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THE INVESTIGATION OF RELATIONSHIP OF HEATING AND COOLING DEGREE HOUR CALCULATIONS FOR SOUTHEASTERN ANATOLIA REGION WITH ALTITUDE, LATITUDE AND LONGITUDE

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Abstract

Degree-day values can be calculated using climatic data. Thus, seasonal, monthly, daily and hourly energy requirements for heating and cooling in buildings can be calculated. The effect of outside ambient temperature can be determined by means of the degree-day method in determining the basic temperature values in buildings. The altitude and latitude affect significantly the temperature distribution in the Earth. Thus, the latitude and altitude values are required to determine the degree hour values.

This study was taken in 9 provinces located in the Southeastern Anatolia Region (SAR). The annual outdoor dry-bulb thermometer temperatures for a long period of nine provinces in the SAR were obtained to determine heating and cooling degree hour values according to the six different base temperatures. According to the suggested six different base temperature values, the cumulative long-term annual heating degree-hour (HDH) value was 50862 in total for Gaziantep province. The lowest cumulative long-term annual heating degree-hour value took place in Sanliurfa province as 39638. Also, the highest total cooling degree-hour (CDH) value took place in Sanliurfa province as 10886 degree-hour value and the lowest value took place in Sirnak province as 3909.

It was determined that there was not an exact linear or monotonous relationship between HDH and CDH values and altitude, latitude and longitude values. However, although it was seen that the relationship of CDH values with the altitude was not a formal linear or monotonous relationship, it was determined that CDH values decreased linearly together with the increasing altitude values when the values were examined.

Keywords: Altitude, Cooling, Degree-Hours, Heating, Latitude, Longitude

INTRODUCTION

The outside ambient temperature is important in the calculation of heating and cooling values in the energy use in buildings. The effect of outside ambient temperature can be determined by means of the degree-day method in determining the basic temperature values in buildings.

The degree-day method is a method used to estimate the heating and cooling values along with the energy consumption in greenhouses and farm buildings in addition to residential, commercial and industrial buildings (Kadioglu et al., 2001; Matzarakis and Balafoutis, 2004; Yildiz and Sosaoglu, 2007; Castaneda and Claus, 2013). The energy analyses needed in air-conditioning applications in buildings are determined based on climatic data. The realistic values can be achieved only when climatic data are taken into account to determine the energy that is required for air conditioning studies (Buyukalaca et al., 2001). Degree-day values can be calculated using climatic data. Thus, seasonal, monthly, daily and hourly energy requirements for heating and cooling in buildings can be calculated (Durmayaz and Kadioglu, 2003).

In addition to the effects such as humidity, the wind, solar intensity and the location of geographical formations to solar rays which are important parameters that affect the Earth's temperature distribution, the altitude and latitude also significantly affect the temperature distribution, and these effects should be taken into consideration in the determination of degree-day values (Erturk et al., 2015).

There is a significant relationship between altitude and heating and cooling degree-day method. Heating degree-day values increase as the altitude increases. On the contrary, it was determined that the relationship between altitude and the cooling degree-day method was not as strong as in heating degree values (Bulut et al., 2007).

In the Degree-Hour method, firstly the degree-hour values should be determined by a certain balance point temperature. The average hourly measurement values for many years are used for this. The balance point temperature is the outside ambient temperature in case heating or cooling is not needed in a building. Energy calculations are performed over a period of time in which the outside ambient temperature is lower than the balance point temperature (Alaca et al., 1999; Bayram and Yesilata, 2009).

In the degree-hour method similar to the degree-day method, the energy required for heating and cooling the poultry-house during broiler breeding according to different average balance point temperature values required by chickens in each breeding period is accepted to be in the direct proportion to the difference between the outside ambient temperature out of the poultry-house (T_0) and different average balance point temperature value (T_b). In this way, the energy required for heating and cooling the poultry-house during broiler breeding according to different average balance point temperature values required by chickens in each breeding period can be estimated (Ertürk, 2012; Erturk et al., 2015).

In this study, it was aimed to examine the relationship of heating and cooling degree-hour values calculated for 9 provinces in the SAR region for broiler breeding with the altitude, latitude, and longitude.

MATERIAL AND METHODS

The long-term annual meteorological data were received from the General Directorate of State Meteorology in nine provinces (Adiyaman, Siirt, Kilis, Gaziantep, Sanliurfa, Diyarbakır, Mardin, Batman) located in the SAR, and hourly heating and cooling degree-hour values were determined for each province according to 6 different indoor poultry-house temperatures. As a production period of broiler breeding takes an average of six weeks, basic temperature values were determined for six-week periods. The values in Table 1 were used for different average balance point temperature values required by chickens in each breeding period in broiler breeding (Lindley and Whitaker, 1996; Atilgan et all., 2012; Anonymous, 2015; Anonymous, 2016a).

Table 1. Recommended weekly base temperature for broiler chicken

Weeks	Base Temperature (°C)
1	31
2	27
3	25
4	23
5	21
6	18

Heating degree-hour values in each growth period is calculated according to the equation 1 (Bulut et al., 2007; Erturk, 2012; Erturk et al., 2015),

$$HDH = (1hour)\sum_{l=1}^{n}\left(T_b - T_o\right)^{+} \qquad (1)$$

Cooling degree-hour values in each growth period is calculated according to the equation 2 (Bulut et al., 2007; Erturk, 2012; Erturk ve at al., 2015),

$$CDH = (1hour)\sum_{i=1}^{n}\left(T_o - T_b\right)^{+} \qquad (2)$$

Where T_o is the hourly mean outdoor air temperature, T_b the base temperature recommended for the broiler chicken, n the number of hours of the year. The + sign indicates that only positive values are summed. Information about the provinces and meteorological data set in this study are given in Table 2.

Table 2. Information about the meteorological stations in Southeastern Anatolia Region

City –Station Number	Years	Altitude (m)	Latitude-North	Longitude – East
Adiyaman – 17265	1962 – 2014 (53)	679	37°45’	38°16’
Batman – 17282	1960 – 2014 (55)	610	37°53’	41°07’
Diyarbakır – 17280	1960 – 2014 (55)	649	37°54’	40°13’
Gaziantep – 17261	1960 – 2014 (55)	854	37°04’	37°29’
Kilis – 17262	1960 – 2014 (55)	638	36°43’	37°05’
Mardin – 17275	1960 – 2014 (55)	1050	37°18’	40°46’
Siirt – 17210	1960 – 2014 (55)	896	37°55’	41°56’
Sanliurfa – 17270	1960 – 2014 (55)	547	37°09’	38°47’
Sirnak – 17287	1970 – 2014 (45)	1381	37°31’	42°28’

RESULTS AND DISCUSSION

The amount of annual heating and cooling degree-hours based on the six different base temperature values proposed for broiler breeding was determined for study area. According to Figure 1, the highest heating degree-hour value was in Gaziantep province. According to the suggested six different base temperature values, the cumulative long-term annual heating degree-hour value was 50862 in total for Gaziantep province. The lowest cumulative long-term annual heating degree-hour value took place in Sanliurfa province as 39638.

When cooling degree-hour values in Figure 2 were analysed, the highest total cooling degree-hour value took place in Şanlıurfa province as 10886 degree-hour value. The lowest value took place in Sirnak province as 3909.

Graphics showing the relationships of heating and cooling values with the altitude of nine provinces in the research area were prepared. When the relationship of heating degree-hour values with the altitude was analysed (Figure 3), it was determined that HDH values did not increase linearly or monotonously with the increase of the altitude in the provinces in SAR. Since the highest HDH value could not be achieved in Sirnak province which has the highest altitude (1381m). Gaziantep province with the lower altitude (854m) had the highest HDH value. It was thought that factors such as wind force and sun's angle of incidence could have affected this. Since this factor that determines the sun's angle of incidence and mountains' exposure to sunlight is an important parameter affecting the emission of heat on Earth (Sensoy et al., 2015).

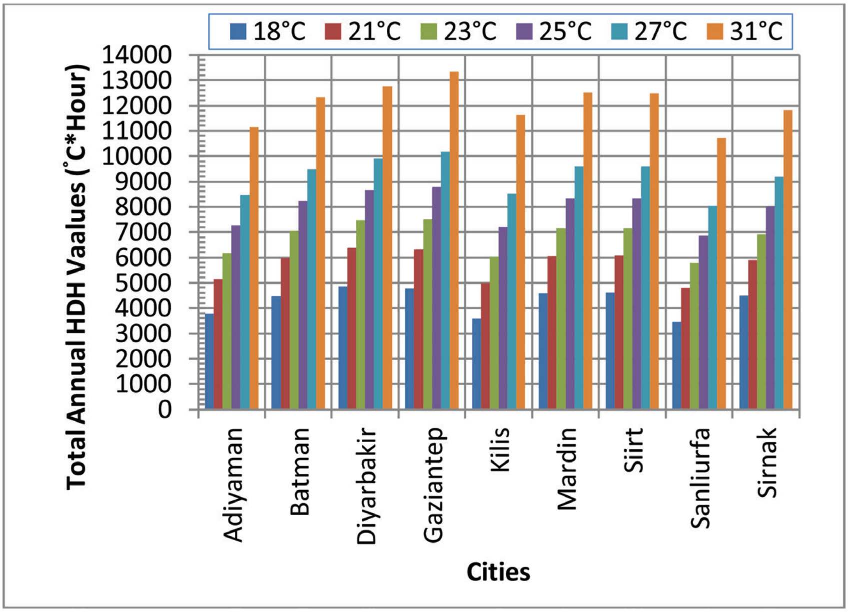

Figure 1. Distribution of HDH values according to the six different temperate in 9 provinces for SAR

Similarly, the graphic showing the relationships of the provinces discussed in the research with the latitude was also prepared. This relationship was examined considering that the relationship of latitude could affect HDH values as well as altitude could influence HDH values. The HDH latitude relationship results are shown in Figure 4. However, it is seen that there was not a linearly or monotonously increasing/decreasing relationship between provinces. It could be considered as the effect of a very small latitude differences as much as maximum 1^{o} 12' terms of latitude between provinces since it was thought that this occurred because regions on the same latitude are in the same climate zone and receive the sunlight at the same angle (Anonim, 2016b).

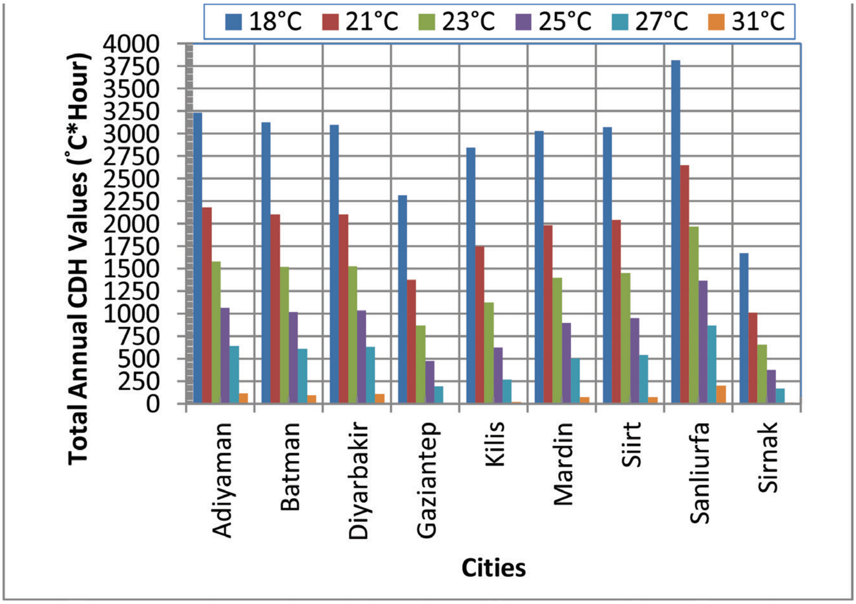

Figure 2. Distribution of CDH values according to the six different temperate in 9 provinces for SAR

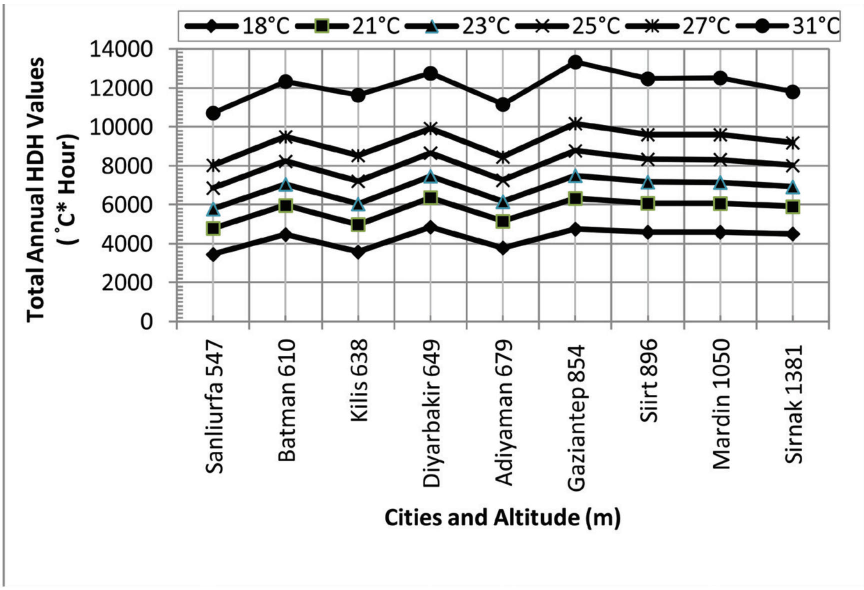

Figure 3. The relationship between the total HDH values and altitude according to the six different base temperatures

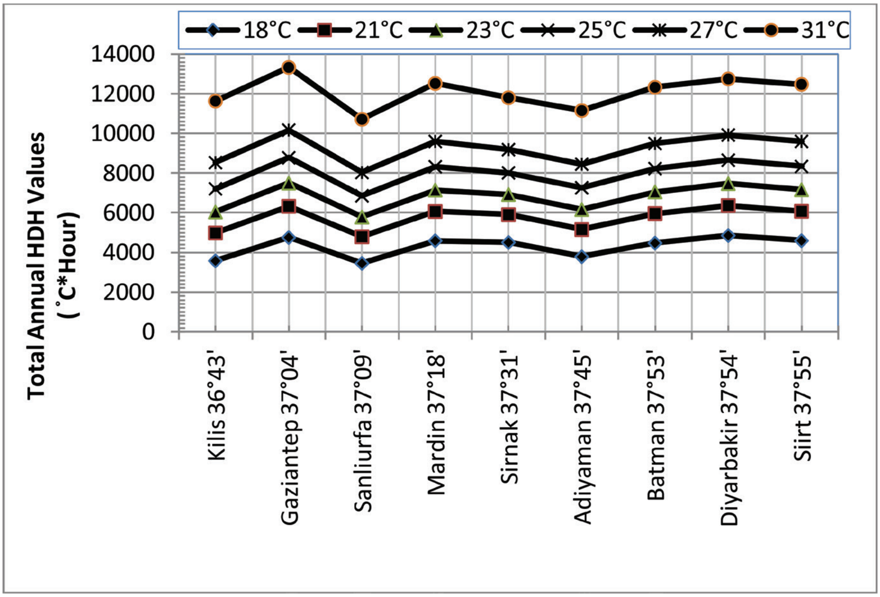

Figure 4. The relationship between the total HDH values and latitude according to the six different base temperatures

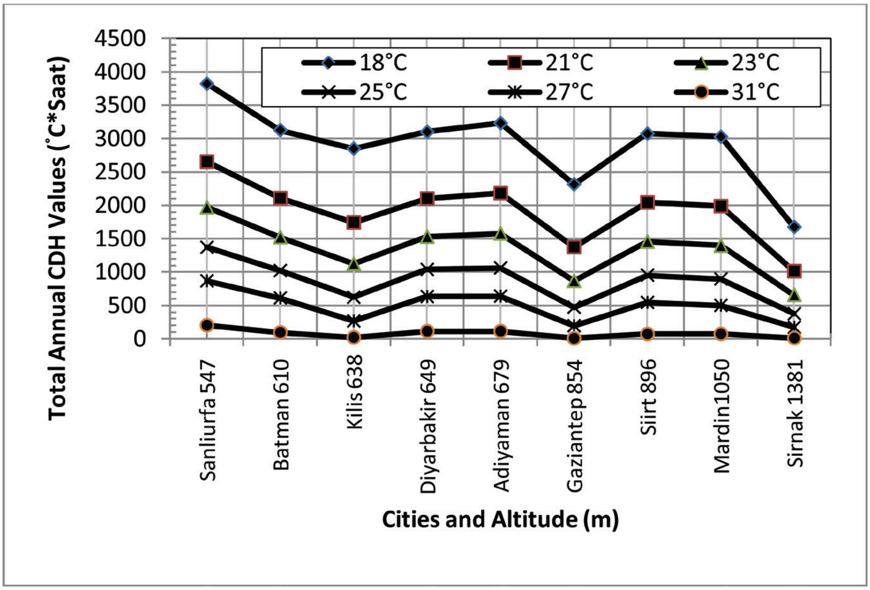

Figure 5. The relationship between the total CDH values and altitude according to the six different base temperatures

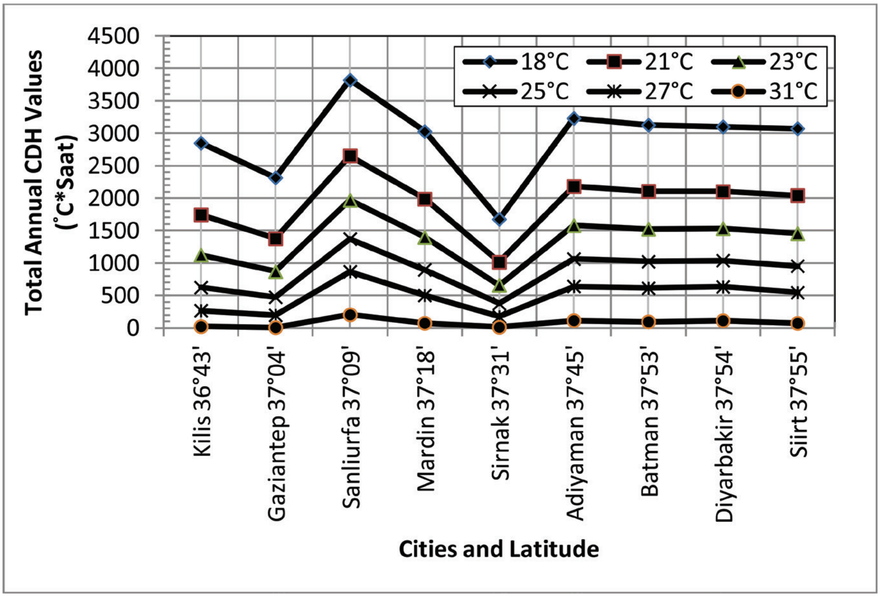

Figure 6. The relationship between the total CDH values and latitude according to the six different base temperatures

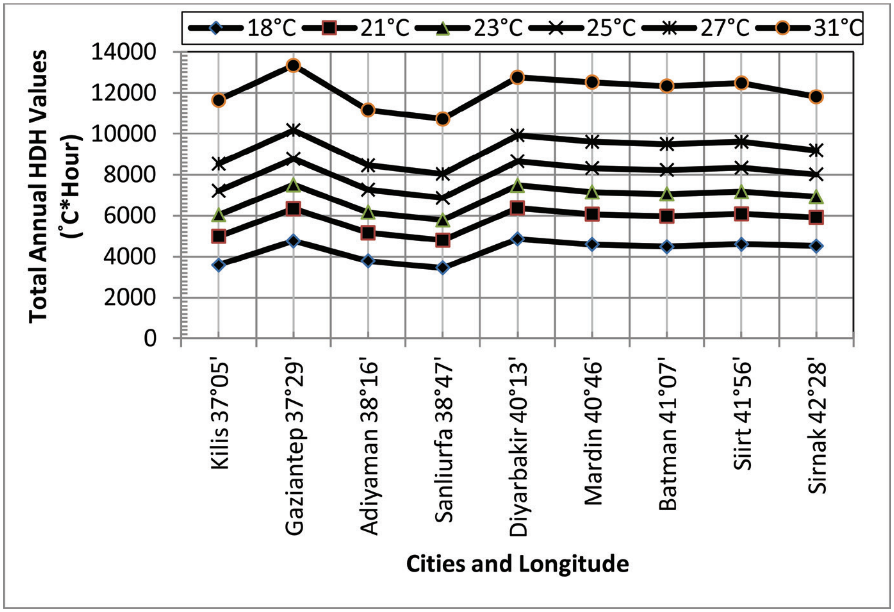

Figure 7. The relationship between the total HDH values and longitude according to the six different base temperatures

It is not seen that annual cooling degree-hour values have a formal linear relationship with the altitude values (Figure 5). However, when the values were analysed, the lowest total cooling degree-hour value took place in Sirnak, which has the highest altitude (1381m), and the highest total cooling degree-hour value took place in Sanliurfa, which has the lowest altitude (547m). Likewise, when other provinces' total cooling degree-hour values were correlated with the altitude values, it was determined that they linearly decreased depending on the altitude. Erturk et al. (2015) reached similar findings in their study.

The CDH latitude relationship analysis results are given in Figure 6. It can be said that CDH value generally showed a decrease as the latitude increased, except for Sanliurfa and Sirnak provinces.

Graphics in Figure 7 and Figure 8 were obtained by correlating HDH and CDH values with the longitude in a similar way. When the HDH values are analysed, it can be said that there is a monotonous decrease although there is not a very large increase in longitude values, especially with Diyarbakir province.

The CDH Longitude relationship analysis results are presented in Figure 8. It was demonstrated in this figure that the relationship of CDH with longitude did not show a characteristic behaviour.

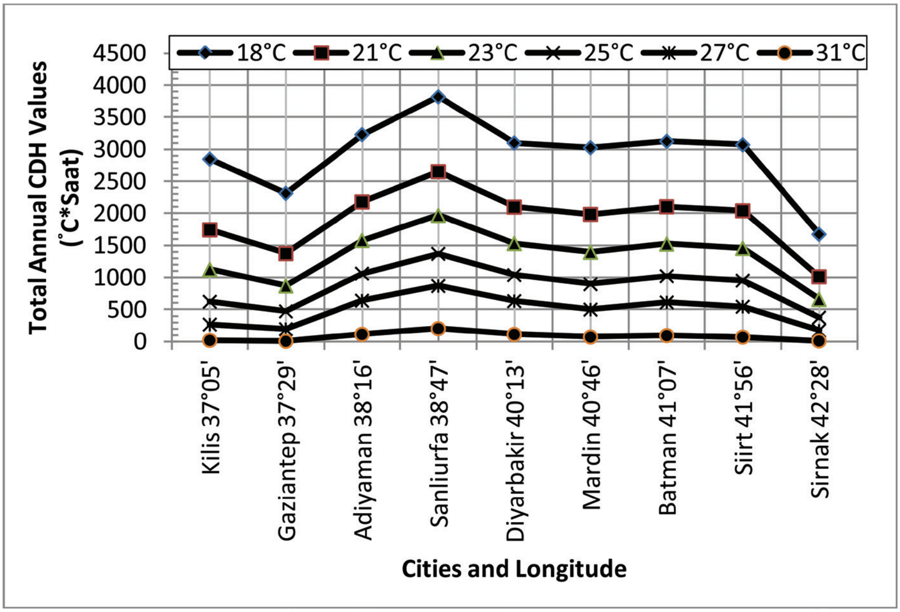

Figure 8. The relationship between the total CDH values and longitude according to the six different base temperatures

CONCLUSIONS

The heating and cooling degree-hour values for six different base temperatures were determined using long-term annual meteorological hourly outside ambient temperature in nine provinces (Adiyaman, Siirt, Kilis, Gaziantep, Sanliurfa, Diyarbakır, Mardin, Batman and Sirnak) of the SAR. These heating/cooling degree-hour values were examined with the base temperature values suggested for broiler breeding by considering the altitude, latitude, and longitude values. It was determined that there was not an exact linear or monotonous relationship between HDH and CDH values and altitude, latitude and longitude values. However, although it was seen that the relationship of CDH values with the altitude was not a formal linear or monotonous relationship, it was determined that CDH values decreased linearly together with the increasing altitude values when the values were examined.

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