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Effects of feeding systems on yield and performance of Linda geese (*Anserinae sp*.) in hot climatic conditions

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Abstract

This study evaluated the effects of various types of feeding on fattening period and performance of Linda geese. Feeding patterns consisted of concentrate feed-based intensive and pasture feed-based semi-intensive. A total of 150 goslings aged three days were divided into two groups, each consisting of three replications. All groups were given rations containing 23% crude protein and 3100 kcal/kg ME in weeks 0–6, and rations containing 20% crude protein 3100 kcal/kg ME between weeks 7 and 17. After the seventh week, the feed for the semi-intensive group was diluted with 20% barley and from the tenth week, this group started to graze on pasture. Live weight gain of the two groups was similar, although geese kept indoors consumed more concentrate. Feed protein digestion of geese was similar in the two feeding types. Digestion-related visceral weight in the pasture-supplemented group increased, whereas carcass weight decreased. Growth curves were used to estimate the age of Linda geese to the end of the fattening period. The average slaughter age was the fourth and fifth months, as indicated by Von Bertalanffy, Logistic, and Gompertz growth models, which used the data from the third week. Concentrate feeding enabled Linda geese to reach earlier higher slaughter weight, although it was not considered economical. Although averages of bodyweight gain over the trial appeared slightly better in the concentrate-based intensive group, the results revealed that concentrate feed supplement and pasture may be the best and most economical form of feeding for Linda geese.

Keywords: fattening performance, goose fattening, growth curve, pasture feeding, ryegrass
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Introduction

Geese are known as poultry that are adapted to cold weather conditions. This stereotype causes the misperception that Sanliurfa Province in Turkey, where summers are dry and hot, is not suitable for goose breeding. Contrary to common opinion, geese can adapt not only to cold climates, but also to hot and arid climates (Liu & Zhou, 2013). Easy maintenance and feeding compared with other poultry species make goose breeding popular in all regions. Despite increasing attention on breeding in Turkey, the number of goose farms in Sanliurfa is not known. The total number of geese in Turkey was 1 080 000, of which 25 000 were located in Sanliurfa (TUIK, 2018). However, there are no commercial goose farms in the centre of Sanliurfa. Nor has a study investigated economic breeding and feeding programmes for geese in the region. Geese consume a lot of feed and are mobile animals that make good use of pasture (NRC, 1994). Therefore, feeding with concentrate indoors is not economical and does not fit the nature of geese. Feeding with mown grass is not realistic for geese either. On the other hand, feeding programmes based solely on pasture would not be sufficient to provide the 20% protein and 3000 kcal kg^{-1} energy required in starter feed (NRC, 1994). The increasing demand for free-range poultry meat has brought the breeding of geese and turkey, which are the most suitable poultries for this system, into the agenda (Mancinelli *et al.*, 2018). Goose breeding under free range, which is preferred for animal welfare, could provide an important advantage for Sanlıurfa region.

The annual egg production of domestic geese is between 15 and 20 eggs (Kaya & Yurtseven, 2019), and domestic varieties cannot compete with hybrid breeds, whose average yield is between 40 and 50 eggs per laying season. Although Linda geese have been the preferred hybrid in Turkey in the last 10 years, its

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adaptability to hot weather and pasture-supported feeding has not been evaluated. Thus, its suitability for the hot and dry conditions of Şanlıurfa should be investigated. The reasons for breeders' preference (Sarı *et al.*, 2019) are the higher egg yield and hatching efficiency compared with other hybrid breeds and their white colour. The free-range system, which is one of the goose breeding systems in pasture, is expected to increase interest in goose breeding as an alternative to traditional rearing systems in the region. Therefore, it is important to investigate the advantages of the free-range system compared with other breeding systems, compatibility with the region, and yield and growth characteristics of Linda geese. Research has not yet determined the optimum slaughter age for Linda geese.

Ryegrass belongs to the *Gramineae* family, which is preferred in goose pastures because of its high yield, rich nutrient content, and palatability (Humphreys, 2003). A small amount of ryegrass in goose rations could contribute to flavour and reduce carcass fat deposition (Yu *et al*., 1998). However, the effects of ryegrass on Linda geese rations have not been studied in Turkey. Therefore, the current study was also aimed to investigate the effects of ryegrass on goose breeding, to introduce and goose production in the region, and to determine the effects of feeding type on fattening period and performance of Linda geese.

Material and Methods

Permission was obtained from the Ethics Committee of Harran University for the use of animals in the study (ethics document number: HRU-HADYEK-2020/001-01/07). The experiments were carried out between 15 June and 1 October 2019 at the goose farm of Harran University in Şanlıurfa Province, which is located at 37° 9' 32.9364 latitude and 38° 47' 48.8724 longitude. The air temperature between June and October varied from 26 to 37 °C, and precipitation was from 2 to 31 mm.

The study was conducted to compare two feeding systems, namely an intensive, mainly concentrate feed and an extensive concentrate and pasture-supported system. The goslings were hatched on 19 June 2019 and fed chick starter until the beginning of the trial at three weeks old. All age values, such as optimum slaughter age, growth course, first sexual maturity, and spawning age, were reported as time from hatching. In fitting the growth curves, the starting time was three weeks. One hundred and fifty goslings were divided into two equal live weight groups based on their three-week-old weights, and each group was later divided into three subgroups (replicate) with 25 goslings in each.

Since gender differentiation of geese is difficult during the gosling period, gender was not considered in the distribution of goslings to the groups. The numbers of males and females in the groups appeared when the sex characteristics became clear at 4 - 5 months old. Genders were determined by visual hand contact and external appearance of the geese that came to slaughter and the gender distribution of the groups was recorded.

The goslings in the first group were given concentrate feed indoors and were taken to the pasture only once a week. The goslings in the second group were grazed every day on the pasture and fed indoors from the seventh week until the end of the fattening period. Pasture was designed to have one adult goose per square meter. Ryegrass *(Lolium multiflorum*) was planted in the pasture in the middle of June, 1.5 months prior to geese grazing. Grazing started approximately 30 - 40 days after planting or when the grass was 15 cm high. Concentrate feed was given to the pasture group geese only on return from pasture towards evening. Feeding with compound feed alone would not have been economical, thus the geese were given concentrate mixed with barley and corn, which was the practice of many breeders. The distribution of the trial groups and the rations given in the various feeding periods are shown in Table 1. Compound feed and concentrate feed applications were changed depending on the growth period. Until six weeks old, both groups were fed with a feed containing 23% crude protein (CP) and 3100 kcal kg^{-1} metabolic energy (ME), which is recommended for 0 - 6 weeks old (starting period) goslings. Then, a commercial broiler grower feed containing 21% CP and 3100 Kcal kg^{-1} ME was used for brooding and rearing throughout the trial.

Table 1 Feeding programme of ration components in the starting and growing periods

Weeks	Concentrate feed group	Semi intensive feeding (pasture group)
3 - 6	Chick starter feed	Chick starter feed
7 - 9	Broiler grower feed	Broiler grower feed + barley
10 - 14	Broiler grower feed	Broiler grower feed + barley + pasture (ryegrass)
15 - 17	Broiler grower feed + barley	Broiler grower feed + barley + pasture (ryegrass)

Geese have high feed consumption, and many breeders mix their concentrate feed compounds with cereal grains such as barley or corn. To provide economical feeding conditions similar to those of regular goose breeders, the mixture was prepared with four units of concentrate and one unit of cereal. The identification numbers were placed on the feet of the goslings, and the live weight gain and feed consumption were determined by weighing them individually once a week to determine feed utilization. Drinking water was provided ad libitum throughout the trial. At the end of the experiment, 10 geese (5 males, 5 females) were randomly selected from each group for slaughter, and carcass yield and weights of the liver, pancreas, heart, and gizzard were recorded. During dissection, abdominal fat was removed and weighed, and all visceral weights were recorded directly, not as a proportion of bodyweight.

Growth curves were created to determine the most appropriate slaughter age and fattening period of Linda geese raised for meat production. In addition, the most beneficial feeding method was determined in the concentrate feed and pasture feeding systems. From three weeks old, the geese were weighed every week on the same day throughout the trial. The weights were recorded through the 20th week.

The humped beak structure specific to the Linda breed and symptoms of sexual maturity are considered indicators of growth. Therefore, relationships of humped beak structure and sexual maturity with feeding system were monitored throughout the fattening period.

To examine the contributions of feeding system to feed digestibility, faeces were collected by placing five geese from each group in a closed box for 24 hours. Feed and water were given ad libitum and feed consumptions were determined. Grass mowed from pasture and concentrate feed were given to geese in the pasture group and their concentrate and forage utilization were calculated separately. The geese were placed in the boxes at 08h30 with faeces being collected and weighed after 24 hours. Dry matter content of the weighed faeces was determined, and nitrogen content was analysed. The following equation was used to determine nitrogen digestibility:

$$\text{Digestibility (\%)} = 100*(A - B) / A$$

where: A = the amount of nitrogen in the feed (input), and
B = the amount of nitrogen in the dry faeces (output).

Statistical analysis of the data was carried out using SPSS software (IMB Corp., Armonk New York, USA). Performance and digestibility between groups was examined using t-tests for independent samples. The differences between groups were tested at the 5% significance level. Weight records of the male and female Linda geese were fitted to Von Bertalanffy, Logistics, and Gompertz growth models. The results were used to predict the asymptotic weight (A), relative growth rate (K), and end of growth and time to slaughter (IPA). Goodness of fit of the models was summarized using the coefficient of determination (R^2), predicted age and weight at the inflection point (IPA and IPW) and residual mean standard error (RMSE) for each model.

Results and Discussion

The differences in growth between the feeding systems were not significant during the individual feeding periods. However, overall the live weight gain in the intensive system was significantly higher throughout the fattening period compared with the semi-intensive system. Feed consumption values of the two groups were similar during the early periods of the trial, but diverged from the tenth week, with the concentrate-fed geese consuming more feed from that point to the end of the trial. However, this reflects the measurable feed consumption and the amount of grass that was consumed by the geese in the pasture is unknown. The mean daily live weight gain, feed intake and feed efficiency in various periods of fattening are given in Table 2.

Feed utilization rates were similar throughout the trial, except between 7 and 9 weeks (P =0.04). The diet of the pasture group contained 20% barley in addition to the concentrate that was fed prior to grazing. Therefore, live weight gains and feed consumption of this group had a tendency to decrease during this period. Feed consumption of geese released to pasture after the ninth week decreased by 20% compared with indoor feed consumption. The concentrate feed was also diluted with barley at a 1/5 ratio after the ninth week. Allowing geese to forage has economic advantages when one considers the high cost of concentrate compared with pasture grass. Therefore, many breeders prefer pasture for more economical fattening. In vivo nitrogen digestibility was similar for the two groups of geese (P =0.52) averaging 66%. Daily nitrogen (N) excretion in total faeces was 2.8 g and 2.5 g in the concentrate and pasture groups. Corresponding values of N consumed in feed were 9.6 and 9.8 g.

The viscera weights of the pasture-supplemented group increased significantly, whereas their carcass weights decreased (Table 3).

Table 2 Live weight gain, feed intake and efficiency of Linda geese while being fattened for slaughter[1]

Weeks	Feeding system	Live weight gain, g/d	*P*-value	Feed intake, g/d	*P*-value	Feed efficiency	*P*-value
3 - 6	Concentrate	50.9 ± 8.8	0.15	205.7 ± 5.6	0.790	7.1 ± 2.0	0.54
	Pasture	33.6 ± 6.3		207.5 ± 6.2		8.6 ± 1.5	
7 - 9	Concentrate	32.5 ± 6.7	0.09	238.1 ± 0.5	0.140	9.5 ± 1.5	0.04
	Pasture	46.9 ± 4.4		228.9 ± 6.8		5.4 ± 0.5	
10 - 14	Concentrate	39.6 ± 8.2	0.68	234.0 ± 1.2	0.002	8.6 ± 1.3	0.17
	Pasture	36.8 ± 4.7		197.3 ± 0.7		6.6 ± 0.8	
15 - 17	Concentrate	14.5 ± 4.8	0.40	238.7 ± 0.4	0.001	17.7 ± 5.3	0.96
	Pasture	11.2 ± 1.9		199.2 ± 0.1		18.2 ± 4.2	
3 - 17 (overall)	Concentrate	42.8 ± 4.5	0.05	227.7 ± 2.7	0.002	8.5 ± 1.2	0.62
	Pasture	30.1 ± 3.1		205.5 ± 2.9		9.2 ± 0.9	

[1]Geese were weighed individually, whereas the groups were divided into sub-groups of 25 birds each to record feed intake

Table 3 Carcass and some internal weights of Linda geese on concentrate-based system or on pasture with concentrate supplementation

Traits	Feeding system	Weights, g	P-value
Carcass weight	Concentrate	2375.1 ± 111.0	0.003
	Pasture	1915.0 ± 70.2	
Liver weight	Concentrate	66.0 ± 3.3	0.001
	Pasture	84.4 ± 3.4	
Pancreas weight	Concentrate	11.9 ± 1.4	0.005
	Pasture	17.4 ± 0.9	
Abdominal fat weight	Concentrate	77.6 ± 7.0	0.070
	Pasture	59.5 ± 6.2	
Heart weight	Concentrate	33.9 ± 2.3	0.390
	Pasture	36.3 ± 1.5	
Gizzard weight	Concentrate	102.4 ± 3.5	0.007
	Pasture	116.5 ± 3.0	

The parameters of growth curves created by considering the sex and descriptive values of live weight data for Linda geese are given in Table 5. The R^2 and RMSE values indicated that the three growth models were compatible and similar in explaining the growth curves of Linda geese. These growth curves showed that the intensive group had higher live weight values and needed shorter time to complete fattening. In other words, IPA values, which express the inflection point at which live weight gain stabilizes, were lower in the intensive group in all three models. In addition, more time was needed for male Linda geese to complete fattening in both feeding systems (Figure 1).

Similar to many species, geese show an S-shaped growth curve, and these three models best explain this growth type (Osei-Amponsah *et al*., 2014; Gao *et al*., 2016). The age at inflection of the growth curve and the predicted body weight at this age were similar in male and female chickens (Atıl *et al*., 2007) and ducks (Vitezica *et al*., 2010). However, in the current study females were younger and lighter in weight than

males at the inflection point of their growth curve (Table 5, Figure 1). Önder *et al*. (2017) reported similar results in domestic geese with male geese maturing later compared with female geese. Sarı *et al.* (2019) indicated that adult Linda geese could reach 5 to 7 kg live weight. The growth curve data obtained in this study showed that males reach up to 4.3 kg and females up to 3.8 kg, and growth plateaued after the 17th week. Low live weights recorded in this study may be attributed to the hot climate, to which geese were thought not to be well adapted. In addition, the higher weights reported by Sarı *et al.* (2019) were mostly for mature geese, which may have had more fat deposition than the younger ones in this study. The growth characteristics reported in this study are the first for Linda geese and thus are important because of the economic contribution of these birds to agricultural systems.

Table 5 Parameter estimates for growth curves describing live weight gain of Linda geese from 3 to 20 weeks old

Growth model	Feeding system	Sex	A	B	K	R^2	RMSE	IPA	IPW	MI
Von Bertalanffy	Concentrate	Male	4299.7	0.96	0.29	0.95	328.3	3.6	1273.9	567.2
		Female	3736.7	1.01	0.33	0.93	314.1	3.3	1107.1	551.7
	Pasture	Male	3929.5	0.64	0.15	0.95	193.5	4.3	1164.3	265.7
		Female	3400.9	0.61	0.16	0.95	184.1	3.6	1007.6	255.0
Logistic	Concentrate	Male	4080.3	15.10	0.51	0.95	288.1	5.3	2043.1	527.4
		Female	3600.9	15.69	0.55	0.93	315.5	4.9	1800.4	501.6
	Pasture	Male	3364.7	.56	0.29	0.95	199.3	6.8	1682.3	250.8
		Female	2980.3	6.88	0.31	0.94	191.2	6.2	1490.1	233.0
Gompertz	Concentrate	Male	4180.8	4.24	0.35	0.95	281.1	4.1	1538.5	543.7
		Female	3686.3	4.45	0.38	0.93	311.2	3.9	1356.5	479.3
	Pasture	Male	3850.7	2.65	0.18	0.95	194.3	5.2	1417.0	500.7
		Female	3232.9	2.52	0.20	0.95	185.4	4.5	1189.7	420.4

A: predicted asymptotic weight, B: growth parameter, K: relative growth rate, R^2: coefficient of determination, RMSE: root mean square error (the lower R^2 value indicated a better model), IPA: age at point of inflection, IPW: weight at point of inflection, MI: maximum increment, absolute growth rate

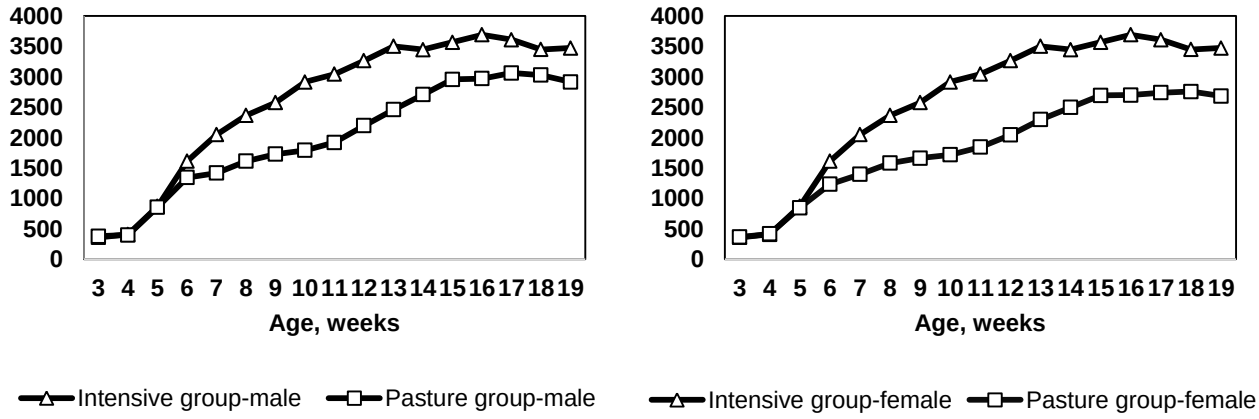

Figure 1 Weekly bodyweights for Linda geese based on gender under intensive concentrate and pasture-based feeding systems

One of the characteristics of Linda geese is the formation of a lump on the forehead on the upper part of their beak, which is considered an important indicator of sexual maturity and development (Figure 2a). The formation of the lump was monitored throughout the trial and was first observed in the intensively fed

group at five months old (Figure 2b). The first mating was observed at the fifth month in the intensively fed geese, and the geese in this group started to lay eggs in the eighth month.

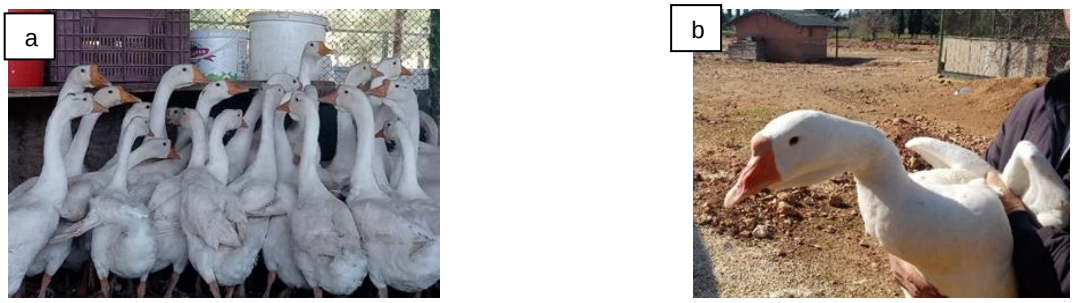

Figure 2 Typical beak structure and throat formation of male Linda geese that is an important sign of sexual maturity

Torki *et al*. (2018) suggested that geese should be fed grass in addition to concentrate, even in intensive fattening systems. Geese are not suited to living in a permanent shelter and studies indicated that grazing was a practical economical method of feeding geese (Elminowska-Wenda *et al*., 1997). However, the current results suggested that feeding based only on pasture grazing may not be suitable for goose fattening. Guy *et al*. (1996) recommended feeding goslings with a concentrate containing 20.5% CP until the eighth week and then raising the geese on pasture with only 150 g barley added to their diet. However, in the current study the pasture-fed group continued to be fed concentrate for nine more weeks, and the differences in live weight gain and carcass weight were significant when considered overall. Daily live weight gains were similar in the individual periods in the two feeding systems, but overall, the intensive group grew more rapidly than the pasture-fed group. The discrepancy is probably related to the shorter periods.

Ünal *et al*. (2005) stated that domestic geese do not need more than 15% protein in their diet. In this study, goslings were fed a ration with 23% CP at the beginning and then 21% CP. Subsequently, the CP content of the concentrate ration was decreased to 15%. Since Linda geese are not as heavy as the domestic geese used in Unal *et al*. (2005), the CP content of the rations used in this study were considered sufficient. Despite being lighter in weight and growing more slowly than other breeds, Linda geese are preferred for their high egg yields.

Compared to the intensive group, the pasture group had less carcass and belly fat because their diet consisted in part of less energy dense grass, and they were more active. Low fat deposition in the carcass is a desired feature in goose meat. Arslan (2003) stated that the weight of the carcass decreased in geese fed with 10% fresh alfalfa in addition to the mixed feed, but the quality of meat improved with the decrease in fat content. However, a significant weight gain was recorded in digestive organs such as liver, pancreas, and gizzard. The weight of these organs in pasture groups increased because of the consumption of fibre, which is more difficult to digest. González-Alvarado *et al*. (2008) stated that inclusion of a certain level of fibre in goose rations promotes gizzard growth and enzyme production, which would benefit performance and digestive functions. In this study, in addition to pasture, grass accounted for 15% of the total consumption of geese fed with concentrate and free feed indoors. The findings of Guo *et al*. (2020) and Liu *et al*. (2013) support the positive effects on digestion of forage added to goose rations. These researchers stated that geese fed with 50% ryegrass in the total ration had increased amino acid, zinc, and polyunsaturated fatty acid contents in the carcass, and improved growth performance.

Conclusion

Linda geese could reach slaughter age in four months under hot and dry conditions in both feeding systems. Concentrate and pasture could be the best and most economical management system. Under these conditions, Linda geese would be ready for slaughter when they were 4.6 months (138 days) old.

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Authors' Contributions

SY: conception, project design, statistical analysis and drafting of the article; ZK: data collection and analysis.

Conflict of Interest Declaration

There is no conflict of interest.

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