

## Buffaloes and climatic change: mitigation and adaptation

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### ABSTRACT

Climate change, especially global warming, may highly influence the production performance of farm animals throughout the world. Global warming has a great impact on the production and reproductive activity of cattle and buffaloes. The Egyptian buffalo is an important tropical species adapted to the environmental conditions in Egypt and other developed countries. In the last ten years, Egypt was exposed to waves of heat and cold which stressed the animals and decreased animal production. This was clear in 2015. So we needed animals more tolerance to stress (cold or heat) and can make modifications to micro-environmental conditions around it, faster recovery from heat stress, less water consumption, and lower methane emissions. It is more necessary to make an adaption of animals and their mitigation with environmental conditions, to decrease the adverse bad effects of climatic change in environmental conditions on animals for increasing the animal production. In this review, we discussed the roles of all environmental factors related to changes in animal production.

**Keywords:** Buffalo, Temperature Humidity Index, Climatic change.

### INTRODUCTION

The environmental condition is a combination of several factors as temperature, humidity, rainfall, air movement, radiation, barometric pressure, and ionization. Extreme weather conditions as heat can cause substantial livestock production losses resulting in heat stress (Ghavi *et al.*, 2013). Global warming has a great impact on the production and reproductive activity of cattle and buffaloes. It is anticipated that the temperature rise will be 1.8 - 4°C by 2100. The Intergovernmental Panel on Climate Change IPCC (2013).

Climate change especially global warming may highly influence the production performance of farm animals throughout the world. Meanwhile, climate change is a threat to livestock production because of the impact on the quality of feed crop and forage, water availability, animal and milk production, livestock diseases, animal reproduction, and biodiversity (IPCC, 2013), the livestock sector contributes 14.5% of global greenhouse gas (GHG) emissions, driving further climate change (Gerber *et al.*, 2013). Omran *et al.* (2019a) reported that the elements of animal production are diverse and interrelated thus to maintain the production of animals, the physiological modification of housing systems and animal nutrition is needed noting that each region has certain characters, the negative effects of heat stress will become more and more apparent in the future, if climatic changes continue without a solution it will be difficult to maintain animal production. In the last ten years, Egypt was exposed to waves of heat and cold which stressed the animals and decreased animal production this was clearly in the year 2015. Omran *et al.* (2011a) under artificial conditions (40°C in the lab) reported that the buffalo calves exposed to heat stress were the better and faster recovery in all measurements under study Physiological, Hematological, and hormonal response, water, and feed intakes and growth rate compared with Friesian calves under as seam conditions with found Friesian under Egyptian conditions more than 60 years. Omran and Foda (2013) under environmental conditions in Medill Egypt found that the temperature-humidity index THI >87 could be considered dangerous for Friesians, while this threshold was at THI >91 for Buffalo. The best THI for production in both types is lower than 68 but Buffalo starts to be under cold stress at this threshold. Friesians is colder tolerant and heats susceptible than buffalos under natural environmental Egyptian conditions. Omran *et al.* (2017) reported that using supplementing diets reduces the sensitivity of buffaloes to cool with climatic change under Medill Egypt conditions. Omran and Foda (2012) reported that the buffalo calves were successful live in the reclaimed land with harsh conditions and give good production. Added to the economy, prefer fattening buffalo calves over one year.

The Egyptian buffalo is an important tropical species adapted to the environmental and managerial conditions in Egypt and other developed countries. It is the main source of milk and meat production where it contributes 45-50 % and about 35 to 40% respectively. MALR (2018). The buffalo population in Egypt is about 3.7 million head according to FAOSTAT (2018). The buffalo produces 157 gm methane per day while a cow produces 376 gm methane per day which is 58% less than the methane emission cow, the buffalo's eco-friendly than cows (Sarubbi *et al.*, 2013 and Appuhamy *et al.*, 2016). Atwa *et al.* (2019) reported that in Egypt buffaloes are important animals for both farmers and breeders due to it's against diseases, adaptation to harsh environmental conditions, and higher efficiency of digestion of fibers, produce a good percentage of milk fat and its milk has the best order for making Mozzarella and Raiba cheese. The primary goal of this study is to look at the impacts of climate change on buffaloes. To evaluate its environmental adaptation and mitigation, as well as to improve animal production. Also, research on the risks and effects of climate change on their water buffalo farming systems was investigated (Figure 1).

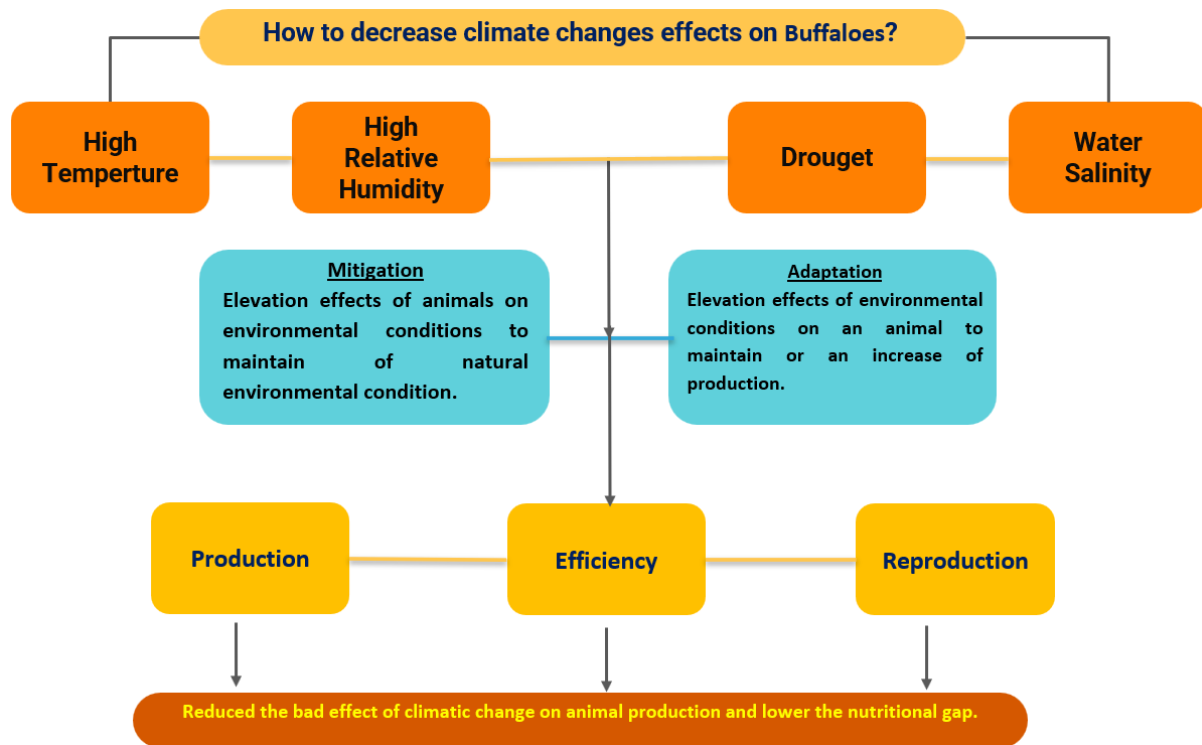


Fig. 1. The main objectives of the current review article

**Climatic change**

**Temperature Humidity Index (THI):**

The temperature-humidity index (THI) is a single value depicting the integrated effects of air temperature and humidity associated with the level of heat stress. This index has been developed as a weather safety index to control and decrease heat stress-related losses (Bohmanova *et al.*, 2007, Omran and Fooda 2013, Omran *et al.*, 2019b,c, e, and 2020).

The THI is a practical and useful tool for many applications in animal biometeorology. THI is extensively used in hot regions all over the world to evaluate the effect of heat stress on dairy cows and used to estimate the cooling necessities of dairy cattle to improve the efficiency of management strategies to alleviate the negative effects of heat stress (Ghavi *et al.*, 2013). The direct impacts of air temperature, humidity, and wind speed capable of influencing growth rate, milk production, and reproduction have been reported by Rust and Rust (2013).

Khalil and Omran (2018) under environmental conditions in Egypt reported that the impact of climate change on THI values in different three regions (Lowe, Middle, and Upper Egypt) during the period 2016 up to 2060, the results give evidence for significant changes in the THI values during the period from 2046 to 2060. The classifications of THI during the study period found that the moderate class shows a significant gradual increase with time in all studied governorates where its record highest percentage in the last studied period (2046 – 2060) and the non-sever class percentage tends to decrease in all governorates to the account of increasing the mild and moderate heat stress classes. Omran *et al.* (2020) reported that the temperature-humidity index (THI) is commonly used as a relevant indicator of the degree of climatic stress on animal productivity, the classifications of the environmental regions in Egypt using this index to three regions, under Lower Egypt is climatic more stressful in comparison with Middle and Upper Egypt (due to higher of relative humidity). Moreover, the close relationship between THI and the tested responses including animal RR r/min and Ht % in particular revealed the ability to use those parameters as predictive measures for animal acclimation in each specific region. Thus, livestock holder has the choice to select the appropriate breed for rising to get efficient productivity according to compatibility with his farm location.

Omran *et al.* (2019c) reported that relative humidity (RH %) under climatic conditions of North Delta was playing an important role in increased values of a temperature-humidity index (THI). Omran and Food (2013) reported that any improvement in an animal index (THI) will ideally be useful as a base for continued development of biologic response function and representative of consequences resulting from primary factors influencing energy exchange between the animal and its surroundings., Temperature humidity index (THI) is still the best, simplest which causes stress (heat or cold) in dairy cattle and physiological parameters changing climate. Omran *et al.*, (2019b and 2020) recommend that it is very important with climatic change, using the prediction equations which enable in maintaining water and productivity of animals without a greater drop of production.

**1-Water Buffaloes:**

Two types of water buffalo are traditionally recognized worldwide, the river and the swamp buffaloes. The river buffaloes are currently widespread in Italy, few eastern European countries, the middle east, and India.

The river buffalo has been selected as a dairy animal with several recognized breeds, spread from the Indian subcontinent to the eastern Mediterranean countries (The Balkans, Italy, and Egypt). More recently river buffaloes have been imported to eastern Asia, southern America, and central Africa to improve milk production (Kierstein *et al.*, 2004).

In Egypt, buffalo is considered an important genetic resource with great potential as a source of milk and meat. Water buffalo is the main dairy animal raised by small farmers in Egypt. Water buffaloes are found in the humid tropics and the suitability of the buffaloes to the hot climatic conditions is shown to be achieved by morphological, anatomical, and physiological characteristics (Shafie, 1993a and b, Shafie and Omran, 2018, Omran, 2013 a,b, Omran *et al.*, 2013 and Omran and Fooda, 2013).

Shafie and Omran (2018) reported that the buffalo can change the morphology and histology of their skin to maintain bioprocesses, and the size of the surface area to the animal's body and skin color show special adaptation to environmental factors. And the differences may simply be a reflection of the animal's environment; this pattern might indicate an adaptation to their environment and not genetically associated.

Many local buffalo populations show wide variation in their size and color, but none of these is believed to be according to separate breed (Borghese, 2011) this agreement with Omran *et al.* (2019d) reported that higher significant phenotypic and morphometric variations were found between buffalo populations raised under Nile Delta (ND) and Nile Valley (NV) under environmental climatic conditions in Egypt. In addition to the temperature-humidity index (THI) was playing a prominent role in the variation of size between buffalo under different thermal conditions.

**1- Buffalo skin:**

The Buffaloes have sparse hair coat particularly with age progress. Collier et al. (2006) found that skin temperature is highly correlated with respiration rates and it is a good tool to measure the microenvironment around the animals. They also added that, if the skin surface temperature is below 35 °C, the temperature gradient between the core and skin is large enough for the animals to effectively use all routes of heat exchange. This agreement with Omran and Hamdon (2018).

Shafie and Omran (2018) reported that buffalo under two different thermal artificial conditions had the total number of hair per cm<sup>2</sup> (449.50 and 915.00 in a lab) (A at 40°C) and lab (B at 25°C), respectively. This decreased number of hairs under heat stress to easily distribute heat to decrease the load of the higher temperature and the morphological characteristics of hair coat are markedly influenced by climate as observed in (Table1).

**Table (1).** Morphological changes of hair and skin of buffalo calves due to exposed to two different thermal artificial conditions at 40 °C (Lab A) and 25 °C (Lab B). (Shafie and Omran, 2018).

Item	Group (A), 40 °C	Group (B), 25 °C
<b>Hair</b>		
<b>Hair color</b>	Wooden color	Light Gray
<b>Hair texture</b>	Rough	Soft
<b>Hair length</b>	Long	Short
<b>Distribution of hair on the body</b>	Sparse and there are parts of the	Harmonic and covered
<b>Hair density</b>	hair-free	the body
	Slight	Heavy
<b>Skin</b>		
<b>Skin color</b>	Tends to redness	Dark gray
<b>Skin texture</b>	Wet	Dry
<b>Sebum substance</b>	Find	Not find

The hair was soft, short, heavy, and harmonic under conditions in a lab (B) while under conditions in a lab (A) was rough, long, slight and this results in agreement with Omran *et al.* (2019d) under environmental conditions in Nile Delta and Nile Valley. The actual density of hairs is less than that of follicles due to the phenomenon of hair shedding (Shafie, 1985) so that the adult hair is scattered sparsely and all provide no insulation in comparison to the young buffalo which have a complete cover.

Therefore, heat dissipation in these animals would be seriously hampered unless it requires a special behavior to moisten its surface from outside water such as by swimming and wallowing. The great effect of direct solar radiation on the sebum secretion in buffaloes followed by Friesians and then the other cattle breeds could be attributed to the black skin in the former two breeds. However, the buffaloes showed a negative reaction to solar radiation by decreasing the sebum secretion while cattle breed showed positive reaction. Shafie and Omran (2018) Addition that, the development of the size, sebaceous glands, and thickness of epidermis and dermis were decreased in a group (A) comparative with group (B). while a total of hair follicles number increased in group B than group A by 3.11 (μ) but the length of hair follicles and length of hair was higher in a group (A) comparative with a group (B) this development increase the efficiency of animal to microclimatic conditions around them.

**Table (2).** Thickness of epidermis ( $\mu$ ) and Dermis ( $\mu$ ), total number of hair follicles filed ( $\mu$ ), length of hair follicles ( $\mu$ ), length of hair ( $\mu$ ), number of sebaceous gland filed ( $\mu$ ) and number of sweat gland filed ( $\mu$ ) of buffalo calves due to exposure to two different thermal artificial conditions at 40 °C (Lab A) and 25 °C (Lab B). (Shafie and Omran, 2018)

Item	Group (A), 40 °C	Group (B), 25 °C
Thickness of epidermis ( $\mu$ )	2.09±0.12 <sup>b</sup>	4.22±0.16 <sup>a</sup>
Thickness of Dermis ( $\mu$ )	90.45±1.74 <sup>b</sup>	105.05±2.55 <sup>a</sup>
total number of hair follicles filed ( $\mu$ )	3.35±0.23 <sup>b</sup>	6.47±1.04 <sup>a</sup>
Length of hair follicles ( $\mu$ )	26.0±1.83 <sup>a</sup>	18.36±0.00 <sup>b</sup>
Length of hair ( $\mu$ /filed)	9.67±0.33 <sup>a</sup>	3.00±0.00 <sup>b</sup>
number of sebaceous gland filed ( $\mu$ )	3.38±0.37 <sup>a</sup>	3.50±0.42 <sup>a</sup>
number of sweat gland filed ( $\mu$ )	4.17±0.60 <sup>a</sup>	3.75±0.48 <sup>a</sup>

Mean values in the same row with different superscripts are significantly different (P<0.05).

The thickness of the skin has increased the alarm for the sensory nerves, which increases the speed of skin alarm hypothalamus (central nervous system) to increase the efficiency of tensor hair and increase blood supply in the surface layer of the skin, which increases the speed of loss the heat from the body temperature, due to the blood supply was the biggest and more in-group (A) compared to group (B).

## 2- Buffalo rumen:

Under heat stress in a lab at 40°C and 25°C, Omran et al. (2011b) reported that the rumen plays a certain role in the adaptation process the greater volume of water content in the rumen compared to the case in the single stomach has a significant role in evaporative cooling of the animal body during hot conditions. In addition to the large volume of water due to the high specific heat capacity of water, it absorbs a lot of any excessive heat from the endangered body tissues. Also see the average weight of the rumen fresh tissue were 2.5±0.05 and 4.75±0.14 kg, respectively and the average weight of abomasum's tissue were 1.09±0.12 and 0.94±0.19 kg, concomitant with increased feed intake FI/ Kg during trial two in a lab under heat stress compared with trail one and this reflected on the daily gain from decreased by (-0.49 kg/day) to increase by (+0.03 kg/day) at the scanted exposure heat stress in lab.

Omran (2013a) under different thermal conditions for buffalo calves in Lab at 40°C groups ( A) and 25°C groups (B) reported that the water capacity was lower compared with several respiration rates under stress in a minute, this gives an indicator to performance of buffalo calves to maintain on body temperature by losing low quantity from water. These differences between groups indicated that in heat stress buffalo calves maintained their body temperature by losing a quantity of RWC/L day and increased respiration rate (RR r/min), heat stress reduced feed intake (FI /Kg) and increased water intake (WI/L/day) and respiration rate (RR r/min) (Table 3).

**Table (3).** Feed intake (FI, kg), respiration rate (RR, r/min), water intake (WI, L) and rumen water capacity (RWC, L) for two groups (A & B) in buffalo calves exposed to different thermal condition. (Omran, 2013a).

Items	Group (A) 40°C	Group (B) 25°C
<b>Feed intake (kg):</b>		
Concentrate (Con.)	2.5±0.0 <sup>b</sup>	4.8±0.14 <sup>a</sup>
Wheat straw (R1)	0.5±0.0 <sup>b</sup>	1.0±0.0 <sup>a</sup>
Barseem hay (R2)	0.16±0.03 <sup>a</sup>	0.22±0.03 <sup>a</sup>
<b>Respiration rate (RR)</b>	122.0±1.62 <sup>a</sup>	20.0±0.35 <sup>b</sup>
<b>Water intake (WI, L)</b>	20.0±1.25 <sup>b</sup>	26.0±0.48 <sup>a</sup>
<b>Rumen water capacity(RWC/L)</b>	23.8 <sup>b</sup>	32.7 <sup>a</sup>

In the same row means with different superscripts are significantly different (P<0.05).

In addition to, the changing of histology rumen under differing thermal conditions in Table (4 and 5) This difference between the two groups increased efficiency of animal to lives under heat stress condition by abundant change of tissue with decreased or increased of a thickness of layers in response to heat stress, the density of papillae, length and diameters of papillae increased of total absorbed of feed digested so, any improved of quality of feed increased of microbial fermentation due to increase the total observed this lower effect of a decrease in the production of an animal under heat stress.

**Tables (4).** Thickness of the different layers of rumen and abomasum ( $\mu$ ) tissues for the two experimental groups (A & B) in buffalo calves exposed to different thermal condition. (Omran, 2013a).

Items	Group (A) 40°C	Group (B) 25°C
<b>Rumen :</b>		
<b>Tunica muscular</b>	54.2±1.7 <sup>b</sup>	82.2±3.29 <sup>a</sup>
<b>Mucosa</b>	19.2±0.59 <sup>a</sup>	16.7±0.58 <sup>b</sup>
<b>Abomasums :</b>		
<b>Tunica muscular</b>	49.8±3.9 <sup>a</sup>	25.8±0.49 <sup>b</sup>
<b>Sub mucosa</b>	21.6±1.5 <sup>a</sup>	23.7±1.4 <sup>a</sup>
<b>Mucosa</b>	26.9±0.6 <sup>b</sup>	33.0±0.6 <sup>a</sup>

In the same row means with different superscripts are significantly different ( $P < 0.05$ ).

**Table (5).** Measurements of rumen papillae in two experimental groups (A & B) of buffalo calves exposed to different thermal conditions. (Omran, 2013a).

Items	Group (A) 40°C	Group (B) 25°C
<b>Number of papillae /field</b>	17.0±0.58 <sup>b</sup>	20.0±0.47 <sup>a</sup>
<b>Length of papillae (<math>\mu</math>)</b>	41.3±7.3 <sup>a</sup>	48.8±3.5 <sup>a</sup>
<b>Diameter of papillae (<math>\mu</math>)</b>	18.3±0.8 <sup>b</sup>	23.19±1.0 <sup>a</sup>
<b>Space between papillae (<math>\mu</math>)</b>	26.9±2.8 <sup>a</sup>	13.7±3.5 <sup>b</sup>
<b>Papillae surface aria/field (<math>\mu^2</math>)</b>	11892.47±2717 <sup>b</sup>	22974.46±2576 <sup>a</sup>
<b>Total surface papillae area /field (<math>\mu^2</math>)</b>	202062.1±41532 <sup>b</sup>	439443.2±47511 <sup>a</sup>

In the same row means with different superscripts are significantly different ( $P < 0.05$ ).

Field,  $\mu^2 = 20096$       Field,  $\text{cm}^2 = 0.61544$

### 3- Physiological and haematological responses for buffaloes under thermal conditions:

Under heat stress, the animal behavioral and physiological responses are initiated to increase heat loss and reduce heat production in an attempt to maintain body temperature within the range of normality (38.3-38.7°C).

Many investigators reported that Thermo-physiological responses, rectal temperature (RT,°c), and respiration rate (RR, r/min) are good measures to detect the response of an animal to variation in the microenvironment around the animal thus giving clear evidence of the better capacity of heat tolerance (Ashour *et al.*, 2004, Omran and Fooda 2013, Omran and Hamdoon (2018) and Omran *et al.*, 2013, 2017, 2020). Omran *et al.* (2020) under different regions climatic conditions in Egypt on buffaloes and cows reported that increased respiration rate RR r/min is the first reaction when animals are exposed to an environmental temperature above the thermo-neutral zone; this response ensures direct heat stimulation of the peripheral receptors which transmit nervous impulses to the heart center in the hypothalamus, and the values of RR r/min were relatively higher in the young animals as compared with the older animals of both buffaloes and cows. However the variance in RR r/min between age categories of cows was increasing in concomitant with the higher seasonal temperatures the values of RR r/min for both species were the highest at Lower Egypt (LE) followed by Middle Egypt (ME) and Upper Egypt (UE), the differences between two species in RR r/min were highly significant so that the range of RR r/min in cows lies between 39.3-54.6 r /min while in buffaloes it was 32.3- 40.5 RR r/min. This finding clarified the ability of buffaloes to dissipate the influence of heat stress through different internal mechanisms.

Also reported that animal RR r/min is a faster indicator of any changes in the microenvironment when compared with the slow alterations in skin temperature (ST °C). On the other side, hematocrit value (Ht %) is a sensitive indicator to the surrounding thermal conditions when compared with hemoglobin (Hb,g/dl) concentrations reason for the thermal conditions around animals. Therefore, RR r/min and Ht% can be used as a good and faster indicator of animal stressed.

The Hematological parameters represent a fine mirror that reflects healthy conditions of the animal most species of domestic animals have Ht % values from (38 to 40 %).

The Hemoglobin Hb g/dl values decreased as a result of exposing animals to high air temperature (AT °C) in a lab or under normal environmental conditions (Ashour *et al.*, 2004 and Omran *et al.*, 2013).

Omran *et al.* (2011a, c, 2013, 2020 and Omran and Hamdoun (2018) reported that blood pictures for buffalo calves showed a clear drop in Ht% and Hb g/dl values and increased count of white blood cells count (WBCsx10/mm)) under heat stress. Such change may refer partially to hemodilution by the excess water intake (WI/L/day).

The drop in Hb g/dl and RBCsx10/mm was more pronounced than the decline in value Ht% which indicates other mechanisms imposing a drop in Hb g/dl and RBCsx10/mm to reduce oxidation activity of metabolism followed by a drop in metabolic heat production.

The white blood cells WBCsx10/mm count was increased as an indication of higher immunological activity. The author attributed the higher estimates of Ht% and Hb g/dl in buffaloes to adaptability of the animal and fast recovery from heat stress as compared with Friesian denoting the buffaloes can alleviate the heat stress through evaporation from the skin and the respiratory system. Omran *et al.* (2011d) reported that responses of leukocyte cell types (LCT%) difference in five types due to exposure to heat stress (HS) the changes occurred in the percentage of Lymphocytes (Ly%) decreased and Neutrophils (Ne%) increased, eosinophil's (Eo%) increased and monocytes (Mo %) decreased and these values were higher in Frisian calves (FC) than buffalo calves (BC) Ne % was higher in FC than BC and ( Ly% ) lower in FC than BC due to adaptability in BC compared to FC for high temperature, values of the ratio Ne/ Ly% was significant between two breed.

Omran (1999) under natural environmental conditions reported that the average values in Buffalo calves for Ne% and Ly% were 58.3%&34.1% in winter compared to that in summer 56.98%, 35.4%. In FC respective values were 56.8%, 35.4 in winter, and 60.4%& 29.5% in summer this change agreement with, Ashour et al. (2004).

#### 4- Blood metabolites, mineral ions and hormonal profile:

The tolerance capacity of Egyptian buffaloes was determined in Egypt under natural seasonal conditions and artificial laboratory conditions of heat stress at 40°C (lab A), and comfort state at 25°C (lab B) by Omran (2011d) on buffalo calves reported that blood plasma metabolites to heat stress showed great decrease in total lipids (TL, mg/dl), triglycerides (TC, mg/dl) followed by glucose (Glu, mg/dl). These reductions indicated hamper of metabolic activities subsequently less product of metabolic heat. The drop in total protein (TP, g/dl) suggests an effect of hemodilution along with the drop in buildup of plasma proteins, the increase in globulin (Glo, g/dl) against a drop in albumin (Alb, g/dl) indicates control in colloid osmotic pressure to maintain proper blood circulation. The level of blood urea nitrogen (BUN, mg/dl) was also significantly lowered in group A than in group B during the two trials in response to heat stress. Also reported heat stress caused increasing in concentration of Potassium (K, mg/dl), sodium (Na, mg/dl) around 10% opposite to 20% decrease in calcium (Ca, mg/dl). The phosphorus (P, mg/dl) showed a more than 50% increase this increase should be, particularly, due to hem concentration by activated water vaporization from the animal's surfers and increased respiratory vaporization.

Nevertheless, the difference in the rate of increase between K, Na, and P indicated active physiological arrangements concomitant with the hem concentration. The opposite trend by a reduction in Ca, equal in the two treatments, emphasizes effective physiological interference. In addition to heat stress caused reduction in insulin (Ins, ulu/ml) concentrations, coincidentally, the glycogen (Glg, pg/ml) concentration increased. These hormones indicate hormonal control on a critical drop in Glu concentration. in blood plasma under heat stress (47 and 40 mg/dl) in comparison to (79 and 75 mg/dl) under comfort conditions, and it is clear that triiodothyronine (T<sub>3</sub>, ng /dl) and thyroxin (T<sub>4</sub>, ug/dl) hormone concentration were decreased more than 50% in response to heat stress, almost with equal levels in two trials in lab, devoting depression in general metabolic activity, thus metabolic heat production (Ashour *et al.*, 2000, Omran *et al.*, 2011b). Shaffer *et al.*, (1981) identified a highly significant effect of seasonal temperature on blood glucose levels. El-Masry and Habeeb (1989) reported that high air temperature caused a drop in insulin this agreement with (Omran, 2011d and Ashour *et al.*, 2004) there reported that high air temperature caused a drop in insulin.

#### 5- chemical components, physical characteristics, histology and Meat quality:

The nutritional value of buffalo meat is higher than that of beef; it has a much lower fat and cholesterol content and is a highly concentrated source of protein, It contains almost all the essential amino acids needed for human health, a high concentration of A and B vitamins. It is also an important source of iron, copper, zinc, and selenium (Rebak *et al.*, 2010).

Omran (2013b) under artificial heat stress in ( lab A at 40°C) reported that the area of longissimus dorsi muscle decreased by 17%, and this area /Kg was more by 20% in the comfort group (B) more than in stressed group (A) in a lab, the effect of heat stress on the meat chemical component; the values of sodium( Na), potassium (K) and phosphorus ( p) were higher under heat stress while the values of iron I and calcium (Ca ) were lower in blood., the level of Ca was decreased in meat under heat stress may be due to mechanism of Ca in activated dependent protease (CDP) systems to activation or inhibitor enzymatic activity causes to tenderness in meat under heat stress and this agreement with Whipple et al. (1999).

While the value of Na was higher under heat stress the increase of Na may be due to an increase in blood with heat stress and the decrease of Ca in meat Omran (2008). Then fined relationship between levels of Na to K and Ca to P in the blood to maintained and balance in all biological processes in the body. the protein and ash in meat were higher, while the lipid was lower, the color of meat was light, and the tenderness and taste were excellent as the veal with level from protein high and low lipid, low level of moisture (%) due to decrease the loss cooking., Thus all these needs by the consumer taste and healthily, heat stress don't effect of quality of meat and give meat good to the consumer. Rebak et al. (2010) found that in normal meat buffalo, the values of crude protein, lipids, and ash were 70.1, 11.13, and 3.39, respectively. Omran (2013b) reported that the exposure of buffaloes to heat stress doesn't affect levels of protein and ash but decreases the level of fat, the biological value of meat buffalo don't affect by heat stress (Table 6).

**Table (6).** Chemical analysis of longissimus dorsi (LD) for two meat buffalo calves groups exposure under 40°C (A) and 25°C (B). (Omran, 2013b).

Items	Group A (40°C)	Group B (25°C)
	Mean ± SE	Mean ± SE
Protein	71.07±0.87 <sup>a</sup>	69.15±2.24 <sup>a</sup>
Lipid	5.64±0.96 <sup>b</sup>	19.71±0.78 <sup>a</sup>
Ash	14.30±1.07 <sup>a</sup>	6.81±2.39 <sup>b</sup>
Moisture	22.90±2.70 <sup>a</sup>	23.20±2.30 <sup>a</sup>
Sodium (Na, mM/L)	0.55±0.11 <sup>a</sup>	0.170±0.03 <sup>b</sup>
Potassium (K, mM/L)	26.80±0.17 <sup>a</sup>	26.97±0.170 <sup>a</sup>
Calcium (Ca, mM/L)	3.07±0.03 <sup>b</sup>	3.80±0.060 <sup>a</sup>
Phosphor (P, mg/dl)	0.63±0.12 <sup>b</sup>	1.83±0.030 <sup>a</sup>

In the same row means with different superscripts are significantly different (P<0.05).

Added to study physical characteristics; the color intensity of meat under heat stress (lab A) as like the meat veal (pink) while under comfort conditions the color was red as like the meat for calving greater than a year the first due to decreased of level in Iron in the blood comparative with iron under comfort conditions (lab B) this reflected of the color due to the values of hemoglobin (Hb) is blood-related to the level iron in the blood under heat stress animals reduced the Hb content in their blood to check the metabolic rate, thus reducing the production of metabolic heat. The decrease of the feed intake and metabolic due to decrease of all blood components thus the lower value of iron under heat stress. The red color of meat is light due to myoglobin which is a protein very similar in properties to blood hemoglobin. Addition to, the chemical and physical characteristic was good under heat stress, the tenderness and fiber under stress were smooth and the fiber was thin and coherent while under comfort conditions the meat was rough and the fiber was stretch and disjointed and the tenderness was high under heat stress comparative with comfort during the meat the chewing and the best taste test (Table 7).

**Table (7).** Physical characteristics for two meat buffalo calves groups exposure under 40°C (A) and 25°C (B). (Omran, 2013b).

Items	Group A (40°C)	Group B (25°C)
<b>Color</b>	Pink	Red
<b>Tenderness</b>	High	Low
<b>The cooking loss</b>	+	+
<b>Meat quality after cooking</b>	High	Medium

The tenderness and fibers with histology explain that they found significant between heat stress and comfort condition the intermediate connective tissue (collagen fiber) was higher under heat stress.

The histology and physical characteristics explain the meat quality; the fiber package diameter, fine fiber diameter, and intermediate connective tissue (collagen) were higher under heat stress and lower the connective tissue, buffalo calves under heat stress try decrease of energy from the body, for this reason, the calves reaction maybe merge the fiber to lower thin the mussels to decrease the effect of heat stress, this clear on an area of longissimus dorsi under heat stress compared comfort conditions by 3.3cm and the higher of collagen fiber under heat stress reflect on the good quality of meat due to increase of this fiber is best to cooking.

#### 8- Housing system:

Housing System is mainly designed to suit the requirements of temperature climate and has proved unsuitable for tropical climates. The system of the house reduced the effect of environmental conditions on animals and the effects of animals on environmental conditions (adaption and mitigation). Thomas and Sastry (1991) reported that the shelter system not only fulfils its principal function but also providing to health-sustaining and comfortable environment to animal behavioral and physiological responses that are initiated to increased heat loss and reduce heat production in an attempt to maintain body temperature within the range of normality. The significance of the increase of the respiration rater RRr/min under heat stress is that it enables the animals to dissipate the excess of body heat by vaporizing more moisture in the expired air, which accounts for about 30 % of the total heat dissipation HD°C (Omran *et al.*,2017 and 2019c, e). The processes of conduction convection and radiation are all dependent on a thermal gradient, thus as air temperature rises towards body temperature the thermal gradient is reduced and heat dispersion is less effective, in addition, the non-evaporative cooling will shift to evaporative cooling when the ambient temperature is equal or above body temperature as described by Khalifa (2003) & Omran and Hamdon (2018). The shade reduced death losses to 33 % and production losses of surviving cows to 50 % for cows without shadow (Hahn, 1981).

Factors that contribute to variation in temperature and humidity include housing material and construction, forced ventilation, and bedding type plying important role in animal production High-yielding dairy cows are the most sensitive to the influence of heat at the beginning of lactation and in cases when a body temperature is higher than 39 °C production of milk significantly falls (Ravagnolo and Misztal, 2000). Omran and Fooda (2012) reported that the buffalo was successful life in the reclaimed land with harsh conditions. Under conditions, the close house from clay and roof from maize stoke above unit of wood give appropriate temperature-humidity index (THI), physiological performance and production for buffalo cow in the reclaimed land. Omran *et al.* (2019e) reported that the semi-open System was a lower value of heat dissipation (HD°C) under an environment in Nile valley, and The best roofs were mat and maize stoke for two species buffalo and cow respectively. The cottonwood was a good bedded compared with rice straw to reduce emission gas under buffaloes with increased urine., Added that the dirt land only was good without any bedded this clary from results of respiration rate (RR r/min), heat dissipation for animals (HDA/°C) and gas emanation gas emission as nitrous oxide (No2/L) and Carbon dioxide (Co2/L) for two species the values of buffaloes for all parameters were reduced compared with the cows. The milk production and lactation period LP/day for buffaloes and cows in (Table 8 and 9).

**Table (8).** Mean  $\pm$  SE for total milk yield (TMY/kg) and lactation period (LP/day) as affected by type of roof for buffaloes and cows under environmental conditions in the Nile Valley. (Omran et al., 2019e).

Type of roof	Buffaloes		Cows	
	TMY	LP	TMY	LP
1	1333 $\pm$ 57.42 <sup>c</sup>	154.0 $\pm$ 4.50 <sup>c</sup>	1483 $\pm$ 319.19 <sup>c</sup>	167.00 $\pm$ 46.00 <sup>b</sup>
2	1005 $\pm$ 56.45 <sup>d</sup>	158 $\pm$ 4.28 <sup>c</sup>	1084 $\pm$ 216.19 <sup>d</sup>	143.34 $\pm$ 4.37 <sup>c</sup>
3	-	-	1055 $\pm$ 21.82 <sup>d</sup>	168.89 $\pm$ 1.31 <sup>b</sup>
4	632.5 $\pm$ 30.00 <sup>e</sup>	133 $\pm$ 4.23 <sup>d</sup>	-	-
5	1050 $\pm$ 50.00 <sup>d</sup>	175 $\pm$ 17.00 <sup>b</sup>	-	-
6	950.0 $\pm$ 117.17 <sup>d</sup>	170 $\pm$ 3.78 <sup>b</sup>	978 $\pm$ 33.9 <sup>e</sup>	162.00 $\pm$ 1.6 <sup>b</sup>
7	2135 $\pm$ 24.57 <sup>a</sup>	225 $\pm$ 1.89 <sup>a</sup>	1809 $\pm$ 251 <sup>a</sup>	182.30 $\pm$ 6.39 <sup>a</sup>
8	1732 $\pm$ 71.13 <sup>b</sup>	211 $\pm$ 4.06 <sup>a</sup>	1718 $\pm$ 213.44 <sup>b</sup>	180.48 $\pm$ 5.56 <sup>a</sup>

1: Palm leaves, 2: Wood, Rice Straw and Cottonwood, 3: Sheet metals, 4: Asbestos, 5: Wood and Canvas, 6: Cement, 7: Mat; 8: maize stoke

(-): non fond diary animal under this model of roof.

Mean values for each item with different superscripts in the same column are significantly different ( $P \leq 0.05$ ).

**Table (9).** Mean  $\pm$  SE for total milk yield (TMY/kg) and lactation period (LP/day) as affected by type of bedded for buffaloes and cows under environmental conditions in the Nile Valley. (Omran et al., 2019e).

Type of roof	Buffaloes		Cows	
	TMY	LP	TMY	LP
1	1830 $\pm$ 215.0 <sup>a</sup>	210 $\pm$ 11.34 <sup>a</sup>	1905 $\pm$ 209.4 <sup>a</sup>	185 $\pm$ 5.16 <sup>a</sup>
2	1183 $\pm$ 59.5 <sup>c</sup>	179.75 $\pm$ 4.30 <sup>b</sup>	875 $\pm$ 66.0 <sup>c</sup>	145 $\pm$ 1.89 <sup>b</sup>
3	1394 $\pm$ 59.2 <sup>b</sup>	188.6 $\pm$ 4.26 <sup>b</sup>	1364 $\pm$ 104.4 <sup>b</sup>	171.36 $\pm$ 1.96 <sup>a</sup>
4	1487 $\pm$ 125.5 <sup>b</sup>	163 $\pm$ 9.32 <sup>c</sup>	-	-

1: dirty land, 2: Rice straw, 3: Mixture from cottonwood and rice straw, 4: cottonwood only.

Mean values for each item with different superscripts in the same column are significantly different ( $P \leq 0.05$ ).

The best for animal production and lower the effects of animal on environmental conditions the land under animal without bed, and the cow was more sensitive to effects of bedded to milk production compared with buffaloes on-seam bedded.

Omran et al. (2019c) reported that the closed system housing was bad as a micro-environmental condition around an animal, the open system was the best selected to design house under climatic conditions in North of Delta for buffaloes and cows, the roof from sheet metal is a good roof with all parameter (heat dissipation, respiration rate, and gas emanation (GE)) from animal to house and *vas versa*, all parameters for two species mostly significant effects  $P \leq 0.001$  except a type of land under animal for buffaloes. Added to the significant effect for total milk yield (TMY/Kg) and lactation period (LP/day) ( $P \leq 0.001$ ), the open housing reduces the impact of climatic conditions on animal and *vas versa*, and the land from cement, with necessary cover sewage network and place of manure collection to biosafety these reduce the impact of animals on climatic conditions.

### 9- Milk production, composition and quality:

Buffaloes play a very important role in the dairy sector in Egypt. Major constituents of the milk namely the fats, proteins, sugars are high in buffalo milk and it is also rich in vitamins and minerals making it a great source of nutrition buffalo milk contains higher levels of total solids, crude protein, fat, calcium, and phosphorous and a slightly higher content of lactose compared with those of cows' milk. The high level of total solids makes buffalo milk ideal for processing to value-added dairy products such as cheese as reported by Claeys *et al.* (2014).

The changes in environmental factors like ambient temperature, relative humidity, wind speed, and solar radiation cause stress in lactating cattle, heat stress adversely affect both the quantity and quality of milk. the outside temperature of 35 °C the quantity of milk is decreased by 33 % and at the temperature of 40 °C by 50 % (West, 2003 and Rhoads *et al.*, 2009). Heat-stressed cattle may try to reduce the body heat through thermoregulatory mechanisms which in turn affect feed conversion efficiency and lead to decreased milk production. Omran et al. (2017) under an environmental condition in middle Egypt on buffaloes at late gestation the THI index around animals was 58.64 (January to March) and after birth 69.33 (April to June until time of peak) reported that the value of milk yield Kg /day was 4.20Kg, Fat 4.3%, protein 3.59%, lactose 4.3 %, total solids13.3% and solids not fat 9.1%, this decreased due to more sensitivity to buffaloes to cold stress and elevated this stress by added diets supplemented as ZAD increased the all values respectively (5.8Kg, 6.7%, 4%,5.1%,16.7%, and 10%). Fooda and Omran (2012) under different conditions in middle Egypt, the farms were located in different geographical regions, one in the village(farm one) and the other in reclaimed land(farm two) the THI index were 64.0 in the winter month and 82.4 in summer (farm one) and the other hand (farm two) were 55.6 and 64.0 respectively, reported that the means of total milk yield (TMY/Kg) and lactation period (LP/day) in farm one were higher than farm two while the persistency in farm one was lower than farm two. Added to, the estimates of the initial milk yield (a) were 51 and 56 kg in farm one and farm two, respectively. Concerning the rate (kg/two weeks) of increase to peak during the ascending phase (b), the higher rate was 1.32 kg/two weeks in farm one and the lower rate was 0.87 kg/two weeks in farm two. For



the rate (kg/two weeks) of decrease during the descending phase (c), farm one gave the highest decreasing rate (-0.25 kg/two weeks), while farm two had the lowest decreasing rate (-0.15 kg/two weeks, and this clear that, the persistency value was high in farm two, although decreased of LP and TMY.  $R^2$  value in farm one was higher than in farm one. Despite these conditions, the average daily milk is less than 1 kg only with increasing persistence. Many authors estimated lactation curve parameters for milk yield of Egyptian buffaloes using the nonlinear form of the incomplete gamma function in the large holder (Aziz *et al.*, 2006 and Foda *et al.*, 2009).

#### 10- Water and feed intakes:

Productive performance is the most important index out of various indices of animal adaptability to environmental conditions. This index is an outcome of water and feed intakes behavior, which is affected, greatly by stress factors mainly that of climatic and nutritional conditions. Water and feed intakes are affected markedly by ambient temperature (Omran *et al.* 2011a,b, 2013 and 2019b). There is a lack of research related to the implications of reduced water availability for land-based livestock systems due to climate change (Thornton *et al.*, 2009). Several physiological changes indicate the response of dairy cows to heat which is manifested by the number of efforts reactions, including reduced feed intake increased water intake, evaporative water losses from the body, increased respiration rate, and altered endocrine functions (Calamari *et al.*, 2007 and Omran *et al.*, 2011a,c, 2013 and 2019b). Water salination could affect animal metabolism, fertility, and digestion.

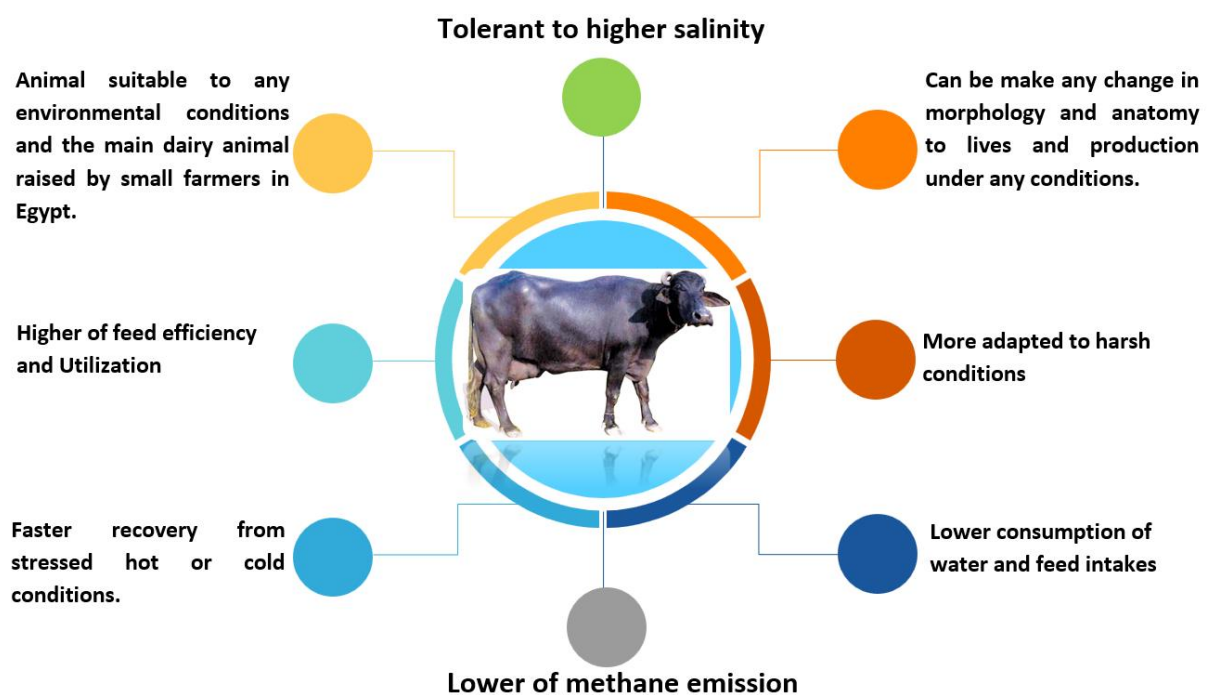
Chemical contaminants and heavy metals could impair cardiovascular, excretory, skeletal, nervous, and respiratory systems, as well as the impairing, hygienic quality of production (Nardone *et al.*, 2010). With climatic change under Egyptian conditions, a regular adjusting of water consumption is needed for both buffaloes and cows where is potentially the main ingredient in milk and meat production in Egypt. Under thermoneutral conditions, water intake equals water loss in the normal adult animal, while under heat stress the major physiological reaction is an increased water intake and consequently body water content., As water is lost through urine, skin, and respiratory vaporization under heat stress, a temporary water deficit with increased body fluids concentration stimulates the hypothalamic thirst center to control water consumption (Ashour, 1990, Ashour *et al.*, 2007, Omran *et al.*, 2013 and 2019b). Omran *et al.* (2019b) reported that the best climatic condition for buffaloes and cows was THI between 71- 74 under environmental conditions in Egypt and the higher consumption from the water was in (Lower Egypt) and the lower consumption was in (Upper Egypt). In addition to the cows were higher than buffaloes in consumption water and feed in the three climatic regions in Egypt (LE, ME, and UE) and through two the ages less than one year and more than one year.Omran and Foda (2012) reported that the reclaimed land is called Abou-Suroor land. Its sandy land, they planted olive and Peanut. The animal feeding is depending on concentrate at the milking time and Alfalfa clover, alfalfa hay, and bean hulls were offered adlib in the winter, while in summer depending on concentrate at the milking time and Alfalfa clover, Alfalfa hay, and bean hulls and wheat straw were offered adlib. The water from wells (salinity 2500 to 3000 ppm) the animals were drinking twice/day in winter and were 3 times/day in summer without any diversity on animal productivity. Omran *et al.* (2019a) found that the Most animals of watering (92%) by spouts was the salinity of water 400 ppm, and the higher values of water salinity were 3500 ppm from well in reclaims area to watering green crops and buffalo and cow., needed under this condition water under shaded maintain suitable salinity of the water., without shaded the salinity increased during the day between 30 to 50 ppm. Ashour (1990) found that buffalo calves increased their water intake in summer than in winter by two folds as absolute values (39.2 vs. 20.1 L/day) and by three times relative values to metabolic body weight (MBW)<sup>0.75</sup>, this increase in water intake (WI, L/day) with the hot condition is augmented by a behavioral eagerness to gulp copious cold water., due to reflects of the physiological role of (WI, L/ day) in counteracting heat stress by increasing water vaporization through the skin and or respiratory surface

Ashour *et al.* (2007) reported that the interaction between water intake and temperature showed no significant effect while the interaction between concentrate intake and the temperature had a highly significant effect on average daily gain (ADG/kg). This Contrast in those interactions proves that the major effect of temperature on growth is through control of feed intake (FI/Kg). Omran *et al.* (2017) used product containing anaerobic bacteria and a mixture of natural cellulosic enzymes as a dietary supplement (ZAD) for buffaloes feeding reduced the harmful effects of cold waves through improving the postpartum physiological status and reducing the sensitivity of buffaloes to cold climatic Plasma thyroxin and triiodothyronine level is found to be decreasing during heat stress than in normal thermoneutral conditions. El-Masry and Marai (1991) reported that buffalos were more tolerant than Friesians to the environmental condition of Egypt; in addition to the buffalo, calves had poorer feed efficiency and higher dry matter intake in winter and higher growth rate in summer than Friesian calves ( $P \leq 0.05$ ). Omran (1999) reported that constant heat stress in a lab at 40°C increased water consumption per metabolic body weight (MBW)<sup>0.75</sup> by 16% in buffalo calves and 25% in Friesian calves, added to the concentrate intake was reduced by 20% in buffalo and 18%in Friesian calves and reduced the average daily gain (ADG/kg) by 25% in buffalo calves and 20% in Frisian calves., The feed intakes as related to metabolic body weight showed that concentrate intakes were reduced in response to heat stress, from that pre-stress by 13% in buffaloes and 17% in Friesian per Kg (BW) 0.75. In addition to the ratio of roughage to concentrate was higher in summer than winter in Friesian calves and buffalo calves being 31.3 vs. 29.8% for buffalo, 31.8 vs. 28.5% in Friesian.

## CONCLUSION

We can conclude that buffaloes the first animal of climatic change, can be changed both morphology and histology of skin to maintain bioprocess and do not make any change genetically. Buffaloes changing by the thickness of skin, length of hair, number of hair follicles, the color of hair and skin to make acclimation with any conditions to make the buffalo's

characteristic form suitable for any place to live. It's faster recovering from heat stress during few days and can acclimatize to transportation stress during the first year after transportation but need to three seasons to be acclimatized regarding total milk yield and curve of lactation. Under heat stress in a lab, the water capacity of rumen was lower compared with several respiration rates under stress in a minute, this gives an indicator to the performance of buffalo calves to maintain on body temperature by losing low quantity from water. The buffalo tolerant water salinity and lower consumption of water and feed intakes and lower methane emission. It can be live in the reclaimed land under harsh conditions. And it's tolerant salinity of water until 3500 ppm. It's feeding green crops watering as seam salinity. The feed and water consumption by Frisian calve was high compare with buffalo calves, this economically costly in the other hand, the buffalo calve was efficient and better maintained the physiological balance of the body which ensures no disruption leading to loss of animal and this uneconomic. It concluded The Buffalo can be make changed its morphology and histology to maintain bioprocess, can acclimatize under any environmental conditions around it; it is more adapted to hot conditions, and by supplementation diets tolerant cold weaves. With the climatic change, we can increase milk and meat production from buffalo without a drop in production or disruption on animals. With available suitable shades above animals, and shading watering to protect from solar radiation direction. We needed to increase of study on buffaloes between adaption and mitigation to lower the bad effect of climatic change (Fig. 2).



**Fig. 2.** The conclusion of this invited review.

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## الجاموس والتغيرات المناخية: . تأقلمه مع البيئه وتاقلم البيئه معه

فايزة ابراهيم عمران

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### الملخص

التغيرات المناخية لها تأثير سلبي على الكفاءة الانتاجية للحيوانات على مستوى العالم. الاحتباس الحراري له تأثير عالي على النشاط التناسلي والانتاجي للابقار والجاموس. الجاموس المصري متحمل للحراره والرطوبه العاليه ومتأقلم مع الظروف البيئيه في مصر وبعض الدول الناميه. آخر عشر سنوات تعرضت مصر لموجات من الحراره والرطوبه العاليه نتج عنها نقص في انتاجيه الحيوانات. ظهر أثرها السلبي واضحا في الموجه التي اصابت مصر عام 2015. لذلك نحن في حاجه الى حيوانات اكثر تحمل للاجهاد الحراري (موجات حاره او بارده) وتستطيع التكيف مع اي تعديل للظروف البيئيه المحيطه به، وتكون سريعه الاستشفاء من أثر الاجهاد الحراري، وأقل استهلاك لمياه الشرب وقل إنبعاث لغازات الاحتباس الحراري خاصه الميثان. فمن الضروري عمل تأقلم للحيوان مع الظروف البيئيه وكذلك عمل تأقلم للبيئه مع الحيوان لتقليل الأثر السلبي للتغيرات المناخيه. مما يؤدي لزياده انتاجيه الحيوان اوعلى الأقل الحفاظ على الانتاجيه. ففي هذه مقاله ناقش دور العوامل البيئيه المترتب عليه التغيرات في الانتاجيه للحيوان .

**الكلمات المفتاحية:** الجاموس، دليل الحراره والرطوبه، التغيرات المناخيه.