the milk fat synthesis of dairy cow mammary epithelial cells. Int J Mol Sci 15:16998-17013.

Li R, Beaudoin F, Ammah AA, Bissonnette N, Benchaar C, Zhao X, Lei C, Ibeagha-Awemu EM (2015) Deep sequencing shows microRNA involvement in bovine mammary gland adaptation to diets supplemented with linseed oil or safflower oil. BMC Genomics 16:884.

Li Y-S, Raso G, Zhao Z-Y, He Y-K, Ellis MK, McManus DP (2007) Large Water Management Projects and Schistosomiasis Control, Dongting Lake Region, China. Emerging infectious diseases 13:973-979.

Liao SF, Brown KR, Stromberg AJ, Burris WR, Boling JA, Matthews JC (2011) Dietary Supplementation of Selenium in Inorganic and Organic Forms Differentially and Commonly Alters Blood and Liver Selenium Concentrations and Liver Gene Expression Profiles of Growing Beef Heifers. Biological trace element research 140:151-169.

Lin J, Bao ZK, Zhang Q, Hu WW, Yu QH, Yang Q (2015) Transcriptome analysis of the mammary gland from GH transgenic goats during involution. Gene 565:228-234.

Little TJ, O'Connor B, Colegrave N, Watt K, Read AF (2003) Maternal transfer of strain-specific immunity in an invertebrate. Current biology 13:489-492.

Littlejohn MD, Tiplady K, Lopdell T, Law TA, Scott A, Harland C, Sherlock R, Henty K, Obolonkin V, Lehnert K, Macgibbon A, Spelman RJ, Davis SR, Snell RG (2014) Expression variants of the lipogenic AGPAT6 gene affect diverse milk composition phenotypes in Bos taurus. PloS one 9:e85757.

Liu S, Lorenzen Eline D, Fumagalli M, Li B, Harris K, Xiong Z, Zhou L, Korneliussen, Thorfinn S., Somel M, Babbitt C, Wray G, Li J, He W, Wang Z, Fu W, Xiang X, Morgan Claire C, Doherty A, O'Connell Mary J, McInerney James O, Born Erik W, Dalén L, Dietz R, Orlando L, Sonne C, Zhang G, Nielsen R, Willerslev E, Wang J (2014) Population Genomics Reveal Recent Speciation and Rapid Evolutionary Adaptation in Polar Bears. Cell 157:785-794.

Liu Z, Ezernieks V, Wang J, Arachchillage NW, Garner JB, Wales WJ, Cocks BG, Rochfort S, (2017) Heat Stress in Dairy Cattle Alters Lipid Composition of Milk. Scientific reports 7:961.

Loker ES, Adema CM, Zhang S-M, Kepler TB (2004) Invertebrate immune systems – not homogeneous, not simple, not well understood. Immunological reviews 198:10-24.

Long NM, Tousley CB, Underwood KR, Paisley SI, Means WJ, Hess BW, Du M, Ford SP (2012) Effects of early- to mid-gestational undernutrition with or without protein supplementation on offspring growth, carcass characteristics, and adipocyte size in beef cattle1. Journal of animal science 90:197-206.

Loor JJ, Bionaz M, Drackley JK (2013) Systems physiology in dairy cattle: nutritional genomics and beyond. Annual review of animal biosciences 1: 365-392.

Lundberg Å, Nyman AK, Aspán A, Börjesson S, Unnerstad HE, Waller KP (2016) Udder infections with *Staphylococcus aureus*, *Streptococcus dysgalactiae*, and *Streptococcus uberis* at calving in dairy herds with suboptimal udder health. Journal of dairy science 99:2102-2117.

Mabjeesh SJ, Sabastian C, Gal-Garber O, Shamay A (2013) Effect of photoperiod and heat stress in the third trimester of gestation on milk production and circulating hormones in dairy goats. Journal of dairy science 96:189-197.

Mair B, Drillich M, Klein-Jöbstl D, Kanz P, Borchardt S, Meyer L, Schwendenwein I, Iwersen M (2016) Glucose concentration in capillary blood of dairy cows obtained by a minimally invasive lancet technique and determined with three different hand-held devices. BMC veterinary research 12:34.

Malkaram SA, Hassan YI, Zempleni J (2012) Online tools for bioinformatics analyses in nutrition sciences. Advances in nutrition 3:654-665.

Manjunathareddy GB, Sajjanar B, Sejian V (2017) Impact of Climate Change on Sheep Disease Occurrences and Its Management, in: Sejian V, Bhatta R, Gaughan J, Malik PK, Naqvi SMK, Lal R (Eds.), Sheep Production Adapting to Climate Change, Springer Singapore, Singapore, pp. 197-207.

Marques RE, Marques PE, Guabiraba R, Teixeira MM (2016) Exploring the Homeostatic and Sensory Roles of the Immune System. Frontiers in immunology 7:125.

Martin SAM, Król E (2017) Nutrigenomics and immune function in fish: new insights from omics technologies. Developmental & Comparative Immunology 75:86-98.

Masur F, Benesch F, Pfannkuche H, Fuhrmann H, Gabel G (2016) Conjugated linoleic acids influence fatty acid metabolism in ovine ruminal epithelial cells. Journal of dairy science 99:3081-3095.

Matthews JC, Zhang Z, Patterson JD, Bridges PJ, Stromberg AJ, Boling JA (2014) Hepatic Transcriptome Profiles Differ Among Maturing Beef Heifers Supplemented with Inorganic, Organic, or Mixed (50 % Inorganic:50 % Organic) Forms of Dietary Selenium. Biological trace element research 160:321-339.

Matthews TK, Wilby RL, Murphy C (2017) Communicating the deadly consequences of global warming for human heat stress. Proceedings of the National Academy of Sciences of the United States of America 114:3861-3866.

McGhee JR, Fujihashi K (2012) Inside the Mucosal Immune System. PLOS Biology 10:e1001397.

McNamara, J.P., 2012. Ruminant Nutrition Symposium: a systems approach to integrating genetics, nutrition, and metabolic efficiency in dairy cattle. Journal of animal science 90:1846-1854.

McTaggart SJ, Wilson PJ, Little TJ (2012) Daphnia magna shows reduced infection upon secondary exposure to a pathogen. Biology Letters 8:972-975.

Melendez P, Severino K, Marin MP, Duchens M (2017) The effect of a product with three gluconeogenic precursors during the transition period on blood metabolites and milk yield in Chilean Holstein cattle. Journal of Applied Animal Research 1-5.

Merila J, Hendry AP (2014) Climate change, adaptation, and phenotypic plasticity: the problem and the evidence. Evolutionary applications 7:1-14.

Merilä J, Hoffmann AA (2016) Evolutionary Impacts of Climate Change, Interactive Factory.

Miller RS, Farnsworth ML, Malmberg JL (2013) Diseases at the livestock–wildlife interface: Status, challenges, and opportunities in the United States. Preventive veterinary medicine 110:119-132.

Milutinovic B, Kurtz J (2016) Immune memory in invertebrates. Seminars in immunology 28:328-342.

Moallem U, Altmark G, Lehrer H, Arieli A (2010) Performance of high-yielding dairy cows supplemented with fat or concentrate under hot and humid climates. Journal of dairy science 93:3192-3202.

Moore S, Shrestha S, Tomlinson KW, Vuong H (2012) Predicting the effect of climate change on African trypanosomiasis: integrating epidemiology with parasite and vector biology. Journal of the Royal Society Interface 9:817-830.

Moosavi M, Mirzaei A, Ghavami M, Tamadon A (2014) Relationship between season, lactation number and incidence of clinical mastitis in different stages of lactation in a Holstein dairy farm. Veterinary research forum : an international quarterly journal 5:13-19.

Morand S (2015) Impact of Climate Change on Livestock Disease Occurrences, in: Sejian V, Gaughan J, Baumgard L, Prasad C (Eds.) Climate Change Impact on Livestock: Adaptation and Mitigation, Springer India, New Delhi, pp. 113-122.

Mordak R, Anthony SP (2015) Periparturient stress and immune suppression as a potential cause of retained placenta in highly productive dairy cows: examples of prevention. Acta veterinaria Scandinavica 57:84.

Morella NM, Koskella B (2017) The Value of a Comparative Approach to Understand the Complex Interplay between Microbiota and Host Immunity. Frontiers in immunology 8:1114.

Moretti J, Blander JM (2014) Insights into phagocytosis-coupled activation of pattern recognition receptors and inflammasomes. Current Opinion in Immunology 26:100-110.

Mosites E, Thumbi SM, Otiang E, McElwain TF, Njenga MK, Rabinowitz PM, Rowhani-Rahbar A, Neuhouser ML, May S, Palmer GH, Walson JL (2016) Relations between Household Livestock Ownership, Livestock Disease, and Young Child Growth. The Journal of nutrition 146:1118-1124.

Moyes KM, Larsen T, Ingvartsen KL (2013) Generation of an index for physiological imbalance and its use as a predictor of primary disease in dairy cows during early lactation. Journal of dairy science 96:2161-2170.

Mueller K (2011) Diagnosis, treatment and control of left displaced abomasum in cattle. In Practice 33:470.

Müller O, Krawinkel M (2005) Malnutrition and health in developing countries. CMAJ : Canadian Medical Association Journal 173:279-286.

Mulligan FJ, Doherty ML (2008) Production diseases of the transition cow. Veterinary journal 176:3-9.

Mulligan FJ, O'Grady L, Rice DA, Doherty ML (2006) A herd health approach to dairy cow nutrition and production diseases of the transition cow. Animal reproduction science 96:331-353.

Nabenishi H, Ohta H, Nishimoto T, Morita T, Ashizawa K, Tsuzuki Y (2011) Effect of the temperature-humidity index on body temperature and conception rate of lactating dairy cows in southwestern Japan. The Journal of reproduction and development 57:450-456.

Nakad R, Schumacher B (2016) DNA Damage Response and Immune Defense: Links and Mechanisms. Frontiers in genetics 7:147.

Negev M, Paz S, Clermont A, Pri-Or NG, Shalom U, Yeger T, Green MS (2015) Impacts of Climate Change on Vector Borne Diseases in the Mediterranean Basin — Implications for Preparedness and Adaptation Policy. International journal of environmental research and public health 12:6745-6770.

Norhisham AR, Abood F, Rita M, Hakeem KR (2013) Effect of humidity on egg hatchability and reproductive biology of the bamboo borer (Dinoderus minutus Fabricius). SpringerPlus 2:9.

O'Doherty AM, O'Gorman A, al Naib A, Brennan L, Daly E, Duffy P, Fair T (2014) Negative energy balance affects imprint stability in oocytes recovered from postpartum dairy cows. Genomics 104:177-185.

O'Reilly J, Oreskes N, Oppenheimer M (2012) The rapid disintegration of projections: the West Antarctic Ice Sheet and the intergovernmental panel on climate change. Social studies of science 42:709-731.

Oczypok EA, Oury TD, Chu CT (2013) It's a Cell-Eat-Cell World: Autophagy and Phagocytosis. The American journal of pathology 182:612-622.

Oliveira DM, Chalfun-Junior A, Chizzotti ML, Barreto HG, Coelho TC, Paiva LV, Coelho CP, Teixeira PD, Schoonmaker JP, Ladeira MM (2014) Expression of genes involved in lipid metabolism in the muscle of beef cattle fed soybean or rumen-protected fat, with or without monensin supplementation1. Journal of animal science 92:5426-5436.

Ontsouka EC, Albrecht C, Bruckmaier RM (2016) Invited review: Growth-promoting effects of colostrum in calves based on interaction with intestinal cell surface receptors and receptor-like transporters. Journal of dairy science 99:4111-4123.

Pae M, Meydani SN, Wu D (2012) The Role of Nutrition in Enhancing Immunity in Aging. Aging and Disease 3:91-129.

Palombi C, Paolucci M, Stradaioli G, Corubolo M, Pascolo PB, Monaci M (2013) Evaluation of remote monitoring of parturition in dairy cattle as a new tool for calving management. BMC veterinary research 9:191.

Pearce S, Huff-Lonergan E, Lonergan S, Baumgard L, Gabler N (2014) Heat stress and reduced feed intake alter the intestinal proteomic profile (246.1). The FASEB Journal 28.

Peiso OO, Bronsvoort BMdC, Handel IG, Volkova VV (2011) A Review of Exotic Animal Disease in Great Britain and in Scotland Specifically between 1938 and 2007. PloS one 6:e22066.

Perry B, Grace D (2009) The impacts of livestock diseases and their control on growth and development processes that are pro-poor. Philosophical Transactions of the Royal Society B: Biological Sciences 364:2643-2655.

Pigeault R, Garnier R, Rivero A, Gandon S (2016) Evolution of transgenerational immunity in invertebrates. Proceedings of the Royal Society B: Biological Sciences 283.

Polsky L, von Keyserlingk MAG (2017) Invited review: Effects of heat stress on dairy cattle welfare. Journal of dairy science 100:8645-8657.

Ponton F, Wilson K, Cotter SC, Raubenheimer D, Simpson SJ (2011) Nutritional Immunology: A Multi-Dimensional Approach. PLOS Pathogens 7:e1002223.

Popescu S, Borda C, Diugan EA, Spinu M, Groza IS, Sandru CD (2013) Dairy cows welfare quality in tie-stall housing system with or without access to exercise. Acta veterinaria Scandinavica 55:43-43.

Price AA, Grakoui A, Weiss DS (2016) Harnessing the Prokaryotic Adaptive Immune System as a Eukaryotic Antiviral Defense. Trends in microbiology 24:294-306.

Quinteiro-Filho WM, Ribeiro A, Ferraz-de-Paula V, Pinheiro ML, Sakai M, Sa LR, Ferreira AJ, Palermo-Neto J (2010) Heat stress impairs performance parameters, induces intestinal injury, and decreases macrophage activity in broiler chickens. Poultry science 89:1905-1914.

Raboisson D, Mounié M, Maigné E (2014) Diseases reproductive performance, and changes in milk production associated with subclinical ketosis in dairy cows: A meta-analysis and review. Journal of dairy science 97:7547-7563.

Rahal A, Ahmad AH, Prakash A, Mandil R, Kumar AT (2014) Environmental attributes to respiratory diseases of small ruminants. Veterinary medicine international 853627.

Ramasamy R, Surendran SN (2012) Global Climate Change and Its Potential Impact on Disease Transmission by Salinity-Tolerant Mosquito Vectors in Coastal Zones. Frontiers in Physiology 3:198.

Randall LV, Green MJ, Chagunda MGG, Mason, C, Green LE, Huxley JN (2016) Lameness in dairy heifers; impacts of hoof lesions present around first calving on future lameness, milk yield and culling risk. Preventive veterinary medicine 133:52-63.

Randow F, MacMicking JD, James LC (2013) Cellular Self-Defense: How Cell-Autonomous Immunity Protects Against Pathogens. Science (New York, N.Y.) 340: 10.1126/science.1233028.

Raqib R, Cravioto A (2009) Nutrition, immunology, and genetics: future perspectives. Nutrition reviews 67:S227-S236.

Raszek MM, Guan LL, Plastow GS (2016) Use of Genomic Tools to Improve Cattle Health in the Context of Infectious Diseases. Frontiers in genetics 7, 30.

Rauw WM, Gomez-Raya L (2015) Genotype by environment interaction and breeding for robustness in livestock. Frontiers in genetics 6:310.

Raven L-A, Cocks BG, Hayes BJ (2014) Multibreed genome wide association can improve precision of mapping causative variants underlying milk production in dairy cattle. BMC Genomics 15:62-62.

Raven LA, Cocks BG, Kemper KE, Chamberlain AJ, Vander Jagt CJ, Goddard ME, Hayes BJ (2016) Targeted imputation of sequence variants and gene expression profiling identifies twelve candidate genes associated with lactation volume, composition and calving interval in dairy cattle. Mammalian genome : official journal of the International Mammalian Genome Society 27:81-97.

Reyad MA, Sarker MAH, Uddin ME, Habib R, Rashid MHU (2016) Effect of heat stress on milk production and its composition of Holstein Friesian crossbred dairy cows 2:6.

Robert JHD, Naomi EM, Kate MW, David EP (2014) Analysis of heat stress in UK dairy cattle and impact on milk yields. Environmental Research Letters 9:064006.

Robinson SJ, Neitzel DF, Moen RA, Craft ME, Hamilton KE, Johnson LB, Mulla DJ, Munderloh UG, Redig PT, Smith KE, Turner CL, Umber JK, Pelican KM (2015) Disease Risk in a Dynamic Environment: The Spread of Tick-Borne Pathogens in Minnesota, USA. EcoHealth 12:152-163.

Roche JR, Heiser A, Mitchell MD, Crookenden MA, Walker CG, Kay JK, Riboni MV, Loor JJ, Meier S (2017) Strategies to gain body condition score in pasture-based dairy cows during late lactation and the far-off nonlactating period and their interaction with close-up dry matter intake. Journal of dairy science 100:1720-1738.

Rodrigues J, Brayner FA, Alves LC, Dixit R, Barillas-Mury C (2010) Hemocyte differentiation mediates innate immune memory in Anopheles gambiae mosquitoes. Science 329:1353-1355.

Rojas-Downing MM, Nejadhashemi AP, Harrigan T, Woznicki SA (2017) Climate change and livestock: Impacts, adaptation, and mitigation. Climate Risk Management 16:145-163.

Roth O, Sadd BM, Schmid-Hempel P, Kurtz J (2009) Strain-specific priming of resistance in the red flour beetle, Tribolium castaneum. Proceedings of the Royal Society B: Biological Sciences 276:145-151.

Roth Z (2017) Effect of Heat Stress on Reproduction in Dairy Cows: Insights into the Cellular and Molecular Responses of the Oocyte. Annual review of animal biosciences 5:151-170.

Round JL, Mazmanian SK (2009) The gut microbiome shapes intestinal immune responses during health and disease. Nature reviews. Immunology 9:313-323.

Rowley AF, Powell A (2007) Invertebrate immune systems specific, quasi-specific, or nonspecific? Journal of immunology 179:7209-7214.

Ruiz R, Tedeschi LO, Sepúlveda A (2017) Investigation of the effect of pegbovigrastim on some periparturient immune disorders and performance in Mexican dairy herds. Journal of dairy science 100:3305-3317.

Sadd BM, Kleinlogel Y, Schmid-Hempel R, Schmid-Hempel P (2005) Trans-generational immune priming in a social insect. Biol Lett 1:386-388.

Sadd BM, Schmid-Hempel P (2006) Insect Immunity Shows Specificity in Protection upon Secondary Pathogen Exposure. Current Biology 16:1206-1210.

Sakatani M (2017) Effects of heat stress on bovine preimplantation embryos produced in vitro. The Journal of reproduction and development 63:347-352.

Sakatani M, Alvarez NV, Takahashi M, Hansen PJ (2012) Consequences of physiological heat shock beginning at the zygote stage on embryonic development and expression of stress response genes in cattle. Journal of dairy science 95:3080-3091.

Samy AM, Peterson AT (2016) Climate Change Influences on the Global Potential Distribution of Bluetongue Virus. PloS one 11:e0150489.

Sanchez-Guillen RA, Munoz J, Rodriguez-Tapia G, Feria Arroyo TP, Cordoba-Aguilar A (2013) Climate-induced range shifts and possible hybridisation consequences in insects. PloS one 8:e80531.

Sanjuan MA, Green DR (2008) Eating for good health: linking autophagy and phagocytosis in host defense. Autophagy 4:607-611.

Santoni G, Cardinali C, Morelli MB, Santoni M, Nabissi M, Amantini C (2015) Danger- and pathogen-associated molecular patterns recognition by pattern-recognition receptors and ion channels of the transient receptor potential family triggers the inflammasome activation in immune cells and sensory neurons. Journal of Neuroinflammation 12:21.

Satrapa RA, Nabhan T, Silva CF, Simões RAL, Razza EM, Puelker RZ, Trinca LA, Barros CM (2011) Influence of sire breed (*Bos indicus* versus *Bos taurus*) and interval from slaughter to oocyte aspiration on heat stress tolerance of in vitro-produced bovine embryos. Theriogenology 76:1162-1167.

Savopoulou-Soultani M, Papadopoulos NT, Milonas P, Moyal P (2012) Abiotic Factors and Insect Abundance. Psyche 2.

Schmid-Hempel P (2005) Evolutionary ecology of insect immune defenses. Annual review of entomology 50:529-551.

Schüller LK, Michaelis I, Heuwieser W (2017) Impact of heat stress on estrus expression and follicle size in estrus under field conditions in dairy cows. Theriogenology 102:48-53.

Seebacher F, Post E (2015) Climate change impacts on animal migration. Climate Change Responses 2:5.

Seerapu SR, Kancharana AR, Chappidi VS, Bandi ER (2015) Effect of microclimate alteration on milk production and composition in Murrah buffaloes. Veterinary World 8:1444-1452.

Sejersen H, Sorensen MT, Larsen T, Bendixen E, Ingvartsen KL (2012) Liver protein expression in dairy cows with high liver triglycerides in early lactation. Journal of dairy science 95:2409-2421.

Seo S, Larkin DM, Loor JJ (2013) Cattle genomics and its implications for future nutritional strategies for dairy cattle. Animal : an international journal of animal bioscience 1:172-183.

Sevi A, Caroprese M (2012) Impact of heat stress on milk production, immunity and udder health in sheep: A critical review. Small Ruminant Research 107:1-7.

Sexton MF, Buckley W, Ryan E (2007) A study of 54 cases of left displacement of the abomasum: February to July 2005. Irish veterinary journal 60:605-609.

Shafer ABA, Northrup JM, Wikelski M, Wittemyer G, Wolf JBW (2016) Forecasting Ecological Genomics: High-Tech Animal Instrumentation Meets High-Throughput Sequencing. PLOS Biology 14:e1002350.

Sheldon IM, Williams EJ, Miller ANA, Nash DM, Herath S (2008) Uterine diseases in cattle after parturition. Veterinary Journal 176:115-121.

Shen S, Pyo CW, Vu Q, Wang R, Geraghty DE (2013) The essential detail: the genetics and genomics of the primate immune response. ILAR journal 54:181-195.

Shi HB, Zhang CH, Zhao W, Luo J, Loor JJ (2017) Peroxisome proliferator-activated receptor delta facilitates lipid secretion and catabolism of fatty acids in dairy goat mammary epithelial cells. Journal of dairy science 100:797-806.

Shi HB, Zhao WS, Luo J, Yao DW, Sun YT, Li J, Shi HP, Loor JJ (2014) Peroxisome proliferator-activated receptor gamma1 and gamma2 isoforms alter lipogenic gene networks in goat mammary epithelial cells to different extents. Journal of dairy science 97:5437-5447.

Sigl T, Schlamberger G, Kienberger H, Wiedemann S, Meyer HH, Kaske M (2010) Rumen-protected conjugated linoleic acid supplementation to dairy cows in late pregnancy and early lactation: effects on milk composition, milk yield, blood metabolites and gene expression in liver. Acta veterinaria Scandinavica 52:16.

Silva CF, Sartorelli ES, Castilho ACS, Satrapa RA, Puelker RZ, Razza EM, Ticianelli JS, Eduardo HP, Loureiro B, Barros CM (2013) Effects of heat stress on development, quality and survival of Bos indicus and Bos taurus embryos produced in vitro. Theriogenology 79:351-357.

Smith GL, Friggens NC, Ashworth CJ, Chagunda MGG (2017) Association between body energy content in the dry period and post-calving production disease status in dairy cattle. Animal : an international journal of animal bioscience 11:1590-1598.

Sordillo LM (2013) Selenium-Dependent Regulation of Oxidative Stress and Immunity in Periparturient Dairy Cattle. Veterinary medicine international 8.

Sordillo LM (2016) Nutritional strategies to optimize dairy cattle immunity. Journal of dairy science 99:4967-4982.

Sordillo LM, Contreras GA, Aitken SL (2009) Metabolic factors affecting the inflammatory response of periparturient dairy cows. Animal health research reviews 10:53-63.

Sork VL, (2016) Gene flow and natural selection shape spatial patterns of genes in tree populations: implications for evolutionary processes and applications. Evolutionary applications 9:291-310.

Sotolongo J, Ruiz J, Fukata M (2012) The role of Innate Immunity in the Host Defense Against intestinal Bacterial Pathogens. Current Infectious Disease Reports 14:15-23.

Spier SJ, Azevedo V (2017) Corynebacterium pseudotuberculosis infection in horses: Increasing frequency and spread to new regions of North America. Equine Veterinary Education 29:436-439.

St-Pierre NR, Cobanov B, Schnitkey G (2003) Economic Losses from Heat Stress by US Livestock Industries¹. Journal of dairy science 86:E52-E77.

Ster C, Loiselle MC, Lacasse P (2012) Effect of postcalving serum nonesterified fatty acids concentration on the functionality of bovine immune cells. Journal of dairy science 95:708-717.

Sun F, Cao Y, Cai C, Li S, Yu C, Yao J (2016) Regulation of Nutritional Metabolism in Transition Dairy Cows: Energy Homeostasis and Health in Response to Post-Ruminal Choline and Methionine. PloS one 11:e0160659.

Sundrum A (2015) Metabolic Disorders in the Transition Period Indicate that the Dairy Cows' Ability to Adapt is Overstressed. Animals 5:978-1020.

Sunyer JO (2012) Evolutionary and Functional Relationships of B Cells from Fish and Mammals: Insights into their Novel Roles in Phagocytosis and Presentation of Particulate Antigen. Infectious disorders drug targets 12:200-212.

Suon S, Hol D, Siek S, McLean M, Copeman B (2006) Seasonal differences in the incidence of infection with Fasciola gigantica in Cambodian cattle. Tropical animal health and production 38:23-28.

Szucs E, Geers R, Jezierski T, Sossidou EN, Broom DM (2012) Animal welfare in different human cultures, traditions and religious faiths. Asian-Australasian journal of animal sciences 25:1499-1506.

Takahashi M (2012) Heat stress on reproductive function and fertility in mammals. Reproductive Medicine and Biology 11:37-47.

Tao H, Chang G, Xu T, Zhao H, Zhang K, Shen X (2015) Feeding a High Concentrate Diet Down-Regulates Expression of ACACA, LPL and SCD and Modifies Milk Composition in Lactating Goats. PloS one 10:e0130525.

Tao S, Dahl GE (2013) Invited review: Heat stress effects during late gestation on dry cows and their calves. Journal of dairy science 96:4079-4093.

Tao S, Monteiro APA, Thompson IM, Hayen MJ, Dahl GE (2012) Effect of late-gestation maternal heat stress on growth and immune function of dairy calves. Journal of dairy science 95:7128-7136.

Tedeschi LO, Fox DG, Fonseca MA, Cavalcanti LFL (2015) Models of protein and amino acid requirements for cattle. Revista Brasileira de Zootecnia 44:109-132.

Tenghe AMM, Bouwman AC, Berglund B, Strandberg E, de Koning DJ, Veerkamp RF (2016) Genome-wide association study for endocrine fertility traits using single nucleotide polymorphism arrays and sequence variants in dairy cattle. Journal of dairy science 99:5470-5485.

Terahara K, Takahashi KG (2008) Mechanisms and immunological roles of apoptosis in molluscs. Current pharmaceutical design 14:131-137.

Thanh LP, Suksombat W (2015) Milk Production and Income over Feed Costs in Dairy Cows Fed Medium-roasted Soybean Meal and Corn Dried Distiller's Grains with Solubles. Asian-Australasian journal of animal sciences 28:519-529.

Thilsing-Hansen T, Jørgensen RJ, Østergaard S (2002) Milk Fever Control Principles: A Review. Acta veterinaria Scandinavica 43:1-19.

Thompson PB (2010) Animal ethics and public expectations: the North American outlook. Journal of veterinary medical education 37:13-21.

Thornton PK (2010) Livestock production: recent trends, future prospects. Philosophical transactions of the Royal Society of London. Series B, Biological sciences 365:2853-2867.

Thornton PK, van de Steeg J, Notenbaert A, Herrero M (2009) The impacts of climate change on livestock and livestock systems in developing countries: A review of what we know and what we need to know. Agricultural systems 101:113-127.

Tian H, Zheng N, Wang W, Cheng J, Li S, Zhang Y, Wang J (2016) Integrated Metabolomics Study of the Milk of Heat-stressed Lactating Dairy Cows. Scientific reports 6:24208.

Tian P, Luo Y, Li X, Tian J, Tao S, Hua C, Geng Y, Ni Y, Zhao R (2017) Negative effects of long-term feeding of high-grain diets to lactating goats on milk fat production and composition by regulating gene expression and DNA methylation in the mammary gland. Journal of Animal Science and Biotechnology 8:74.

Tidbury HJ, Pedersen AB, Boots M (2011) Within and transgenerational immune priming in an insect to a DNA virus. Proceedings of the Royal Society B: Biological Sciences 278:871.

Trevisi E, Amadori M, Cogrossi S, Razzuoli E, Bertoni G (2012) Metabolic stress and inflammatory response in high-yielding, periparturient dairy cows. Research in veterinary science 93:695-704.

Tsiplakou E, Flemetakis E, Kalloniati C, Papadomichelakis G, Katinakis P, Zervas G (2009) Sheep and goats differences in CLA and fatty acids milk fat content in relation with mRNA stearoyl-CoA desaturase and lipogenic genes expression in their mammary gland. Journal of Dairy Research 76:392-401.

Valtonen TM, Roff DA, Rantala MJ (2011) Analysis of the effects of early nutritional environmenton inbreeding depression in Drosophila melanogaster. Journal of evolutionary biology 24:196-205.

Van den Abbeele P, Van de Wiele T, Verstraete W, Possemiers S (2011) The host selects mucosal and luminal associations of coevolved gut microorganisms: a novel concept. FEMS microbiology reviews 35:681-704.

van Niekerk G, Engelbrecht AM (2015) Commentary on: "A common origin for immunity and digestion". Frontiers in microbiology 6:531.

VandeHaar MJ, Armentano LE, Weigel K, Spurlock DM, Tempelman RJ, Veerkamp R (2016) Harnessing the genetics of the modern dairy cow to continue improvements in feed efficiency1. Journal of dairy science 99:4941-4954.

Vanselow J, Vernunft A, Koczan D, Spitschak M, Kuhla B (2016) Exposure of Lactating Dairy Cows to Acute Pre-Ovulatory Heat Stress Affects Granulosa Cell-Specific Gene Expression Profiles in Dominant Follicles. PloS one 11, e0160600.

Vazquez L, Alpuche J, Maldonado G, Agundis C, Pereyra-Morales A, Zenteno E (2009) Review: Immunity mechanisms in crustaceans. Innate immunity 15:179-188.

Vedder O, Bouwhuis S, Sheldon BC (2013) Quantitative assessment of the importance of phenotypic plasticity in adaptation to climate change in wild bird populations. PLoS Biol 11:e1001605.

Vernon RG (2005) Lipid metabolism during lactation: a review of adipose tissue-liver interactions and the development of fatty liver. Journal of Dairy Research 72:460-469.

Vicente F, Rodr M, Luisa a, Mart, Soldado A, Argamenter A, Pel ez M, de la Roza-Delgado B (2014) Subclinical Ketosis on Dairy Cows in Transition Period in Farms with Contrasting Butyric Acid Contents in Silages. The Scientific World Journal 4.

Villarroel A, Lane VM (2010) Effect of systematic parturition induction of long gestation Holstein dairy cows on calf survival, cow health, production, and reproduction on a commercial farm. Canadian Journal of Veterinary Research 74:136-144.

Wang H, Luo J, Chen Z, Cao WT, Xu HF, Gou DM, Zhu JJ (2015) MicroRNA-24 can control triacylglycerol synthesis in goat mammary epithelial cells by targeting the fatty acid synthase gene. Journal of dairy science 98:9001-9014.

Wang JZ, Sui HS, Miao DQ, Liu N, Zhou P, Ge L, Tan JH (2009) Effects of heat stress during in vitro maturation on cytoplasmic versus nuclear components of mouse oocytes. Reproduction 137:181-189.

Warne RW (2014) The micro and macro of nutrients across biological scales. Integrative and comparative biology 54:864-872.

Weed AS, Ayres MP, Hicke JA (2013) Consequences of climate change for biotic disturbances in North American forests. Ecological Monographs 83:441-470.

Wheelock JB, Rhoads RP, Vanbaale MJ, Sanders SR, Baumgard LH (2010) Effects of heat stress on energetic metabolism in lactating Holstein cows. Journal of dairy science 93:644-655.

White HM (2015) The Role of TCA Cycle Anaplerosis in Ketosis and Fatty Liver in Periparturient Dairy Cows. Animals 5:793-802.

Whitfield L (2016) Heat stress and its impact on fertility in dairy cattle. Livestock 21:218-221.

Whiting TL, Postey RC, Chestley ST, Wruck GC (2012) Explanatory model of cattle death by starvation in Manitoba: Forensic evaluation. The Canadian Veterinary Journal 53:1173-1180.

Wilson BA, Ho M (2013) Pasteurella multocida: from zoonosis to cellular microbiology. Clinical microbiology reviews 26:631-655.

Witteveldt J, Cifuentes CC, Vlak JM, van Hulten MC (2004) Protection of Penaeus monodon against white spot syndrome virus by oral vaccination. Journal of virology 78:2057-2061.

Xu HF, Luo J, Zhao WS, Yang YC, Tian HB, Shi HB, Bionaz M (2016) Overexpression of SREBP1 (sterol regulatory element binding protein 1) promotes de novo fatty acid synthesis and triacylglycerol accumulation in goat mammary epithelial cells. Journal of dairy science 99:783-795.

Xu T, Tao H, Chang G, Zhang K, Xu L, Shen X (2015) Lipopolysaccharide derived from the rumen down-regulates stearoyl-CoA desaturase 1 expression and alters fatty acid composition in the liver of dairy cows fed a high-concentrate diet. BMC veterinary research 11:52.

Yang J, Jiang J, Liu X, Wang H, Guo G, Zhang Q, Jiang L (2016) Differential expression of genes in milk of dairy cattle during lactation. Animal genetics 47:174-180.

Yang M, Zou Y, Wu ZH, Li SL, Cao ZJ (2015) Colostrum quality affects immune system establishment and intestinal development of neonatal calves. Journal of dairy science 98:7153-7163.

Yano M, Shimadzu H, Endo T (2014) Modelling temperature effects on milk production: a study on Holstein cows at a Japanese farm. SpringerPlus 3:129.

Yao D, Luo J, He Q, Shi H, Li J, Wang H, Xu H, Chen Z, Yi Y, Loor JJ (2017) SCD1 Alters Long-Chain Fatty Acid (LCFA) Composition and Its Expression Is Directly Regulated by SREBP-1 and PPARγ 1 in Dairy Goat Mammary Cells. Journal of cellular physiology 232:635-649.

York L, Heffernan C, Rymer C, Panda N (2017) A deterministic evaluation of heat stress mitigation and feed cost under climate change within the smallholder dairy sector. Animal : an international journal of animal bioscience 11:900-909.

Zhang H-b, Wang ZS, Peng Q-H, Tan C, Zou H-W (2014) Effects of different levels of protein supplementary diet on gene expressions related to intramuscular deposition in early-weaned yaks. Animal Science Journal 85:411-419.

Zhang H, Ao CJ, Khas E, Song LW, Zhang XF (2015a) Effects of different model diets on milk composition and expression of genes related to fatty acid synthesis in the mammary gland of lactating dairy goats. Journal of dairy science 98:4619-4628.

Zhang H, Dong X, Wang Z, Zhou A, Peng Q, Zou H, Xue B, Wang L (2016) Dietary conjugated linoleic acids increase intramuscular fat deposition and decrease subcutaneous fat deposition in Yellow Breed × Simmental cattle. Animal Science Journal 87:517-524.

Zhang H, Zhang X, Wang Z, Dong X, Tan C, Zou H, Peng Q, Xue B, Wang L, Dong G (2015b) Effects of dietary energy level on lipid metabolism-related gene expression in subcutaneous adipose tissue of Yellow breed × Simmental cattle. Animal Science Journal 86:392-400.

Zhu W, Lin Y, Liao H, Wang Y (2015) Selection of Reference Genes for Gene Expression Studies Related to Intramuscular Fat Deposition in Capra hircus Skeletal Muscle. PloS one 10:e0121280.