Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2019; 7(2): 04-09

Received: 03-01-2019
Accepted: 05-02-2019

Pavan Kumar Mittal
Department of Physiology and Biochemistry, Post Graduate Institute of Veterinary Education and Research, Jaipur, Rajasthan, India

GS Gottam
Department of Veterinary Physiology and Biochemistry, Post Graduate Institute of Veterinary Education and Research, Jamdoli, Jaipur, Rajasthan, India

Barkha Gupta
Department of Veterinary Physiology and Biochemistry, Post Graduate Institute of Veterinary Education and Research, Jamdoli, Jaipur, Rajasthan, India

Desh Raj Bilochi
Department of Veterinary Physiology and Biochemistry, Post Graduate Institute of Veterinary Education and Research, Jamdoli, Jaipur, Rajasthan, India

Correspondence
Pavan Kumar Mittal
Department of Physiology and Biochemistry, Post Graduate Institute of Veterinary Education and Research, Jaipur, Rajasthan, India

The effect of climate change on productivity and reproductive and health performance of livestock: A review

Pavan Kumar Mittal, GS Gottam, Barkha Gupta and Desh Raj Bilochi

Abstract
Climatic change is the major threat at present time, globally. It affects a wide range of components which are related with health, work capacity, production, reproduction, and adaptability of the animals. Animal husbandry sector is mainly affected by high temperature and high humidity. The productivity, reproductive performance and health of livestock are adversely affected by climatic stress which results in significant economic losses. Moreover, heat stress affects animal's reproductive performance and productivity of dairy animals. It has a direct effect on estrus behavior in dairy animals. Further, it produces reduced growth and reproduction, increased susceptibility to diseases, and ultimately delayed initiation of lactation in the livestock. Heat stress may affect the feed intake which reduces reproduction efficiency in hens, egg production and interruption of ovulation. Moreover, egg quality due to heat stress may also be negatively affected. Of late, practices like air cooled shades, sprinklers and proper ventilation will be suitable for adapting to future climates changes and minimize heat stress in dairy animals. During summer stress improved cooling and proper ventilation in animal houses are still the most profitable and effective method to improve both milk production and reproduction. Effective cooling system, housing and feeding management and other newer technologies are available through which climatic impacts on livestock can be diminished.

Keywords: Dairy Animals, Environment, Heat stress, Production, Reproduction, Temperature

1. Introduction
India has vast resources of livestock which plays a vital role for socio-economic status, and food security of the people. The major resources of income for the farmers or livestock owner are animal husbandry and agriculture directly affects the economic conditions of farmers. Climate change is one of the foremost hitches for the stability of livestock production systems in tropical countries like India. Heat stress or high environmental temperature has unfavorable effects on the reproductive, productive and biological function on the body of dairy animals [1]. Many climatic factors, i.e., include temperature, humidity, radiation and wind velocity which affect animal's environment directly or indirectly [2]. A major factor that contributes to reduce in fertility in lactating dairy cows is high ambient temperature [3, 4]. Heat stress causes 20 to 30% reduction in conception rate and pregnancy rate [5, 6]. The concentration of atmospheric CO_2 ranges from 400 to 480 ppm according to the IPCC (Intergovernmental Panel on Climate Change) projections in the year 2030. Global climate change is mainly produced by greenhouse gas (GHG) emissions that consequence in warming of the atmosphere [7]. The contribution of livestock sector is 14.5% in global GHG emissions [8], and thus may increase air and water pollution, land degradation and decreases in biodiversity [9, 10]. IPCC Fifth Assessment Report found that increase in global average surface temperature by 2100, which is between 0.3 LC and 4.8 LC [7]. Surroundings of the animals are directly affected by numerous climatic factors, i.e., relative humidity, temperature, radiation and wind [2]. Thermostatic control unit consists of heat loss center (anterior hypothalamus) and heat production center (post hypothalamus) which maintain core body temperature [11]. The production of poor quality of feed and fodders, forages, grains are important effect of climate change in livestock. Designing scheme to lowering the negative effects of fertility; such as increased environmental temperature, enhanced cooling, sudden change in the rations, and reproductive protocol changes, will enhance the success rate of dairy farm. Most profitable and effective technique to enhance both milk production and reproduction in the livestock during the summer months is decrease the environmental temperature by providing cooling atmosphere.

2. Livestock environment and Environmental stress

The decreases in milk production in animals are directly or indirectly affected by many environmental factors. Heat stress in the animals will cause several changes, which include respiration rates (> 70-80/minute), elevated body temperature (> 102.5 ºF) and blood flow [12]. Significant changes in physiological activities were not occurring within the range of 5–25°C [13]. Under heat stress conditions, the maintenance energy requirement of animals may increase by 20-30%. The low energy diet has detrimental effect on reproduction [14]. This reduces the low intake of energy for productive functions such as milk production in the animals.

2.1 Causes of Heat stress are

- Inability of animals to dissipate sufficient heat to maintain homeostasis.
- High Radiant energy.
- Increase in air temperature.
- Depletion in conception rate.
- Death rate of embryo [2].
- Luteal function impairs [15].
- Disturbs gonadotrophin & oestradiol secretions [16].
- Development of ovarian cysts.

3. Temperature Humidity Index (THI) and Assessment of animal stress

Heat stress is related with temperature humidity index (THI) as the primary environment factor. When body temperature surpass 45–47 °C are lethal in most of the animals. A series of changes in the biological functions of the animal's body that include lowering in efficiency and utilization of feed intake, disturbances in metabolism of protein, water, energy and mineral balances, enzymatic reactions, hormonal secretions and blood metabolites due to exposure in hot climatic conditions. THI index is extensive used to know the effect of the heat stress on dairy cow in the hot climatic area of worldwide. THI is very important for dairy cows for estimation of heat stress [17]. THI is calculated by following equation according to NRC (National Reserch Council) [18].

$$THI = 0.72 (Tdb + Twb) + 40.6$$

Where, Tdb is Dry bulb temperature in ºC, Twb is Wet bulb temperature in ºC.

When THI exceeds 72, it will cause in heat stress to the animal [19]. Milk yield of cows are to be negatively correlated with THI [20].

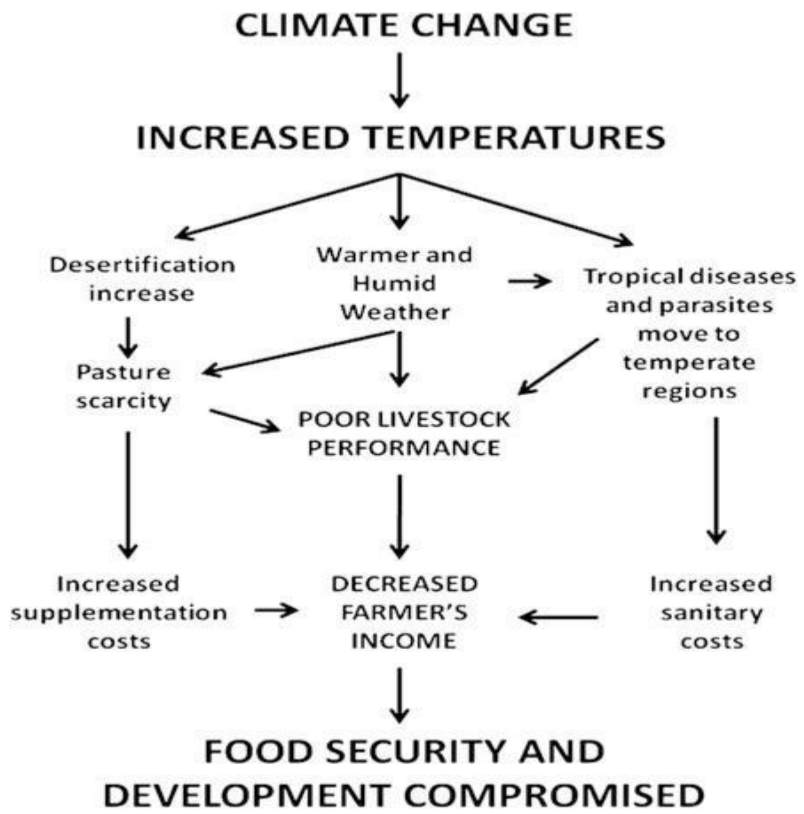
4. Effects of climatic change on livestock productivity

Calves from cooled cows had higher body weight than calves from stressed cows by heat at birth (42.5 vs. 36.5 kg) [21]. Cooled cows had greater milk production (28.9 vs. 33.9 kg/day), lower milk protein concentration (3.01 vs. 2.87%), and tended to have lower somatic cell score (3.35 vs. 2.94) through 280 days in milk than calves from stressed cows by heat [22]. They also proved that calves born from cows (kept at low temperatures) had higher total protein, total serum immunoglobulins G and apparently efficient absorption than the calves from heat-stressed cows. A possible clarification for this difference could be the direct effect of the body weight on fertility or by differences in mammary gland development and altered metabolic efficiency [23]. Elevated heat stress causes low milk production in dairy cows and buffaloes [24]. Winter season is the most favorable season for milk production of lactating animals [25]. Milk components are markedly affected by heat stress during summer. The protein fractions exhibited depletion in percentages of lactoalbumin, casein, IgG and IgA. The body condition of animals are directly affected by heat stress resulting in reduction on dry matter intake and feed conversion efficiency which results in low milk yield [16]. Colostrum composition is greatly modified by high temperatures during late pregnancy and the early post-partum period. Holstein Friesian cows maintained at less than 38°C exhibited lower averages of total solids, protein, fat, ash and lactose yields than when the same animals were maintained under thermo neutral environmental temperatures. In summer season, averages of magnesium and phosphorus values were also found to be less. Citric acid and calcium contents decreased during early lactation, while potassium decreased in all lactation stages at high ambient temperatures [26]. If environmental temperature exceeds 22-23 ºC and THI exceeds 70 results in decrease in milk yield. High ambient temperature causes 35% reduction in milk yield in mid lactating cows and 14% reduction in early lactating dairy cows. Exposure of lactating ewes under high ambient temperature decreases milk yield to 20%. Water buffaloes have less milk yield in summer season.

The heat stress is the one of the major causes of decreased production in the dairy and beef industry resulting in significant economic losses [27]. High producing dairy cows generate more metabolic heat and are more sensitive to heat stress than low producing dairy cows. Consequently, when metabolic heat production increases in conjunction with heat stress, milk production declines [28, 29]. Heat stress also affects buffalo, ewe and goat milk production [27]. Generally ewes are more sensitive to the combined temperature and relative humidity effect. High ambient temperatures also reduce milk production in buffaloes because it affects the animal physiological functions, such as pulse, respiration rate, and rectal temperature [30].

Beef cattle having high weights, thick coats, and darker colors are more dangerous to warming in the case of meat production [27]. Global warming may reduce body size, carcass weight and fat thickness in ruminants [31, 32]. In similar studies, larger pigs will have more depletion in growth, carcass weight and feed intake [27]. High temperatures greater than 25 LC reduce sows feed intake during suckling periods which reduces the milk yield of the sow and may be reduced piglets survivability [33].

Heat stress will reduce body weight gain, feed intake and carcass weight, and protein and muscle calorie component in birds [34]. Heat stress will reduce reproduction efficiency in hens and consequently egg production because of reduced feed intake and interruption of ovulation [27, 35]. In High temperature conditions, egg quality may also be negatively affected [36]. Relative humidity affects both water loss from the egg embryonic mortality and the high relative humidity appeared to have a detrimental effect on embryonic development during incubation [37]. Swine show decreased feed intake under hot-humid environments [38] and higher sow culling rates [39]. In another studies, Dairy cattle produce milk with decreased milk fat and milk protein percentage [40]., The milk yield was increased by increasing the cooling frequency, when dairy cows are exposed to hot-humid climate [41]. The temperature humidity index (THI) is widely used to provide an accurate assessment of the effects of the heat stress on poultry and livestock [42, 43]. Heat stress causes increase in parasitic diseases, free radicals concentrations & reactive oxygen species, leads to damage of macromolecules & disruption of normal metabolism and physiology and changes of immune function resulting in death of livestock.



Schematic view of the expected outcome of climate change as a result of global warming on farm animal productivity: Adapted from the article [44].

5. Effects of climate change in reproductive performance of livestock

The reproductive performance is the key factor markedly affecting profitability in many livestock production systems. Reproduction performance of both livestock sexes may be affected by heat stress. It affects oocyte growth and quality in cows and pigs [45, 46], embryo development impairment, and pregnancy rate [47, 48]. Cow fertility may be affected by heat stress [3, 49]. It also affects lower sperm concentration and quality in bulls, pigs, and poultry [50, 51]. Heat stress has detrimental effect on the reproduction of cattle and buffaloes [52]. The heat stress causes the release of ACTH from the anterior pituitary which triggers release of cortisol and other glucocorticoids from the adrenal cortex. Luteinizing hormones is inhibited by the secretion of glucocorticoids. Thermal stress causes hyperprolactinaemia which inhibits the secretion of both FSH and LH at hypophyseal level [53]. Heat Stress results in low fertility in the livestock because the embryo loses its capacity to alter prostaglandins synthesis in a manner that favours the maintenance of the corpus luteum. Heat stress has more pronounced effects on reproduction than is seen with other stressors [54]. The dry period is very important in the livestock for mammary gland involution and later development, induction of lactation and rapid fetal growth. High ambient temperature or thermal stress can affect endocrine system during dry period that may cause shorten the gestation length, fetal abortions, lower calf birth weight, and reduce follicle and oocyte maturation. Prepartum heat stress may reduce placental estrogen levels and thyroid hormones, while elevating nonesterified fatty acid concentrations in blood; all of these factors alter growth of the udder and placenta, unborn calf growth, and future milk production. Postpartum heat stress affects the ability of the dairy cow to increase production. Dairy cows in late gestation during heat stress had calves with lower birth weights and produced less milk in comparison with cooled cows [55]. The increasing ambient temperature from 12.5°C to 35°C was followed by decline of conception rate in cattle from 40 to 31% [56]. Oocytes quality is deteriorated due to continuous exposure of animals to the heat stress [57] and elevated level of GH and nonesterified fatty acid [58]. Infertility is the significant effect of heat stress in the dairy cows [59]. All the climatic variables showed positive and nonsignificant effects on the intercalving period and dry period [60]. In male livestock, the scrotal circumference, size and weight are decreased in high ambient temperature due to degeneration in the germinal epithelium [61]. High environmental temperature negatively affect the thermoregulatory mechanism of the testes, sexual desire, ejaculate volume, live sperm percentage, sperm concentration, viability and motility [62].

6. Effects of climate change in health performance of livestock

Several livestock health problems associated with climate change [27]. In addition, higher energy deficiencies affect cow fitness and longevity [49]. High ambient temperature may also affects endocrine status [19], metabolic rate [63], oxidative status [64], glucose, protein and lipid metabolism, liver functionality (reduced cholesterol and albumin) [65, 66], nonesterified fatty acids (NEFA) [66], saliva production, and salivary HCO^{-3} content.

7. Conclusion

Climate change such as high ambient temperature, relative humidity etc. could affect the animal's productivity, reproductive and health performance. Of late, few practices to minimize heat stress in dairy cows, such as air cooled shades, sprinklers and proper ventilation will be suitable for adapting to future climates changes. Enhanced cooling and proper ventilation in their houses are still the most profitable and effective method to improve both milk production and reproduction during summer stress. In case of buffalo, allowing for wallowing and water sprinkling are successful step for reduction in heat stress mainly during summer season. In our opinion, it is important that such mitigation strategies would focus on the study and use of local genetic resources exhibiting a highly adaptation to the most significant issue for that specific region, either climate or disease. Such markers would be of great importance and use in the definition of selection strategies and objectives to enhance livestock productivity and reproductive performance, with special reference to developing countries. Selection practices will helpful for genetic improvement of the livestock for important heat tolerance traits. Implementation of newly and scientific strategies to minimize negative effects of heat are proper cooling system, ration adjustments in the diet and changes in reproductive protocol, stress depletion etc. will improve the economic conditions of dairy farms.

8. References

1. Sere C, Zijpp AV, Persley G, Rege E. Dynamics of livestock production system drives of changes and prospects of animal genetic resources. Anim. Genet. Resour. Inf., 2008; 42:3-27.
2. Gwazdauskas FC. Effects of climate on reproduction in cattle. J. Dairy Sci., 1985; 68(6):1568-78.
3. De Rensis F, Scaramuzzi RJ. Heat stress and seasonal effects on reproduction in the dairy cow- A review. Theriogenology. 2003; 60:1139e 51.
4. Dash S, Chakravarty AK, Singh A, Upadhyay A, Singh M, Yousuf S. Effect of heat stress on reproductive performances of dairy cattle and buffaloes. A review. Vet. World. 2016; 9(3):235-244.
5. Schuller LK, Burfeind O, Heuwieser W. Impact of heat stress on conception rate of dairy cows in the moderate climate considering different temperature humidity index thresholds, periods relative to breeding, and heat load indices. Theriogenology. 2014; 81:1050-1057.
6. Khan FA, Prasad S, Gupta HP. Effect of heat stress on pregnancy rates of crossbred dairy cattle in Terai region of Uttarakhand, India. Asian Pac. J. Reprod. 2013; 2(4):277-279.
7. IPCC (Intergovermental Panel on Climate Change), Climate change 2013. The physical science basis. In Stocker, T. F., Qin, D., Plattner, G. K., Tignor, M., Allen, S. K., Boschung, J., Nauels, A., Xia, Y., Bex, V., Midgley, P. M. (Eds.), Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2013, 1535.
8. Gerber PJ, Steinfeld H, Henderson B, Mottet A, Opio C, Dijkman J *et al*. Tackling Climate Change through Livestock. A Global Assessment of Emissions and Mitigation Opportunities. FAO, Rome, 2013.
9. Bellarby J, Tirado R, Leip A, Weiss F, Lesschen JP, Smith P. Livestock greenhouse gas emissions and mitigation potential in Europe. Glob. Change Biol. 2013; 19:3-18.
10. Reynolds C, Crompton L, Mills J. Livestock and climate change impacts in the developing world. Outlook Agric. 2010; 39:245-248.
11. Bianca W. Thermoregulation. In Hafez ESE. Adaptation of domesticated animals, Lea & Febiger, Philadelphia, USA. 1968, 97-118.
12. Pereira AMF, Baccari Jr. F, Titto EAL, Almeida JAA. Effect of thermal stress on physiological parameters, feed intake and plasma thyroid hormones concentration in Alentejana, Mertolenga, Frisian and Limousine cattle breeds. International Journal of Biochemistry. 2008; 52:199-208.
13. McDowell RE. Improvement of livestock production in warm climates. Freeman, San Francisco, C. A., 1972, 711.
14. Lee CN. Environmental stress effects on bovine reproduction. Vet. Clin. North Am. Food Anim. Pract. 1993; 9(2):263-73.
15. Wolfenson D, Luft O, Berman A, Meidan R. Effects of season, incubation, temperature and cell age on progesterone & prostaglandin production in luteal cells. Anim. Reproduction Sci. 1993; 32:27-40.
16. Wilson SJ, Marion RS, Spain JK, Spiers DE, Keisler DH, Lucy MC. Effect of controlled heat stress on ovarian function of dairy cattle. J Dairy Sci., 1998; 1:2124-2131.
17. Thom EC. Cooling degree days. Air conditioning, heating and ventilation, 1998, 65-72.
18. NRC (National Reserch Council), A guide of environmental research on animals. Natl. Acad. Sci., Washington, D. C., 1971.
19. Johnson HD. Environmental management of cattle to minimize the stress of climatic change. Int. J. Biometeorol. 1980; 7:65-78.
20. Mandal DK, Rao AV, MS, Singh K, Singh SP. Effects of macroclimatic factors on milk production in a Frieswal herd. Indian J Dairy Sci., 2002; 55(3):166-170.
21. Tao S, Monteiro AP, Thompson IM, Hayen MJ, Dahl GE. Effect of late gestation maternal heat stress on growth and immune function of dairy calves. Journal of Dairy Science. 2012; 95(12):7128-7136.
22. Tao S, Bubolz JW, Do Amaral BC, Thompson IM, Hayen MJ, Johnson SE *et al*. Effect of heat stress during the dry period on mammary gland development. Journal of Dairy Science. 2011; 94(12):5976-5986.
23. Monteiro APA, Tao S, Thompson IMT, Dahl GE. In utero heat stress decreases calf survival and performance through the first lactation. Journal of Dairy Science, vol. 2016; 99(10):8443-8450.
24. Marai IFM, Habeeb AAM, Gad AE. Rabbits productive and physiological performance traits as affected by heat stress. A review. Livestock Production Science. 2002; 78:71-90.
25. Barash H, Silanikove N, Shamay A, Ezra E. Interrelationships among ambient temperature, day length and milk yield in dairy cows under a Mediterranean climate, 2001.
26. Kamal TH, Johnson HD, Ragsdale RC. Metabolic reactions during thermal stress in dairy animals acclimated at 50° and 80 °F. Research Bulletin. 1962; 785:1-114.
27. Nardone A, Ronchi B, Lacetera N, Ranieri MS, Bernabucci U. Effects of climate change on animal production and sustainability of livestock systems. Livest. Sci. 2010; 130:57-69.
28. Berman AJ. Estimates of heat stress relief needs for

Holstein dairy cows. J. Anim. Sci. 2005; 83:1377-1384.
29. Kadzere CT, Murphy MR, Silanikove N, Maltz E. Heat stress in lactating dairy cows. A review. Liv. Prod. Sci. 2002; 77:59-91.
30. Seerapu SR, Kancharana AR, Chappidi VS, Bandi ER. Effect of microclimate alteration on milk production and composition in Murrah buffaloes. Vet. World. 2015; 8:1444-1452.
31. Mitloehner FM, Morrow JL, Dailey JW, Wilson SC, Galyean ML, Miller MF *et al*. Shade and water misting effects on behaviour physiology, performance and carcass traits of heat stressed fedlot cattle. J. Anim. Sci. 2001; 79:2327-2335.
32. Nardone A. Weather conditions and genetics of breeding systems in the Mediterranean area in XXXX International Symposium of Societa Italiana per il Progresso della Zootecnia, Ragusa, Italy, 2000, 67-92.
33. Lucas EM, Randall JM, Meneses JF. Potential for evaporative cooling during heat stress periods in pig production in Portugal. J. Agric. Eng. Res. 2000; 76:363-371.
34. Tankson JD, Vizzier Thaxton Y, Thaxton JP, May JD, Cameron JA. Stress and nutritional quality of broilers. Poult. Sci. 2001; 80:1384-1389.
35. Novero RP, Beck MM, Gleaves EW, Johnson AL, Deshazer JA. Plasma progesterone, luteinizing hormone concentrations and granulosa cell responsiveness in heat-stressed hens. Poult. Sci. 1991; 70:2335-2339.
36. Mashaly MM, Hendricks GL, Kalama MA, Gehad AE, Abbas AO, Patterson PH. Effect of heat stress on production parameters and immune responses of commercial laying hens. Poult. Sci. 2004; 83:889-894.
37. Bruzual JJ, Peak SD, Brake J, Peebles ED. Effects of relative humidity during incubation on hatchability and body weight of broiler chicks from young breeder flocks. Poultry Science. 2000; 79:827-830.
38. Myer R, Bucklin R. Influence of hot humid environment on growth performance and reproduction of swine, 2001.
39. Zhao Y, Liu X, Mo D, Chen Q, Chen Y. Analysis of reasons for sow culling and seasonal effects on reproductive disorders in Southern China. Animal Reproduction Science. 2015; 159:191-197.
40. Gantner V, Mijic P, Kuterovac K, Solic D, Gantner R. Temperature humidity index values and their significance on the daily production of dairy cattle. Mljekarstvo, 2011; 56-61.
41. Honig H, Miron J, Lehrer H, Jackoby S, Zachut M, Zinou A *et al*. Performance and welfare of high-yielding dairy cows subjected to 5 or 8 cooling sessions daily under hot and humid climate. Journal of Dairy Science. 2012; 95:3736-3742.
42. Gates R, Zhang H, Colliver D, Overhults D. Regional variation in temperature humidity index for poultry housing. Transactions of the ASAE. 1995; 38:197-206.
43. Moraes SRP, de Yanagi Júnior T, Oliveira ALR, de. Yanagi S, de NM, Café MB. Classification of the temperature and humidity index (THI), aptitude of the region, and conditions of comfort for broilers and layer hens in Brazil. International Livestock Environment Symposium - ILES VIII, Iguassu Falls City, Brazil, 2008. August 31 to September 4, 2008. https://www.cabdirect.org/cabdirect/abstract/20093272870.
44. Gurdeep singh, Amitoz kour, Gyan prakash Pathak. Impact of Environmental Factors on Production and reproduction in Domestic Animals. IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS). 2014; 7(2):III.
45. Barati F, Agung B, Wongsrikeao P, Taniguchi M, Nagai T, Otoi T. Meiotic competence and DNA damage of porcine oocytes exposed to an elevated temperature. Theriogenology. 2008; 69:767-772.
46. Ronchi B, Stradaioli G, Verini Supplizi A, Bernabucci U, Lacetera N, Accorsi PA *et al*. Influence of heat stress and feed restriction on plasma progesterone, estradiol-17β, LH, FSH, prolactin and cortisol in Holstein heifers. Livest. Prod. Sci. 2001; 68:231-241.
47. Hansen PJ. Exploitation of genetic and physiological determinants of embryonic resistance to elevated temperature to improve embryonic survival in dairy cattle during heat stress. Theriogenology. 2007; 68(4):S242-S249.
48. Wolfenson D, Roth Z, Meidan R. Impaired reproduction in heat stressed cattle, basic and applied aspects. Anim. Rep. Sci. 2000; 60(1-3):535-547.
49. King JM, Parsons DJ, Turnpenny JR, Nyangaga J, Bakari P, Wathes CM. Modellig energy metabolism of Friesians in Kenya small holdings shows how heat stress and energy deficit constrain milk yield and cow replacement rate. Anim. Sci. 2006; 82:705-716.
50. Karaca AG, Parker HM, Yeatman JB, McDaniel CD. Role of seminal plasma in heat stress infertility of broiler breeder males. Poult. Sci. 2002; 81:1904-1909.
51. Kunavongkrita A, Suriyasomboonb A, Lundeheimc N, Learda TW, Einarsson S. Management and sperm production of boars under differing environmental conditions. Theriogenology. 2005; 63:657-667.
52. Tailor SP, Nagda RK. Conception rate in buffaloes maintained under sub humid climate of Rajasthan. Ind. J. Dairy Sci., 2005; 58(1):69-70.
53. Singh M, Chaudhary BK, Singh JK, Singh AK, Maurya PK. Effect of thermal load on buffalo reproductive performance during summer season. Journal of Biological Sciences. 2013; 1(1):1-8.
54. Moberg GP. Biological response to stress. Implications for animal welfare. The Biology of Animal Stress, CAB 1 Publishing. CAB International, Wallingford, Oxion OX108 DE, UK., 2000, 1-21
55. Collier RJ, Dahl GE, Van Baale MJ. Major advances associated with environmental effect on dairy cattle. Dairy Sci., 2007; 89:1244-1253.
56. Ulberg LC, Burfening PJ. Embryo death resulting from adverse environment of spermatozoa or ova. J. Anim. Sci., 1967; 26:571-577.
57. Roth Z, Meweidan R, Shahmam Albalancy A, Braw Tal R, Wolfenson D. Delayed effect of heat stress on steroid production in medium size and preovulatory bovine follicles. Reproduction. 2001; 121:754-751.
58. Butler WR. Nutritional effect of resumption of ovarian cyclicity and conception rate in postpartum dairy cows. BSAS Edinburg, Occasional publication. 2001; 26:133-45.
59. Lopez Gatius F. Fertility declining in dairy cattle, a retrospective study in north eastern Spain. Theriogenology. 2003; 60:89-99.
60. Zewdu W, Thombre BM, Bainwad DV. Effect of macroclimatic factors on milk production and reproduction efficiency of Holstein Friesian x Deoni

crossbred cow, 2014.
61. Chou IP, Chuan L, Chen Chao C. Effect of heating on rabbit spermatogenesis. Chinese Medical Journal. 1974; 6:365-367.
62. Gamcik P, Mesaros P, Schvare F. The effect of season on some semen characters in Slovakian Merino rams. Zivocisna Vvrobo. 1979; 24:625-630.
63. Webster AJ. Metabolic responses of farm animals to high temperature. In Ronchi, B., Nardone, A., Boyazoglu, J. (Eds.), Animal Husbandry in Warm Climates. EAAP Publication, 1991, 15-22.
64. Bernabucci U, Lacetera N, Ronchi B, Nardone A. Markers of oxidative status in plasma and erythrocytes of transition dairy cows during hot season. J. Dairy Sci. 2002; 85:2173-2179.
65. Bernabucci U, Lacetera N, Basirico L, Ronchi B, Morera P, Seren E *et al*. Hot season and BCS affect leptin secretion of periparturient dairy cows. Dairy Sci. 2006; 89:348-349.
66. Ronchi B, Bernabucci U, Lacetera N, Verini Supplizi A, Nardone A. Distinct and common effects of heat stress and restricted feeding on metabolic status in Holstein heifers. Zootec. Nutr. Anim. 1999; 25:71-80.