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Climatic challenges for domestic ruminants under the Egyptian conditions in relation to temperature humidity index (THI)

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ABSTRACT

This study was conducted to demonstrate the physiological responses of domestic ruminants to climatic challenges with special reference to temperature humidity index (THI) under environmental conditions of Egypt. The study involved 15 governorates: 6 in the Nile Delta, 7 in the Nile Valley, and 2 out of the Nile Valley. Monthly visits were carried out during the period extending from 2010 to 2022. The data was collected and analyzed by a research team belonging to Animal Production Research Institute and Central Laboratory for Agricultural Climate Institute, Agriculture Research Center. Respiration rate (RR, r/min), rectal temperature (RT °C) and Hematological parameters including Hematocrit value (Ht %) for buffaloes and cows, while goats and sheep respiration rate RR (r/min) was only recorded. The temperature humidity index (THI) was calculated by the meteorological data (air temperature AT°C and relative humidity RH %) in the entire region. The main objective of this study was to; Pout description of the climate of Egypt. Assess the physiological performance of domestic ruminants with regard to climatic challenges under the environmental conditions of Egypt. Suggest of recommendations for ruminants with different levels of THI characteristic of different regions under study were presented, this included the major required modification in nutrition, housing, or both to increase animal productivity or maintain it.Temperature humidity index (THI) is still the best indicator for ruminant performance under the environmental conditions of Egypt. It is not fair to evaluate that performance using the global THI. In Egypt, the expected THI trend towards 2050 includes Mild and moderate heat stress, it is expected that Mild heat stress could be interrupted by waves from cold waves and thermo-neutral. The moderate heat stress is expected to be interrupted by waves from Heat stress, Severe and Very severe heat stress especially during the months characterized by high relative humidity. Cows were highly sensitive to any change in micro-environmental conditions. Buffalo had the lowest RR under all levels of the THI. Buffalo and goats were sensitive to cold waves. Otherwise, cows and sheep were sensitive to heat waves. It has been concluded that it is not fair to evaluate the performance of domestic ruminants using the global THI. Buffalo and goats are efficient under conditions of climatic changes. Further adaptation studies for buffalo and goat are needed.

Keywords: Climatic challenges, Egyptian temperature humidity index (THI), Ruminants, and Description of Egyptian climate.

INTRODUCTION

Agriculture is a key pillar of the Egyptian economy as a major source of national income. Its contribution to the gross national production (GNP) is about 15% during 2023. It provides work opportunities for a large proportion of the national labor force. More than 70% of agricultural holders in Egypt are small farmers. The elements of animal production are many 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 its certain features. The negative effects of heat stress will become more and more apparent later on (If climatic stresses remain without 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 reflected to decrease in animal production (waves in 2015, 2020, 2022, and 2023 under environment condition in Egypt). Ghavi *et al.* (2013) and Omran *et al.* (2019a) reported that, extreme weather conditions can cause losses in livestock production through increased animal mortality and reduced feeding efficiency and this is reflected on production. The main sources of milk and meat production for human consumption in Egypt are buffalo and cows, the both species are raised under climatic conditions trying to maintain their biological activity.

The number of buffalo in Egypt is about (1.4 million heads) while the number of local cows and foreign (2.8 million/head) add to sheep (1.9 million/head) and goats (1.1 million/head) (EAS, 2022). Khalifa (2003) and Omran and Hamdone (2018) reported that, (CC) especially global warming may highly influence of farm animals around the world; Animals under these conditions try to maintain their biological activity. Since processes of conduction convection and radiation are all dependent on the thermal gradient. The Fifth Assessment Report identified the "likely range" of increase in global average surface temperature between 0.3°C and 4.8°C by reaching 2100 (IPCC, 2013). NOAA (2008) reported that, the climate in Egypt is generally moderate. Egypt receives less than 80 mm of precipitation annually in most areas, although in the coastal areas, it reaches 200mm, it hardly ever rains during the summer. Therefore, according to the drought definition, Egypt is a semi-arid country and suffers from drought, particularly in desert areas.

Mechanisms of animal adaptation have been defined by (HS) influences the performance of animals as; anatomical, morphological, and physiological by reducing feed intake, feed efficiency, feed utilization, and more activation to the normal thermoregulation reaction i.e. RR, RT, and sweating causing disturbances in the metabolism (increased water intake and body water content) by Shafie and Omran (2018), Omran *et al*., (2019, 2020); Omran and Fooda (2023). Temperature-humidity index (THI) is a single value depicting the integrated effects of air temperature and humidity associated with the level of heat stress (Bohmanova *et al.,* 2007). Values of THI are practical, useful tool and a standard for many applications in animal biometeorology. THI is extensively used in hot regions all over the world to evaluate the effect of HS on dairy cows and is currently used to estimate cooling necessities of dairy cattle in order to improve the efficiency of management strategies to alleviate the negative effects of HS (Ghavi *et al.,* 2013). Omran *et al.* (2020) reported that the respiration rate (RR) alterations in skin temperature (ST), on the other side, hematocrit (Ht) is a sensitive indicator to the surrounding thermal conditions when compared with hemoglobin Hb concentrations reason for the thermal conditions around animals. Therefore, RR and Ht can be used as good indicators of animal stress.

The effect of HS is accompanied by high ambient humidity, in the Egypt there are different climatic regions based on geographical locations classification of environmental conditions was carried out in Lower, Middle, and upper Egypt, each of them has its natural characteristics, the highest values of THI were recorded in August while the lowest values of THI were found in February at the same regions. Any improved animal index of THI will ideally be useful based on the continued development of biologic response functions and representative of consequences resulting from primary factors influencing energy exchange between the animal and its surrounding (Hahn *et al.,* 2003 and Omran and Fooda, 2013). Aboul Naga *et, al.* (2021a) under Upper Egypt reported that Saidi sheep and goats are considered in their comfortable zone when temperature-humidity index value is ≤ 74 in moderate stress when temperature-humidity index values range from 75-78 under dangerous heat stress when temperature-humidity index is 79-83, and ≥84 is under emergency heat stress. Also, under the New Valley in Governorate; Dakhla, Kharga, and Farafra the values of THI were from (101.8 to 103.8) for White sheep and goats. In addition, it reported that desert sheep and goats are producing and reproducing successfully under the environmental stress of hot dry areas, where they have been raised and selected naturally for centuries. Desert goats seem to tolerate physical stress under hot dry conditions (simulating summer grazing on poor pasture), better than desert sheep Aboul Naga *et, al.* (2021b). Moreover, Khalil and Omran (2018) reported that; The influence of CC on THI values was observed in different three regions (Lower Egypt, Middle Egypt, and Upper Egypt) during the period from 2016 up to 2060 giving evidence for significant changes in THI values during the period from 2046 to 2060. Also, they reported that classifications of THI during the study period indicated the Moderate class. And shows a significant gradual increase with time in all studied governorates where its reached highest percentage in the last period (2046 - 2060) and none HS class percentage tends to decrease in all governorates on the account of increasing the Mild heat stress and Moderate heat stress. The main objectives of the present work were: 1) Pout description of the climate of Egypt. 2) Assess the physiological performance of domestic ruminants regarding climatic challenges under the environmental conditions of Egypt.3) Suggest of recommendations for ruminants with different levels of THI characteristic of different regions under study were presented, this included the major required modification in nutrition, housing, or both to increase animal productivity or maintain it.

MATERIAL AND METHODS

Relying on estimating the evidence of temperature and humidity index (THI) is an essential factor for maintaining the physiological performance and productive efficiency of animals in general, and its importance has increased with climate changes and expectations of many scenarios for lack of production and an increase in the food gap, in

addition to the lack of animal numbers due to the high mortality rate at young ages and the geographical location of Egypt made it clearly affected by changes. The climate, especially in the last eight years (from 2015 to 2023), increased waves of heat stress (HS), severe heat stress (SHS) and very severe heat stress (VSHS), and decreased cold waves but they are very strong waves. Their consequences affect the agricultural sector plants and animal productions are so bad. The efficiency of the performance of farmed animals; the buffalo, cows, goats, and sheep under the climatic conditions in Egypt allows them to bear higher values of THI.

Monthly visits were carried out from (2010) to (2022). Data collection was accomplished by a team of researchers from the Animal Production Research Institute and Central Laboratory for Agricultural Climate Institute, as the following (5 villages x 5 different point x 2 visited each center x almost 7 centers within each Governorate). The visits occurred monthly to recording Physiological parameters: (respiration rate RR, r/min and rectal temperature RT, °C, Hematological parameters: hematocrit value (Ht, %) for Buffaloes and Cows while Goats and Sheep recording respiration rate RR, r/min only. And recording the Meteorological data including air temperature (AT, °C), relative humidity (RH, %), which leads to calculate the temperature humidity index (THI) during the experimental period using equation of Mader *et al.* (2006) as following:

$$THI = (0.8*T) + [(RH100) * (T- 14.4)] + 66.4$$

Where: T is air temperature (°C), RH is the relative humidity (%).

The visit was recorded using GPS. The THI values have been classified in to sevens classes according to (Omran and Fooda, 2013).

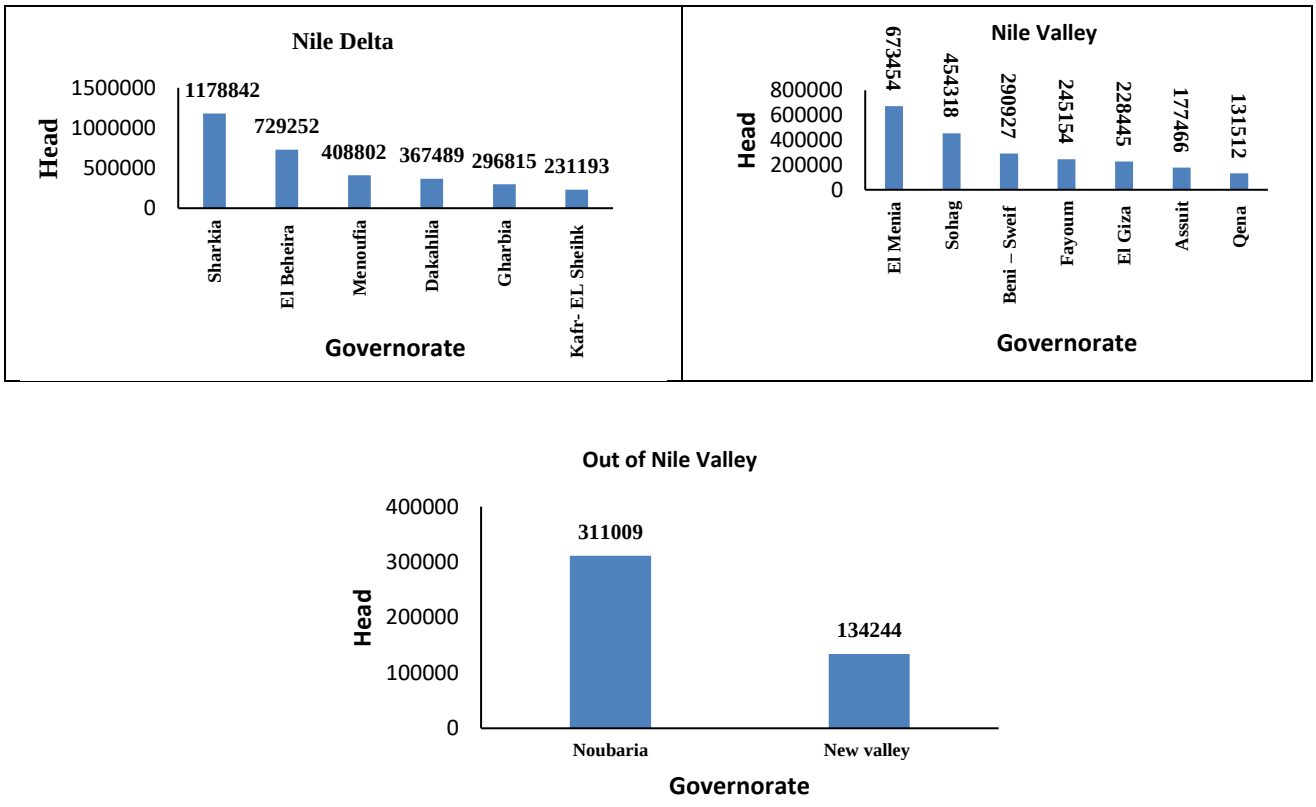

Fig. 1. Number of animals in Governorates under study (EAS, 2022)

Statistical Analysis:

Data concerning RT, RR, and Ht estimates were analyzed by SAS (2002) according to the following model:

$$Y_{ij} = \mu + A_i + E_{ij}$$

Where: Y_{ij}: observation on the j^{th} animals of the i^{th} type of animals, μ: Overall mean, A_j: fixed effect due to the type of animal (1= Buffaloes, 2= Cows, 3= Goats and 4= Sheep), and E_{ij}: random error assumed N.I.D. (0, $\sigma^2 e$).

RESULTS

Under environmental conditions in Egypt classified THI in Table (1). Classification of THI according to Omran and Fooda (2013) in Egypt; seven classes from THI: The value differs between THI in the cooled and thermo-neutral was15.6 unit of THI this value was the highest increased value between the classes of THI. From thermo-neutral to Mild heat stress the value of HTI increased by 4.4 units. While the increase between Mild heat stress and Moderate heat stress value was 9.9 units, from Moderate heat stress to heat stress the value increased by 4.2 units, from heat stress to severe heat stress the value increased by 6.6 units, and the value increased by 4.9 units between severe heat stress and very severe heat stress. Within the three climatic regions; the lowest values recorded were in the region out of Nile Valley, and the highest values were in the Nile Delta region was a higher level of relative humidity RH (%) reflected on THI values.

Table 1. Values of temperature/ humidity index (THI) under environmental thermo climatic conditions inEgypt from (2010 to 2022) in Nile Delta, Nile Valley and Out Nile Valley.

Class of climatic Conditions	Nile Delta	Nile Valley	Out Nile Valley	Average
Cold	60.20	57.60	54.10	57.30
Thermo- neutral	74.40	73.00	71.30	72.90
Mild heat stress	79.77	76.60	75.50	77.30
Moderate heat stress	89.92	86.70	84.90	87.20
Heat stress	98.12	89.74	86.31	91.40
Sever heat stress	101.45	97.92	94.77	98.00
Very sever heat stress	110.50	100.30	97.92	102.90

Respiration rate RR had been considered the first indicator of the physiological status of animals under environmental conditions and heat tolerance of cattle could be measured. And following it rectal temperature RT add to hematological reaction; hematocrit Ht. In table (2) Values of THI was ≤ 57.3 waves are called Cold stress; physiological (RR &RT) and hematological Ht responses for buffaloes and cows, while goats and sheep measuring physiological responses RR only shown that; the values of RT and Ht was significantly higher in cows than buffaloes, while values of RR in goats was higher significant than buffaloes, cows and sheep, respectively.

Table 2. Mean ± SE for respiration rate (RR), rectal temperature (RT) and hematocrit (Ht) for buffalo and cows but, for goats & sheep only RR under Cold stress (THI=57.3).

Items	Buffaloes	Cows	Goats	Sheep
Physiological				
RT, °C	37.00±3.10^{b}	38.00±.4.32^{a}	-	-
RR, r/ min	22.83±2.20^{c}	25.73±2.50^{b}	29.11±3.10^{a}	25.95±3.20^{b}
Hematological				
Ht, %	29.50±3.50^{b}	32.48±3.50^{a}	-	-

Mean values of groups for each item with different superscripts in the same column are significantly different (P ≤ 0.05).

In Table (3) the values of RT were significant in cows than buffaloes, while Ht value was significant in buffaloes than cows, the values of RR were significantly between all species, the values respectively cows, sheep, goats, and buffaloes. The higher values were caws and the lower values were buffaloes.

Table 3. Mean ± SE for respiration rate (RR), rectal temperature (RT) and hematocrit (Ht) for buffalo and cows but for goats & sheep only RR under Thermo-neutral (THI=72.9).

Items	Buffaloes	Cows	Goats	Sheep
Physiological				
RT, °C	37.5 0±.340^{b}	38.53±.4.90^{a}	-	-
RR, r/ min	20.03±2.90^{d}	27.14±3.10^{a}	24.13±2.30^{c}	26.67±3.10^{b}
Hematological				
Ht, %	30.14±3.10^{a}	28.96±3.50^{b}	-	-

Mean values of groups for each item with different superscripts in the same column are significantly different (P ≤ 0.05).

In Table (4) the values of RT were significant in cows than buffaloes while Ht the value was significant in buffaloes than cows., the values of RR were significantly between all species the values respectively cows, sheep, goats, and buffaloes. The higher values were cows and the lower values were buffaloes

Table 4. Mean ± SE respiration rate (RR), rectal temperature (RT) and hematocrit (Ht), for buffalo and cows, but for goats & sheep only RR under Mild heat stress (THI=77.3).

Physiological				
RT, °C	37.64±4.90^{b}	38.80±3.90^{a}	-	-
RR, r/ min	21.63±2.40^{d}	28.93±5,7^{a}	25.01±2.30^{c}	27.71 ±3.00^{b}
Hematological				
Ht, %	29.79±2.80^{a}	27.68±1.9^{b}	-	-

Mean values of groups for each item with different superscripts in the same column are significantly different (P ≤ 0.05).

In Table (5) the values of were significant in cows than buffaloes while Ht, the value was significant in buffaloes than cows., the values of RR were significantly between all species the values respectively sheep, goats, cows and buffaloes. The higher values were sheep and the lower values were buffaloes.

Table 5. Mean ± SE respiration rate (RR), rectal temperature (RT) and hematocrit (Ht) for buffalo and cows, but for goats & sheep only RR under Moderate heat stress (THI=87.2).

Items	**Buffaloes**	**Cows**	**Goats**	**Sheep**
Physiological				
RT, °C	38.5 7±4.20^{b}	39.22±3.70^{a}	-	-
RR, r/ min	25.47±2.30^{d}	29.44±2.70^{c}	32.56±3.40^{b}	34.83±3.90^{a}
Hematological				
Ht, %	28.99±2.90^{a}	25.81±2.80^{b}	-	-

Mean values of groups for each item with different superscripts in the same column are significantly different (P ≤ 0.05).

In Table (6) the values of was significant in cows than buffaloes while Ht the value was significant in buffaloes than cows., the values of RR were significantly between all species the values respectively sheep, cows, goats and buffaloes. The higher values were sheep and the lower values were buffaloes.

Table 6. Mean ± SE respiration rate (RR), rectal temperature (RT) and hematocrit (Ht), for buffalo and cows, but for goats & sheep only RR, under heat stress (THI=91.4).

Items	**Buffaloes**	**Cows**	**Goats**	**Sheep**
Physiological				
RT, °C	38.39±3.90^{b}	39.83±3.20^{a}	-	-
RR, r/ min	28.95±2.50^{d}	35.05±3.90^{b}	34.45±3.70^{c}	36.87±3.60^{a}
Hematological				
Ht, %	28.66±2.80^{a}	24.59±3.30^{b}	-	-

Mean values of groups for each item with different superscripts in the same column are significantly different (P ≤ 0.05).

In Table (7) the values of RT were significant in cows than buffaloes while Ht the value was significant in buffaloes than cows., values of RR were significantly between all species the values respectively sheep, goats, cows and buffaloes. The higher values were sheep and the lower values were buffaloes.

Table 7. Mean ± SE respiration rate (RR), rectal temperature (RT) and hematocrit (Ht) for buffalo and cows, but for goats & sheep only RR under severe heat stress (THI=98).

Items	Buffaloes	Cows	Goats	Sheep
Physiological				
RT, °C	39.09±4.20[b]	40.16±4.20[a]	-	-
RR, r/ min	30.84±2.90[d]	38.73±3.50[c]	47.42±3.90[b]	59.79±4.90[a]
Hematological				
Ht, %	28.13±2.10[a]	22.68±2.00[b]	-	-

Mean values of groups for each item with different superscripts in the same column are significantly different (P ≤ 0.05).

In Table (8) the values RT was significant in cows than buffaloes while Ht the value was significant in buffaloes than cows., the values of RR were significantly between all species the values respectively sheep, goats, cows and buffaloes. The higher values were sheep and the lower values were buffaloes.

Table 8. Mean ± SE respiration rate RR, rectal temperature RT and hematocrit Ht, for buffalo and cows, for goats & sheep only RR under Very sever heat stress (THI=102.9).

Items	Buffaloes	Cows	Goats	Sheep
Physiological				
RT, °C	39.53 ±4.10[b]	40.59 ±4.30[a]	-	-
RR, r/ min	40.73±3.80[d]	56.94±4.50[c]	59.0 3±4.90[b]	65.67±5.90[a]
Hematological				
Ht, %	27.74±2.50[a]	20.26±2.00[b]	-	-

Mean values of groups for each item with different superscripts in the same column are significantly different (P ≤ 0.05).

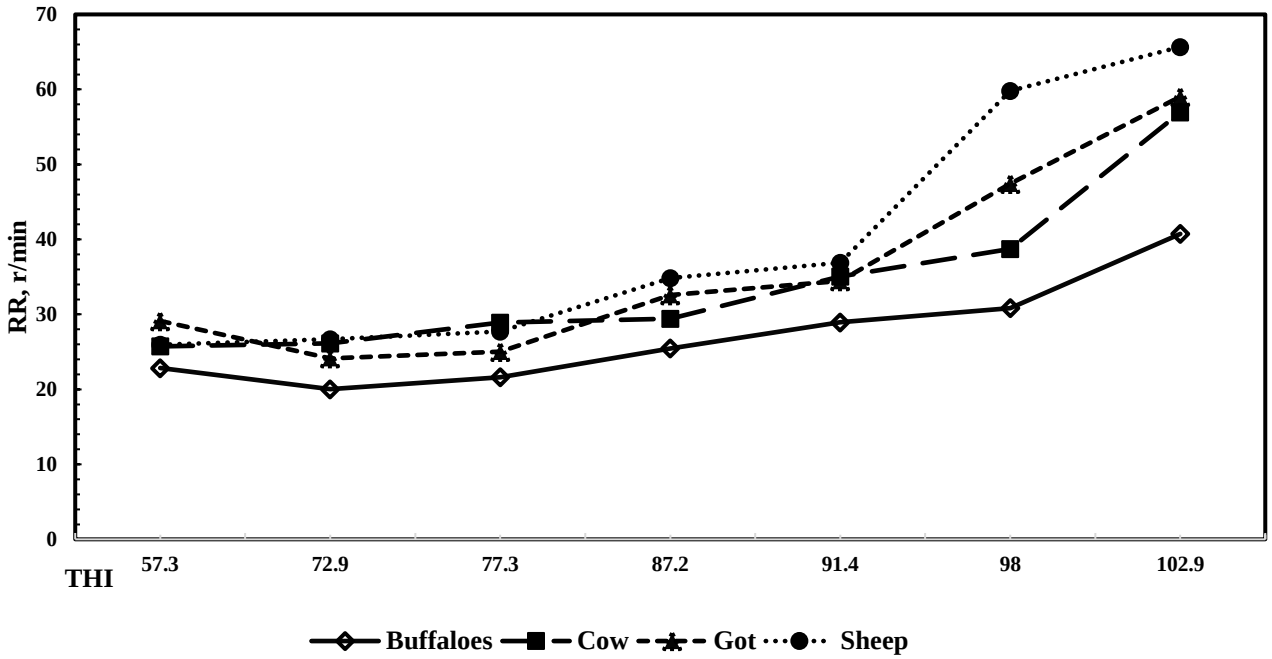

Fig. 2. Animal respiration rates RR recorded within different classes index of (THI) under environmental conditions in Egypt.

Figure (2) explains the relation between rater RR of domestic ruminant species, and the different levels of THI under environmental conditions in Egypt:

- Cold stress (CS); the buffalo have the lowest values, cows and sheep highest than buffaloes and two at the same point, while goats had the highest values in RR.

- Thermo-neutral (TN); the buffaloes are less than goats while cows and sheep have the same point in RR and the cows a little higher than sheep.
- Mild heat stress (MS); the buffaloes are less than goats, while cows and sheep have the same point in RR and the sheep a little higher than cows.
- Moderate heat stresses (MHS); the lowest values of RR in buffaloes. Goats lower than sheep and higher than cows and the highest values were sheep.
- Heat stress (HS); the RR of buffaloes are lower values. The values of sheep were higher than cows, goats respectively.

Sever heat stress (SHS); the shock of buffalo under these conditions is almost identical to cold shock, although it still has a lower RR. There are wide differences in the increase in RR between the three type's cows, goats and sheep, which recorded the highest RR.

Very severe heat stresses (VSHS); the RR increased in buffalo, and it is still the lowest value despite the critical conditions that the animal was going through. Values of RR increase in cows at a critical rate. Matching goats at the same point of increase in a lesser, the sheep have the highest RR we need rapid intervention with severe and very severe heat stress because these are critical conditions for the preservation of the animals.

DISCUSSION

Descripted of the climate of Egypt:

With climatic changes and increase in earth's temperature, many scenarios and expected for this increase. The wide difference between the class values of THI under Cold heat stress and Thermo-neutral conditions for animal performance. These values of evidence of THI values we can say their disappearance year after year with the continuous increase in the Earth's temperature., and this makes a start of the classification of THI under the environmental conditions in Egypt is; the Mild heat stress, Moderate heat stress (Khalil and Omran, 2018) under Egyptian environmental conditions., With repetition waves from cold stress and Thermo-neutral during THI values Mild heat stress. In addition, waves from Heat stress, Sever heat stress, and very severe heat stress during Moderate heat stress.

Depending on the months of the year, Moderate heat stress (8 months) starting from second half of April until the first half of December. Waves from Heat stress, severe and very severe heat stress it is happening during this period and the most clarity are waves from Heat stress. The months of June, July, August, and September it is characterized by high relative humidity due to waves from severe and very sever heat stress intermittent waves. Mild heat stress (4 months) starting from second half of December until the first half of April, Waves from cold stress, Thermo-neutral and Heat stress. The most of period Thermo- neutral, waves of cold stress clearly show in January and the first half of February and waves of Heat stress clearly shows at intervals within March and the first half of April.

Performance of domestic ruminants Under Egyptian environmental conditions:

Incidence of VSHS at different periods and locations include all climatic regions in Egypt, such stress increases the ability of farm animals in Egypt to be more tolerant to the highest temperature and it showed the highest gene expression efficiency under highest values of THI, this reflected to animal production from milk or meat without highest drop with some modifications. Therefore, global THI is not suitable for evaluating the performance of ruminants under environmental conditions in Egypt.

This appeared clearly in the physiological performance, of farm animals more adapted to environmental conditions in Egypt and an unfair judgment for farm animals by using the global index guide, it clearly shows that the values of THI Moderate heat stress under environmental conditions in Egypt are equivalent or above values of THI Heat stress in the global THI. Omran and Fooda (2023) under Nile Valley environmental conditions reported that, the Comprehensive Climate Index (CCI) value was 42.95 from July to August these values maybe equivalent to MHS Moderate heat stress under Egyptian environmental conditions. The value of CCI was 40 from July to August under conditions in the United States that were severe heat stress. In addition, they found the Correlation coefficient (r) between THI and CCI Index under direct solar radiation in Egypt during July to August was (0.84) which confirms that THI is still the best, simplest climatic parameter. Farm animals show an increase in the values of RR and RT with an increase of THI while Ht decreased, observed for buffaloes, cows, goats, and sheep.

The sensitivity of buffaloes and goats to cold stress reduces the value of RR in buffaloes while the increase of goats RR due to metabolic body weight to maintain body temperature and bioactivity in their bodies under lower

ambient temperature. Values of RR for cows and sheep during cold stress indicate better conditions for physiological performance and enhance productive performance, with the availability of nutrition. With the first increase in the values of THI, RR and values were increasing, which proves the sensitivity of cows and sheep to any increase in temperature in the microenvironment around it, and cows were more sensitive.

Variation between species under the influence of different values of THI indicators showed that those species are more adapted to the Egyptian climate and their raped recovery from the effects of waves of cold or heat stress, due to the differences in RR within a small range for each species, which increases the efficiency of the domestic animal under the bad conditions in light of climatic changes.

Under artificial heat in the lab at (40°C and THI100), the buffalo calves BC and the Friesian calves FC calves exposed to heat stress show that the BC was a better and faster recovery in all measurements than FC (Omran *et. al.,* 2011a). Omran *et, al.* (2020) reported that among adaptive responses RR is a good measure to detect the response of an animal to any variation in the microenvironment around the animal, thus giving clear evidence of the better capacity of heat tolerance and similarly Ht from the hematological response. Added to this, the close relationship between THI and the tested responses including RR and Ht in particular revealed the ability to use those parameters as predictive measures for animal acclimation in each specific region. Accordingly, livestock holder has the choice to select the appropriate breed for rising to get efficient productivity according to compatibility with his farm location.

The buffaloes under this study threshold were at THI ≤57.3 cause to increase sensitivity to cold stress and threshold when THI was 98 severe heats stresses. This shows the importance of the buffalo under bad weather (cold or hot) and we can say that it is an animal of climatic change. There must be increased attention to the buffalo because it is a primary source of milk and secondary meat production under harsh conditions and it is the first to the small breeder is the real owner of the livestock in Egypt, with the expected scenarios for the coming. It is also clear from the study that over approximately ten years, the trend for the values of THI for cold waves decreased by about 10.7 units, and an increase in the trend for the values of waves of severe heat stress by 7 units from the studded., it clearly appears that domestic animals are not only challenging the climate but that this challenge is constant and strong., its ability increases year after year. Omran and Fooda (2013) under the Middle Egypt environmental conditions reported that the values of THI >87 were critical for Friesian, while this threshold was at THI >91 for Buffaloes.

The best THI for production in both types is lower than 68 but Buffaloes start to be under cold stress at this threshold, Friesian which has been present for more than 60 years under Egyptian environmental conditions. In addition, Friesian is colder tolerant and heat susceptible than buffalos under natural environmental Egyptian conditions, the changes in RT ºC must be considered under natural environmental changes as it increased significantly by 1 ºC in Friesian when THI was >82, than animals maintain their heat balance through vasomotor control by regulating the amount of blood flowing through the coetaneous vessels by either vasodilation or vasoconstriction., Vasodilation stimulates the pilomotor center to flatten the hair cover to allow better heat dissipation through sensible means. Shafie and Omran (2018) for buffalo calve reported that loss from the surface of the body as a result of diffusion of water through the skin as insensible perspiration. Also, heat lost by evaporation through the lungs is affected by color, length, and density, efficiency of Tensor muscle for hair, and the thickness, and number of sweat glands in the skin. Omran *et. al.* (2017) under Nile Valley environmental conditions; reported that improving of feeding by using supplementing diets reduced the harmful effects of cold waves, helping to improve the physiological postpartum status and reducing the sensitivity of buffaloes to face climatic change.

The outcome of these physiological reactions and behavioral performances in the face of stress is reflected on the rate of growth. The morphological, anatomical, and physiological characteristics of buffalo are more suitable for hot conditions, and this agreement with Shafie (1993 a & b). Shafie and Omran (2018) under artificial heat in lab at (40 &25°C) resulted that, the skin of animals plays an important role in animal adaptation to with the cope surrounding environment. High negative correlation between the body weight of animals and skin weight but the correlation with hair was moderately positive, the weight of skin proportions the body weight to increase the dressing percentage. Also, the buffalo can change its morphology and histology to maintain bioprocess. And do not make any genetic change to the number of sebaceous or sweet glands but increase the efficiency and the body supply and nerve estimation, buffaloes change the thickness of skin, length of hair, number of hair follicles, color of hair to make acclamation with any conditions to make change the buffalo's characteristic to be suitable for different places to live. The body coat of an animal plays a major role in adaptation and production under climatic

conditions. Omran *et. al.,* (2019b) reported that THI values in the Nile Delta climatic conditions is higher than that of the Nile Valley due to higher relative humidity (RH%) in the Nile Delta, highly significant between phenotypic and morphometric variations between buffalo populations raised under Nile Delta and Nile Valley climatic conditions, values of THI was to play a prominent role in the variation of size between buffalo under different thermal conditions, pointing at the powerful impact of environmental conditions effect on phenotypic and morphometric characteristics of any specific breed.

The size and the surface area of the animal's body and skin color show special adaptation to environmental factors, and the differences found may simply be a reflection of the animal's environment (Borghese 2011). However, Hafez (1989) reported that the familiar variations of color in the animals are genetically controlled and result from qualitative modifications of melanin pigmentation The degree of such pigmentation can be associated directly with the climate, more precisely, the solar radiation, especially at high altitudes, and those animals inhabiting warm and humid regions show greater pigmentation than animals found in the cooler drier areas.

The morphological characteristics of hair coat are markedly influenced by climate, in the temperate zone; cattle have long, colored, and non-glossy hairs, in the tropics and subtropics, the indigenous cattle have short, glossy hairs ranging in Coburn from grey to fawn and yellow. The skin temperature is highly correlated with RR and it is a good measure of the microenvironment around the animals (Collier *et al*., 2006, 2008 and Omran and Hamdon, 2018). 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. The size and surface area of an animal's body show special adaptation to environmental factors. The extent of heat exchange between an animal and its surroundings depends partly on body surface area, resulting in the metabolic rate of an animal being routinely expressed in terms of kilocalories per square meter of body surface per hour.

Omran *et al.* (2011b) reported that buffalo under artificial heat stress in a lab at 40°C decreased visceral and non-visceral organ weight led to lower meat production to increase the efficiency to heat tolerance when the buffalo animal is exposed to stress for a long duration (chronic stress), they try to acclimatize in the adverse conditions. Acclimation involves phenotypic responses to environmental changes which are reflected in hormonal signals and also in alteration in target tissue responsiveness to hormonal stimuli. Added to the time required for acclimation varies according to tissue type and from a few days to several weeks, for example, changes in metabolism in response to heat stress occur over a few days.

Omran and Hamdon (2018) transported the Buffaloes from the Nile Delta to out the Nile valley they reported that the buffaloes can acclimatize to transportation stress during the first year after transportation, but need three seasons to be acclimatized regarding total milk yield and curve of lactation. Omran and Fooda (2023) under Nile Valley environmental conditions on buffalo dams during dry the period reported that the percentage increase in the THI value has a greater effect on the hematological responses compared to the physiological response, it agrees with the direction of the data under the study Also, they found that the stress of exposure to direct solar radiation reduces average of daily milk by 0.800 g/day and average of birth weight was 10Kg with increased values of THI by10 unit. They added that, heat stress caused by direct exposure to solar radiation may be the reason leading to abortion by 20%. They recommended that buffalo adaptation to climatic changes under any environmental conditions must be considered in this critical period. Also, the suitable shades above animals and sinks are needed to protect them from direct solar radiation. We can maintain milk and meat production from buffaloes with bad environmental conditions.

Omran *et al,* (2019c) reported that the best climatic conditions for the buffaloes and cows are between 71- 74 THI under the three climate regions (Lower, Middle, and Upper Egypt), added to the higher animal consumption of water was noticed in Lower Egypt and the lower consumption was in Upper Egypt. Cows were superior than buffaloes in consumption water and feed in the three climatic regions including the two ages. And concluded that it is still possible to maintain or increase meat and milk production from buffaloes and cows under different climatic regions, particularly in Upper Egypt (UE), with available suitable shades above animals, and shading watering to protect from solar radiation direction with climatic change. Gaughan *et al.,* (2008) reported that sheep and goats can survive and reproduce longer under hot, dry conditions than other livestock. They rely on their behavioral and physiological adaptive mechanisms to heat stress. Sheep can tolerate water deprivation for up to 7 days and survive without food for more than 4 days under hot summer conditions. Additionally, Galal *et al.* (2005) reported that Saidi sheep and Saidi goats are the indigenous Upper Egypt breeds. They are raised in small flocks and are tolerance to heat stress and the prevailing hot dry environment. Also, Khalifa *et al.* (2005) reported

that sheep and goats are thought to be less susceptible to environmental stress than other domesticated ruminant species they are widely distributed in regions with diverse climatic conditions and possess unique characteristics such as water conservation heat metabolism capability, higher sweating rate, lower basal higher respiration rate, higher skin temperature, constant heart rate and constant cardiac output, Goats are a very good example of a domestic animal that is highly adapted to harsh conditions. Silanikove (2000) postulated that goats living in harsh environments represent a climax in the capacity of domestic ruminants to adjust to such areas. Again, this ability is multifactorial, while the performance in terms of growth rate is greatly reduced, low body mass and low metabolic requirements of goats can be regarded as important assets in minimizing their maintenance and waste requirements in areas where water sources are widely distributed and food sources are limited by their quantity and quality. In addition to ability to reduce metabolism allows goats to survive even after prolonged periods of severely limited food availability.

A characterization of the different climatic regions in Egypt according to THI levels and suggested modification to maintain animal productivity:

- **Cold stress THI ≤ 57.3:**

Adaptation to cold is part of the ability of animals to maintain stability by feedback control mechanisms, long –term adaptations can be considered as modification of homeostatic regulations. Under Egyptian conditions the cold waves are, lasting from 48 hours to several days, and most of the time the prevailing is almost Thermo- neutral conditions. And some day's waves from Mild heat stress. Over time, temperatures may continue to rise than the expected scenarios. What is known as cold stress is: that waves occur at this time of the year, its two months in a year from the second half of December until the half first of February.

Under the cold waves, animal production declines although increase in feed intake this is because metabolic energy goes toward warming the animal body, producing milk, or preparing for a new milk season, and the fetus if the animal is in the last period of pregnancy.

The RR decreases due to conditions, Water intake (WI) decreases due to the availability of green fodder. Lower the air temperature despite the increase in urine production due to increased metabolic activity to warming. The buffaloes and goats are sensitive to cold waves. While cows and sheep it is good conditions

The modification: 1-supplementing diets; reduce the harmful effects of cold waves, and help to improve physiological status during cold weather, animals' appetite may be stimulated and feed intake increases to fulfill the body's requirement of energy, but the efficiency of energetic feed utilization still under optimum level for milk production. Therefore, improving rumen fermentation and digestibility of feedstuff using specific supplements to upgrade energy production at the low cost of feeding will be beneficial to reducing cold stress on animals. This sensitivity increases especially with climatic change.

2- Hosing; As well as in some climatic regions, especially at night and early morning when reaches zero or below zero they use artificial sheds to protect the animals from cold, which increases the feed utilization this reflected to increase the milk production, birth weight, and reproductive activity without any drop. While cold waves are characterized by cows and sheep the best conditions have no problems but the availability of good nutrition is very good and highest in milk production, birth weight, and reproduction. The animals used chemical methods to increase metabolic activity. The best of them are cows and sheep almost the same effect followed by buffaloes and goats. The buffalo had the lowest RR and the goats had the highest RR due to metabolic body weight to maintain body temperature. While cows and sheep same point according to RR.

- **Thermo - neutral (THI 72.9):**

A short period during the year (Few days or weeks) could be considered an ideal period for small or large ruminants to resume the highest production. This period from the second half of February until the first half of April, occurs at frequent intervals waves from Mild heat stress. The milk production, birth weight, reproduction, and RR are not any problem, and it's a wave in Mild heat stress., as some of the performance with there is little change in production, reproduction, and birth weight we can say there is no problem. A normal RR increases slightly in cows due to high sensitivity to any change in temperature, while in buffaloes, goats, and sheep it is in the best conditions without any problem. The consumption of food is natural but the WI increased slightly under Mild heat stress. The Thermo- neutral conditions decrease towards until 2050 and disappear year after year, and become Mild heat stress its climate conditions. We do not need to modify the animals using natural methods of heat dissipation to maintain their body temperature by convection, conduction, and radiation without any stress.

Under Egyptian conditions, Egypt is good receives to what is happening around it. In the world including winds, storms, earthquakes, volcanoes, avalanches, hurricanes, and low air conditions in addition to human activities, etc., this is due to its geographical location. Therefore, impact of climatic change on climate of Egypt is rapid and variable.

According to animal RR are Buffaloes and goats followed by cows and sheep as same points under these conditions.

- **Mild heat stress (THI 77.3):**

The period from the second half of February until the first half of April, lasts from 72 hours to 10 days. These waves also appear during October and November, with less extreme waves of HS at intermittent periods. It is expected to increase until the year 2050; The milk production, birth weight, reproduction, RR feed intake (FI), and (WI) still have no problems under these conditions, and do not need any modification each breeder deals with the conditions of his farm according to its location and important suitable shades above animals.

The roof must be raised from 5.5 to 6 meters this is the height standard to get rid of the bad effect of the nature of the roof material, because each region has material of the roof suitable for it. We recommend the following: under any time or any region from year, shading watering to protect from solar direction radiation because it maintains the salinity and acidity of water. In addition, the feeding when exposed to direct solar radiation raises the temperature of the feed, which leads to chemical activity for a long time, and toxins are present. The height of the shaded is 2 meters from the highest point of the animal's body.

Production under these conditions increases or maintains for it whiteout any deceased. The cows are affected faster than sheep by a change from cold stress to Thermo- neutral conditions, while sheep are affected faster than cows under mild heat stress due to the high sensitivity of cows to any change in the surrounding environment this is for cross cows and pure Friesian adapted to, the conditions of the Egyptian farmer for thousands of years. The best animals according to RR are buffaloes, goats, sheep, and cows as same points under these conditions.

- **Moderate heat stresses (THI 87.2):**

These are the longest periods of the year, starting from the second half of April to the first half of December, during this period; we are exposed **to three** waves : HS, another difficult wave of SHS stress and a third danger waves of heat VSHS, this waves is problem for animals. The stage of MHS includes three waves the ranges from 48 to 72 hours, or a few days, or a week to maximum 10 days and the true problem following at close intervals.

Under these environmental conditions; the beginning of stress and problems in the animal's production and reproduction, drop in birth weight, mortality, distribution in hematological responses and blood metabolism, Also, these beginning of animal's use of physiological methods (more activation to the normal thermoregulation reaction i.e. increased RR at the moment, increased sweating and RT, causing disturbances in the feed metabolism, reduced FI, feed efficiency, feed utilization and increased WI and body water content., so animals needed to protect to maintain the production and this is the real beginning of the importance of modifications in helping animals under bad conditions. According to animal RR, the most resistant species to MHS are buffaloes, cows, goats, and sheep under these conditions.

- **Heat stress (THI 91.4)**:

Waves inside the MHS at a minimum of 48 hours to and a maximum from 3days to 10 days, then it decreases for a period and returns a second time, and it is the most apparent during the year within MHS. These waves gradually increase in the months of (June, July, August, and September) and maybe its appearance in October. However, it is not apparent from November to the first half of December. The physiological methods used by strong., The real beginning of a decline in milk production, reproductive, and a clear decrease in birth weight, which could result in the death of the calves, dry of milk, or abortion especially if animals are exposed to chronic waves of heat stress and follow waves from SHS and VSHS. There are many ways to relieve HS, such as spraying by cold water, watering cold waters, diuretics, diaphoretics, hormones, antioxidants, and others, and each type has advantages and disadvantages, and there are conditions for safe use. But the best and safest for the animal healthy and a good product using; the supplementing diets or housing or both due to the climatic region in which it fits the type of animal and animal sauté. The supplementing diets reduce the harmful effects of heat waves, help to improve physiological status.

The housing: the highest roof 5.5 to 6 meters reduces the negative impact of the roof material, and the dirt land without bedded, or cement it's under the animal played an important role in gashouse emission to micro-environmental conditions around an animal that was also influenced in production due to reduces heat emission

from land and this increased the heat in micro-environmental conditions. In closed housing, the height of the ventilation for 1 to 1.5 meters from the highest point in the animal's body. The buffaloes alone show the lowest RR, goats, cows, and sheep at approximately one point especially goats and cows, as seam point and cows are followed by sheep at one point. According to animal RR, the most resistant species to HS are buffaloes, goats, cows and sheep under these conditions.

- **Sever heat stress (THI 98.0):**

Difficult waves inside the Moderate heat stress in the months of (June, July, August, and September) intermittent and lasted from 48 hours to 3 to 4 days. Very clear increase in RR, RT, sweating, WI and decreased of FI, due to reduce of milk production (quality and quantity) and meat production (only quantity), birth weight, reproductive, loss of the fetus and stop the milking season or dry of the mother calves. This is very difficult especially if follow-up weaves from Heat stress long waves like waves 2015, 2020 2022, and 2023 in Egypt were exposed for those around it, from the sequence, we notice the speed of change occurring in the world around us, which led to the speed of receiver of winds and others around us from the world, the most difficult waves of 2015, and this is not because of its strength, but because it was the real beginning of SHS and VSHS waves.

The first difficult Waves were 2015, after 5 years in 2020, after 2 years in 2022, and after one year in 2023. This difference explains the speed of the occurrence of climate change and the speed of the receiver of its consequences. Modification to maintain production without any significant decrease by using the supplementing diets and housing it is necessary to use both together, with available suitable shades above the animal's height or roof material suitable for the climate region, and shading watering, and feeding to protect from solar radiation direction, and cleanliness of the place, and applying the biosafety under these conditions very important, Addition to providing cold watering. The buffaloes had the lowest RR, cows were higher than them, while goats were higher than them, and sheep had the highest RR the reaction between each type and another was big and clear.
According to animals RR are the resistant species to SHS buffaloes, cows, goats, and sheep under these conditions.

- **Very severe heat stress was (THI≥102.9):**

Dangerous waves (lasting 24 to 48 hours) require rapid help by cold watering, available green forages, silage, and salt mold inside the barn. Appropriate housing and diet supplement should also be practiced specially in dry regions. The increase in RR and disturbances in physiological performance and metabolism; Here the problem increases loss is not a decrease in production only but also loss the animal dames or calves. The decrease in the quantity of meat, and milk and a decrease in the number of animals just; but the quality of the milk decreased due to it affects the manufacturing of dairy products, while meat like meat veal due to low fat, increased of tenderness, fiber smooth and decreased internal and external viscera increased the rate of in the carcass whit maintaining the proportion of protein, vitamins and minerals.

A successful breeder must maintain the feeding system and additives, as well as housing systems, and follow up on new ones so that he does not have significant losses during periods of different stress, cold or hot. Buffaloes are the lowest in respiration rate, despite the noticeable increase in RR. The cows have a noticeable increase, and at one point with goats, sheep increased in RR, but the increase were greater clearly in SHS like cows and this reflects that cows and sheep are highly sensitive to heat stress compared to buffalo and goats. The animals live and produce without a significant decrease in production, under these harsh conditions, with the help of basic modifications in nutrition and housing. The best animals according to RR are buffaloes, cows, goats, and sheep under these conditions.

CONCLUSION

The THI is still the best indicator for evaluating the efficiency of the physiological performance of ruminants under environmental conditions of Egypt. It is not appropriate to evaluate the domestic ruminant by using the global THI.
There must be increased attention to buffalo as the essential milk and meat producer (Regarding the expected scenarios). It is necessary to preserve the genetic origins of Egyptian farm animals due to their ability to withstand climatic changes conditions regardless of their productivity. In Egypt, the expected THI trend towards 2050 includes Mild, as well as, moderate heat stress. It is expected that Mild heat stress could be interrupted by waves from cold waves and thermo-neutral. The moderate heat stress is expected to be interrupted by waves from Heat stress, Severe and Very severe heat stress especially during the months characterized by high relative humidity.

Cows were highly sensitive to any change in micro-environmental conditions. Buffalo had the lowest respiration rate under all levels of the THI. Buffalo and goats were sensitive to cold waves. Otherwise, cows and

sheep were sensitive to heat waves. Suitable housing and appropriate diet supplement are necessary to withstand stresses (cold or hot). Shading of watering and feeding troughs is recommended for protection from direct solar radiation. Cleaning of the place is also recommended throughout the year round. Providing cold watering and applying the biosafety measures are also essential during the times of heat, severe and very severe stresses. Recommended it is not fair to evaluate the performance of domestic ruminants on the basis of the global THI. It is shown that buffalo and goat are efficient under the conditions of climate changes of Egypt. Further adaptation studies for both species are needed.

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التحديات المناخيه للمجترات المحلية تحت الظروف المناخية في مصر وعلاقتها بدليل الحرارة والرطوبة.

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اجريت هذه الدراسه لاظهار كفائة الأداء الفسيولوجى للمجترات المحلية، والتحديات المناخية مع "دليل الحرارة والرطوبة" تحت ظروف البيئه المصرية فى ثلاث اقاليم مناخية مختلفة. اشتملت الدراسه على 15 محافظة من محافظات الجمهورية: دلتا النيل (6 محافظات) ,وادى النيل (7 محافظات)، وخارج وادى النيل (محافظتين)، حيث تم تنفيذ زيارت شهرية لهذه المحافظات خلال الفتره من 2010 إلى 2022، وقد قام بتجميع البيانات فريق عمل من معهد بحوث الانتاج الحيوانى، والمعمل المركزى للمناخ الزراعى، حيث تم تقييم الأداء الفسيولوجى للحيوان (من خلال تسجيل قياسات معدل تنفس الحيوان فى الدقيقة - درجة حرارة الجسم بالإضافة إلى سحب عينة دم لإجراء تقديرات هيماتولوجى الدم متضمنة تقدير نسبه الهيماتوكريت فى الجاموس والابقار (المجترات الكبيره)، بينما تم فى الاغنام والماعز (المجترات الصغيره) تسجيل الاداء الفسيولوجى من خلال معدل التنفس فقط، كذا – فقد تم تسجيل درجات حرارة الهواء والرطوبه النسبيه لحساب دليل الحرارة والرطوبة.

واستهدف البحث:-

1- وضع توصيف لمناخ مصر .
2- تقييم الأداء الفسيولوجى للمجترات المحليه وكفائتها فى مجابهة التحديات المناخية "مع دليل الحراره والرطوبه" تحت ظروف البيئة المصرية.
3- طرح التوصيات الملائمة للمجترات مع مستويات دليل الحراره والرطوبه باختلاف المناطق تحت الدراسه وتتضمن تعديلات فى التغذية أو إسكان او الاثنان معا للوصول الى اعلى انتاجيه للحيوان اوعلى الاقل الحفاظ على الانتاج .

هذا – وقد قد اظهرت النتائج ما يلى:-

- مازل دليل الحرارة والرطوبة هو افضل مقياس لكفائة الأداء الفسيولوجى للمجترت تحت الظروف البيئيه فى مصر.
- ليس من الصائب تقييم أداء المجترات المحلية تحت ظروف البيئة المصرية باستخدام دليل الحرارة والرطوبة العالمى.
- الاتجاه نحو 2050 يصبح التصنيف لدليل الحراره والرطوبه تحت الظروف المصريه كما يلى:- إجهاد حرارى خفيف - اجهاد حرارى متوسط..ويتخلل الاجهاد الحرارى الخفيف موجات من الاجهاد الحرارى البارد والاجواء المثلى. و الاجهاد الحرارى المتوسط يتخلله موجات من الاجهاد الحرارى - والاجهاد الحرارى الشديد -والاجهاد الحرارى الشديد جداً فى الشهور عاليه الرطوبه النسبية.
- تميز الجاموس باقل معدل تنفس تحت جميع المستويات من دليل الحرارة والرطوبة .
- أظهرت النتائج حساسية الجاموس والماعز للموجات الباردة، بينما اتضحت حساسية الأبقار والأغنام للموجات الحارة.
- أظهرت النتائج أيضاً أهمية الإسكان واستخدام الاضافات الغذائية تحت ظروف الإجهاد البارد أو الحار.
- يوصى أيضاً بتغطية أحواض الشرب وأماكن التغذية لحمايتها من اشعه الشمس المباشرة، ونظافة المكان بوجه عام المكان تحت كل الظروف، ذلك .بالاضافه الى شرب الماء البارد، وتطبيق معايير الأمان الحيوى فى اوقات الإجهاد الحرارى - والإجهاد الحرارى الشديد - والشديد جداً.
- الجاموس والماعز اكفاء فى الاداء الفسيولوجى مع التغيرات المناخيه ونحن فى حاجه الى زياده دراسات الاقلمه عليهم .

الكلمات المفتاحية: التحديات المناخية، مؤشر درجة الحرارة والرطوبة المصري (THI)، المجترات، ووصف المناخ المصري.