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Review Article

Meta-Analysis of Performance and Carcass Values in Lamb Fattening in Türkiye

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Abstract

This study aimed to reach a common conclusion for different breeds, regions, years, ages and fattening periods by examining studies on lamb fattening in Türkiye between 2000-2024 years concerning performance and carcass characteristics with a meta-analysis. The analysis included 51 research results from 21 studies that met the study criteria consisting of being conducted after the year 2000, investigating variables such as initial live weight (ILW), slaughtered body weight (SBW), daily weight gain (DWG), feed conversion ratio (FCR), hot carcass weight (HCW) and dressing percentage (DP), cold carcass weight (CCW) and yield (CCY), with at least three studies on a breed, and being conducted in Türkiye. The highest values for ILW and SBW were detected in the Awassi breed and the Eastern Anatolia region. For DWG, significantly highest value was calculated in the Morkaraman breed (265.95 g; P<0.05). The best values for FCR were calculated in Akkaraman breed (5.10 kg); in Eastern Anatolia region (4.84 kg); <90 days (5.06 kg) according to fattening start age, and according to fattening period, ≥90 days (4.77 kg) (P<0.01). The Awassi breed had the highest values concerning HCW, DP, CCW, and CCY from the carcass data, whereas Marmara region had the lowest values among the regions. In conclusion, it can be speculated that the Awassi, Morkaraman, and Akkaraman breeds are preferred primarily, Eastern and Central Anatolia are more suitable regionally, and fattening lambs <90 days old and long-term fattening (≥90 days) are prominent both technically and economically.

Keywords: Carcass, Lamb, Meta-analysis, Performance, Türkiye

Introduction

Lamb fattening is the process of raising and feeding lambs after weaning for butchering. This process is carried out to ensure that the animals grow healthily, demonstrate optimum yield capabilities and obtain high amounts of quality meat. Red meat obtained from lamb farming is one of the leading sources of meeting animal protein needs [1]. At least 40-50% of the daily protein requirements of a balanced and healthy diet must be met by animal-based proteins [2].

The total red meat production of Türkiye in 2023 was calculated as 2.384.047 tons, of which 70.1% (1.670.606 tons) was beef, 23.9% (569.066 tons) was mutton, and the remaining 6% (144.375 tons) was goat and buffalo meat [3].

In sheep breeding in Türkiye, one of the primary sources of income is lamb meat, and lamb meat production holds particular importance due to the presence of 42 million sheep and the traditional consumption habits of the people [4]. Considering the negative effects of red meat production and the instability in prices in recent years, sheep breeding has become a good alternative that can be used to solve these problems.

The demand for animal products in Türkiye has been increasing every day due to rapid population growth, tourism, refugee migration, and socio-economic and cultural development. To meet this increasing demand, increasing the carcass and meat yield per unit of animal is more economically important than increasing the number of animals.

The fattening performance of lambs, which is affected by factors such as breed, sex, age, care-feeding method, feed amount and quality, can be listed as post-slaughter carcass weight, yield and quality [5]. Producers raising lambs aim to achieve maximum fattening performance and carcass yield at minimum cost by paying optimum attention to the existing elements. There are many individual studies on lamb fattening, conducted over many years on different breeds, regions, times, ages and fattening periods in Türkiye that were used in the present study.

The current article is a comprehensive study in which lamb fattening researches carried out after the year 2000 in Türkiye are handled together, analyzed and interpreted in a way to guide producers/stakeholders.

The results obtained from individual studies conducted independently on a particular subject can be very diverse and different. In the current study, meta-analysis appeared to be a good option for both evaluating and interpreting information from a large number of studies, obtaining new information, and reaching a more comprehensive and reliable common conclusion by eliminating heterogeneity between studies [6]. Meta analysis is the process of reaching a common conclusion by systematically combining the results of studies conducted independently on a certain subject using a specific method. With this analysis, the results of studies with small sample sizes can be combined with scientific methods, and parameter estimates with higher power and precision can be made with larger samples [7,8].

In the current study, it was aimed to reach a common conclusion for different breeds, regions, years, ages, and fattening periods by examining studies on lamb fattening in Türkiye between 2000-2024 regarding performance and carcass characteristics through a meta-analysis and to guide producers who will engage in lamb fattening in the future.

Material and Methods

The study material consisted of results from studies investigating the fattening performance and carcass yield characteristics of sheep in Türkiye conditions. This study was not subject to ethics committee approval because the research data were obtained from articles available in the open-access literature. The flow diagram for selecting eligible studies for meta-analysis is given in *Fig. 1*.

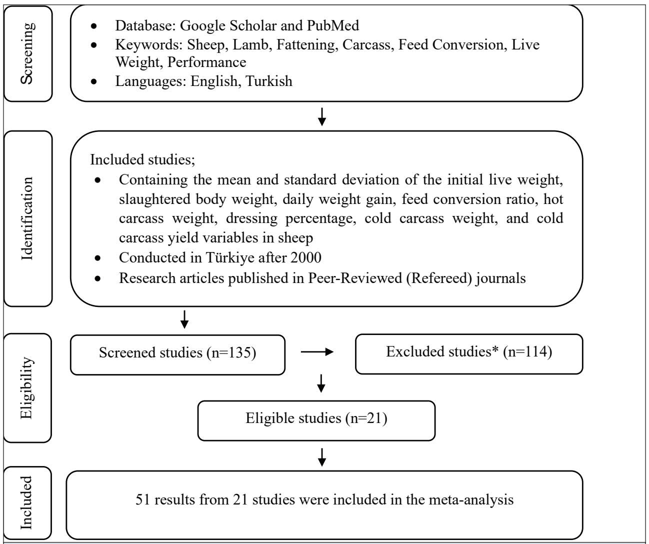

Fig 1. Flow diagram of studies included in the meta-analysis (* Studies that do not meet the inclusion criteria)

In the study, separate meta-analyses were performed for initial live weight (ILW), slaughtered body weight (SBW), daily weight gain (DWG), feed conversion ratio (FCR), hot carcass weight (HCW), dressing percentage (DP), cold carcass weight (CCW), and cold carcass yield (CCY) variables. In the meta-analysis, results that did not have mean and standard deviation values specified for the variables and did not form subgroups were eliminated. Therefore, the number of studies in the general meta-analysis and subgroup analysis differed according to variables. In this study, subgroups were determined as breed (Awassi, Akkaraman, Kıvırcık, Morkaraman, Tuj, Karayaka), geographical region (Southeast Anatolia, East Anatolia, Central Anatolia and Marmara), fattening start age (<90 days, 90-120 days and >120 days) and fattening duration [Short (≤60), Medium (61-89) and Long (≥90)].

Heterogeneity among the study results included in the analysis was evaluated using Cochran's Q and I^2 statistics. Meta-analysis results were presented with a random effects model in studies with heterogeneity, and with a common effects model in studies with homogeneity. Egger's linear regression test was used to detect publication bias, and Duwal and Tweedie's trim and fill method was used to eliminate publication bias. Furthermore, effect sizes and weights (%) of the studies were showed with forest plot [9].

The statistical significance level was determined as $P<0.05$, for the difference between effect sizes and $P<0.10$ for Cochran's Q statistics. Analyses were performed with the "meta" package in RStudio (version 2024.04.22+764) software. Characteristics of the studies used in the meta-analysis are shown in *Table 1*.

Results

In this study, the analysis values of fattening performance (ILW, SBW, and DWG), carcass yield (HCW, DP, CCW, CCY), and other statistical information are presented in *Table 2*.

According to the meta-analysis results, it was observed that there was a high level of heterogeneity among the studies for all variables. The values calculated with the random effects model for some variables were found as

Table 1. Characteristics of studies used in meta-analysis

No	References
1	**Adıgüzel Işık S, Sarı M, Muammer T, Önk K:** The effect of fattening time on fattening performance, slaughter and carcass characteristics in Tuj male lambs. *MAS JAPS,* 8 (2): 256-264, 2023.
2	**Altın T, Karaca O, Cemal İ, Yılmaz M, Yılmaz O:** Kıvırcık ve Karya kuzularda besi ve karkas özellikleri. *J Anim Prod,* 46 (1): 19-29, 2005.
3	**Balcı F, Karakaş E:** The effect of different slaughter weights on the fattening performance, slaughter and carcass characteristics of male Karayaka lambs. *Turk J Vet Anim Sci,* 31 (1): 25-31, 2007.
4	**Demir H, Kahraman R, Özcan M, Kaygısız FH, Ekiz B:** Kıvırcık kuzuların rasyonuna katılan zinc bacitracin'in besi performansına, bazı karkas özelliklerine ve kuzu maliyetine etkisi. *İstanbul Üniv Vet Fak Derg,* 28 (1): 185-198, 2002.
5	**Esenbuga N, Macit M, Karaoglu M, Aksakal V, Aksu MI, Yoruk M A, Gül M:** Effect of breed on fattening performance, slaughter and meat quality characteristics of Awassi and Morkaraman lambs. *Livest Sci*, 123, 255–260, 2009.
6	**Gökdal Ö, Atay O, Eren V, Demircioğlu SK:** Fattening performance, carcass and meat quality characteristics of Kivircik male lambs. *Trop Anim Health Prod,* 44, 1491-1496, 2012.
7	**Gül M, Yörük MA, Macit M, Esenbuga N, Karaoglu M, Aksakal V, Aksu IM:** The effects of diets containing different levels of common vetch (Vicia sativa) seed on fattening performance, carcass and meat quality characteristics of Awassi male lambs. *J Sci Food Agric,* 85, 1439-1443, 2005.
8	**Gül S, Biçer O:** İvesi koyunlarında besi performansı ve EAAP metoduna göre karkaslarının değerlendirilmesi. *MKUJAS*, 25 (1):20-26, 2020.
9	**Gürbüz A, Akman N, Ankaralı B, Öztürk H:** Ile De France (If), Akkaraman (Ak) ve bunların melezi̇ (F1 Ve G1) erkek kuzularda besi̇ performansı. *Lalahan Hay Araşt Enst Derg,* 40 (2) 27-33, 2000.
10	**Karabacak A, Boztepe S:** Yağlı kuyruklu ve yağsız i̇nce kuyruklu koyun ırklarının besi̇ performanslarının karşılaştırılması. *Selcuk J Agric Food Sci,* 21 (42): 89-95, 2007.
11	**Koyuncu M:** Growth performance and carcass quality of fattening lambs of Kivircik and Karacabey Merino breeds. *LRRD,* 20 (12):197, 2008.
12	**Kul S, Şeker İ:** İvesi ve Tahirova x İvesi Melezi (F1) erkek kuzuların besi performansı, kesim ve karkas özellikleri. *F U Vet J Health Sci,* 16 (1): 57-64, 2002.
13	**Küçük M, Bayram D, Orhan Y:** Morkaraman ve Kıvırcık X Morkaraman (G1) melezi kuzularda büyüme, besi performans, kesim ve karkas özelliklerinin araştırılması. *Turk J Vet Anim Sci,* 26, 1321-1327, 2002.
14	**Macit M:** Growth and carcass characteristics of male lambs of the Morkaraman breed. *Small Ruminant Res,* 43, 191-194, 2002.
15	**Mis A, Öztürk Y:** Akkaraman toklularda besi performansı, kesim ve karkas özellikleri. *MAKÜ Sag Bil Enst Derg,* 6 (2): 72-83, 2018 .
16	**Önk K, Sarı M, Yüksel A, Muammer T, Tuncay T, İsa Y:** Effects of different fattening systems on fattening performance, slaughter and carcass characteristics of male tuj lambs. *Kafkas Univ Vet Fak Derg,* 23 (1): 109-115, 2017.
17	**Özbey O, Akcan A:** Morkaraman, Kıvırcık x Morkaraman (F1) ve Sakız x Morkaraman (F1) melez kuzulurda verim özellikleri II. Besi performansı, kesim ve karkas özellikleri. *YYÜ Vet Fak Derg,* 14 (2): 35-41, 2003.
18	**Şen U, Sirin E, Ulutas Z, Kuran M:** Fattening performance, slaughter, carcass and meat quality traits of Karayaka lambs. *Trop Anim Health Prod,* 43, 409-416, 2011.
19	**Şahin E H, Akmaz A:** Farklı kesim ağırlıklarında Akkaraman kuzuların besi performansı, kesim ve karkas özellikleri. *Vet Bil Derg,* 18 (3): 29-36, 2002.
20	**Tekel N, Şireli HD, Vural M E:** Besi süresinin İvesi erkek kuzuların besi performansı ve karkas özelliklerine etkisi. *JAS,* 13 (4): 372-378, 2007.
21	**Ünal N, Akçapınar H, Aytaç M, Atasoy F:** Fattening performance and carcass traits in crossbred ram lambs. *Medycyna Wet,* 62 (4): 401-404, 2006.

follows; ILW 24.96 kg, SBW 43.18, DWG 244 kg, FCR 5.44, DP 48.80% and CCY 7.73% (P<0.001; *Table 2*). Forest plot analysis variables are shown in *Fig. 2* and *Fig. 3*.

The publication bias values in this study are presented in *Table 3*.

According to Egger's linear regression test results, there was a publication bias among the studies in terms of the results of the ILW, FCR, and HCW variables (P<0.05). Duwal and Tweedy's trim and fill method was applied to eliminate publication bias, and the means were adjusted to 22.43 (95% CI 19.89-24.96), 4.27 (95% CI 3.48-5.07), and 26.74 (95% CI 24.76-28.71), respectively, by adding seven virtual studies to ILW, 10 to FCR, and 24 to HCW (*Table 3*).

To determine the sources of heterogeneity in this study, subgroup analyses of data on performance (ILW, SBW, DWG, FCR and hot/cold carcass weight (HCW, CCW) and dressing percentage (DP) were performed according to breed, region, fattening start age and fattening duration, and the results are presented in *Table 4* and *Table 5*, respectively.

In the subgroup analysis of ILW, a statistically significant difference was found for all subgroups (P<0.05). The subgroups with the lowest and highest ILW values were

Table 2. *General meta-analysis results for performance and carcass data*

Variables	k	n	Mean (%95 CI)	Heterogeneity	
				Cochran's Q	I^2(%)
ILW, kg	51	808	24.96 (22.94-26.98)	Q=2592.47, Df=50, P<0.001	98.1
SBW, kg	47	753	43.18 (41.10-45.27)	Q=4757.91, Df=46, P<0.001	99.0
DWG, g	45	733	244.78 (233.71-255.86)	Q=8542076.00, Df= 44, P<0.001	100.0
FCR, kg	25	368	5.44 (4.80-6.07)	Q=1637.52, Df= 24, P<0.001	98.5
HCW, kg	47	766	21.26 (20.13-22.40)	Q=21941.00, Df=46, P<0.001	99.8
DP, %	36	631	48.80 (48.01-49.58)	Q= 169833.34, Df= 35, P<0.001	100.0
CCW, kg	44	727	20.90 (19.73-22.07)	Q= 5263.40, Df=43, P<0.001	99.2
CCY, %	37	642	47.73 (46.93-48.53)	Q=9126.42, Df= 36, P<0.001	99.6

k: Number of studies; n: Number of animals; CI: Confidence interval; I^2: The proportion of total variation in study estimates that is due to heterogeneity; Cochran's Q: The estimation of a weighted average of effect in the overall population

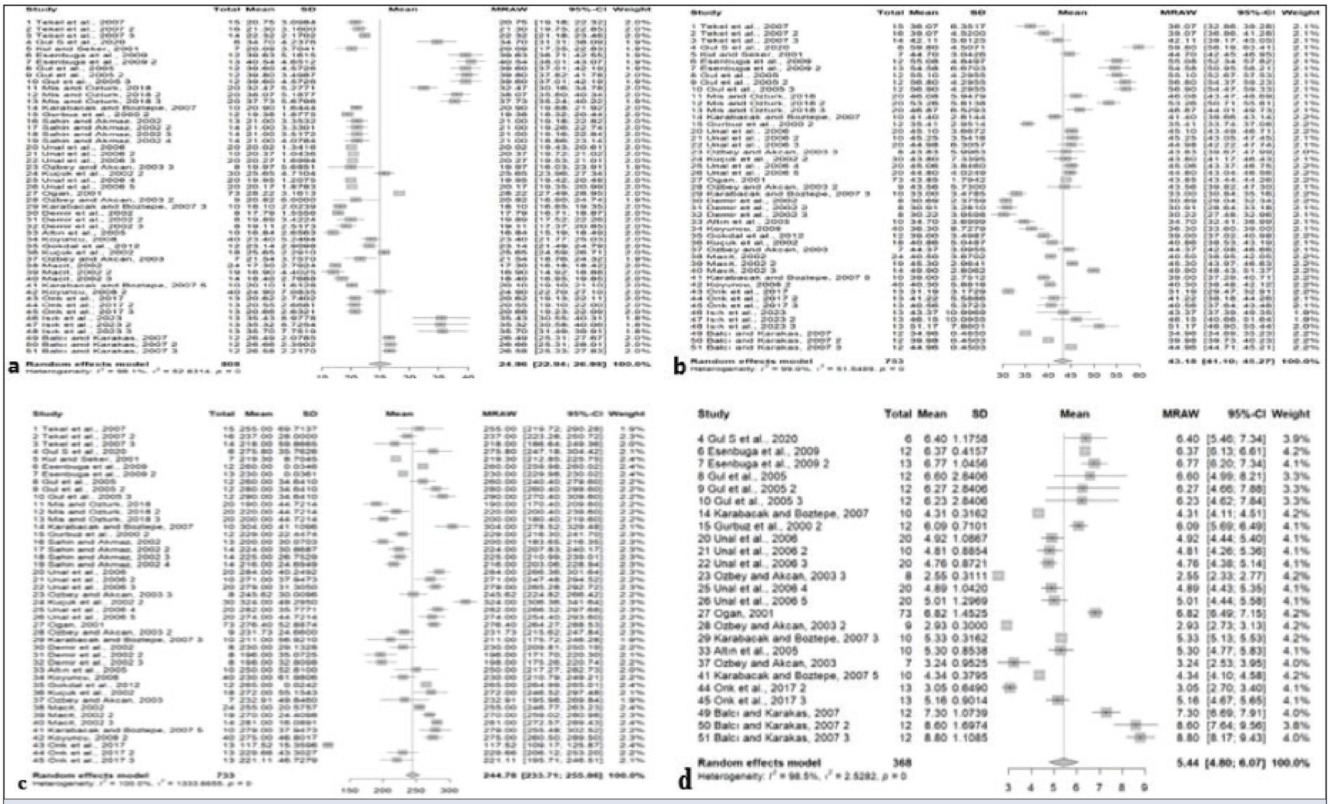

Fig 2. Forest plots. a-ILW, b-SBW, c-DWG, d-FCR

calculated in the following subgroups: Kıvırcık (19.73 kg) and Awassi, (31.79 kg) breeds; Central Anatolia (20.11 kg) and Eastern Anatolia (28.73 kg) regions; <90 days (20.02 kg) and >120 days (35.81 kg) fattening start age; and ≥90 days (21.92 kg) and ≤60 days (28.73 kg) fattening periods, respectively (P<0.05; *Table 4*).

In the subgroup analysis for SBW, there was a significant difference between the subgroups of breed, geographical region, and fattening start age (P<0.001), whereas no significant difference was found between the fattening duration subgroups (P>0.05). The subgroups with the lowest and highest values in terms of SBW were calculated in the following subgroups: Kıvırcık (33.55 kg) and Awassi, (50.01 kg) breeds; Marmara (36.99 kg) and Eastern Anatolia (46.75 kg) regions; and <90 days (39.52 kg) and >120 days (50.70 kg) fattening start age subgroups, respectively (P<0.001; *Table 4*).

The difference between breed subgroups for DWG was statistically significant (P<0.05), whereas no significant difference was found between geographical region, fattening start age and fattening duration subgroups (P>0.05). The subgroups with the lowest and highest

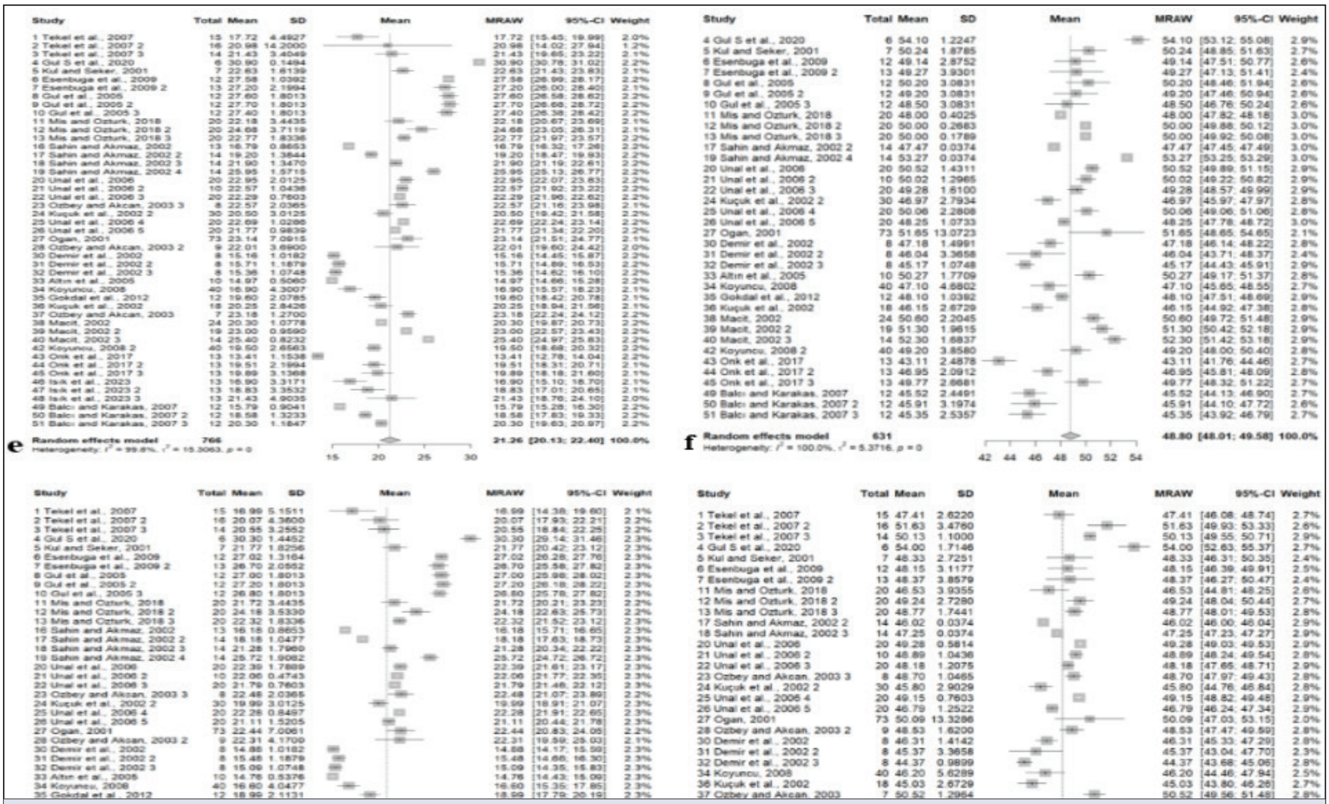

Fig 3. Forest plot e-HCW, c-DP, g-CCW, h-CCY

Table 3. *Publication bias results for performance and carcass data*			
Variables	**Egger's Linear Regression Test**		
	t-statistic	**Df**	**P-value**
ILW, kg	3.59	49	**<0.001**
SBW, kg	1.21	45	0.231
DWG, g	-0.23	43	0.817
FCR, kg	2.19	23	**0.039**
HCW, kg	-4.35	45	**<0.001**
DP, %	-0.30	34	0.763
CCW, kg	1.04	42	0.306
CCY, %	1.11	35	0.273

DWG values were calculated in the Tuj (188.60 g) and Morkaraman (265.95 g) breeds, respectively (P<0.05; *Table 4*).

A statistically significant difference was found in all subgroups for FCR (P<0.01). The lowest and highest FCR values were calculated in the subgroups of Akkaraman (5.10 kg) and Karayaka (8.21 kg) according to breeds; Eastern Anatolia (4.84 kg) and Marmara (7.83 kg) according to geographical regions; <90 days (5.06 kg) and >120 days (6.58 kg) according to fattening start age and ≥90 days (4.77 kg) and ≤60 days (6.70 kg) according to fattening duration, respectively (P<0.01; *Table 4*).

There was a significant difference in all subgroups for HCW (P<0.01). The lowest and highest values for HCW were calculated in the subgroups of Kıvırcık (16.22 kg) and Awassi, (25.38 kg) according to breeds; Marmara (17.79 kg) and Eastern Anatolia (22.50 kg) according to geographical regions; 90-120 days (19.52 kg) and >120 days (25.01 kg) according to fattening start age and 61-89 days (20.12 kg) and ≥90 (25.53 kg) according to fattening period, respectively (P<0.01; *Table 5*).

In the subgroup analysis for DP, there was a significant difference between the subgroups in terms of breed, geographical region and fattening period (P<0.05), whereas no significant difference was found between the subgroups in terms of fattening start age (P>0.05). The

Table 4. *Subgroup analysis results for ILW, SBW, DWG and FCR data*

Variables	ILW (kg)			SBW (kg)			DWG (g)			FCR (kg)		
	Mean (%95 CI)	**k**	I^2	**Mean (%95 CI)**	**k**	I^2	**Mean (%95 CI)**	**k**	I^2	**Mean (%95 CI)**	**k**	I^2
Breed Subgroups												
Awassi	31.79 (25.97-37.62)	10	98.8	50.01 (44.68 (55.33)	10	97.3	251.85 (235.94-267.75)	10	100.0	6.42 (6.22-6.63)	6	0.0
Akkaraman	25.21 (20.50-29.92)	10	98.2	44.63 (39.85-49.41)	6	96.9	228.75 (206.69-250.80)	10	91.8	5.10 (4.07-6.13)	3	96.8
Kıvırcık	19.73 (17.79-21.66)	7	90.8	33.55 (31.09-36.01)	7	89.4	226.98 (206.55-247.41)	7	93.9	-	-	-
Morkaraman	19.96 (16.67-23.25)	5	97.2	44.23 (40.84-47.61)	5	95.4	265.95 (252.91-278.99)	5	82.1	-	-	-
Tuj	27.77 (21.25-34.28)	6	95.5	42.03 (36.50-47.56)	6	95.6	188.60 (117.15-260.05)	3	98.4	-	-	-
Karayaka	26.57 (25.84-27.29)	3	0.0	39.97 (34.31-45.62)	3	99.9	-	-	-	8.21 (7.25-9.17)	3	84.0
General	25.69 (23.25-28.12)	41	98.1	43.13 (40.49-45.77)	37	99.2	236.35 (224.03-248.67)	35	100.0	6.54 (5.77-7.31)	12	97.3
Significance	Cochran's Q (df=5) = 58.24, **P<0.001**			Cochran's Q (df=5) = 50.03, **P<0.001**			Cochran's Q (df=4) = 17.05, **P=0.002**			Cochran's Q (df=2) = 19.45, **P<0.001**		
Regional Subgroups												
Southeastern Anatolia	21.58 (20.61-22.56)	3	28.5	39.13 (35.88-42.38)	3	73.0	236.32 (224.49-248.16)	3	16.6	-	-	-
Eastern Anatolia	28.73 (25.03-32.43)	23	98.5	46.75 (44.06-49.43)	23	96.9	241.43 (221.95-260.92)	20	100.0	4.84 (3.73-5.94)	10	98.9
Central Anatolia	20.11 (19.87-20.35)	13	35.9	41.55 (38.47-44.62)	9	95.7	252.03 (233.21-270.86)	13	93.2	4.93 (4.57-5.29)	9	92.5
Marmara	23.71 (21.19-26.23)	9	97.6	36.99 (33.27-40.70)	9	99.8	235.26 (206.82-263.71)	6	93.5	7.83 (6.87-8.80)	4	91.8
General	24.97 (22.89-27.05)	48	98.1	43.10 (41.04-45.17)	44	99.1	243.47 (231.77-255.18)	42	100.0	5.40 (4.71-6.09)	23	98.6
Significance	Cochran's Q (df=3) = 35.79, **P<0.001**			Cochran's Q (df=3) = 22.10, **P<0.001**			Cochran's Q (df=3) = 2.06, P=0.560			Cochran's Q (df=2) = 30.82, **P<0.001**		
Feeding Start Age (Days) Subgroups												
<90	20.02 (18.69-21.35)	13	89.9	39.52 (36.97-42.07)	13	96.4	254.56 (240.11-269.01)	13	88.5	5.06 (4.40-5.72)	5	96.3
90-120	22.88 (20.80-24.96)	22	95.0	40.73 (37.75-43.72)	18	99.5	228.99 (207.55-250.43)	16	98.1	5.71 (4.56-6.85)	10	97.6
>120	35.81 (32.07-39.56)	10	98.0	50.70 (46.76-54.63)	10	97.9	247.41 (226.26-268.57)	10	100.0	6.58 (6.30-6.87)	6	10.8
General	24.99 (22.77-27.22)	45	98.2	42.78 (40.53-45.03)	41	99.1	241.91 (230.08-253.75)	39	100.0	5.76 (5.15-6.37)	21	97.3
Significance	Cochran's Q (df=2) = 61.56, **P<0.001**			Cochran's Q (df=2) = 23.07, **P<0.001**			Cochran's Q (df=2) = 3.76, P=0.153			Cochran's Q (df=2) = 18.27, **P=0.001**		
Feeding Duration (Days) Subgroups												
Short (≤60)	28.73 (24.77-32.68)	17	98.5	42.84 (38.29-47.39)	17	99.3	256.45 (239.28-273.63)	15	100.0	6.70 (6.38-7.02)	7	46.2
Medium (61-89)	23.68 (20.83-26.54)	22	97.2	41.86 (39.36-44.36)	20	96.1	235.91 (215.79-256.04)	19	98.1	5.11 (4.41-5.81)	12	95.9
Long (≥90)	21.92 (19.40-24.44)	12	93.7	46.34 (43.92-49.36)	10	91.9	244.33 (228.79-259.87)	11	94.8	4.77 (2.83-6.72)	6	98.8
General	24.96 (22.94-26.98)	51	98.1	43.18 (41.10-42.27)	47	99.0	244.78 (233.71-255.86)	45	100.0	5.44 (4.80-6.07)	25	98.5
Significance	Cochran's Q (df=2) = 8.10, **P=0.017**			Cochran's Q (df=2) = 5.12, P=0.077			Cochran's Q (df=2) = 2.43, P=0.297			Cochran's Q (df=2) = 19.26, **P<0.001**		

k: *Number of studies;* ***CI:*** *Confidence interval;* I^2*: The proportion of total variation in study estimates that is due to heterogeneity;* ***Cochran's Q:*** *The estimation of a weighted average of effect in the overall population*

Table 5. *Subgroup analysis results for HCW, DP, CCW and CCY data*

Variables	HCW (kg)			DP (%)			CCW (kg)			CCY (%)		
	Mean (%95 CI)	**k**	I^2	**Mean (%95 CI)**	**k**	I^2	**Mean (%95 CI)**	**k**	I^2	**Mean (%95 CI)**	**k**	I^2
Breed Subgroups												
Awassi	25.38 (22.86–27.91)	10	98.6	50.18 (48.68–51.69)	7	90.0	24.54 (21.96–27.12)	10	96.0	49.76 (47.98–51.54)	7	90.0
Akkaraman	22.02 (19.98–24.06)	8	98.7	49.87 (48.22–51.53)	6	100.0	21.46 (19.32–23.61)	8	98.7	47.86 (46.70–49.02)	6	99.9
Kıvırcık	16.22 (14.85–17.60)	6	91.9	47.36 (45.90–48.81)	6	92.6	15.90 (14.65–17.15)	6	90.2	45.48 (44.36–46.59)	4	74.5
Morkaraman	22.46 (20.54–24.37)	5	98.6	50.11 (47.48–52.74)	4	95.5	21.97 (20.01–23.93)	5	98.4	49.18 (47.08–51.28)	5	94.6
Tuj	18.21 (15.89–20.53)	6	96.5	46.60 (42.84–50.37)	3	95.5	17.06 (12.92–21.19)	3	98.2	45.25 (41.35–49.15)	3	96.4
Karayaka	18.22 (15.63–20.80)	3	98.3	45.55 (44.68–46.42)	3	0.0	17.67 (15.05–20.28)	3	98.8	44.08 (43.30–44.87)	3	0.0
General	21.11 (19.72–22.51)	38	99.8	48.68 (47.74–49.63)	29	100	20.75 (19.29–22.20)	35	99.3	47.57 (46.54–48.59)	28	99.7
Significance	Cochran's Q (df=5) = 59.82, **P<0.001**			Cochran's Q (df=5) = 43.28, **P<0.001**			Cochran's Q (df=5) = 56.85, **P<0.001**			Cochran's Q (df=5) = 59.80, **P<0.001**		
Regional Subgroups												
Southeastern Anatolia	19.84 (16.95-22.73)	3	68.8	-	-	-	19.38 (17.36–21.41)	3	61.6	49.70 (47.35-52.04)	3	88.9
Eastern Anatolia	22.50 (20.98-24.02)	23	98.8	48.94 (47.89–49.99)	17	97.6	22.53 (20.94–24.12)	20	98.8	47.90 (46.77–49.02)	17	94.6
Central Anatolia	21.78 (20.12-23.45)	9	98.7	49.84 (48.43–51.25)	7	100.0	21.21 (19.45–22.97)	9	98.9	47.93 (46.98–48.88)	7	99.9
Marmara	17.79 (16.03-19.54)	9	97.1	46.84 (45.64–48.03)	9	84.1	17.36 (15.68–19.04)	9	97.3	45.71 (44.50–46.92)	9	83.3
General	21.22 (20.13-22.32)	44	98.9	48.61 (47.83–49.40)	33	100.0	20.87 (19.74–22.00)	41	99.0	47.56 (46.81–48.30)	36	99.6
Significance	Cochran's Q (df=3) = 17.85, **P<0.001**			Cochran's Q (df=2) = 11.48, **P=0.003**			Cochran's Q (df=3) = 21.14, **P<0.001**			Cochran's Q (df=3) = 13.07, **P=0.005**		
Feeding Start Age (Days) Subgroups												
<90	19.99 (17.75–22.24)	9	99.6	50.19 (48.79–51.59)	6	88.8	19.48 (17.41–21.55)	9	99.4	49.28 (48.05–50.50)	8	87.3
90-120	19.52 (18.14–20.90)	22	99.0	47.94 (46.70-49.18)	17	100.0	19.07 (17.54–20.60)	19	99.2	46.41 (45.36–47.47)	17	99.8
>120	25.01 (23.19–26.83)	10	96.7	49.23 (48.55–49.90)	10	98.1	24.46 (22.64–26.28)	10	96.4	48.50 (47.71–49.29)	6	37.8
General	20.97 (19.77–22.17)	41	99.2	48.77 (48.00–49.54)	33	100.0	20.58 (19.33–21.82)	38	99.2	47.52 (46.71–48.34)	31	99.7
Significance	Cochran's Q (df=2) = 23.68, **P<0.001**			Cochran's Q (df=2) = 5.79, P=0.055			Cochran's Q (df=2) = 22.02, **P<0.001**			Cochran's Q (df=2) = 14.36, **P<0.001**		
Feeding Duration (Days) Subgroups												
Short (≤60)	20.83 (18.49–23.17)	17	99.3	47.81 (46.93–48.68)	15	84.9	20.58 (18.18–22.99)	16	99.2	46.41 (45.43–47.39)	12	83.3
Medium (61-89)	20.12 (18.71–21.53)	18	99.2	48.63 (47.55–49.72)	14	99.8	19.60 (18.09–21.11)	16	99.2	47.51 (46.24–48.79)	14	99.0
Long (≥90)	23.53 (21.91–25.16)	12	99.7	50.98 (48.88–53.08)	7	97.3	23.06 (21.46–24.66)	12	97.5	49.25 (47.80–50.69)	11	97.8
General	21.26 (20.13–22.40)	47	99.8	48.80 (48.01–49.58)	36	100.0	20.90 (19.73–22.07)	44	99.2	47.73 (46.93–48.53)	37	99.6
Significance	Cochran's Q (df=2) = 9.98, **P=0.007**			Cochran's Q (df=2) = 7.76, **P=0.021**			Cochran's Q (df=2) = 9.73, **P=0.008**			Cochran's Q (df=2) = 10.20, **P=0.006**		

k: *Number of studies;* ***CI:*** *Confidence interval;* ***I^2:*** *The proportion of total variation in study estimates that is due to heterogeneity;* ***Cochran's Q:*** *The estimation of a weighted average of effect in the overall population* subgroups with the lowest and highest values for DP were determined as Karayaka (45.55%) and Awassi (50.18%) breeds; Marmara (46.84%) and Central Anatolia (49.84%) regions; and ≤60 days (47.81%) and ≥90 days (50.98%) fattening period, respectively (P<0.05; *Table 5*).

A significant difference was found for CCW in all subgroups (P<0.01). The lowest and highest values for CCW were calculated in the subgroups of Kıvırcık (15.90 kg) and Awassi (24.54 kg) according to breed; Marmara (17.36 kg) and Eastern Anatolia (22.53 kg) according to geographical regions; 90-120 days (19.07 kg) and >120 days (24.46 kg) according to fattening start age and 61-89 days (19.60 kg) and ≥90 days (23.06) according to fattening period, respectively (P<0.01; *Table 5*).

A statistically significant difference was found for CCY in all subgroups (P<0.01). The lowest and highest values for CCY were calculated in the following subgroups: Karayaka (44.08%) and Awassi (49.76 according to breed; Marmara (45.71%) and Southeastern Anatolia (49.70%) according to geographical regions; 90-120 days (46.41%) and <90 days (49.28%) according to fattening start age; and ≤60 days (46.41%) and ≥90 days (49.25%) according to fattening duration, respectively (P<0.01; *Table 5*).

Discussion

Lamb farming is very important for meeting the red meat demand in the country, reducing the foreign trade deficit, and strengthening the national economy. However, lamb fattening can be done profitably and sustainably by selecting appropriate breeds suitable for fattening or by crossbreeding between local and meat breeds. The fattening performance of animals can increase to the extent that their genetic capacity allows [10]. However, breed selection alone is not enough; the region where fattening is performed and the fattening period must also be well determined. In addition, it is beneficial to protect and improve existing pastures, which are important for lamb fattening.

In addition to the increasing population in Türkiye, immigration from abroad and tourism have increased the total demand for food and meat. As production was not adequately planned in response to the increasing demand, a supply deficit occurred, and the country started importing live animals and red meat [11].

Under normal conditions, in Türkiye, the demand for red meat is mostly met by beef, whereas 23.9% is met by sheep meat. To meet the demand for red meat and eliminate the foreign trade deficit, sheep meat, which is produced in smaller quantities than beef, must be increased as an alternative. The way to realize this is not only to increase the number of sheep but also to increase the productivity per unit of animal. To increase productivity, it is necessary to select suitable breeds for fattening and implement appropriate feeding programs.

In the current study, a meta-analysis was performed to determine the suitable breeds for lamb fattening. Thus, this study enabled the comparison of different breeds and provided decision support to producers regarding the selection of appropriate breeds. In terms of fattening performance, daily weight gain and feed conversion were evaluated together [12]. Therefore, in the current study, the breeds with higher/better fattening performance in Türkiye's conditions were Awassi, and Morkaraman in terms of DWG, whereas the Akkaraman breed was better for FCR.

This study showed that the best performance concerning starting age for fattening is achieved in the young age group (<90 days old), and that should not be late to start fattening for better results and development, and fattening should be started after weaning.

On the other hand, it was determined that the breed with the highest values concerning ILW, SBW, HCW, DP, CCW and CCY was Awassi. The breed with the lowest value concerning ILW, SBW, DWG, HCW and CCW was Kıvırcık, whereas the breed with the lowest value in terms of DP and CCY was Karayaka. Studies reporting the higher fattening performance of Awassi breed than other breeds support the results of the current study [10,13]. In addition, studies have shown that one of the factors affecting fattening performance is the season [14,15], and the fact that the Awassi breed is generally raised in provinces with high temperatures in the Southeastern Anatolia Region (Şanlıurfa, Gaziantep, etc.) is another reason why the fattening performance of this breed is better than that of other breeds.

Different lamb feeding methods are applied in every region of Türkiye. The Eastern Anatolia Region has more pastures than the other regions [16]. This causes lamb farming enterprises in the Eastern Anatolia Region to engage in extensive pasture-based farming. In Western Anatolia, the scarcity of pastures has directed breeders to intensive lamb farming. Extensive pasture-based lamb farming creates lower production costs compared to intensive lamb farming due to the lower feed costs. Therefore, producers in the Eastern Anatolia Region can continue lamb fattening for a longer period of time and achieve higher fattening performance compared to the other regions. Lamb producers in the Western Anatolia Region tend to slaughter lambs early because of the increasing costs of long-term fattening. It can be seen that production costs affect the differences in fattening performance between regions. Breeding different breeds in each region also causes differences in the fattening performance between regions. Sheep breeding has been performed in the Eastern Anatolia Region for many years, and the producers here have more experience in sheep breeding, which is one of the factors that positively affect the fattening performance of the animals.

Different fattening periods are another factor affecting fattening performance. It was observed that breeders prefer lambs with higher IW in short fattening periods. Thus, lambs can reach the desired slaughter weight in a short time. In the long term, producers appear to prefer animals with lower weights. The reason for this may be to reduce the cost of purchasing the feeding material. Better FCR and higher carcass yields in long-term fattening (≥90 days) indicated that short-term fattening preferred for early lamb slaughter is not the right choice in economic terms.

Concerning carcass yields, the Awassi and Morkaraman breeds prominent with DP values above 50% and CCY values close to 50%. Regarding carcass values, it can be said that long-term feeding (≥90 days) is more advantageous. Although the Awassi and Morkaraman breeds had the best fattening performance among the existing lamb breeds in Türkiye, previous studies [17-19] reported that the fattening performance data of meat lamb breeds (Suffolk, German Meat Merino, Ile de France, etc.) were higher than the Awassi and Morkaraman breeds. This shows that concerning efficiency, the use of meat lamb breeds or their crossbreeds in lamb fattening can be considered in Türkiye. In conclusion, when both fattening performance and carcass values are evaluated together, according to the criteria determined in the current study for lamb fattening in Türkiye, it can be speculated that the Awassi, Morkaraman, and Akkaraman breeds are preferred primarily, Eastern Anatolia and Central Anatolia are more suitable regionally, and fattening lambs <90 days old and long-term fattening (≥90 days) are prominent both technically and economically.

Declarations

Availability of Data and Materials: The data and materials of this study are available from the corresponding author (S. Demir).

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