Egyptian Journal of Veterinary Sciences
https://ejvs.journals.ekb.eg/

Influence of Temperature-Humidity Index, Annual, and Seasonal Scenarios on Performance, Bulk Milk Portfolio, and Financial Impacts of Egyptian Holstein Cows

Ferial M. Sahwan[1], Ghada G. Afifi[2], Eman M. El-Ktany[3*] and Sarah A. Abou-Alella[4]

[1] *Department of Animal Husbandry and Wealth Development (Animal Breeding and Production), Faculty of Veterinary Medicine, Alexandria University, Egypt.*
[2] *Department of Genetic Engineering and Biotechnology Research Institute, Sadat City University, Egypt.*
[3*] *Department of Animal Husbandry and Wealth (Veterinary Economics and Farm Management), Faculty of Veterinary Medicine, Alexandria University, Egypt.*
[4] *Department of Food Hygiene and Control, Faculty of Veterinary Medicine, Alexandria University, Egypt.*

Abstract

IN THIS STUDY, the impacts of temperature-humidity index (THI), year and season were assessed on the performance of Holstein cows and their bulk milk portfolio at an Egyptian dairy farm using bulk tank milk data. The dataset involved 10,000 lactation records for Holstein cows, from January 2019 to December 2020. The lower dry matter intake (DMI), daily milk yield (DMY), and milk feed ratio (MFR) averages were achieved at THI>72. Furthermore, the bacteriological parameters including TBC and coliform count reached lower levels in bulk milk at THI≤72. The DMI and DMY were significantly affected by the year, while MFR and milk composition were not affected. The greatest DMI, DMY and MFR averages were observed in winter and spring, while improved milk composition was achieved in winter and autumn. The DMI was significantly affected by THI with lower values when THI>72 for the fresh and high-yielding cows. The DMY was significantly affected by THI>72 for all cows, however, the greatest effect was observed for the high-yielding cows (31.81kg/day). High economic losses in daily milk production were recorded in the high-producing cows at high THI>72 due to heat stress. The THI has a considerable impact on both the performance and bulk milk parameters of Holstein cows in Egypt with high economic losses in daily milk production especially in the high-producing cows which are highly impacted by heat stress.

Keywords: Coliforms, economic losses, Holstein cows, Milk yield and quality, THI.

Introduction

Nowadays, bovine milk is considered one of the highest production systems in Egypt. It constitutes nearly about 52.11% of whole milk produced in Egypt [1]. Among highly lactating breeds, Holstein Friesian cows contribute considerably to milk production and the dairy industry in Egypt. In addition, they are considered the highly prevalent type in the commercialized Egyptian dairy herds, and the most susceptible to heat stress and the existing climatic variables [2]. As a result of growing attention, Egyptian consumers and producers have come to be more mindful of the type, composition, quality, nutritive value, and safety of the milk they drink. In addition, milk price usually depends on its compositional quality and therefore the management systems of Egyptian dairy farms often aim to produce high-quality milk in association with improved quality and safety [3].

It is well known that the nutritional benefit of milk particularly based on milk portfolio (fat and solid not fat, protein, lactose, minerals, vitamins, enzymes, and pigments) [4]. Generally, this portfolio

*Corresponding author: Eman Mohamed El-Ktany, E-mail: eman.elkataeny@alexu.edu.eg, Tel. 01094677883
(Received 26 February 2024, accepted 22 August 2024)
DOI: 10.21608/EJVS.2024.272784.1875

is influenced by several factors such as heat stress, stage of lactation, breed, herd, management, feeding, year, and season [5].

Exposing dairy cows to higher levels of environmental temperature and relative humidity for prolonged periods hinder their ability to disintegrate heat, leading to heat stress. The hot weather is one of the most important reasons that could adversely affect milk yield, milk composition and dry matter intake of dairy cows, especially in high-yielding cows [6]. Heat stress is usually associated with a decline in the productive performances and feed conversion efficiency of dairy cows due to its effects on thermo-regulation mechanisms to avoid hyperthermia [7]. There are numerous indicators for assessing heat stress, but the most accurate one is the temperature-humidity index (THI).

In particular, the temperature-humidity index (THI) can be described as a special evaluation that illustrates the combined consequences of environmental temperature and corresponding relative humidity [8].

Generally, milk yield, milk composition, and feed intake are affected by heat stress when THI values are higher than 72, while A THI lower than 72 indicates an environment devoid of heat stress [9].

The reduction in the profit of dairy farms subjected to heat stress is not only a result of reduced milk production but also includes deteriorated milk quality, and augmented healthcare costs. The annual economic loss due to heat stress in the US dairy industry is about 897-1,500 million dollars [10].

Under Egyptian conditions, the studies on Holstein cows' performance and bulk milk traits did not present complete information about the relationship between THI and complete milk portfolio in association with milk price. They only focused on studying the effect of seasonal variations on dry matter intake and milk yield [11, 12, 13].

In our experience only few trials have explored the impacts of THI on dry matter intake (DMI), daily milk yield (DMY), milk and feed efficiency ratio (MFR), bulk milk portfolio (compositional quality, physicochemical and bacteriological parameters) and milk price for Holstein cows in Egypt. Moreover, this study involved a unique illustration of the relationship between all examined climatic variables and milk prices in Egypt. Thus, this study aimed to investigate the impact of THI and other microclimatic variables such as season and year on the performance parameters and bulk milk portfolio of Egyptian Holstein cows. In addition, the relations between THI and DMI, DMY, MFR, fat%, SNF, TS, specific gravity, pH, acidity%, TBC, total Coliforms, and milk prices were studied as indicators of the Egyptian economy.

Material and Methods

Dairy herd management

The data of this study were obtained from the performance records of multiparous Holstein cows (about 4,000 cows) covering the period from January 2019 to December 2020. Holstein cows were raised in a huge, commercialized herd placed at a private farm, located about 80 km on the Cairo-Alexandria desert road, Egypt. The study area has dry weather with rain falling in winter and hot-dusty winds or sandstorms may invade this area during spring [14]. Animals were housed free in yards fenced with shades. Cows were of higher parity (2^{nd}- 4^{th} lactation) and their body condition score (BCS) was on average 3.5-4 (scale of 1= thin and 5 = fat) [15]. The lactating cows were grouped according to average daily milk yield into fresh (from calving till 60 days post-partum), high-producing cows, and low-producing cows. Cows were fed a total mixed ration (TMR) throughout the year and concentrate feeding was offered according to their milk production. The TMR consisted of concentrates, corn silage, alfalfa hay, wheat bran, minerals, vitamins, and calcium bicarbonate. The Ingredients and chemical composition of the total mixed ration used for lactating Holstein cows were designed to meet the National Research Council [16]. Rations were offered twice daily, cows were machine milked three times a day at eight-hour intervals and milk yield was recorded for each cow daily via computerized milking units.

Barometric information:

Temperature- Humidity Index

The barometric information (the air temperature and relative humidity) was recorded daily throughout the two years of study, and The THI was computed according to the following National Research Council formula set by [17]:

$$THI = (1.8 \times T + 32) - (0.55 - 0.0055 \times RH) \times (1.8 \times T - 26)$$

Where T is the air temperature (◦C) and RH is the relative humidity (%). According to the value of temperature- humidity index (THI), two subgroups were created (T1 where THI≤72 and T2 where THI>72) [18]. The effect of THI on performance parameters (DMI, DMY, and MFR) and bulk milk parameters (compositional quality, sanitary, and bacteriological parameters) of the multiparous cows was estimated throughout the two years. Meanwhile, its effect was estimated only on the performance parameters (DMI, DMY, and MFR) of the three various groups (fresh, high, and low-yielding cows).

Determination of performance parameters (DMI, DMY, and MFR)

The average daily dry matter intake (DMI) for the Holstein cows and the various groups was obtained from the home-kept farm records, and was calculated by subtracting the refused from the offered feed. For estimating the effect of THI on the performance parameters of the multiparous Holstein cows, DMY for lactating cows in the herd was determined by dividing total milk from total lactating cows by number of lactating cows /days. The various groups, DMY was determined by dividing total milk from total lactating cows in each group by the number of lactating cows in each group/day.

The efficiency of conversion of feed to milk (MFR) was calculated by dividing the average daily milk yield by the average daily dry matter intake [19].

Determination of compositional quality parameters of bulk milk

Milk samples were obtained once daily from the bulk tank of the multiparous cows. The time elapsed between the collection and analysis was 36-72 hours. All samples were analyzed for fat, solid nonfat (SNF), and total solids (TS) contents (%) by the MilkoScan FT6000 (FOSS Electric, Hillerød, Denmark). The samples were tempered in a water bath at 45°C for 5 min., then mixed before reading and results compared with national standards of raw cow milk [20].

Determination of sanitary quality parameters of bulk milk

Samples of bulk milk were examined for specific gravity by using a portable density meter (DMA 35, Anton Paar GmbH, Tokyo, Japan).

The pH was determined by using a digital pH meter (LCD, Shanghai, China, model pH PHS-3C). Titratable acidity was determined as previously described by [21]. Determination of bacteriological quality parameters of bulk milk

Total bacterial count (TBC) and total Coliforms were applied by using the Petrifilm culture system (3M Canada, London, Ontario) according to [22]. Plates for enumeration of TBC were incubated at 32◦C for 48 h. Plates for total Coliforms were incubated at 32◦C for 24 h. All plates were read using an automated counter (3M Petrifilm Plate Reader, 3M Canada, London, Ontario). The total colony count per ml of the sample was calculated and registered as CFU/ml. All values of TBC and total Coliforms were log transformed according to this equation, TBC = log10 (TBC). The limit is fixed at an acceptable level according to Microbiological Standards for raw cow milk [23]. In the EU and US were (<5 and < 5/< 5.5 log cfu/ml milk) for TBC, and 1 log cfu/ml or non-detectable for total Coliforms.

Statistical analysis

Statistical analysis was performed by SPSS/PC+ "version 25" to estimate the effect of THI on the performance of Holstein cows, their bulk milk parameters and sanitary and bacteriological parameters based on the following linearity model:

$$Yijk = \mu + Ti + Sj + Yk + eijk$$

Where: Yijk = the dependent variable (DMI, DMY, MFR, milk compositional quality, sanitary and bacteriological parameters), μ = the overall mean of the model, Ti = effect of THI group (i = THI≤72; THI>72) [18], Sj = effect of season (j = Spring (March to May); Summer (June to August); Autumn (September to November); Winter (December to February), Yk = effect of year (k=2019; 2020), and eijk = the random error.

Furthermore, results were evaluated by SPSS/PC+ "version 25" for estimating the effect of THI on the performance parameters of Holstein cows about the effect of the group, the following fixed-effect model was used:

$$Yijkl = \mu + Gi + Tj + Sk + Yl + eijkl$$

Where: Yijkl = the dependent variable (DMI, DMY, and MFR), μ = the overall mean of the model, Gi = group (i= fresh; high; low), Tj = effect of THI group (j = THI≤72; THI>72), Sk = effect of season (k = Spring (March to May); Summer (June to August); Autumn (September to November); Winter (December to February), Yl = effect of year (l= 2019; 2020), and eijkl = the random error.

The significant differences among variable means were tested using Duncan's multiple range procedure (SPSS, Version 25) at 5% probability levels.

For evaluation of the economic effect of heat stress on daily milk yield (DMY) the following Formula was used:

The economic loss = Decline in DMY × Average milk price

The decline in DMY (Kg/cow) and Average milk price (LE and $/Kg).

Results and Discussion

The results of the current study established the fundamental role of heat stress and climatic conditions (year and seasonal variations) on the performance and bulk milk parameters of Holstein cows reared under Egyptian conditions.

The effect of THI on the performance of Holstein cows

The results in Table 1 show the effect of THI as an indicator of heat stress on the performance parameters of Holstein cows at 2 levels (THI≤72 and THI>72). The lower averages of DMI, DMY, and MFR were achieved at THI>72 to be 21.68, 30.72 kg/day and 1.41 compared with their higher values of 22.71, 33.22 kg/day and 1.46 at THI≤72, respectively. Furthermore, all the means of DMI and DMY were significantly affected ($p<0.05$) by THI except MFR.

Our results of the unfavorable effect of heat stress on milk yield agree with the estimates of [24] who found that the decline in milk yield was 0.2 kg per unit increase in THI when THI exceeded 72. Moreover, [25] in Lebanon confirmed that the performance of dairy cows, fed TMR daily, decreased when THI surpassed 72 with DMI, MY, MFR, fat, SNF and TS values of 20.50 kg/day, 27.69 kg/day, 1.35, 3.94%, 6.83%, and 10.77%, respectively. Our result is in the same line with [12] which showed that the DMY value was higher (25.7 kg/day) at THI≤72 than at THI>72 (17.6 kg/day) for Friesian cows in Beni-Suef, Egypt. Also, [13] revealed that the average DMY of Egyptian Holstein cows was higher in THI≤72 (31.91 kg/day) when compared with high THI (13.66 kg/day). A study of [26] found that the daily THI was negatively correlated to milk yield ($r = -0.76$) and feed intake ($r = -0.24$). Similarly, [27] found that the values of DMI and DMY were 16.9 and 17.03 kg/day at THI>78 and 19.9 and 19.73 kg/day at THI≤70.

The exposure of dairy cows to heat stress increases when the air humidity and temperature exceed the thermo-comfortable zone of the animal, thus resulting in difficulty in heat dissipation and causing a decline in feed intake by the animals [28]. Additionally, the reduction of DMI due to heat stress may be related to declines in the metabolic heat production, prolonged digestion, and shifting from lipid to glucose assimilation in the bodies of lactating cows [29].

The decrease in milk yield is most likely caused by a declined DMI and energy intake. The decline in DMI decreases the nutrients required for milk synthesis. So, milk production and yield are greatly affected [30]. It is established that glucose assimilation is more frequent in heat-stressed cows which could result in a reduction of glucose synthesis in the liver, a change in glucose revenue and amplified glucose demand for generating energy. This in turn could lead to a lowering of the accessibility of glucose for the mammary gland to synthetize lactose which is the main osmoregulatory and determining factor of milk yield. Therefore, decreased lactose and glucose levels result in reduced milk yield [31]. Furthermore, an elevation of body temperature of dairy cows during heat stress can indirectly affect milk yield by changing of hormonal level of lactogenesis like prolactin and thus may negatively affect milk yield [32].

The effect of THI on compositional quality parameters of bulk milk

The results in Table 1 demonstrate the impact of THI as a marker of heat stress on the compositional quality parameters of bulk milk for Holstein cows at 2 levels (THI≤72 and THI>72). In the present study, the mean values of fat, SNF, and TS% were relatively lower for THI>72 compared with THI≤72. In this context, the mean values of fat, SNF, and TS% were 3.20, 8.76 and 11.95% at THI>72, while their values were quite higher to be 3.25, 8.89, and 12.14% at THI≤72, respectively. Additionally, the whole means of compositional quality parameters of bulk milk were meaningfully influenced ($p<0.05$) by THI. According to Egyptian Standards of raw cow's milk (ES, 154|1|2005) fat, SNF and TS% of raw cow milk should be not less than 3, 8.25, and 11.25%, respectively. The obtained results reveal that all examined milk samples were compatible with the standards.

The deteriorating effect of exceeded THI on the compositional quality traits of bulk milk was also observed in other studies. For example, [18] showed that the fat content of milk of dairy cows in Croatia decreased significantly because of increased THI>72. Similarly, [24] reported a decline in the fat content of dairy cows in Georgia, USA by 0.012 kg for each unit of increase in THI above 72. Furthermore, the compositional components of milk were also increased with the decreased THI in a study of [12] who reported that the mean values of fat were (3.51 vs. 3.24%), SNF was (8.16 vs. 7.55%), and TS were (11.67 vs. 10.79%) for THI≤72 and THI>72, respectively. This result also agrees with [33] who reported that the fat content of bulk milk for Iranian Holstein cows was 3.36% at THI>72 which was lower than at THI≤72 (3.47%).

The interior metabolic heat production during lactation can reduce the resistance of lactating cows to sophisticated environmental temperatures as a heat stress factor, leading to the alteration of milk compositional quality traits [34].

A decrease in the fat content may be stimulated by a reduced ability of milk biosynthesis because of heat stress which can cause impairment of the secretory epithelium and alveolus system of mammary glands. Also, reduced fat may be due to the activity of lipase enzymes from leukocytic origin [35].

Exposing dairy cows to elevated THI could result in a decrease in SNF and TS levels of milk supplemented through either direct or indirect effects of heat stress on the conveyance of blood precursors to the alveolus system of mammary glands [36].

The effect of THI on sanitary quality parameters of bulk milk

The results in Table 1 reveal the influence of THI as a sign of heat stress on the sanitary parameters of bulk milk for Holstein cows at 2 levels (THI≤72 and THI>72). Accordingly, the mean values of specific gravity, pH, and acidity% were 1.03, 6.70 and 0.15%, respectively which were nearly similar at both levels of THI. In this study, all the values of acidity% are nearly compatible with [37] who confirmed that fresh milk has a titratable acidity of 0.14 to 0.16% expressed as lactic acid. Furthermore, our result of the milk pH agrees with the statement of [38] that recognized that the normal pH of fresh milk is between 6.5 and 6.8 which means that milk is a good growth medium concerning acidity (pH).

This result shows that THI did not have any significant effect on the sanitary parameters of bulk milk during heat stress. This result disagrees with those reported by [39] who found that there was an elevation in the milk pH (6.83) when THI was lower than 72. In contrast, [40] reported a decline in the pH value of milk for Italian Holstein cows (6.56) when THI was higher than 72.

Developed acidity is formed by the action of bacteria on lactose in milk and lactic acid is finally produced. Exposing dairy cows to heat stress might cause an increase in bacterial contamination in milk from the surrounding environment which can raise the milk acidity. Therefore, good hygienic practice is necessary during the milking process to decrease to some extent, the presence of microbial contamination in milk.

The sanitary parameters are the key elements that judge the hygienic and sanitary quality of bulk milk during production at dairy farms. Additionally, they are fundamental in the dairy industry as they must be continuously monitored to maintain the required milk quality standards and ensure food safety [41]. The results of normal acidity and pH indicate about maintaining the hygienic and sanitary quality of bulk milk in the examined herd.

The effect of THI on bacteriological quality parameters of bulk milk

The results in Table 1 describe the role of THI as a key element for assessing the effect of heat stress on the bacteriological parameters of bulk milk for Holstein cows at 2 levels (THI≤72 and THI>72) with an increasing effect on TBC and total Coliforms (log cfu/ml) of bulk milk reported for THI>72. Regarding this, the mean values (log cfu/ml) of TBC and total Coliforms were (6.7 and 2.7 log cfu/ml) vs. (5.5 and 2.5 log cfu/ml) for THI>72 and THI≤72, respectively. Additionally, the bacterial counts of bulk milk were significantly influenced ($p<0.05$) by THI. The obtained TBC values in this study exceeded the borderline of 5-5.5 log cfu/ml for TBC and 1 log cfu/ml for Coliforms, as secured by Microbiological Standards for raw cow milk [23] when THI surpassed 72.

This finding is higher than those reported by [39] who confirmed that there was a weak correlation between THI and the average TBC in Italian bulk milk which was 2.6 log cfu/ml at the lower THI class. In Egypt, [12] reported that the highest count of total Coliforms in bulk milk (3.9 logs cfu/ml) was recorded at THI>72, while the lowest was (2.3 logs cfu/ml) at THI≤72 and these findings are in the same line with our results. Comparably, [42] found a positive relation between THI and TBC and revealed a significant difference at THI above and below 72.

Under Egyptian climatic conditions, it is well recognized that heat stress usually happens in warm weather due to higher levels of temperature and humidity in the surrounding environment which in turn increases the level of bacterial contamination. Thus, bacteria can enter the teats during milking and then increase their numbers [43].

The effect of the year on the performance of Holstein cows and their bulk milk

The results in Table 2 show the effect of the year (2019 and 2020) on the performance and compositional quality parameters of bulk milk for Holstein cows. Regarding to this, the average values of DMI and DMY were significantly affected ($p<0.05$) by the year and were greater during 2020 compared with 2019. Accordingly, the mean values of DMI and DMY were (21.88 vs. 22.18 kg/day) and (31.35 kg/day vs. 31.81 kg/day) in 2019 and 2020, respectively. In contrast, in both years they had no effect on MFR which was 1.43. Concerning the bulk milk compositional traits, fat, SNF and TS% were (3.20, 8.84 and 12.04% in 2019) and (3.23, 8.77 and 12.04% in 2020). Although these values were greater in 2019 than in 2020 however, there were no significant differences in the efficiency of conversion of feed to milk (MFR) and the compositional quality traits of milk between the two years. This result is in the same line with those recorded by **[44]** who found that milk components (fat, SNF and TS) remained stable from January 2014 to December 2016 in Brazilian dairy farms under investigation. In contrast, [42] studied the effect of years (from 2003 to 2009) on milk fat and found that there was a significant variation in fat% in relation to the year with the highest ($P<0.001$) levels of fat (3.95, 3.93, and 3.92% recorded in 2009, 2007 and 2004, respectively. It is suggested that the milk yield of the herd improved throughout the years under this study, perhaps due to the slight increase in the number of cows in the year and variation in climatic conditions between the years.

The effect of the season on the performance of Holstein cows and their bulk milk

The results in Table 2 reveal the effect of the season (winter, spring, summer, and autumn) on the performance and compositional quality parameters of bulk milk for Holstein cows. In this context, the season had a significant effect on all the performance parameters. Winter and spring seasons showed the highest DMI, DMY, and MFR while autumn and summer seasons showed the lowest of these traits. This finding points to the importance of green fodder season in improving milk productivity which is usually available in winter and spring. The mean values of DMI were (22.80, 22.75, 21.37, and 21.21 kg/day) for winter, spring, autumn, and summer, respectively. The mean values of DMY were (33.80, 33.27, 29.79, and 29.48 kg/day) for spring, winter, autumn, and summer, respectively. Furthermore, the mean values of MFR were (1.49 in spring, 1.46 in winter, and 1.39 in (autumn and summer), respectively. Similarly, [11] found that the high milk yield of Friesian cows under Egyptian conditions was obtained in winter and spring seasons while the lowest milk yield was achieved in the summer and autumn seasons. Also, the results of [45] indicated that Holstein- Friesian cattle in the winter season produced a higher milk yield than the summer season.

Regarding the effect of the season on milk compositional quality parameters, our results reveal that the season had a significant effect (P<0.05) on milk components. Winter and autumn seasons showed higher milk components (fat%, SNF%, and TS %) than those reported during spring and summer seasons.

The mean values of fat% were (3.34, 3.25, 3.15, and 3.13%) for autumn, winter, spring, and summer, respectively. Concerning SNF% in milk, the mean values were 8.89% in winter, 8.79% in (autumn and spring), and 8.73% in summer. Furthermore, the mean values of TS% were 12.14, 12.13, 11.94, and 11.86% for winter, autumn, spring, and summer, respectively. This finding is nearly compatible with those obtained by [42] who reported that the values of fat% of bulk milk of Italian Holstein cows were 4.01 and 3.79% in winter and autumn which were higher than in spring (3.85%) and reached the lowest level in summer (3.74%).

Our findings of the effect of season on milk components are consistent with those reported by [26] where they found that milk fat was lower for the summer season. Also, [46] confirmed that milk fat and total solids in cow milk were the highest during winter and the lowest during summer. Furthermore, [47] studied the effect of season on milk constituents in Dutch dairy cows and found that TS and SNF% were dramatically reduced with the increased heat stress conditions. Moreover, [48] showed that the mean values of fat% and TS% in winter were 3.6 ± 0.055 and 12.4 ± 0.071 and in summer were 3.1 ± 0.058 and 11.1 ±0.092, respectively.

A decrease in milk fat, SNF and TS% throughout warm climates could be ascribed to the decrease of DMI, and subsequent energy intake, which could lead to a significant decrease in milk biosynthesis [36]. Furthermore, the DMY and compositional quality parameters of bulk milk may differ based on the season where the milk is produced. Seasonal features certainly impact the herd managemental system, since during quite wet and warm seasons the cows can freely graze in pastures, in contrast to dry and cold seasons in which the cows are restricted.

One of the leading factors for the dropdown of fat% in spring is the increasing frequency of calving and the increase in number of fresh cows compared with other seasons. Additionally, fat content in milk can be changed based on the level of milk yield which is usually influenced by sunlight days and rises in association with increasing day length. Therefore, it is important to consider in this study that decrease in milk compositional parameters reported in spring could be associated with increasing in milk yield because of the prolonged daylight, with a consequential reduction of fat content [49]. Regarding the 2 years (2018 and 2019) the mean value of DMY in spring was the highest 33.80 kg/day compared with that recorded during other seasons of the year.

The dropdown in milk compositional quality traits during the summer is related to the undesirable effect of hot weather on milk biosynthesis of milk nutrients. Furthermore, the habit of grazing by lactating cows most frequently occurs in summer, when THI is high. Therefore, it is necessary to assess the responses of cows to heat stress during the summer season **[**27**]**.

The effect of THI on DMI, DMY, and MFR concerning the effect of cow group.

The results in Table 3 describe the effect of THI on the performance parameters (DMI, DMY, and MFR) for groups of Holstein cows (fresh, high, and low yielding cows) at 2 levels (THI≤72 and THI>72). Concerning the effect at THI≤72, the DMI of fresh cows was limited (20.48 kg/day) however, the DMY of these cows was high (35.43 kg/day). This may be due to cows in the early stage of lactation being able to convert more feed to milk efficiently (MFR=1.73) and producing high milk yield. The DMI and DMY of the high-yielding group were high (23.85 and 35.22 kg/day, respectively), while the values of DMI and DMY for the low-yielding group were the lowest (18.58 and 16.40 kg/day, respectively). Regarding the efficiency of conversion of feed to milk, the mean values of MFR were 1.73, 1.48, and 0.88 for the fresh, high, and low-yielding groups at THI≤72, respectively.

On the other hand, THI>72 showed a more decreasing effect on the levels of the performance parameters among groups than THI≤72. Consequently, the DMI values were 19.14, 22.30, and 18.13 kg/day while, the DMY values were 32.28, 31.81, and 14.88 kg/day for fresh, high, and low-yielding cows, respectively. By the same way, the mean values of MFR were 1.68, 1.44, and 0.82 kg/day for fresh, high, and low-yielding cows, respectively.

Practically, the effect of THI on DMI was significant ($p<0.05$) for the fresh and high yielding cows. The DMI was decreased by 1.34 and 1.55 kg/day for the fresh and high yielding cows, respectively. Furthermore, heat stress decreased DMI by 0.45 for the low yielding cows but was not statically significant.

Regarding the effect of heat stress on the milk yield, it was statically significant ($p<0.05$) for the three groups (fresh, high, and low yielding cows) however, the highest effect was observed for the high yielding cows (35.22 kg/day at THI≤72 and 31.81 kg/day at THI>72). Milk yield declined by 3.15, 3.41, and 1.52 kg/day for the fresh, high, and low groups, respectively. The decline in the efficiency of conversion of feed to milk wasn't statically significant for the fresh, high, and low yielding cows.

The findings of the adverse effect of heat stress on milk yield and feed intake are consistent with the findings of [50] who found that the heat stress adversely affected the quantity of milk during the first 60 days of lactation and the high-yielding cows were more susceptible than the low-yielding cows. Also, [51] reported that high- yielding dairy cows, as well as cows during peak production, were adversely affected by heat stress. Furthermore [52] found a significant relationship between THI and milk yield for cows in different lactations. The cows countenance the risk of heat stress and milk production can be decreased by as much as 50% when the environmental temperature is above the body temperature.

Generally, high-yielding cows are more susceptible to heat stress than low-yielding cows, as both feed intake and milk production increase thermoneutral zone shifts to a lower temperature. So, the physical and biochemical processes to counter stress and maintain thermal equilibrium adversely affect the milk production of these cows [53].

In addition, heat stress can affect milk composition and yield particularly in high yielding cows by increasing the level of lactic acid in their rumen and so, decreasing pH and then hindering bacterial growth, and causing metabolic disorders in the rumen that can lead to suppressing milk production [54].

Economic losses in daily milk yield (DMY) due to heat stress

The following equations explain the economic losses in daily milk production due to heat stress. The remaining inputs were kept constant. (THI>72) for the three groups (Fresh, high, and low yielding cows).

A. Fresh Group

Economic loss = Decline in DMY (3.15 kg/cow) x Average milk price (0.36$/kg) (6.78 LE/Kg)

= 3.15 x 0.36$ (6.78 LE/Kg) = 1.13$/cow/day (21.36 LE/cow/day).

B. High-producing group.

Economic loss = Decline in DMY (3.41 kg/cow) x Average milk price (0.36$/kg) (6.78 LE/Kg)

= 3.41 x 0.36$(6.78 LE/Kg) = 1.23$/cow/day (23.12 LE/cow/day).

C. Low-producing group.

Economic loss = Decline in DMY (1.52 kg/cow) x Average milk price (0.36$ LE/kg) (6.78 LE/Kg)

= 1.52 x 0.36$(6.78 LE/Kg) = 0.55$/cow/day (10.30 LE/cow/day).

From the previous results, we notice that the economic losses in DMY/cow recorded the highest value (1.23 $) in the high-yielding group followed by the fresh group (1.13 $) and the lowest value (0.55 $) was recorded in the low-lactating group. These results run in the same line with those reported by [53] who reported that the high- producing cows were more susceptible to heat stress than low-producing ones. So, the high decline in DMY which was recorded for the high-producing cows resulted in high economic losses for this group.

However, we propose additional studies using similar multivariable approaches with further Egyptian dairy farms, for prolonged intervals and using various techniques to recognize the impact of microclimatic parameters on the bulk milk traits in extra detail. Furthermore, we need to connect the climatic conditions with the milk's functional profile like coagulation, fat separation, boiling off and fermentation properties. This will suggest a desirable correlation between the environment and the dairy industry by improving milk composition, milk quality, milk safety and economy.

Conclusions

We conclude that THI had a significant effect on DMI, DMY and bulk milk portfolio with an economic impact on the daily production of Egyptian Holstein cows. The decline rates in the performance and bulk milk parameters were more negatively influenced by THI>72 than THI≤72. Although THI>72 caused the most terrible milk parameters in terms of composition (Fat, SNF, and TS%), as well as bacteriological quality (TBC and total Coliforms), it did not effect on the feed efficiency and the sanitary parameters of bulk milk. Furthermore, high-producing cows were highly affected by heat stress with significant economic impacts on milk production and price. Although the annual variations had relative impact on DMI and DMY, they did not affect the feeding efficiency and the milk composition. Concerning the scenarios of season, winter and spring had the most desirable effect on DMI and DMY, while winter and spring caused the most superior milk composition. All milk traits noticed in the summer season signify a threat of exceeding the Egyptian restrictions for milk commercialization. This may result in a reduction of the milk price, which in turn will cause economic losses for the dairy farmers. These findings might be useful for dairy producers, permitting them to implement specialized management policies to minimize heat stress and to reach the optimal performance of dairy cows. Additional studies should shed some light on the safety profile of bulk milk to ensure human health. Also, we should investigate the linkage between high THI and milk functional parameters in relation to the dairy industry such as protein coagulation, creaming up, fermentation, churning and boiling off.

Acknowledgement

For all colleagues in the department.

Funding statement

Self-funded

Conflicts of interest

There are no conflicts to declare. The authors declared no competing interests.

Authors' contribution

FMS planned the research study, explained the data, and drafted the manuscript. GGA participated in assembling of data and wrote the manuscript. EME organized, analysis of data, conducted and interpreted the statistical part of data, calculate economic losses, writing and revision. SAEAA played a role in interpreting the data, writing, and checking this manuscript, and organizing it for publication in the journal.

TABLE 1. The effect of THI on performance parameters (DMI, DMY, and MFR) and bulk milk portfolio (compositional quality, sanitary quality, and bacteriological quality parameters) of Holstein cows

		Performance parameters			Bulk milk Portfolio							
					Compositional quality			Sanitary quality			Bacteriological quality	
	N	DMI Mean (SE)	DMY Mean (SE)	MFR Mean (SE)	Fat% Mean (SE)	SNF% Mean (SE)	TS% Mean (SE)	Sp.Gr. Mean (SE	pH Mean (SE)	TA% Mean (SE)	TBC Mean (SE)	TC Mean (SE)
THI≤72	250	22.71 [a] (0.04)	33.22 [a] (0.10)	1.46 [a] (0.00)	3.25 [a] (0.01)	8.89 [a] (0.01)	12.14 [a] (0.01)	1.03[a] (0.00)	6.70 [a] (0.01)	0.15 [a] (0.00)	5.5 [b] (2.3)	2.5 [b] (1.6)
THI>72	480	21.68 [b] (0.04)	30.72[b] (0.10)	1.41 [a] (0.00)	3.20 [b] (0.01)	8.76 [b] (0.01)	11.95 [b] (0.01)	1.03[a] (0.00)	6.71 [a] (0.00)	0.15 [a] (0.00)	6.7 [a] (3.3)	2.7 [a] (1.5)

N: Number of days; DMI: Dry matter intake (kg/day); DMY: Daily milk yield (kg/day); MFR: Milk feed ratio (kg DMY/kg DMI); SNF: Solid nonfat (%), TS: Total solids (%); Sp. Gr: Specific gravity; TA%: Titratable acidity (%); SE: Standard error; TBC: Total bacterial count (log cfu/ml); TC: Total *Coliforms* (log cfu/ml).

*Means within the same column bearing different superscripts are significantly different at (p<0.05).

TABLE 2. The effect of year and season on performance parameters (DMI, DMY, and MFR) and bulk milk compositional quality parameters (Fat, SNF, and TS%) of Holstein cows.

Climatic changes	N	Performance parameters Mean (SE) DMI	DMY	MFR	Milk compositional quality Mean (SE) Fat%	SNF%	TS%
Year							
2019	365	21.88^b (0.05)	31.35^b (0.12)	1.43^a	3.20^a (0.01)	8.84^a (0.01)	12.04^a (0.01)
2020	365	22.18^a (0.03)	31.81^a (0.12)	1.43^a	3.23^a (0.01)	8.77^a (0.01)	11.99^a (0.01)
Season							
Winter	179	22.80^a (0.03)	33.27^b (0.08)	1.46^a	3.25^b (0.01)	8.89^a (0.01)	12.14^a (0.01)
Spring	184	22.75^a (0.03)	33.80^a (0.11)	1.49^a	3.15^c (0.01)	8.79^b (0.01)	11.94^b (0.02)
Summer	184	21.21^d (0.04)	29.48^d (0.08)	1.39^c	3.13^c (0.01)	8.73^c (0.01)	11.86^c (0.01)
Autumn	182	21.37^c (0.03)	29.79^c (0.08)	1.39^c	3.34^a (0.01)	8.79^b (0.02)	12.13^a (0.02)

N: Number of days; DMI: Dry matter intake (kg/day); DMY: Daily milk yield (kg/day); MFR: Milk feed ratio (kg DMY/kg DMI); SNF: Solid nonfat (%), TS: Total solids (%); SE: Standard error.
*Means within the same column bearing different superscripts are significantly different at ($p<0.05$).

TABLE 3. The effect of THI on the performance parameters (DMI, DMY, and MFR) for the various groups of Holstein cows (fresh, high, and low yielding cows).

Holstein cows THI	Performance parameters Mean (SE) DMI	Decline	DMY	Decline	MFR	Decline
Fresh yielding						
THI≤72	20.48^c (0.19)	1.34	35.43^a (0.36)	3.15	1.73^a (0.02)	0.05
THI≤72	19.14^d (0.16)		32.28^b (0.51)		1.68^a (0.02)	
High yielding						
THI≤72	23.85^a (0.17)	1.55	35.22^a (0.51)	3.41	1.48^b (0.02)	0.04
THI>72	22.30^b (0.19)		31.81^b (0.48)		1.44^b (0.02)	
Low yielding						
THI≤72	18.58^e (0.14)	0.45	16.40^c (0.16)	1.52	0.88^c (0.01)	0.06
THI>72	18.13^e (0.06)		14.88^d (0.15)		0.82^c (0.01)	

THI: Temperature-humidity index; DMI: Dry matter intake (kg/day); DMY: Daily milk yield (kg/day); MFR: Milk feed ratio (kg DMY/kg DMI); Decline (THI≤72 - THI≤72) (kg/day).
*Means within the same column bearing different superscripts are significantly different at ($p<0.05$).

References

1. FAOSTAT. 2015. http://faostat3.fao.org/browse/Q/QL/E, retrieved 15th November 2015.
2. Elischer, M., History of dairy cow breeds–Holstein. (2014) http://msue.anr.msu.edu/ news/history_of_dairy_cow_breeds_holstein.
3. Nasr, M.A.F., The impact of crossbreeding Egyptian and Italian buffalo on milk yield and composition under subtropical environmental conditions .*Journal of Dairy Research*, **83**,196-201(2016). https://doi.org/10.1017/S0022029916000194.
4. Fusco, V., Chieffi, D., Fanelli, F., Logrieco, A.F., Cho, G.S., Kabisch, J., Böhnlein, C. and Franz, C.M.A.P., Microbial quality and safety of milk and milk products in the 21st century. *Comprehensive Reviews in Food Science and Food Safety*, **19**, 2013–2049(2020). https://doi.org/10.1111/1541-4337.12568.
5. Bernabucci, U., Basiricò, L., Morera, P., Dipasquale, D., Vitali, A., Cappelli, P. and Calamari, L., Effect of summer season on milk protein fractions in Holstein cows. *Journal of Dairy Science*, **98**, 1815-1827(2015). https://doi.org/10.3168/jds.2014-8788
6. Casa, A., Ravelo, A., Assessing temperature and humidity conditions for dairy cattle in Cordoba, Argentina. *International Journal of Biometeorology*, **48**(1), 6 -9(2003).
7. Nardone, A., Ronchi, B., Lacetera, N. and Bernabucci, U., Climatic effects on productive traits in livestock. *Veterinary Research Communications*, **30**(1), 75–81(2006). https://doi.org/10.1007/s11259-006-0016-x

8. Nigm, A.A., Sadek, R.R., Sherien, A., Yassien M.A.M., and El-Wardani, M.A. Effect of climate change on test-day milk yield of Holstein cows maintained in the Nile Delta of Egypt. *Egyptian Journal Animal Production*, **52**(2),113–121 (2015).
9. Hammami, H., Bormann, J., M'hamdi, N., Montaldo, H.H. and Gengler, N., Evaluation of heat stress effects on production traits and somatic cell score of Holsteins in a temperate environment. *Journal of Dairy Science***,** **96**, 1844–1855 (2013). https://doi.org/10.3168/jds.2012-5947.
10. St-Pierre, N.R., Cobanov, B. and Schnitkey, G. Economic losses from heat stress by US livestock industries *Journal of Dairy Science*, **86**(E), 52–77 (2003). https://doi.org/10.3168/jds.S0022-0302(03)74040-5.
11. Sanad, S.I. and Afify, A.A. Comparing genetic parameters of Friesian milk production traits in commercial and state farms in Egypt. *Egyptian Journal of Agricultural Research*, **94** (4), 971-984(2016).
12. Zeinhom, M.A., Abdel Aziz, R.L., Mohammed, A.N. and Bernabucci, U. Impact of Seasonal Conditions on Quality and Pathogens Content of Milk in Friesian Cows. *Asian Australasian Journal of Animal Sciences*, **29**(8), 1207-1213 (2016). https://doi.org/10.5713/ajas.16.0143.
13. Nasr, M.A.F. and El-Tarabany, M.S. Impact of three THI levels on somatic cell count, milk yield and composition of multiparous Holstein cows in a subtropical region, *Journal of Thermal Biology*, **64**,73–77(2017). http://dx.doi.org/10.1016/j.jtherbio.2017.01.004.
14. Egyptian Metrological Authority, EMA. Environmental characterization of Alexandria governorate. Support for environmental management component of governorate, EEAA. Alexandria, Egypt (2017).
15. Garnsworthy, P.C. and Topps, J.H. The effect of body condition of dairy cows at calving on their food intake and performance when given complete diets. *Animal Science*, **35**, 113-119(1982).
16. National Research Council NRC. 2001. Nutrient Requirements of Dairy Cattle. 7th ed. National Academy Press, Washington, DC.
17. National Research Council NRC. 1971. A Guide to Environmental Research on Animals. National Academy of Sciences, Washington, DC.
18. Gantner, V., Mijić, P., Kuterovac, K., Solić, D. and Gantner, R. Temperature-humidity index values and their significance on the daily production of dairy cattle. *Mljekarstvo / Dairy*, **61**(1),56-63(2011).
19. Berry, D.P. and Crowley, J.J. Genetics of feed efficiency in dairy and beef cattle. *Journal of Animal Science*, **91**, 1594–1613(2013).
20. Egyptian Standard ES. 154-1/2005. Egyptian Organization for Standardization and Quality control. Raw milk the part 1. 2005; ES:154-1/2005.
21. Association of Official Agricultural Chemists AOAC, Official methods of analysis. 13th edition, The Association of Official Analytical Chemists, Inc., Washington, D.C., pp 25–78(2012).
22. Wehr, H.M. and Frank, J.F. Standard Methods for the Examination of Dairy Products, 17th ed. *American Public Health Association*, New York, USA(2004).
23. Microbiological Standards for Milk (FAO WHO, Codex Standard, 2000. Alimentarius Commission, 26th Session, Report of the 5th session of the Codex Committee on milk and milk products; Draft Revised Standard for Fermented milks.
24. Ravagnolo, O., Misztal, I. and Hoogenboom, G. Genetic component of heat stress in dairy cattle, development of heat index function. *Journal of Dairy Science*, **83**, 2120-2125(2000). https://doi.org/10.3168/jds.S0022-0302(00)75095-8.
25. Lasheen, M.E., Safwat, M.A. and Elsaadawy, S.A., Effect of Nutrition and Temperature Humidity Index on The Performance of Lactating Holstein Cattle. *Journal of Animal and Poultry Production*, **8**(8), 285 – 292(2017).
26. Bouraoui, R., Lahmar, M., Majdoub, A., Djemali, M., Belyea, R. he relationship of temperature-humidity index with milk production of dairy cows in a Mediterranean climate. *Animal Research*, **51**(6), 479-491(2002). https://doi.org/10.1051/animres:2002036.
27. Cowley, F.C., Barber, D.G., Houlihan, A.V. and Poppi, D.P. Immediate and residual effects of heat stress and restricted intake on milk protein and casein composition and energy metabolism. *Journal of Dairy Science*, **98**,356–2368 (2015). http://dx.doi.org/10.3168/jds.2014-8442.
28. Renaudeau, D., Collin, A., Yahav, S., Basilio, V., Gourdine, J.L. and Collier, R.J. Adaptation to hot climate and strategies to alleviate heat stress in livestock production. *Animal*, **6**,707–728(2012). https://doi.org/10.1017/S1751731111002448.
29. Eslamizad, M., Lamp, O., Derno, M. and Kuhla, B. The control of short-term feed intake by metabolic oxidation in late-pregnant and early lactating dairy cows exposed to high ambient temperatures. *Physiology & Behavior*, **145**(6), 64-70(2015). https://doi.org/10.1016/j.physbeh.2015.03.044.
30. Wheelock, J.B., Rhoads, R.P., VanBaale, M.J., Sanders, S.R. and Baumgard, L.H. Effects of heat stress on energetic metabolism in lactating Holstein cows. *Journal of Dairy Science*, **93**, 644-655(2010). https://doi.org/10.3168/jds.2009-2295
31. Baumgard, L.H. and Rhoads, R.P. The effects of hyperthermia on nutrient partitioning. *Proc. Cornell Nutrition Conference*, 93-104(2007).

32. Tao, S., Dahl, G.E., Heat stress effect during late gestation on dry cows and their caves. *Journal of Dairy Science*, **96** (7), 4079-4093(2013). https://doi.org/10.3168/jds.2012-6278.

33. Ghavi Hossein-Zadeh, N., Mohit, A. and Azad, N., Effect of temperature-humidity index on productive and reproductive performances of Iranian Holstein cows. *Iranian Journal of Veterinary Research*, **14** (2),106-112(2013).

34. Das, R., Sailo, L., Verma, N., Bharti, P., Saikia, J. and Imtiwati Kumar, R. Impact of heat stress on health and performance of dairy animals: *A Review Veterinary World*, **9**, 260-268(2016). https://doi.org/10.14202/vetworld.2016.260-268.

35. Li, N., Richoux, R., Boutinaud, M., Martin, P. and Gagnaire, V. Role of somatic cells on dairy processes and products: *a review. Dairy Science & Technology*, **94**(6), 517-538(2014). https://doi.org/10.1007/s13594-014-0176-3.

36. Bernabucci, U., Lacetera, N., Baumgard, L.H., Rhoads, R.P., Ronchi, B. and Nardone, A. Metabolic and hormonal acclimation to heat stress in domesticated ruminants. *Animal*, **4**,1167-1183. 1167–1183(2010). https://doi.org/10.1017/S175173111000090X.

37. Al-Zenki, S.F., Al-Mazeedi, H.M. and Al-Hooti, S.N. Quality and safety characteristics of milk sold in the state of Kuwait. *Journal of Food Processing and Preservation*, **31**, 702–713(2007). https://doi.org/10.1111/j.1745-4549.2007.00155.x.

38. Marouf, A.A.S. and Elmhal, S.I., Monitoring pH During Pasteurization of Raw Cow's Milk using Nd:YAG Laser. *International Journal of Advanced Research in Physical Science*, **4**(12), 1-4(2017).

39. Costa, A., De Marchi, M., Battisti, S., Guarducci, M., Amatiste, S., Bitonti, G., Borghese, A. and Boselli, C. On the Effect of the Temperature-Humidity Index on Buffalo Bulk Milk Composition and Coagulation Traits. *Frontiers in Veterinary Science*, **7**, 577758(2020). https://doi.org/10.3389/fvets.2020.577758.

40. Beux, S., Cassandro, M., Nogueira, A. and Waszczynskyj, N. Effect of THI on milk coagulation properties of Holstein-Friesian dairy cattle. *Revista Brasileira de Zootecnia,* **46**(5), 429-432(2017). http://dx.doi.org/10.1590/s1806-92902017000500009.

41. Picinin, L.C.A., Bordignon-Luiz, M.T., Cerqueira, M.M.O.P., Toaldo, I.M., Souza, F.N., Leite, M.O., Fonseca, L.M. and Lana, A.M.Q. Effect of seasonal conditions and milk management practices on bulk milk quality in Minas Gerais State – *Brazil. Arquivo Brasileiro de Medicina Veterinária e Zootecnia,* **71** (4), 1355-1363(2019). http://dx.doi.org/10.1590/1678-4162-10063.

42. Bertocchi, L., Vitali, A., Lacetera, N., Nardone, A., Varisco, G. and Bernabucci, U. Seasonal variations in the composition of Holstein cow's milk and temperature–humidity index relationship. *Animal*, 1-8(2014). https://doi.org/10.1017/S1751731114000032.

43. Jayarao, B.M., Pillai, S.R., Sawant, A.A., Wolfgang, D.R. and Hegde, N.V. Guidelines for monitoring bulk tank milk somatic cell and bacterial counts. *Journal of Dairy Science*, **87**(10), 3561-3573(2004). http://dx.doi.org/10.3168/jds.S0022-0302(04)73493-1.

44. Stürmer, M., Busanello, M., Velho, J.P., Heck, V.I. and Haygert-Velho, I.M.P. Relationship between climatic variables and the variation in bulk tank milk composition using canonical correlation analysis. *International Journal of Biometeorology*, **62**(9), 1663-1674(2018). https://doi.org/10.1007/s00484-018-1566-7.

45. Barozai, Y.H., Rafeeq, M., Baloch, H., Shahzad, I., Hilal, B., Abbas, F. and Jehan, M. Study on performance analysis of Holstein Friesian cattle under intensive management at government dairy farm, *Pishin, Balochistan. ABAH Bioflux.*, **3**(1), 65-70(2011).

46. Ozrenk, E. and Inci, O.S. The effect of seasonal variation on the composition of cow milk in Van Province. *Pakistan Journal of Nutrition*, **7**(1), 161–164(2008). https://doi.org/10.3923/pjn.2008.161.164.

47. Heck, J.M.L., van Valenberg, H.J.F., Dijkstra, J. and van Hooijdonk, A.C.M., Seasonal variation in the Dutch bovine raw milk composition. *Journal of Dairy Science*, **92**, 4745–4755(2009). https://doi.org/10.3168/jds.2009-2146.

48. Kabil, O.I., Ibrahim, E.M., El Barbary, H.A. and Ali, M.A. Effect of seasonal variation on chemical composition of Cow's milk. *Benha Veterinary Medical Journal*, **28**(1), 150-154 (2015). https://doi.org/10.21608/bvmj.2015.32728.

49. Dahl, G.E. and Petitclerc, D. Management of photoperiod in the dairy herd for improved production and health. *Journal of Animal Science*, **81**(3), 11–17(2003). https://doi.org/10.2527/2003.81suppl_311x.

50. Pragna, P., Archana, P.R., Aleena, J., Sejian, V., Krishnan, G., Bagath, M., Manimaran, A., Beena, V., Kurien, E.K., Varma, G. and Bhatta, R. Heat stress and dairy cow: impact on both milk yield and composition. International *Journal of Dairy Science*, **12**(1), 1-11(2017). https://doi.org/10.3923/ijds.2017.1.11.

51. Ben Salem, M. and Bouraoui, R. Heat Stress in Tunisia: Effects on dairy cows and potential means of alleviating it. South African *Journal of Animal Science*, **39**(5), 256-259(2009). https://doi.org/10.4314/sajas.v40i5.65351.

52. Gabbi, A.M., Peripolli, V., Cobuci, J.A., Fischer, V., Costa, J.B.G. and Jr McManus, C. Can meteorological variables affect milk production in different lactation orders of dairy cows in the Cfb climatic zone? A case study in southern Brazil. *Archivos De Zootecnia*, **66**, 271–278(2017). https://doi.org/10.21071/az.v66i254.2332.

53. Habeeb, A.A., Gad, A.E. and Atta, M.A. Temperature-Humidity Indices as Indicators to Heat Stress of Climatic Conditions with Relation to Production and Reproduction of Farm Animals. International *Journal of Biotechnology and Recent Advances*, **1**(1), 35-50(2018). https://doi.org/10.18689/ijbr-1000107.

54. Zhao, S., Min, L., Zheng, N. and Wang, J. Effect of Heat Stress on Bacterial Composition and Metabolism in the Rumen of Lactating Dairy Cows. *Animals,* **9**(11), 925(2019). https://doi.org/10.3390/ani9110925.

تأثير مؤشر درجة الحرارة والرطوبة والسيناريوهات السنوية والموسمية على الأداء وملف اللبن والآثار المالية لأبقار الهولشتاين فى مصر

فريال محمد صهوان[1] ، غادة جمال الدين عفيفي[2] و ايمان محمد القطعاني[1] و سارة عبد المحسن أبو العلا [3]

[1] قسم رعاية الحيوان - كلية الطب البيطري - جامعة الاسكندرية - مصر.

[2] قسم الهندسة الوراثية والبيوتكنولوجي - جامعة السادات - مصر.

[3] قسم الرقابة الصحية على الاغذية - كلية الطب البيطري - جامعة الإسكندرية - مصر.

الملخص

في هذه الدراسة تم تقييم تأثيرات مؤشر درجة الحرارة والرطوبة والسنة والموسم على أداء أبقار هولشتاين واللبن المنتج منها في مزرعة البان مصرية تضمنت مجموعة من البيانات ل 10000 سجل لأبقار هولشتاين خلال الفترة من يناير 2019 الى ديسمبر 2020. وسجلت المتوسطات الصغرى لمؤشرات DMIو DMYوMFRعند THI≥72. علاوة على ذلك ، وصلت المؤشرات البكتريولوجية بما في ذلك TBC وعدد القولونيات إلى مستويات أقل في اللبن عند THI≤72. تأثر DMI وDMY بشكل كبير بالسنة، في حين لم يتأثر MFR وتكوين اللبن. وقد لوحظت أكبر متوسطات DMI وDMY وMFR في الشتاء والربيع، بينما تم تحقيق تحسن في تكوين اللبن في الشتاء والخريف. تأثر DMI بشكل كبير ب THI مع قيم أقل عند THI>72 للأبقار حديثة وعالية الانتاج. تأثر DMY بشكل كبير ب THI>72 لجميع الأبقار، ومع ذلك، لوحظ التأثير الأكبر للأبقار عالية الانتاج (31.81 كجم / يوم). تم تسجيل خسائر اقتصادية عالية في إنتاج الحليب اليومي في الأبقار عالية الإنتاج عند ارتفاع THI>72 بسبب الإجهاد الحراري. وهذا يدل على THI له تأثير كبير على كل من الأداء ومعايير اللبن لأبقار هولشتاين في مصر مع خسائر اقتصادية عالية في إنتاج الحليب اليومي خاصة في الأبقار عالية الإنتاج والتي تتأثر بشدة بالإجهاد الحراري.

الكلمات الدالة: القولونيات ، أبقار هولشتاين ، الخسائر الاقتصادية ، إنتاج الحليب ، جودة الحليب ، الموسم ، THI ، السنة.