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The effects of season and chick sex on certain performance parameters in commercial turkey farms in the Aegean Region

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Abstract: The aim of this study was to determine the effects of season and sex on the production efficiency of commercial turkey farms in the Aegean Region. The data of 1161 production periods (570 male and 591 female) on 139 turkey farms between 2008 and 2017 were analysed. Daily feed consumption, feed conservation ratio (FCR), average daily gain (ADG), performance index, and carcass weight ($P < 0.001$) were higher in males than females. While males and females had a similar mortality rate in the first week ($P > 0.05$), the mortality rate in the later stages was higher in males ($P < 0.001$). The mortality rate in the initial period was highest in production periods that began in winter and lowest in those that began in summer ($P < 0.001$). The total mortality rate was higher in the autumn group than in the spring and summer groups ($P < 0.001$). Rearing season × sex interaction had a significant influence on the performance characteristics investigated in the study, except for mortality rates and survival. In males, FCR was lower in the autumn and winter groups than that of the spring and summer groups ($P < 0.05$). The highest ADG values were observed in the summer group for males and in the winter group for females. The best performance index was in the summer group in males, and the lowest performance index was observed in the autumn group for both males and females. In conclusion, environmental arrangements are needed in order to reduce the mortality rate and improve performance in production periods that began in autumn and winter.

Key words: Turkey breeding, production efficiency, feed conservation ratio, survival, carcass dressing, performance index

1. Introduction

Animal products are highly important food resources for human nutrition because they contain high protein ratios and some essential amino acids that are not found in plant-based products. In countries where animal production is developed, animal-based proteins, such as meat and milk, constitute an important part of daily nutrients [1]. According to the FAO statistics[1], as of 2017, 38.80% of Turkey's meat demand is provided by red meat, while 61.20% is provided by white meat. In the meantime, turkey meat has a small share in both white meat and total meat production in Turkey, such as 2.39% and 1.46%, respectively. On the other hand, rapid population growth, urbanization and industrialization, and mistakes in livestock policy have led to the emergence of a huge "red meat deficit/domestic production cannot meet the needs" problem in Turkey [2]. This situation resulted in increased red meat prices and caused people to prefer white meat to meet their protein need. Additionally, the increase in the education level and living standards of societies can cause changes in consumption habits. Recently, people have become more aware that their cardiovascular health will be adversely affected due to excessive consumption of animal fats. Increased awareness about cardiovascular health issues has led some consumers to prefer lean/low-fat meat, while some have started to avoid consumption of red meat [3].

White meat, which includes turkey, is an alternative product for those who avoid red meat consumption due to its low cholesterol level and high protein/calorie ratio [4]. The amount of lipid in 100 g of edible servings (with meat and skin) of turkey meat is lower than that of chicken meat (8 g vs. 15.1 g) [5]. In addition, turkey leg has similarities with red meat in terms of flavour and nutritional value. This ensures that turkey legs are liked and consumed by the Turkish consumer [6]. Turkeys can be grown up to high live weights (20–25 kg) while having lower production costs than red meat; higher dressing percentage and edible meat ratios are other factors that make turkey breeding advantageous [5,7].

[1] Food and Agriculture Organization of the United Nations. FAOSTAT, Livestock Primary, http://www.fao.org/faostat/en/#data/QL [accessed 20 April 2020].

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Prior to 1995, turkey production in Turkey was traditionally conducted with the bronze genotype and based on the utility of pasture under the extensive system. The first integrated turkey production was founded in 1995 in Bolu Province. In the following years, integrated companies established in provinces such as İstanbul, Adapazarı, and İzmir started their production with white turkeys. In recent years, there has been an increase in the number of intensive enterprises. Nowadays, turkey production is mostly carried out under intensive conditions (totally closed barns) with commercial hybrids, and production under semiintensive conditions was conducted in a few enterprises for Christmas consumption in small herds [6].

In order to increase productivity in animal production, the yield levels in the current production models and the effects of various environmental factors on the yields should be determined. In poultry husbandry, ambient temperature is an important environmental factor affecting various performance characteristics, especially feed consumption ratio and average daily weight gain [8,9]. Therefore, in many studies conducted with broiler chickens [10] and turkeys [8,9,11], the effect of the season or ambient temperature on various performance characteristics was found to be significant.

This study was carried out to compare the seasonal variation of certain performance characteristics and production efficiency in commercial farms that reared male and female turkeys under intensive conditions in the Aegean Region.

2. Materials and methods

2.1. Production periods, feeding, and management procedures

The research data were obtained from production periods between 2008 and 2017 in the integration of commercial turkey enterprises operating in İzmir, Manisa, and Aydın provinces. Within the scope of the study, growth, carcass characteristics, survival rate, and performance index data of 1161 production periods in 139 different enterprises were evaluated. Performance records of 17, 62, and 60 enterprises were used in Aydın, İzmir, and Manisa provinces, respectively. All turkeys (*Meleagrisgallopavo*) investigated in the study were of the Hybrid Converter genotype. The hatchery was in Seferihisar, İzmir. Turkey eggs were obtained from a commercial supplier in Canada by air cargo and hatched in Turkey after 28 days of incubation. In accordance with the routine processes of the hatchery, turkey eggs were loaded to the setters without taking into consideration which breeder farm they come from. This practice has resulted in rearing the turkeys hatching from eggs obtained from different breeder flocks at the same time on a commercial farm. On the other hand, in the hatchery, information about the breeder flocks was recorded. Regarding turkey eggs assessed between 2008 and 2017 in the hatchery, breeder hen age varied from 31 to 57 weeks (mean = 41.92 weeks, standard deviation = 5.89 weeks).

Chicks were discharged at the end of the 28th day and manually separated by trained sexers. Since male and female chicks were obtained from the same breeder flocks, it might be assumed that there was no difference between male and female turkeys in terms of breeder hen age. After sexing, vaccinations were given on the same day against turkey rhinotracheitis (TRT) and Newcastle Disease (ND) with subcutaneous injection and coarse spray, respectively.

Day-old chicks were transported to rearing farms in İzmir, Manisa, and Aydın provinces. Since the study was conducted in 139 enterprises, the distance between the hatchery and the rearing farms varied between 1 and 231 km (Uluderbent, Alaşehir, Manisa). The handling, feeding, health protection practices, arrangement of the environmental conditions, and keeping the performance records of turkeys in all enterprises where the research data were obtained were made in agreement with the recommendations and directions of the integration. In the integration of commercial enterprises, 1st day inactive ND (subcutaneous injection) and live ND (mucosal spraying), 7th and 20th days TRT (drinking water), and 14th day live ND B1 (drinking water) vaccinations were administered to all turkeys. After the 1st day's inactive ND vaccination, the front parts of the upper beaks of the chicks were cut by using an ultraviolet ray.

Although there were small differences between the houses, all enterprises were approximately 100 m long and 11–12 m wide, with a 1.5-m-high from the ground wall, and windows covered with bird wires continuing up to the ceiling beam. In addition, a curtain system was used in all turkey houses. In the "Hybrid Turkey" guideline, it is recommended that carbon dioxide, carbon monoxide, ammonia, and humidity levels in turkey houses should be lower than 2500 ppm, 20 ppm, 25 ppm, and 60%, respectively[2]. In the same guideline, the optimal temperature in week 1 is specified as 34–34.5 °C. In the following weeks, it is recommended to gradually reduce the indoor ambient temperature to 14.5 °C for males and 16.5 °C for females until slaughter week. Farmers tried to keep the environmental conditions in the turkey houses within the thermal neutral zone with the following practices: The windows were closed or opened with tarpaulin curtains that could be managed manually or automatically from outside the house. With this practice, the temperature,

[2] Hybrid turkeys web page. https://www.hybridturkeys.com/en/resources/commercial-management/environmental-controls/ [accessed 08 September 2020].

humidity, ammonia, and light levels of the turkey houses were attempted to be kept under control. On days when the ambient temperature was low, stoves were burned to keep the temperature within the thermal neutral zone. When the interior temperature of the house increased, the curtains were opened and the house was attempted to be ventilated. Farmers had been informed that they needed to control ammonia levels during the whole production period to ensure optimum environmental conditions within the turkey house. Especially in the months when the air temperature differences were high between day and night, breeders were careful about balancing the optimum temperature inside the houses by burning the stoves and opening the curtains. In addition, technical personnel of the integration such as veterinarians and zootechnicians controlled the compliance with environmental conditions of the turkey houses during weekly inspections.

In all integration enterprises, 3 m in diameter circles were established by laying wood shavings 1 day before for chick acceptance in turkey houses whose cleaning and disinfection processes have been completed. Two hundred and fifty chicks were placed in each circle and according to this, drinker and feeder numbers were calculated as 1 feeder per 40 chicks and 1 drinker per 80 chicks, respectively. Beginning with the 2nd week, the adjacent circles were combined and the chicks were gradually released into the whole house. Turkeys roamed freely in the poultry house and ad libitum feed and fresh water were provided until slaughter. Dead animal counts and feed and water consumption were recorded daily. In all enterprises, turkeys were fed with a four-step feed regime; 0–4 weeks with thin granules (29.38% crude protein; 2900 kcal/kg metabolizable energy), 5–8 weeks with crumble (27.39% crude protein; 3000 kcal/kg metabolizable energy), 9–11 weeks with pellet (22.93% crude protein; 3200 kcal/kg metabolizable energy), and from 12th week to slaughter with another pellet (19.69% crude protein; 3300 kcal/kg metabolizable energy). Descriptive information about the rearing period is summarized in Table 1.

The most appropriate slaughter date was determined by investigating performance parameters such as body weight, feed consumption rate, and mortality rate, which were constantly monitored during the production period. At the point where the parameters such as feed consumption and mortality rate began to increase the cost of carcass, it was decided that all turkeys in the farm had reached the most appropriate slaughter age.

All turkeys were slaughtered in a commercial turkey slaughterhouse in Kemalpaşa, İzmir. The distance between the enterprises and the slaughterhouse varied between 1 and 165 km (Didim, Aydın). After the 3-h lairage period, the turkeys were hung on the cutting band, stunned by electroshock, and then slaughtered by hand. The carcasses were weighted after the feather wetting tub, plucking band, removal of feet, removal of internal organs, separation of the tail, head and wing tip, internal-external washing and trimming (removal of uninfected wounds and defects) procedures, respectively.

In the provinces of Aydın, İzmir, and Manisa, where the study was carried out, the Mediterranean climate is seen in hot and dry summers and warm and rainy winters. According to the records of the Turkish State Meteorological Service, the annual precipitation amount was 664.9, 711.1, and 746.2 mm in Aydın, İzmir, and Manisa provinces, respectively[3]. In order to determine the possible effects of seasonal differences on the investigated parameters, the production periods were divided into 4 seasons according to the beginning month of rearing: a. Spring (production periods starting in March and April); b. Summer (production periods starting in June and July); c. Autumn (production periods starting in September and October); and d. Winter (production periods starting in December and January). Descriptive statistics for temperature and humidity values by months were obtained from MeteoblueAG (Basel, Switzerland) and are presented in Table 2. Moreover, the altitude information of the districts where the enterprises were located has been compiled from the "haritatr" webpage and in the light of this information, the average of the altitudes of the farms in each province was calculated[4]. Average altitudes of farms in Aydın, İzmir, and Manisa provinces were calculated as 111.2, 108.9, and 139.8 m, respectively.

2.2. Performance traits and data editing procedures

The following data regarding the performance records of the farms during one production period between 2008 and 2017 were obtained digitally by integration: Delivery dates of chicks, number of chicks placed in a house, number of dead turkeys during the first week and later periods of growth, slaughter dates of turkeys, total preslaughter and carcass weights of turkeys, dressing percentages, feed consumption during the entire production period, average daily gain (ADG), and feed conversion ratio (FCR).

Within the scope of the research, the following parameters were calculated by using these performance records for each of the production periods: Total feed intake per turkey (TFI), daily feed intake (DFI), average preslaughter weight, average carcass weight, the mortality rate during the initial period (%, the proportion of the chicks that died during the first week), the mortality rate during the rearing period (%, the proportion of turkeys

[3] Turkish State Meteorological Service web page. https://www.mgm.gov.tr/veridegerlendirme/il-ve-ilceler-istatistik.aspx?k=A&m=IZMIR [accessed 01 August 2020].

[4] "Haritatr" webpage. https://www.haritatr.com/ [accessed 01 August 2020].

Table 1. Descriptive statistics for production periods by sex groups.

Items	Males (n[1]=570)		Females (n[1]=591)	
	Mean	SE	Mean	SE
Number of day-old chicks	6709.90	206.29	6396.22	164.43
Number of slaughtered turkeys	5862.54	178.57	5784.36	149.67
Stocking density, day-old chicks/m^2	3.31	0.051	4.65	0.101
Stocking density, kg weight/m^2	39.06	0.706	37.16	0.844

[1] The experimental unit was the production period

Table 2. Descriptive statistics for meteorological data by months in Aydın, Manisa, and İzmir provinces between 2008 and 2017[a].

Month	Temperature [b], °C						Relative humidity [b], %					
	Aydın		Manisa		İzmir		Aydın		Manisa		İzmir	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
January	8.83	0.54	7.25	0.60	8.13	0.63	73.77	1.06	73.02	0.99	70.85	0.87
February	10.20	0.51	9.20	0.62	9.57	0.60	72.92	1.33	70.57	1.07	69.63	1.34
March	12.35	0.32	11.58	0.35	11.75	0.39	69.58	1.07	65.73	1.18	66.04	1.77
April	16.55	0.41	15.86	0.49	15.65	0.41	64.13	1.22	59.40	1.60	61.34	2.42
May	21.29	0.34	20.64	0.37	19.77	0.40	57.88	1.74	55.59	1.91	60.15	2.16
June	26.15	0.40	25.04	0.33	24.25	0.37	50.68	1.60	51.41	1.41	55.38	2.23
July	29.18	0.25	27.41	0.22	26.86	0.35	45.13	1.09	48.64	0.82	50.78	2.77
August	29.42	0.29	27.40	0.37	26.89	0.49	45.30	1.14	51.93	0.75	58.23	2.10
September	24.72	0.32	23.53	0.29	23.01	0.37	52.00	1.67	54.72	1.52	57.66	2.51
October	19.52	0.47	18.01	0.57	18.07	0.48	58.31	1.56	62.89	1.59	63.41	2.11
November	15.15	0.53	14.01	0.75	14.33	0.63	62.95	1.64	66.84	0.90	66.41	1.45
December	10.90	0.58	9.30	0.74	10.17	0.61	68.85	2.26	70.23	1.32	67.35	2.62

[a] The data presented in the table are calculated over the monthly temperature and relative humidity averages between 2008 and 2017.
[b] Daily mean values for temperature and relative humidity.

that died after the second week), the total mortality rate (%, sums of mortality rates in the initial period and rearing period), and performance index (PI). The European Production Efficiency Factor (EPEF) was used to express the performance index. PI was calculated for the entire feeding period by the formula given below [12]:

PI = (survival rate × average preslaughter weight × 100) / (FCR × slaughter age)

2.3. Statistical analysis

The experimental unit of the study was the production period (sum or average of the values of the animals raised on a farm during a production period for the relevant trait). Statistical analysis focused on determining the effects of the rearing season, sex, and rearing season × sex interaction on the investigated characteristics, in line with the aims of the study. On the other hand, a preliminary analysis with the GLM procedure was investigated to determine whether the year and province factors also had an effect on these characteristics. The GLM model of the preliminary analysis included fixed effects of rearing season, sex, year, province, and rearing season × sex interaction. According to the results of the preliminary analysis, the effect of the year on all the characteristics investigated in the study was significant, but the effect of the province was not significant. Therefore, the province was excluded from the final GLM model. The final GLM model included fixed effects of rearing season, sex, year, and rearing season × sex interaction. Since the effect of season × sex interaction was found significant in all investigated characteristics, except for mortality rate and survival rate, the data set was also analysed with one-way ANOVA and Duncan multiple comparison test for 8 subgroups (4 seasons × 2 sexes). Both the GLM and one-way ANOVA results are presented in the tables. Statistical analyses were performed using the SPSS 13.0 program (SPSS Inc., Chicago, IL, USA).

3. Results

The effects of season and chick sex on TFI, DFI, FCR, and ADG are presented in Table 3. For these parameters, the effect of season × sex interaction was significant. When the main effects were evaluated, TFI and DFI were lower during the production period that began in the spring season compared to other seasons (P < 0.001). In terms of FCR, better results were obtained during production periods that began in the spring and summer seasons compared to autumn and winter (P < 0.001). ADG was higher during production periods that began in the summer and winter than spring and autumn (P < 0.001). TFI, DFI, and ADG values were higher in males compared to females (P < 0.001). FCR was better in females (P < 0.001). If the interaction effect was evaluated, DFI was highest in males in the autumn group and highest in females in the winter group. In production periods with male turkeys, FCR was found to be better in the spring and summer groups than in autumn and winter groups (P < 0.05), while the differences among seasons in females were

Table 3. Effects of season and sex on total feed intake (TFI), daily feed intake (DFI), feed conservation ratio (FCR), and average daily gain (ADG).

Factors	n[1]	TFI, kg		DFI, kg		FCR[2]		ADG, g	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE
Rearing season (RS)									
Spring	338	28.52[c]	0.350	0.250[c]	0.002	2.472[c]	0.022	100.64[b]	0.525
Summer	281	31.04[ab]	0.383	0.266[b]	0.002	2.500[c]	0.024	105.96[a]	0.574
Autumn	256	30.15[b]	0.419	0.269[ab]	0.002	2.682[a]	0.026	100.25[b]	0.628
Winter	286	31.49[a]	0.380	0.272[a]	0.002	2.573[b]	0.023	105.51[a]	0.570
Sex (S)									
Female	591	21.59	0.268	0.212	0.002	2.479	0.016	85.52	0.401
Male	570	39.01	0.277	0.316	0.002	2.635	0.017	120.66	0.415
RS × S interaction									
Male - Spring	166	35.55[c]	0.511	0.292[c]	0.003	2.481[c]	0.016	117.33[c]	0.891
Male - Summer	140	39.87[b]	0.593	0.318[b]	0.003	2.541[c]	0.016	125.17[a]	0.991
Male - Autumn	117	41.73[a]	1.272	0.336[a]	0.007	2.865[a]	0.096	119.27[c]	1.582
Male - Winter	147	40.78[ab]	0.633	0.325[b]	0.004	2.655[b]	0.028	122.56[b]	0.723
Female - Spring	172	21.56[de]	0.242	0.207[e]	0.002	2.452[c]	0.013	84.31[ef]	0.478
Female - Summer	141	22.20[d]	0.391	0.214[de]	0.002	2.464[c]	0.016	86.43[de]	0.663
Female - Autumn	139	20.41[e]	0.421	0.209[e]	0.003	2.526[c]	0.026	82.88[f]	0.813
Female - Winter	139	22.49[d]	0.291	0.220[d]	0.002	2.491[c]	0.018	88.26[d]	0.499
Overall mean	1161	30.30	0.195	0.264	0.001	2.557	0.012	103.09	0.293
Significance (P-values)									
RS		<0.001		<0.001		<0.001		<0.001	
S		<0.001		<0.001		<0.001		<0.001	
Year		<0.001		<0.001		<0.001		<0.001	
RS × S		<0.001		<0.001		<0.001		0.003	

[1] The experimental unit was the production period (sum or average of the values of the animals raised on a farm during a production period for the relevant trait).
[2] kg feed / kg body weight gain
[a, b, c, d, e, f] Mean values with different letters in the same column differ significantly at P < 0.05.

not significant (P > 0.05). The highest ADG was observed in males in the summer group and females in the winter group.

The results for slaughtering characteristics investigated in the study are given in Table 4. Preslaughter weight and carcass weight were lowest in males in the spring group, and lowest in females in the autumn group (P < 0.001). As the main effects, rearing season and sex had no influence on dressing percentage. However, rearing season × sex interaction significantly influenced the dressing percentage (P < 0.05). Higher mean values were obtained during the production period that began in autumn in males compared to that of spring and summer seasons (P < 0.05), whereas in females, the effect of the season on dressing percentage was not significant (P > 0.05).

The effects of season and chick sex on mortality and survival rates are presented in Table 5. The mortality rate during the initial period was highest in production periods that began in winter and lowest in those that began in summer (P < 0.001). The mortality rate in the rearing period was higher in the autumn group compared to the other season groups (P < 0.001). While the difference between males and females was not significant in terms of mortality rate in the initial period, the mortality rate in the rearing period was higher in males (P < 0.001).

Performance index values regarding season in male and female turkeys are presented in Figure. Performance index values of the production periods with males were higher than those of females (P < 0.001). The lowest performance indices in both males and females were observed in production periods that began in autumn. In males, the performance index was highest in the summer group (P < 0.05); the differences among the spring, summer, and winter groups in females were not significant (P > 0.05).

Table 4. Effects of season and sex on slaughter age, preslaughter weight, carcass weight, and dressing percentage.

Factors	n	Slaughter age, d		Preslaughter weight, kg		Carcass weight, kg		Dressing percentage, %	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE
Rearing season (RS)									
Spring	338	111.80^{b}	0.570	11.46^{b}	0.094	8.82^{b}	0.078	76.99	0.147
Summer	281	113.78^{a}	0.624	12.32^{a}	0.103	9.48^{a}	0.085	76.77	0.161
Autumn	256	107.69^{c}	0.683	11.10^{c}	0.113	8.57^{c}	0.094	76.99	0.176
Winter	286	112.98^{ab}	0.620	12.11^{a}	0.102	9.38^{a}	0.085	77.29	0.160
Sex (S)									
Female	591	101.04	0.436	8.67	0.072	6.67	0.060	76.88	0.112
Male	570	122.08	0.451	14.83	0.074	11.46	0.062	77.13	0.116
RS × S interaction									
Male - Spring	166	120.53^{b}	1.002	14.24^{c}	0.177	11.00^{c}	0.139	77.21^{bc}	0.098
Male - Summer	140	124.81^{a}	0.841	15.67^{a}	0.194	12.05^{a}	0.184	76.63^{c}	0.464
Male - Autumn	117	122.22^{ab}	1.608	14.72^{b}	0.309	11.50^{b}	0.253	77.89^{a}	0.436
Male - Winter	147	124.84^{a}	0.968	15.31^{a}	0.150	11.91^{a}	0.126	77.76^{ab}	0.099
Female - Spring	172	103.52^{c}	0.590	8.75^{d}	0.079	6.74^{d}	0.062	76.94^{c}	0.096
Female - Summer	141	102.82^{c}	0.927	8.93^{d}	0.130	6.89^{d}	0.099	77.04^{c}	0.124
Female - Autumn	139	96.59^{d}	0.966	8.04^{e}	0.071	6.20^{e}	0.107	76.92^{c}	0.207
Female - Winter	139	102.09^{c}	0.687	9.00^{d}	0.109	6.94^{d}	0.058	77.09^{bc}	0.122
Overall mean	1161	111.56	0.318	11.75	0.053	9.06	0.044	77.01	0.082
Significance (P-values)									
RS		<0.001		<0.001		<0.001		0.149	
S		<0.001		<0.001		<0.001		0.113	
Year		<0.001		<0.001		<0.001		<0.001	
RS × S		<0.001		<0.001		<0.001		0.029	

$^{a, b, c, d, e}$ Mean values with different letters in the same column differ significantly at P < 0.05.

Table 5. Effects of season and sex on mortality and survival rates.

Factors	n	Mortality rate in initial period, %		Mortality rate in rearing period, %		Total mortality rate, %		Survival rate, %	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE
Rearing season (RS)									
Spring	338	3.59 b	0.201	6.26 b	0.352	9.85 bc	0.435	90.15 ab	0.435
Summer	281	2.64 c	0.220	6.59 b	0.385	9.23 c	0.476	90.77 a	0.476
Autumn	256	3.62 b	0.241	8.35 a	0.421	11.97 a	0.521	88.03 c	0.521
Winter	286	4.34 a	0.218	6.52 b	0.382	10.87 ab	0.473	89.13 bc	0.473
Sex (S)									
Female	591	3.39	0.154	5.41	0.269	8.79	0.333	91.21	0.333
Male	570	3.71	0.159	8.45	0.278	12.16	0.344	87.84	0.344
RS × S interaction									
Male - Spring	166	3.74 abc	0.227	8.33 ab	0.313	12.07 abc	0.388	87.93 cde	0.388
Male - Summer	140	2.72 de	0.130	7.56 b	0.431	10.28 cd	0.456	89.73 bc	0.456
Male - Autumn	117	3.80 abc	0.316	9.70 a	0.897	13.50 a	1.093	86.50 e	1.093
Male - Winter	147	4.59 a	0.413	8.02 b	0.353	12.61 ab	0.575	87.39 de	0.575
Female - Spring	172	3.61 bcd	0.337	4.28 c	0.273	7.89 e	0.445	92.11 a	0.445
Female - Summer	141	2.64 e	0.111	5.54 c	0.609	8.18 e	0.647	91.82 a	0.647
Female - Autumn	139	3.31 cde	0.299	7.45 b	0.927	10.76 bcd	1.063	89.24 bcd	1.063
Female - Winter	139	4.36 ab	0.457	4.81 c	0.430	9.17 de	0.609	90.83 ab	0.609
Overall mean	1161	3.55	0.112	6.93	0.196	10.48	0.243	89.52	0.243
Significance (P-values)									
RS		<0.001		<0.001		<0.001		<0.001	
S		0.137		<0.001		<0.001		<0.001	
Year		<0.001		<0.001		<0.001		<0.001	
RS × S		0.808		0.191		0.368		0.368	

a, b, c, d, e Mean values with different letters in the same column differ significantly at $P < 0.05$.

4. Discussion

Knowing the seasonal changes of performance criteria, such as daily feed consumption, ADG, and FCR in male and female turkeys can contribute to more productive and profitable turkey breeding. In the current study, the effects of season × sex interaction on TFI, DFI, FCR, and ADG were significant. These results indicate that there is a difference between male and female turkeys in terms of the effect of the season on the performance characteristics studied. While DFI of male turkeys was higher in the autumn group compared to other season groups, ADG determined for production periods that began in autumn was found to be lower compared to that of summer and winter seasons. For production periods carried out with male turkeys, the DFI was higher in the winter group compared to spring, whereas ADG was lower in the winter group than in the summer. These findings related to DFI and ADG resulted in the fact that male turkeys had better FCR values in the production periods that began in spring and summer compared to those that began in autumn and winter. The worst FCR value in male turkeys was obtained for the production periods that began in autumn.

Optimal growth performance can be achieved when birds are raised under conditions within the thermal neutral zone range [9]. For turkeys, the thermal neutral zone may vary depending on the age of the bird and it has been reported to be between 16 and 28 °C by Brody [13]. When the ambient temperature rises above thermoneutral, the birds undergo heat stress [14]. In the event of heat stress, birds activate thermoregulatory mechanisms such as vasodilation and increased evaporation losses from the skin and respiratory system. Moreover, feed intake and production levels are decreased to reduce digestive heat and production metabolism, respectively [9,11]. Bozakova [15]

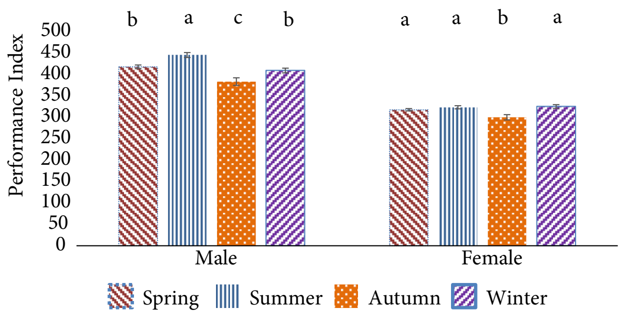

Figure. Performance index values of turkeys reared in different seasons. The effects of season, sex, and year were significant at P < 0.001. [a, b, c]: Means with different letters within a sex group differ significantly (P < 0.05).

stated that the most common adverse conditions in birds raised on the ground in summer are constant exposure to ammonia concentrations with increasing air temperature and humidity. Numerous authors have also reported that rearing birds at high environmental temperatures can have deleterious influences on the physiology and productivity of turkeys [8,9,11] and broiler chickens [10]. In İzmir, Manisa, and Aydın provinces where the data of the study were obtained, the average daytime temperature in July and August (varied between 26.87 and 29.42 °C; Table 2) was at the upper limit of the thermal neutral zone for turkeys. Therefore, one of the possible reasons for less DFI in male turkeys of the summer group than their autumn counterparts might be relatively high environmental temperatures in the summer months. However, the FCR and ADG values for male turkeys in the summer group were not adversely affected by environmental temperature. On the other hand, there was no decrease in DFI of female turkeys in the summer group, and their FCR and ADG values were not worse than the female turkeys of other season groups. The difference between male and female turkeys regarding the effect of season on DFI and FCR might be explained by the difference between sexes in surface area per body weight. Generally, male birds have a lower surface area per body weight due to a higher weight. Therefore, heat loss per kg of body weight is lower in males and the adverse effect of high environmental temperature is more evident in male birds than in females [16]. Relative humidity can affect the thermoregulation mechanism of birds to the environmental temperature; high humidity can increase the negative effect of high temperature [14]. In the conditions of the current study, it can be considered as an advantage that July and August, the hottest months of the year, were also the months with the lowest relative humidity.

Contrary to what is observed in the case of heat stress, in the conditions of cold stress, poultries try to maintain homoeothermia by increasing heat production and feed consumption and decreasing heat loss [17]. In the conditions of the current study, the average daytime temperature during December, January, February, and March (varied between 7.25 and 12.35 °C; Table 2) was lower than the limit of thermal neutral zone for turkeys. Furthermore, in autumn, it is noteworthy that there was a sharp drop in ambient temperature after September. Therefore, in the current study, higher levels of DFI in male turkeys in the autumn group and female turkeys in the winter group might be caused by low environmental temperature. Moreover, this result may indicate that the turkey farms in the Aegean Region have not been sufficiently successful in adjusting the ambient temperature in the houses during the autumn and winter months. In addition, ADG and FCR values of male turkeys in the autumn and winter groups were determined to be worse than those of the summer group. Although the highest DFI value in female turkeys was observed in production periods that began in winter, there was no difference between season groups in terms of FCR. These results can be explained by the fact that the ADG of female turkeys was higher in the winter than in the spring and autumn groups. On the other hand, ADG values obtained for male turkeys in all season groups were compatible with previous reports by Tran et al. [18] for Hybrid Converter male turkeys and by Konca et al. [19] for BUT 6 turkey toms. The FCR values obtained for male and female turkeys were better than previous reports for hybrid strain tom turkeys (between 2.90 and 3.08) by Feddes et al. [20] and for BUT 6 turkey toms (3.10) by Konca et al. [19]. However, the FCR value determined by Tran et al. [18] for hybrid converter tom turkeys (between 2.07 and 2.19) was lower than the current results. Another issue that should not be ignored is that the FCR values determined in all season groups for male and female turkeys in the current study were worse than the performance goals reported for the Hybrid Converter commercial males[5] (2.10 and 2.20 for weeks 17 and 18, respectively) and females (2.04 and 2.14 for weeks 14 and 15, respectively). However, the FCR value of 2.49 reported by Makarynska and Vorona [21] for 18-week-old Hybrid Converter males was consistent with the current study.

In this study, it is seen that male turkeys have higher DFI and ADG values in all-season groups compared to females. In many previous studies conducted with broiler chickens [22,23] and turkeys [24], it was concluded that feed consumption and ADG of males were higher than females. In terms of DFI and ADG, the higher values for males may have been caused by the common effect of

[5] Performance goals converter commercial males and females. https://www.hybridturkeys.com/documents/538/Performance_Goals_Converter_LB_09_17.pdf [accessed 20 April 2020].

many factors, such as greater competition for feed between males, difference in nutritional needs, and greater effect of indigenous hormones in females [22]. Santos-Ricalde et al. [25] attributed the difference in the growth rate between male and female turkeys to sexual dimorphism due to higher levels of growth hormone in males from the second week. On the other hand, males consumed more feed per 1 kg of live weight gain in autumn and winter groups, while there was no difference between male and female turkeys in terms of FCR in the spring and summer groups. Siaga et al. [23] and Havenstein et al. [26] also reported no significant sex influence on FCR value for broiler chickens and for commercial turkey strains, respectively.

As expected, sex and season subgroups with higher ADG had higher preslaughter weight and carcass weight. Also, the effect of season × sex interaction on preslaughter weight and carcass weight was significant. Both in male and female turkeys, the preslaughter weight and carcass weight in production periods that began in autumn were lower than those of summer and winter. In males, production periods that began in spring resulted in the lowest preslaughter weight and carcass weight. Dressing percentage, as well as preslaughter weight, are among the main determinants of carcass weight. When animals are slaughtered at a similar weight, a higher carcass weight is obtained from the animal with a higher dressing percentage [27]. In the current study, rearing season × sex interaction had a significant influence on dressing percentage. The dressing percentage of male turkeys in the summer group was lower compared to male turkeys in the autumn and winter groups. Therefore, according to the comment of Sañudo et al. [27], male turkeys in the summer group would be expected to have a lower carcass weight. However, the preslaughter weights of turkeys raised in different seasons were not similar in the current study. As a result, due to the contribution of greater preslaughter weight, the male turkeys of the summer group still had higher carcass weights than the spring and autumn groups. On the other hand, differences among season groups in terms of dressing percentage were not significant in female turkeys. When male and female turkeys are compared for each season group separately, it is seen that only in the autumn group males have a higher dressing percentage than female turkeys, and in other seasons, the effect of sex was not significant. As the main effect, sex had no influence on dressing percentage. No significant differences between male and female turkeys in terms of dressing percentage were reported previously by Chodová et al. [28] for BUT Big 6 and Hybrid Converter genotypes and by Shamseldin et al. [29] for BUT Big 6 turkeys. On the other hand, Santos-Ricalde et al. [25] found a higher dressing percentage in male Hybrid Converter turkeys than female ones and attributed the difference to the sexual dimorphism effect on tissue synthesis.

In various previous studies carried out in Turkey, Czechia, USA, and Mexico, the dressing percentages of Hybrid Converter turkeys were reported between 75.47% and 78.84% in males [5,25,28] and between 76.63% and 80.02% in females [2,25,28,30]. In the current study, the mean dressing percentage calculated for the season–sex subgroups varied in the range of 76.63%–77.89% and was consistent with the results of previous studies mentioned above. On the other hand, higher dressing percentage values were reported for male (82.7%) and female (between 80.4% and 83.22%) Hybrid Converter turkeys in studies conducted in Poland [12,31–33].

When the mortality rates in different season groups are evaluated, the mortality rate in the first week after being placed on the farm was highest in the winter group while the mortality rate in the subsequent periods of rearing was highest in the autumn group. Both the first week and the total mortality rates were lowest during production periods that began in summer. These findings may indicate that in the conditions of the Aegean Region, the high mortality rates might be associated with cold stress rather than the hot ambient temperature. Indeed, the environmental temperature in the region during the winter months (Table 2) appears to be below the thermal neutral zone for turkeys (16–28 °C) reported by Brody [13]. On one hand, it can be said that the ambient temperature in the Aegean Region in summer was at a level that the turkeys can acclimate to and that does not result in a high mortality rate. On the other hand, it seems that the main problem with the management of turkey farms in the Region is related to the heating of the houses and the regulation of the temperature inside of the houses during the cold autumn and winter months.

In a previous study [34] conducted to investigate the influence of seasonal heat exposure on Nicholas male turkeys, the mortality rate was similar in heat stress groups (32 and 38 °C for night and day, respectively) and control group (16 and 24 °C for night and day, respectively). The authors note that turkeys were acclimated to the high temperatures over a 3-day period. This notification may explain why the mortality rate in the summer group was low in the current study. In another study [35] conducted with broiler chickens subjected to cold stress during the entire rearing period, the mortality rate was significantly higher in the cold stress group compared to the control group (8.88% vs. 2.60%). On the other hand, Olanrewaju et al. [10] observed no significant differences in terms of mortality rate among heavy broiler chickens kept at low (15.6 °C), moderate (21.1 °C), and high (26.7 °C) ambient temperatures during 21–56 days of age.

Male and female turkey chicks had a similar mortality rate during the first week of rearing. However, in later periods of rearing, the mortality rate was higher in male turkeys. Contrary to the results obtained in the current study, Havenstein et al. [26] found that the effect of sex on mortality rate was not significant for commercial turkey strains (Nicholas, British United Turkeys of America, and Hybrid turkeys). In a study conducted with broiler chickens [22], sex had no significant influence on the mortality rate. However, supporting the current result, Doğrul [36] found a significantly higher survival rate for female BUT Big 6 turkeys than for male ones.

Previous reports on mortality rates of turkeys show wide variation. The mortality rate reported by Quinton et al. [37] for Hybrid Converter turkeys (10.8%) was consistent with the mortality rates determined for various season × sex subgroups (7.89%–13.50%) in the current study. Similar survival rates (86.3%–94.3%) have also been reported in a study conducted in Turkey for the BUT Big 6 turkeys [36]. However, Roberson et al. [38] reported a much lower survival rate (79.6%) for male Hybrid Converter turkeys. On the other hand, much lower mortality rates (0.36%–4.98%) were reported for Hybrid Converter turkeys in studies carried out in Poland [12,32,33].

In the current study, the European Performance Efficiency Factor (EPEF) was used as a performance index to evaluate the productivity of the rearing periods. In male turkeys, the highest performance index value was observed in the summer group and the lowest performance index value was observed in the autumn group. Also, the worst performance index for female turkeys was determined for production periods that began in autumn. While an increase in preslaughter weight and survival rate increased the performance index, the increase in slaughter age and FCR (numerically) caused a decrease in the performance index value. The highest mortality rate was in the autumn group for both male and female turkeys. Moreover, the worst FCR value was observed in the autumn group in males, and the lowest preslaughter weight in females was observed in the autumn group. Therefore, the worst performance index value was observed in the autumn group and it might be attributed to the combined effects of the results, which are listed above for mortality rate, FCR, and preslaughter weight.

In a previous study conducted with female Hybrid Converter turkeys [12], the EPEF value was reported between 394.7 and 414.3. When the studies are compared in terms of the variables used in calculating the performance index, it is seen that the mortality rate in the current study was higher than the values reported by Konieczka et al. [12]. Therefore, lower performance index values in the current study might be explained by the higher mortality rates. On the other hand, the performance index values of the current study were higher than the values (213.76 and 249.32) reported by Lalev et al. [39] for male hybrid turkeys.

In conclusion, a total of 1161 (570 males, 591 females) production period data of 139 turkey farms in the Aegean Region between 2008 and 2017 were analysed in this study. The highest DFI was observed in production periods that began in autumn for male turkeys and in winter for female turkeys. Among the production periods of male turkeys, the production periods that began in autumn resulted in the worst FCR. The total mortality rates of production periods that began in autumn and winter were higher than those of summer and spring. The lowest performance index was observed during the production periods that began in autumn for both males and females. These findings indicate that more care must be taken in managing the environmental conditions in the poultry houses during the production periods that begin in autumn and winter. In the conditions of the current study, the distances of 139 enterprises to the slaughterhouse differed. Transportation will cause weight loss in turkeys and this will not be the same for all enterprises. Thus, ignoring transportation duration can be considered as the limitation of the study.

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