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Original Article

Climate Parameters in the Trailer During the Transportation of One-Day-Old-Chicks

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Animal welfare; heat mapping; heat stress; inverse distance weighted method; temperature humidity index.

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ABSTRACT

Various problems may arise during the road transportation of one-day-old broiler chickens from hatcheries to rearing houses. In this study, the transportation vehicles of a private company operating in the Bursa Region were physically examined, and the climate parameters of the trailer were observed. During these observations the exposure of animals to heat stress was measured, and the loss of life during transportation was revealed. Thirteen data logger values were placed in the trailer and their readings were recorded. While the highest heat stress is in the summer and the heat stress is the highest in the front and middle parts of the trailer, the least are in the first row and the last row in vehicles that use natural ventilation in the summer and mechanical air conditioning in the winter.

INTRODUCTION

Poultry has an important position in livestock farming. It can be said that poultry farming is advantageous because the nutritional value of chicken meat is high, the production period is short, and the cost of breeding is low (Şahin & Yıldırım, 2001). Chicken meat is one of the most consumed meat types both in Türkiye and in the world. In 2021, the number of slaughtered chickens worldwide reached 74 billion, and the produced chicken meat reached 122 million tons (FAO 2022). The animal protein deficit, which emerged as a result of the decline in red meat production in Türkiye due to cost problems and crises, has tried to be balanced with the increase in chicken meat production (Dokuzlu *et al.,* 2013). In 2018, 98.4 % of meat production in Türkiye consisted of poultry (Türk Tarım ve Orman Dergisi, 2021). The number of chickens slaughtered in Türkiye in 2019 was 1.128.265 (thousand unit) and the chicken meat produced was 2.016.795 tons (Turkish Statistical Institute 2022).

With the increase in population, animal protein demands also increase. For this reason, broiler production should be done professionally and intensively. It can be said that the integrated production structure is common in broiler production (İnci *et al.,* 2019). This situation necessitated the meeting of different needs in different units and regions during the breeding of profit-oriented enterprises. Due to the emergence of different needs in different regions and the necessity of transport, the factors during the transportation of broiler chicks gain importance. These factors can be classified as the physical condition of the transport vehicle and the welfare of the animals during transportation. According to the study of Ikikat Tumer (2013), the mortality rate of the chicks during the transportation is less if the distance is more than 70 km. The reason of this decrease is explained that high equipped vehicles are being provided for the long distance transportation. On the other hand, the study of Vecerek *et al.* (2006)

claims that over 50 km transportation increases the mortality rate of the chicks.

In cases where welfare is not provided, results may occur even to the death of animals. Schwartzkopf-Genswein *et al.* (2012) found that transport is an important component of the poultry industry and can cause varying degrees of stress in birds, from restlessness and reluctance to death. Factors affecting the mortality rates of animals during transportation can be specified as animal catching method, transport time, waiting time before or during transportation, time of the day during the transportation, animal density in the transport vehicle, and the age and sex of the animals (Onuk *et al.,* 2015). Barnett *et al.* (2008) indicated that the recommended floor space is 400-475 chicks per m^2 with a minimum height of containers of 12cm. One box should include 80-100 chicks at most. If the chicks are fed sufficient and have enough water, they can travel up to 12 hours, excluding loading and unloading time. On condition that the transportation is completed within 72 hours after hatching, the chicks can travel 24 hours at most.

The most important factors affecting animal welfare are temperature and humidity. The negative effects of heat stress include high mortality, low feed consumption, and poor body weight gain and meat quality in broilers, and low laying rate and egg weight and shell quality in laying hens (Howlider & Rose, 1987). It is recommended that the temperature inside the trailer should be in the range of 24-26 °C during transportation, and the temperature value recommended by the breeders is 24 °C and the humidity is 75 % (Mitchell, 2009). According to Barnett *et al.* (2008), the inside of the trailer should be warmed to a range of 24-28 °C before the chicks are loaded. THI indicates the magnitude of heat stress by representing the combined effect of temperature and humidity with a single value. According to Bulancak & Baylan (2015), the degree of stress felt at the effective temperature was classified as normal between 18-23, mild between 24-29, medium between 30-38, and high between 39-66, depending on the relative humidity.

This study aims to obtain data on factors such as temperature and humidity and maintenance-management practices.

MATERIAL AND METHOD

Location Properties of the Research Region

Marmara Region in Türkiye is a region where there are many broiler farms. In this study, the data obtained by the measurements made in the trailer containing the chicks in the transport vehicle, during the transportation of one-day-old broiler chicks from the Company hatchery in Nilüfer District of Bursa Province to the rearing houses in different regions by road, constituted the material of the research.

Air-Conditioning of the Transport Trailer

The climate situation in the trailer is controlled by different methods. One of them is natural ventilation. As can be seen in Figure 1, there are air inlet openings in the front upper section of the trailer. The fresh air entering from the openings fills the room between the driver's cabin and the trailer. The air that fills the room can enter the trailer through the perforated door in front of the trailer, indicated by blue circles. In addition, the side covers of the vehicle can be left open during transportation, while the outlet on the rear covers of the vehicle can be used for natural ventilation.

Figure 1 – Air-conditioning of the transport trailer.
a. Inlet openings b. Room c. Side openings d. Outlet openings e. Fan
Yellow circles: Hood openings – Blue circles: Inlet openings – Red sircles: Heat openings

Mechanical ventilation method can also be used to change the climate situation in the trailer. In the room between the driver's cabin and the trailer, shown in Figure 1, there are engines that operate the air conditioning systems in the trailer. By operating the engines in Figure 2, heating is provided in the winter season and the humid air in the environment is discharged to the outside in the summer season. When the heating engine is started, the air in the room is heated and supplied to the trailer through the holes marked with a red circle on the floor, shown in Figure 1. There are two ways to remove air from the trailer by mechanical means. One of them is provided with the fans located at the back of the trailer. Owing to the fans, the polluted air is removed directly from the transport cabin. The other mechanical device

is the hood on the roof of the trailer, indicated by yellow circles, shown in Figure 1. The hood draws the air in the trailer and transmits it to the room between the driver and the trailer.

Figure 2 – Mechanical ventilation engines.

Data Collection

The dimensions of the trailer are 800 cm x 245 cm x 300 cm, the chick box is 60 cm x 40 cm x 13 cm. While the boxes can be placed 11-12 rows on top of each other, animals are never kept in the bottom boxes. While 4 rows of boxes are placed side by side, the number of boxes from front to back may vary depending on the number of animals transported. While there are 100 chicks in a box in the winter season, there are 80 chicks in a box in other seasons.

Table 1 – In-vehicle location of temperature measuring devices.

Position	Number
front vent	1
front middle	2
left side wall	3
right side wall	4
left aisle	5
right aisle	6
mid aisle bottom	7
mid aisle mid	8
mid aisle top	9
middle top	10
middle back	11
rear vent	12
inside of the box	13

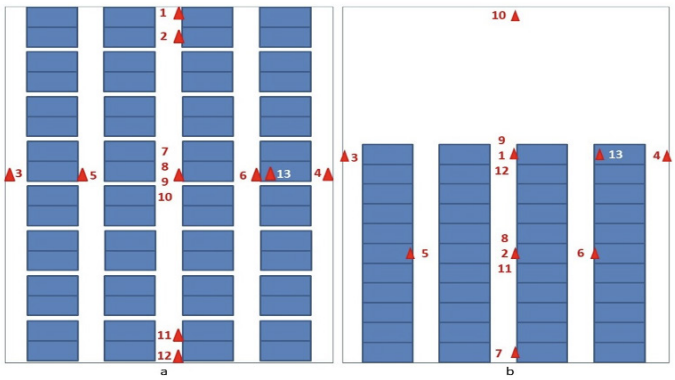

Figure 3 – The positions of the boxes and devices on the trailer.

a. Top view of the trailer – b. Rear view of the trailer.

Red triangles: Temperature-humidity meters – Blue rectangles: Chicken crates.

In total, 13 temperature-humidity meters were installed in the trailers. The positions of the meters were shown in Figure 3. The red triangles in Figure 3 indicate the temperature meters. Table 1 describes where the temperature measuring devices are placed and their numbers. The data were obtained for the whole year without any change in the usual transportation conditions. Since the transportation vehicles are the vehicles that the company uses continuously, the data obtained represent the structural and physical features of all transportation vehicles. The electronic devices used in the research were adjusted to be operational during transportation and to receive 1 data per minute. Thus, it is aimed that each transport of the company reflects variables such as the number of different chicks, the number of different sexes, the direction of transport, and the duration of transport. Indoor temperature and relative humidity were measured in the trailer. The number of chicks that died during transport was recorded and the level of relationship with the measured factors was examined.

THI calculation equation was employed to calculate indoor THI values of transportation vehicle for broilers. $THI_{broilers} = 0.85\ T_{db} + 0.15\ T_{wb}$ (Purswell at al., 2012) where, THI: temperature-humidity index, t_{db}: dry bulb temperature (°C), T_{wb}: wet bulb (°C).

MatLab package program was used to show the heat stress felt at the measurement points in the trailer to the THI scale that Bulancak & Baylan (2015) stated in their study. MatLab is a multi-paradigm programing language and numeric computing environment. There's symbolic computation in MatLab's numeric environment and it helps MatLab supply its numeric and graphical facilities with several other types of mathematical computation (Moler & Costa, 1997).

ArcGis package program was used to create a stress map for trailers. The inverse distance weighted (IDW) method is used in the interpolation tab of the Geostatistical analyst tools section. ArcGis is a package program, which offers unique capabilities and flexible licensing for applying location-based analytics (ESRI 2022). The IDW is a method which assumes that things that are close to one another are more alike than those that are farther apart. To anticipate a value for any immeasurable location, IDW utilizes the quantified values circumventing the prognosis location. The quantified values most proximate to the prognosis location have more influence on the predicted value than those farther away. IDW assumes that each quantified point has a local influence that diminishes with distance (ESRI 2022). According to Setianto & Triandini (2013), in IDW method, it is assumed

substantially that the rate of correlations and similarities between neighbors is proportional to the distance between them that can be defined as a distance reverse function of every point from neighboring points. In addtion, interpolation techniques are based on the principles of spatial autocorrelation which assumes that objects close together are more similar than objects far apart. IDW interpolation is defined by Jiqing *et al.* (2020) as follows: "Inverse distance weighted interpolation is used to estimate pixel values by averaging the sample data points in each pixel neighborhood to be processed. The closer the point is to the center of the pixel to be estimated, the greater its influence or weight in the average process."

RESULTS

Data collection started in March 2019 and ended in February 2020. In total, four different transfers were carried out and all of these provinces are in the Marmara Region. In Table 2, a summary of the measurements made 24 times in a whole year is given. The longest-term transport was carried out during the second measurement of March, while the longest distance was the first measurement of November. Owing to traffic density, climatic conditions, and the travel distance on the main and village roads, the longest duration of the transportation and the longest distance were recorded at different times.

The highest number of animals was recorded in the first measurement of April with 58600 chicks, while the highest number of deaths was seen in the last measurement of August.

In the measurement dated 30/08/2019 seen in Table 2, the minimum temperature value was 24.5 °C, the minimum humidity value was 42.9, the minimum THI value was 20.57. The maximum values were observed at the 13th point, and the temperature, humidity, THI values were determined as 33.8 °C, 74.4 and 31.07 respectively. According to the THI scale of Bulancak & Baylan (2015), it is in medium stress.

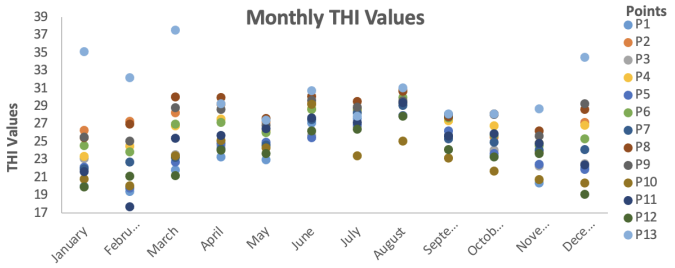

Figure 4 – The monthly average THI values.

Table 2 – Transportations

Date	Duration	City	District	Distance (km)	Outside Temp at destination (°C)	Outside Temp at departure (°C)	Total Number of chicks	Number of chicks in the crate	Number of death
02.03.2019	01:46	Balıkesir	Altıeylül	160	9.0	9.1	37200	100	0
09.03.2019	03:45	Balıkesir	Dursunbey	220	11.5	13.2	34600	100	22
13.04.2019	02:47	Bursa	Iznik	134	15.0	13.8	58600	100	0
27.04.2019	01:27	Balıkesir	Susurluk	160	16.2	16.2	46000	100	0
11.05.2019	01:05	Bursa	Karacabey	70	14.7	16.1	28640	80	0
25.05.2019	01:29	Balıkesir	Susurluk	99	18.2	18.3	33040	80	1
08.06.2019	01:32	Bursa	Inegöl	95	22.5	23.5	48880	80	20
29.06.2019	02:09	Bilecik	Merkez	110	26.4	24.8	35120	80	1
20.07.2019	02:48	Çanakkale	Biga	168	24.0	24.7	34160	80	8
25.07.2019	02:30	Balıkesir	Savaştepe	172	23.2	23.1	45600	80	4
03.08.2019	01:20	Balıkesir	Bandırma	70	28.1	26.6	32880	80	4
30.08.2019	02:19	Balıkesir	Ivrindi	184	22.8	23.7	44800	80	>100
21.09.2019	01:50	Balıkesir	Manyas	125	17.4	16.8	29360	80	10
28.09.2019	01:05	Bursa	Mustafakemalpaşa	83	19.3	18.8	41440	80	0
05.10.2019	01:18	Balıkesir	Susurluk	92	18.6	18.6	37200	80	0
12.10.2019	01:23	Balıkesir	Bandırma	99	19.7	18.6	41600	80	0
09.11.2019	04:15	Balıkesir	Dursunbey	242	14.2	17.3	41529	80	0
15.11.2019	02:20	Çanakkale	Biga	172	14.5	13.9	39960	80	2
07.12.2019	03:12	Çanakkale	Biga	229	4.6	4.4	33800	100	0
20.12.2019	03:31	Çanakkale	Biga	190	12.0	7.9	34600	100	0
11.01.2020	02:35	Balıkesir	Çandır	154	2.3	4.1	31600	100	0
18.01.2020	00:50	Bursa	Nilüfer	22	7.2	7.2	26000	100	0
15.02.2020	01:27	Balıkesir	Bandırma	85	6.9	8.7	48200	100	1
29.02.2020	02:45	Balıkesir	Savaştepe	191	8.8	9.2	47600	100	6

The highest average THI values in the box were observed in cold weather. The main reasons for the highest average value are to place 100 chicks in a crate in the winter season, and to keep one chick close to another in order to be warm in the cold weather, and operate the heaters to increase the temperature inside the trailer. The monthly average THI values are shown in Figure 4. The minimum average value was observed as 17.75 at point 11 in February and the maximum average value was observed as 37.59 at point 13 in March. While the highest average value was observed at point 13, excluding July, the highest average value was observed as 29.53 at point 8 in July.

In the first measurement of February, at point 13, THI values were observed above the high limit of 39 in the last 5 minutes of transportation as seen in Table 3. Although it is expected that the highest THI values are in the crate, the stress level classified as high seen in the winter season reveals that the air conditioning conditions in the trailer are insufficient.

Table 3 – Monthly lowest and highest THI values.

Months	Values	Points												
		1	2	3	4	5	6	7	8	9	10	11	12	13
January	min	15.5	19.5	17.3	16.6	17.3	17.1	15.7	17.0	16.8	15.0	15.6	13.8	18.0
	max	27.7	30.2	26.3	27.1	24.7	28.2	25.6	29.3	28.7	22.9	24.0	23.5	38.7
February	min	17.4	23.1	16.2	21.9	15.1	21.3	18.6	22.7	21.2	16.2	13.7	14.7	26.2
	max	23.9	29.2	25.7	27.8	24.5	27.6	25.2	28.9	28.4	23.1	22.9	24.9	39.2
March	min	18.5	24.6	18.6	25.2	17.1	25.0	20.8	26.4	24.8	20.8	21.5	16.3	32.1
	max	24.3	30.3	27.5	29.2	26.9	29.4	25.8	32.5	32.1	25.8	29.2	23.8	39.0
April	min	20.9	24.6	20.6	24.6	20.3	25.4	21.1	26.2	25.2	21.7	21.9	20.0	22.4
	max	26.2	32.1	28.1	30.0	27.5	28.8	28.3	32.9	32.7	27.8	30.2	27.3	36.9
May	min	19.5	25.4	22.9	24.5	23.1	24.6	22.9	25.5	24.4	21.4	24.9	21.8	23.5
	max	26.0	28.0	26.6	27.5	27.9	27.2	26.4	29.1	28.8	27.0	29.1	25.6	31.0
June	min	24.2	27.2	21.5	25.5	21.7	25.8	24.9	27.2	26.9	0.0	25.0	23.0	26.8
	max	29.5	31.4	29.9	31.5	29.2	31.4	30.8	32.2	33.3	30.3	30.5	29.6	33.2
July	min	25.1	26.5	24.2	27.1	23.6	27.2	26.9	28.5	27.1	0.0	25.5	24.4	26.2
	max	31.8	31.5	29.8	30.8	30.3	30.8	30.6	31.2	31.4	24.6	29.9	29.6	32.8
August	min	25.3	28.1	23.2	24.7	22.1	26.1	25.0	27.0	24.8	20.6	25.0	22.5	24.7
	max	33.8	35.1	34.1	36.0	35.1	36.2	35.9	36.7	35.7	30.9	35.0	33.8	38.8
September	min	21.9	24.5	22.1	24.7	22.0	24.5	22.6	23.8	23.6	19.7	22.9	21.1	24.2
	max	28.2	29.8	28.2	29.8	29.3	30.3	27.4	30.3	30.9	24.7	27.4	26.2	32.4
October	min	20.9	24.3	22.8	25.8	22.4	24.6	24.0	26.3	25.9	20.7	24.0	17.0	26.3
	max	25.6	26.8	25.8	28.6	25.8	27.5	26.1	29.2	29.9	23.3	28.5	25.2	30.6
November	min	15.8	20.1	19.8	22.3	18.5	22.6	22.1	24.0	22.2	18.7	22.4	19.2	25.7
	max	24.4	28.1	24.3	27.6	24.7	27.8	27.7	28.8	28.4	23.3	27.2	25.7	31.4
December	min	18.2	22.5	18.4	21.2	18.1	20.2	17.4	21.6	22.6	17.3	15.0	15.1	26.4
	max	25.5	29.2	27.2	30.8	26.0	29.6	29.0	33.8	33.8	23.0	27.7	23.4	38.0

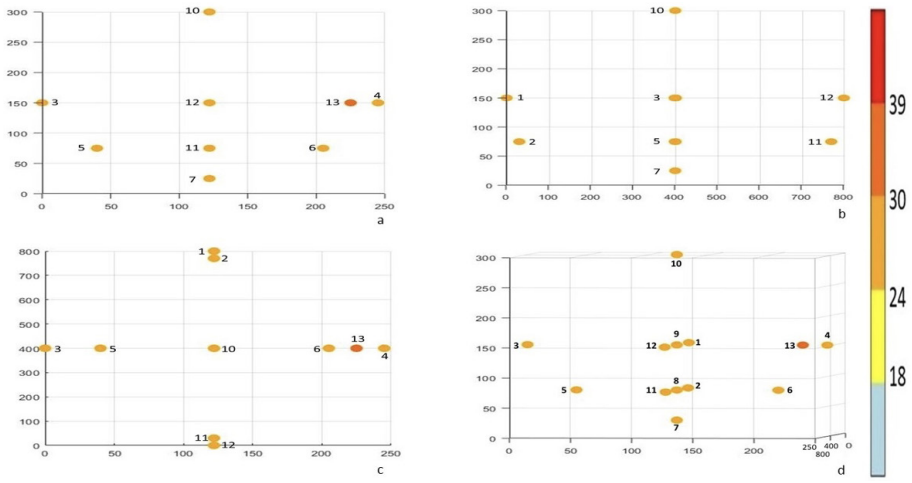

Figure 5 – Heat stress felt at measuring points.
a. Rear view of the trailer – b. Side view of the trailer – c. Top view of the trailer – d. Rear view of the trailer (3D)

The situation in Figure 5 emerges when the annual average values of the data obtained during the study process for each point are analyzed in the MatLab package program according to the THI scale shared by Bulancak & Baylan (2015). The rear view of the trailer is given in Figure 5.a, the side view of the trailer is given in Figure 5.b, the top view of the trailer is given in Figure 5.c, and in Figure 5.d all the points can be seen as 3D from the point of rear view of the trailer. The point which the heat stress is most intense is point

13, where data were collected inside the box. At other points, heat stress is felt as moderate to mild.

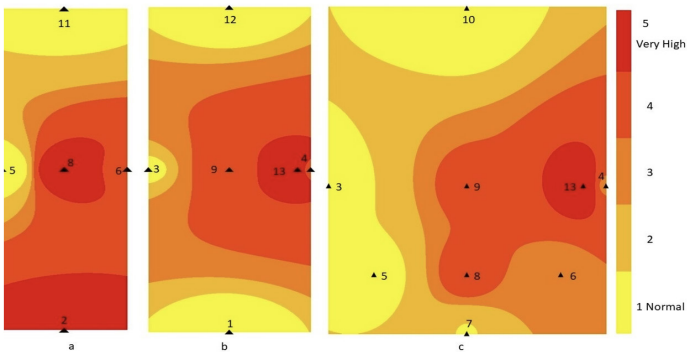

Figure 6 – THI map of inside of the trailer.

a. 75 cm height longitudinal section – b. 150 cm height longitudinal section – c. 400 cm (midpoint) cross section.

It would be correct to make THI estimation at each point of the trailer interpret the average data obtained from certain points over a whole year in a more meaningful way. Therefore, heat stress maps were created by interpolation made by taking the longitudinal section at (a) 75 cm height, (b) 150 cm height cross section, (c) the longitudinal section from the front to the back of the vehicle, as indicated in Figure 6. The highest temperature stress is expressed in red, the lowest stress in yellow. The points in Figure 6.a mostly represent the measurements made in the aisles of the trailer. Therefore, it is expected that the region number 8 at the midpoint will be seen in red. Since it is not directly close to any ventilation point and it is the first affected area because of the heaters being operated in the winter season, the 2nd region is also expressed in red according to the analysis results. As a result of the analysis, the points in Figure 6.b show both the points directly on the trailer and the regions located at the middle point such as 9. It is expected that the data obtained from the measurement device number 13 in the crate would show as the highest values and are shown in red; area 9, located in the middle region, is in orange, which indicates medium stress, as expected. As a result of the analysis made in the longitudinal section taken from the middle of the trailer, the area where the highest stress is seen is region number 13, as can be found in Figure 6.c. The middle sections 9 and 8 are shown in orange, and the sections 3, 4, and 7 close to the ventilation cavities and mechanisms are shown in yellow, where less stress is seen.

DISCUSSION AND CONCLUSION

As a consequence of the study, it is concluded that heat stress was experienced mostly in August. Barbosa Filho *et al.* (2013) also revealed that the highest heat stress was observed in the summer season as a result of their research. Based on the measurements, the place where the most heat stress is experienced is inside of the crate, followed by points 2 and 8 in the summer season. The reason is that there is not enough airflow in these areas. The best conditions are zone 1 where the air intake opening is located, and zone 12, where the fans are located at the rearmost of the vehicle to allow the venting indoor air. Similar results were obtained in the study of Nazareno *et al* (2015). It's concluded that the area with the worst conditions in the vehicle during the transportation of one-day-old broilers was the front and middle of the trailer, and the best conditions were in the crates in the first row. While the heat stress values in the trailer were the same in almost every point in May, the highest variation was observed in March. In the study of Liang & Liang (2015) during December, although the ambient temperatures were single digit, a large variation occurred across the trailer. Additionally, less temperature variations were observed in daytime transport in January and in night transport in May. In the study of Nazareno *et al.* (2015), the microclimatic conditions of the air-conditioned trailers were found below the ideal values for one-day old chicks. According to the observations, as the number of the death chicks during the transportation can be tolerated by the businesses, the transportation conditions of one-day old chicks can be evaluated as sufficient. More than a hundred chicks died only in August 2019 and it is thought that the reason of the deaths were due to the hatchery and not the transportation conditions.

A model could not be created due to external interventions such as opening ventilation windows in the summer months, transporting to different regions, constantly changing vehicle direction and wind direction, and operating heaters in the cold weather. Determining that a small number of chick deaths occurring in short-term transports will not cause economic loss to the enterprise has eliminated the importance of the model to be put forward. The biggest difficulty during the transport is not the animal deaths, but the intervention of the driver in the trailer, such as heating and ventilation, by constantly observing the temperature values in the trailer from a screen in the cabin, and pressing the necessary buttons in the cabin. The temperature inside the trailer is instantly displayed on a screen in the cabin, and the driver decides which action to take according to the temperature value. The fact that these actions are carried out by the driver puts the driver under stress, putting both himself and

other vehicles in the traffic in danger. Based on the temperature factor, it would be ideal to automate the heating, cooling and ventilation engines already in the vehicles with a software. By means of the software, when the temperature sensor to be placed in the trailer reaches certain limits, the required engine will start automatically, and the driver will be able to give his full attention to the road; and so, road safety will be increased.

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