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Study of non-linear growth curve models parameters in sheep

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Abstract
The inheritance of non-linear growth curves is crucial for understanding evolutionary changes and developing successful breeding approaches. It is essential to identify both the hereditary and non-genetic components of development curves because they can be utilized to resolve data anomalies brought on by random environmental effects. Knowledge can therefore be applied to directly choose animals to enhance development characteristics."

Keywords: Non-linear growth curves, breeding approaches

Introduction
The inheritance of non-linear growth curves is crucial for understanding evolutionary changes and developing successful breeding approaches. It is essential to identify both the hereditary and non-genetic components of development curves because they can be utilised to resolve data anomalies brought on by random environmental effects. Knowledge can therefore be applied to directly choose animals to enhance development characteristics."
Non-linear growth curve models are crucial for evaluating the potential value of growth parameters as selection criteria for developing animal breeding programs. Animal growth models are used to determine alternative methods to improve the efficiency of livestock production and to calculate the daily nutrient requirements for animals at various stages of development (Schinckel and de Lange, 1996) [27]. They have also been used to estimate adult weight and increases in live body weight (Nasholm and Danell, 1990; Jenkins and Leymaster, 1993) [23, 15]. The yield changes brought on by this interaction over time (or as a function of age) are explained by the growth curve (Kor *et al.*, 2006) [19]. Age can alter the composition of tissues, cell size, weight of biological organisms, and weight or size of any organ (Eisen, 1976) [9]. Animal production can benefit from growth curves since they can be used to: (1) evaluate the response to different treatments throughout time; (2) investigate the link between treatments and time; and (3) identify heavier animals in a population at younger ages (Bathaei and Leroy, 1996; Freitas, 2005; Malhado *et al.*, 2009) [6, 10, 22].
Asymptotic mature live body weight (A), folding point of growth (B), and growth rate (K) were the three characteristics that were generally analysed using different non-linear growth curve models. According to the species, breed, management methods, effects of the environment, flock size, clusters, nutritional state and selection methods, the parameters changed. The coefficient of determination (R^2) is a measure of fit quality that gives a greater value for a positive indicator of a non-linear model's ability to fit in particular breed of animals.

Brody non-linear growth curve model
Parameter (A) was reported from 20.60 in Mechari sheep by Thirunavukkarasu *et al.*, 2017 [29] to 70.02 in Mehraban Iranian fat-tailed sheep by Bathaei and Leroy 1998 [5], parameter (B) ranged from -3.16 in Marwari sheep by Yadav *et al.*, 2009 [31] to 1.82 in Deccani sheep by Banger *et al.*, 2017 [4] and parameter (K) extended from 0.00 in Mehraban sheep by Hajjati and Hossein-Zadeh 2018 [14] to 0.66 in Deccani sheep by Banger *et al.*, 2017 [4] for both sexes (average to male and female). The coefficient of determination (R^2) was observed for both sexes from 82.15 per cent in West African Dwarf (WAD) sheep by Gbangboche *et al.*, 2008 [13] to 99.00 per cent in Mechari sheep by Thirunavukkarasu *et al.*, 2017 [29].

Gompertz non-linear growth curve model
Both sexes (average to male and female), parameter (A) was exhibited from 18.20 (Thirunavukkarasu *et al.*, 2017) [29] in Mechari sheep to 54.05 (Hajjati and Hossein-Zadeh

2018) [14] in Mehraban sheep, parameter (B) stretched from 0.21 in Baluchi sheep (Saghi *et al.*, 2012) [26] to 2.79 in West African Dwarf (WAD) sheep (Gbangboche *et al.*, 2008) [13] and parameter (K) prolonged from 0.00 in Mehraban sheep (Hajjati and Hossein-Zadeh 2018) [14] to 0.39 in Thalli sheep (Waheed *et al.*, 2016) [30]. The coefficient of determination (R^2) was ranged in different sheep breed for both sexes from 84.15 per cent (Gbangboche *et al.*, 2008) [13] in West African Dwarf (WAD) sheep to 99.00 per cent (Thirunavukkarasu *et al.*, 2017) [29] in Mechari sheep.

Logistic non-linear growth curve model

Asymptotic mature live body weight (A) was observed from 17.50 in Mechari sheep by Thirunavukkarasu *et al.*, 2017 [29] to 51.30 in Mehraban sheep by Hajjati and Hossein-Zadeh 2018 [14], folding point of growth (B) ranged from 1.33 in Sonadi sheep by Gautam *et al.*, 2018 to 11.10 in West African Dwarf (WAD) sheep by Gbangboche *et al.*, 2008 [13] and growth rate (K) stretched from 0.01 in Mehraban sheep by Hajjati and Hossein-Zadeh 2018 [14] to 0.39 in Thalli sheep by Waheed *et al.*, 2016 [30] for both sexes for Logistic non-linear growth curve model in various sheep breeds. The coefficient of determination estimated for both sexes from 82.12 per cent (Gbangboche *et al.*, 2008) [13] in West African Dwarf (WAD) sheep to 98.09 per cent (Hajjati and Hossein-Zadeh 2018) [14] in Mehraban sheep.

Bertallanffy non-linear growth curve model

In Bertallanffy non-linear growth curve model for both sexes (average to male and female), (A) was revealed from 18.68 in Mechari sheep by Thirunavukkarasu *et al.*, 2017 [29] to 62.50 in West African Dwarf (WAD) sheep by Gbangboche *et al.*, 2008 [13], (B) varies from 0.45 in Sonadi sheep by Gautam *et al.*, 2018 [12] to 0.82 in Thalli sheep by Waheed *et al.*, 2016 [30] and (K) extended from 0.00 in Mechari sheep by Thirunavukkarasu *et al.*, 2017 [29] to 0.25 in Sonadi sheep by Gautam *et al.*, 2018 [12]. (R^2) was seen from 84.62 per cent in West African Dwarf (WAD) sheep by Gbangboche *et al.*, 2008 [13] to 99.93 per cent in Mengali sheep by Tariq *et al.*, 2013 for both sexes.

Table 1: Reported non-linear growth curve model parameters for sheep breeds by various researcher

Animal	Growth curve model	Sex	Growth curve model parameters			Goodness of fit	References
			A	B	K	R^2	
Mehraban Iranian fat-tailed sheep	Brody	Both sexes	70.02	0.95	0.11	-	Bathaei and Leroy (1998) [5]
Daglic sheep	Brody	Male	155.95	0.97	0.00	99.91	Akbas *et al.* (1999) [2]
	Gompertz		113.16	2.87	0.00	99.63	
	Logistic		79.93	6.81	0.00	99.37	
	Bertalanffy		110.61	0.78	0.00	99.71	
Kivircik sheep	Brody	Male	168.46	0.97	0.00	99.89	
	Gompertz		88.18	2.35	0.00	99.28	
	Logistic		76.33	6.25	0.00	98.67	
	Bertalanffy		97.85	0.59	0.00	99.49	
Suffolk sheep	Gompertz	Male	109.80	0.01	-	-	Lewis *et al.*, (2002) [20]
		Female	86.30	0.01	-	-	
West African Dwarf (WAD) sheep	Brody	Both sexes	46.9	0.96	0.00	82.15	Gbangboche *et al.*, (2008) [13]
		Male	47.1	0.95	0.00	82.35	
		Female	45.5	0.96	0.00	83.59	
	Gompertz	Both sexes	40.9	2.79	0.00	84.15	
		Male	39.8	2.71	0.00	83.88	
		Female	40.1	2.85	0.00	85.79	
	Logistic	Both sexes	31.0	11.10	0.01	82.12	
		Male	31.1	10.48	0.01	81.68	
		Female	27.6	10.70	0.01	84.01	
West African Dwarf (WAD) sheep	Bertalanffy	Both sexes	62.5	0.65	0.00	84.62	Gbangboche *et al.*, (2008) [13]
		Male	56.3	0.64	0.00	84.39	
		Female	64.1	0.67	0.00	86.24	
Norduz sheep	Brody	Male	62.56	0.00	-14.37	98.87	Karakus *et al.*, (2008) [16]
	Logistic		39.73	5.80	0.02	99.58	
	Gompertz		43.41	0.01	47.90	99.39	
Marwari sheep	Logistic	Both sexes	20.60	3.16	0.01	89.93	Yadav *et al.*, (2009) [31]
	Gompertz		21.10	1.60	0.01	91.50	
	Brody		20.60	-3.16	0.01	89.93	
	Bertalanffy		20.88	0.66	0.01	90.96	
Konya Merino sheep	Gompertz	Male	79.10	2.20	5.58	98.00	Keskin *et al.*, (2009) [18]
		Female	57.00	2.70	3.89	96.00	
	Logistic	Male	70.00	5.85	2.36	96.00	
		Female	52.70	5.26	8.13	96.00	
Horro sheep	Brody	Both sexes	37.6	0.88	0.27	-	Abegaz *et al.*, (2010) [1]
		Male	41.8	0.90	0.25	-	
		Female	33.3	0.87	0.28	-	
Malya sheep (group 1st)	Gompertz	Female	45.10	1.76	0.37	98.59	Aytekin *et al.*, (2010) [3]
Malya sheep (group 2nd)	Gompertz	Female	48.22	1.53	0.40	98.31	
Baluchi sheep	Gompertz	Both sexes	37.23	0.21	-	-	Saghi *et al.*, (2012) [26]
		Male	39.33	0.22	-	-	

		Female	35.08	0.20	-	-	
Mengali sheep	Gompertz	Both sexes	36.99	-	0.01	99.43	Tariq *et al.*, (2013) [28]
	Logistic		35.05	-	0.01	98.52	
	Bertalanffy		44.29	-	0.00	99.93	
Baluchi sheep	Bertalanffy	Male	43.98	0.52	0.01	-	Behzadi *et al.*, (2014) [7]
		Female	40.44	0.52	0.01	-	
	Gompertz	Male	43.07	2.04	0.01	-	
		Female	39.68	2.04	0.01	-	
	Brody	Male	47.62	0.92	0.00	-	
		Female	43.42	0.92	0.00	-	
	Logistic	Male	41.54	5.09	0.02	-	
		Female	38.40	5.09	0.02	-	
Hemsin sheep	Brody	Male	78.93	0.93	0.00	98.70	Kopuzlu *et al.*, (2014) [18]
		Female	60.79	0.90	0.00	98.60	
	Gompertz	Male	74.99	1.97	0.00	97.60	
		Female	58.77	1.79	0.00	96.80	
	Logistic	Male	73.69	4.68	0.00	96.60	
		Female	58.14	3.80	0.00	95.10	
	Bertalanffy	Male	75.76	0.50	0.00	98.00	
		Female	59.19	0.47	0.00	97.40	
Madras red sheep	Brody	Male	58.18	0.92	0.03	98.90	Ganesan *et al.*, (2015) [11]
		Female	31.96	0.87	0.05	98.70	
	Gompertz	Male	40.35	1.92	0.09	98.10	
		Female	27.46	1.68	0.11	97.70	
	Logistic	Male	36.44	4.33	0.14	97.30	
		Female	25.99	3.41	0.17	96.70	
	Bertalanffy	Male	43.09	0.49	0.07	98.40	
		Female	28.36	0.44	0.09	98.00	
Peruvian young llmas (Lama glama)	Gompertz	Both sexes	49.61	1.42	0.01	94.70	Cayo *et al.*, (2015) [8]
	Logistic		46.72	2.77	0.01	94.40	
	Bertalanffy		51.06	0.38	0.01	94.60	
	Brody		55.87	0.79	0.00	94.60	
Segurena sheep	Brody	Male	74.94	0.95	0.00	89.80	Lupi *et al.*, (2015) [21]
		Female	51.34	0.93	0.00	91.50	
	Bertalanffy	Male	67.70	0.62	0.00	90.80	
		Female	48.87	0.58	0.01	92.30	
	Logistic	Male	64.05	4.06	0.01	90.50	
		Female	46.58	3.65	0.01	92.10	
	Gompertz	Male	65.23	2.87	0.01	90.70	
		Female	47.48	2.58	0.01	92.30	
Thalli sheep	Gompertz	Both sexes	28.2	1.30	0.39	97.9	Waheed *et al.*, (2016) [30]
	Brody		33.1	1.12	0.16	96.8	
	Bertalanffy		28.9	0.82	0.32	97.8	
	Logistic		27.1	2.53	0.60	97.3	
Deccani sheep	Brody	Both sexes	30.68	1.82	0.66		Banger *et al.*, (2017) [4]
Rahmani sheep	Brody	Both sexes	43.24	0.92	0.00	96.60	Rashad *et al.*, (2017) [25]
		Male	50.17	0.93	0.00	83.20	
		Female	36.82	0.92	0.00	83.10	
	Gompertz	Both sexes	27.91	2.01	0.01	96.60	
		Male	30.47	2.04	0.01	96.70	
		Female	25.17	1.99	0.01	96.90	
	Bertalanffy	Both sexes	30.05	0.51	0.01	96.60	
		Male	32.84	0.51	0.01	96.70	
		Female	26.90	0.50	0.01	96.80	
	Logistic	Both sexes	25.04	4.92	0.02	96.60	
		Male	26.91	5.03	0.02	96.60	
		Female	22.78	4.85	0.02	96.90	
Mechari sheep	Brody	Both sexes	20.60	0.87	0.00	99.00	Thirunavukkarasu *et al.*, (2017) [29]
		Male	23.61	0.88	0.00	99.00	
		Female	19.79	0.87	0.05	99.00	
Mechari sheep	Gompertz	Both sexes	18.20	1.79	0.01	99.00	Thirunavukkarasu *et al.*, (2017) [29]
		Male	20.23	1.82	0.00	98.00	
		Female	17.45	1.81	0.01	98.00	
	Logistic	Both sexes	17.50	3.98	0.01	96.00	
		Male	19.34	4.05	0.01	96.00	
		Female	16.76	4.06	0.01	97.00	
	Bertalanffy	Both sexes	18.68	0.46	0.00	98.00	
		Male	20.86	0.47	0.00	98.00	

		Female	17.92	0.46	0.00	98.00	
Mehraban sheep	Brody	Both sexes	66.90	0.95	0.00	-	Hajjati and Hossein-Zadeh (2018) [14]
		Male	68.50	0.95	0.00	-	
		Female	65.18	0.95	0.00	-	
	Logistic	Both sexes	51.30	7.03	0.01	-	
		Male	51.95	7.01	0.01	-	
		Female	50.57	7.08	0.01	-	
	Gompertz	Both sexes	54.05	2.44	0.00	-	
		Male	54.84	2.43	0.00	-	
		Female	53.17	2.45	0.01	-	
	Bertalanffy	Both sexes	56.14	0.58	0.00	-	
		Male	57.04	0.58	0.00	-	
		Female	55.14	0.58	0.00	-	
Madgyal sheep	Brody	Male	28.35	0.85	0.19	-	Nimase *et al.*, (2018) [24]
		Female	25.23	0.85	0.21	-	
	Gompertz	Male	26.22	1.62	0.33	-	
		Female	23.60	1.63	0.36	-	
	Logistic	Male	25.40	3.26	0.47	-	
		Female	22.96	3.34	0.50	-	
	Bertalanffy	Male	26.68	0.43	0.29	-	
		Female	23.96	0.43	0.31		
Sonadi sheep	Gompertz	Both sexes	23.30	1.71	0.30	-	Gautam *et al.*, (2018) [12]
		Male	25.99	1.85	0.28	-	
		Female	20.69	1.58	0.33	-	
	Brody	Both sexes	26.03	0.87	0.16	-	
		Male	30.20	0.89	0.13	-	
		Female	22.36	0.84	0.19	-	
	Logistic	Both sexes	22.38	1.33	0.43	-	
		Male	24.74	1.52	0.42	-	
		Female	20.05	1.15	0.46	-	
	Bertalanffy	Both sexes	23.86	0.45	0.25	-	
		Male	26.88	0.48	0.23	-	
		Female	21.07	0.42	0.28	-	

References

1. Abegaz S, Vanwky JB, Olivier JJ. Estimation of genetic and phenotypic parameters of growth curve and their relationship with early growth and productivity in Horro sheep. Leibniz Institute of Farm Animal Biology, Dummerstorf, Germany Archiv Tierzucht. 2010;53(1):85-94.
2. Akbas Y, Taskin T, Demiroren E. Comparison of several models to fit the growth curves of Kivircik and Daglic male lambs. Turkish Journal of Veterinary and Animal Sciences. 1999;23:537-554.
3. Aytekin I, Zulkadir U, Keskin I, Boztepe S. Fitting of different mathematic models to the growth curves of female Malya lambs weaned at two different live weights. Trends Animal Veterinary Sciences. 2010;1(1):19-23.
4. Banger YC, Nimase G, Nimbalkar CA, Shinde O, Lawar VS. Genetic parameter estimate for growth curve characteristics of Deccani sheep. International Journal of Livestock Research. 2017;7(5):78-86.
5. Bathaei SS, Leroy PL. Genetic and phenotypic aspects of growth curve characteristics in Mehraban Iranian fat-tailed sheep. Small Ruminant Research. 1998;29:261-269.
6. Bathaei SS, Leroy PL. Growth and mature weight of Mehraban Iranian fat-tailed sheep. Small Ruminant Research. 1996;22:155-162.
7. Behzadi Behreini MR, Aslaminejad AA, Sharifi AR, Simianer H. Comparison of mathematical model for describing the growth of Baluchi sheep. Journal of Agricultural Sciences Technology. 2014;14:57-68.
8. Cayo AWC, Huanca T, Gutierrez JP, Beltran PA. Modelling of growth and estimation of genetic parameters for growth curve parameters in Peruvian young llamas (*Lama glama*). Small Ruminant Research, 2015;130:81-89.
9. Eisen EJ. Result of growth curve analysis in mice and rate. Journal of Animal Science. 1976;42:1008-1023.
10. Freitas AR. Curvas de crescimento na produc ao animal. R Bras Zootec. 2005;34:786-795.
11. Ganesan R, Dhanavanthan P, Balasubramanyam D, Kumarasamy P, Kiruthika. Growth Modeling and Factors Affecting Growth Treats in Madras Red Sheep. Indian Journal Animal Research. 2015;49(1):20-25.
12. Gautam L, Kumar V, Waiz H, Nagda RK. Estimation of growth curve parameters using non-linear growth curve models in Sonadi sheep. International Journal of Livestock Research. 2018;8(9):104-113.
13. Gbangboche AB, Glele-Kakai R, Salifou S, Albuquerque LG, Lerory PL. Comparision of nonlinear growth models to describe the growth curve in West African Dwarf sheep. Animal, 2008;2(7):1003-1012.
14. Hojjati F, Hossein-Zadeh. Comparison of Non-linear Growth Models to Describe the Growth Curve of Mahraban Sheep. Journal of Applied Animal Research, 2018;46(1):499-504.
15. Jenkins TG, Leymaster KA. Estimation of maturing rates and masses at maturity for body components of sheep. Journal Animal Science. 1993;71:2952-2957.
16. Karakus K, Eyduran E, Kum D, Ozmedir T, Cengiz F. Determination of the growth curve and measurement interval in Norduz male lambs. Journal of Animal and Veterinary Advances. 2008;7(11):1464-1466.
17. Keskin I, Dag B, Sariyel V, Gokmen M. Estimation of

growth curve parameters in Konya Marino sheep. South African Journal of Animal Science, 2009, 39(2).
18. Kopuzlu S, Sezgin E, Esenbuga N, Bilgin OC. Estimation of growth curve characteristics of Hemsin male and female sheep. Journal of Applied Animal Research. 2014;42(2):228-232.
19. Kor A, Baspinar E, Keskin S. The Determination of Growth in Akkeci (White Goat) Female Kids by various Growth Models. Czech Journal Animal Sciences. 2006;51(3):110-116.
20. Lewis RM, Emmans GC, Dingwall WS, Simm G. A description of the growth of sheep and its genetic analysis. Animal Science. 2002;74:51-62.
21. Lupi TM, Nogales S, Leon JM, Barba C, Delgado JV. Characterization of commercial and biological growth curves in Segurena sheep breed. The Animal Consortium, Animal, 2015, 1-8.
22. Malhado CHM, Carneiro PLS, Affonso PRAM, Souza AAO, Jr. Sarmento JLR. Growth curve in Dorper sheep crossed with local Brazilian breeds, Morada Nova, Rabo Largo and Santa Ines. Small Ruminant Research, 2009;84:16-21.
23. Nasholm A, Danell O. Growth and mature weight of Swedish Fine Wool Landrace ewes. I. Growth curves and estimation of individual mature weight. Acta Agric. Scan. 1990;40:71-81.
24. Nimase RG, Kaandalkar YB, Banger YC. Non-linear modeling for estimation of growth curve parameters in Madgyal sheep. Journal of Entomology and Zoology studies. 2018;6(2):463-465.
25. Rashad AMA, Ramadan TA, Mahdy AE. Comparison among Models to Describe Growth Curve of Rahmani Lambs in Relation to Ewe Milk Yeild and Composition. Egyptan Journal of Animal Production. 2017;54(2):125-135.
26. Saghi DA, Aslaminejad A, Tahmoorespur M, Farhangfar H, Nassiri M, Dashab GR. Estimation of genetic parameters for growth traits in Baluchi sheep using Gompertz growth curve function. Indian Journal of Animal Science. 2012;82(8):889-892.
27. Schinckel AP, De Lange CF. Characterization of growth parameters needed as inputs for pig growth models. Journal of Animal Science. 1996;74:2021-2036.
28. Tariq MM, Iqbal F, Eyduran E, Bajwa MA, Huma ZE, Waheed A. Comparison of non-linear functions to describe the growth in Mengali sheep breed of Balochisthan. Pakisthan Journal of Zoology. 2013;45(3):661-665.
29. Thirunavukkarasu M, Balan C, Kathiravan G, Jeichitra V. Non-linear growth modeling in Mechari breed of sheep. Journal of Entomology and Zoology studies. 2017;5(5):2005-2008.
30. Waheed A, Eyduran E, Tariq MM, Ahmad S, Hameed T, Bukhari FA. Comparision of the non-linear models defining the growth of Thalli sheep under desert conditions. Pakistan Journal of Zoology. 2016;48(2):423-426.
31. Yadav DK, Singh G, Jain A, Singh S, Paul AK. Fitting of growth models and evaluation of Marwari sheep under field conditions. Indian Journal of Animal Sciences. 2009;79(12):1242-1244.