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PHENOTYPIC AND GENETIC PARAMETERS OF SOME ECONOMIC TRAITS IN GOATS : A REVIEW

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Abstract

The importance of goats as a potential source of meat and milk has been recognized and in many developing countries was contributed to the livelihood and national economy. This article reviews the available work encountering the phenotypic and genetic parameters for various economic traits in goats. Although there is a considerable range in the heritability estimates of the studied traits, but it seems in general that the h^2 of weights and milk are generally moderate to high and that of reproductive traits are low.

Key words: Goat, Genetic Parameters, Economic Traits.

Introduction

Although goat had received less attention compared to other livestock species in the past, however, their importance as a potential source of meat and milk has been realized and contribute to the national economy and livelihood in many developing countries. Moreover, their productivity is mostly low in these countries as a result of many interrelated factors including the genetic potential of the native stock (Willam *et al*., 2008).

It is known that genetic and environmental improvements offer an opportunity to increase production from existing animal resources. Furthermore, development of breeding objectives and effective genetic improvement programs require knowledge of the genetic variation among economically important traits and the genetic covariation among these traits (Fogarty, 1995). Therefore, the aim of this article is to review the available work encountering the parameters (*i.e.* heritability and genetic correlations) required for developing breeding plans for improving this species.

Studied Traits

The traits covered in this review are those associated with kids live weight at several ages including birth, weaning and 6 month, milk production including TSDM, pre, post and total milk yield and overall measure of doe reproduction and its component including litter size at birth and at weaning, gestation length, age and weight of first kidding, as well kidding interval.

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Heritability of economic traits

• Live body weights

Heritability estimates of birth, weaning and six month weight are presented in table 1. It seems from the table that there is a considerable range in the heritability estimates for birth weight (0.002-0.59), weaning weight (0.01-0.78) and weight at 6 month old (0.03-0.79). As Falconer, (1989) stated that heritability is a property of the trait of the population and the environmental circumstances to which the animals are subjected. Thus, any change in the component of variance will likely change the estimate of heritability. This could explain the differences in the estimates relevant to different studies. Jembere *et al.,* (2017) indicated that the un weighted average h^2 for birth, weaning and 6-months weight were 0.31, 0.27 and 0.35, respectively in different breeds of goat, whereas the weighted h^2 averaged 0.16, 0.40 and 0.28 for the same traits in the same order. Similarly, Forgarty, (1995), Safari *et al.,* (2005) and Juma and Alkass, (2006) concluded that there is a considerable range in the h^2 estimates of these weights in sheep.

• **Milk traits**

Heritability estimates for milk traits ranged between

Table 1: Estimates of heritability for birth, weaning and 6-month old weights in several goat breeds/genetic groups.

Breed/genetic groups	No.	MOE*	BW	WW	W6M	References
Damascus	1542	P.H.S.	0.31	0.27	0.24	Mavrogenis *et al.,* (1984 a)
West African Dwarf	848		0.18	0.14	0.11	Odubote and Akinokun (1992)
Jamunapari	524	P.H.S.	0.26	0.23		Kumar *et al.,* (1993)
Blended	4799	P.H.S.	0.15	0.099	0.148	Das *et al.,* (1994)
Teddy	777	P.H.S.	0.048	0.10		Tahir *et al.,* (1995)
Beetal	196	A.M.	0.45	0.50		Shafiq and Sharif, (1996)
Angora	360		0.25			Hermiz *et al.,* (1997)
Hill goat		RE.ML.	0.53	0.53	0.36	Neopane, (2000)
Local Iraqi, Damascus and Saanen	998	RE.ML.		0.17		Hermiz, (2001)
Boer	248	P.H.S.	0.43	0.347		Hongping, (2001)
Girgentana	276	S.M.	0.49			Portolano *et al.,* (2002)
Saanen	127	RE.ML.	0.43	0.05		Kosum *et al.,* (2004)
Barbari	6540		0.27	0.28		Singh *et al.,* (2005)
Beetal	5445	RE.ML.	0.12	0.16		Khan *et al.,* (2007)
Zaraibi		MTDREML	0.21	0.16	0.12	Shaat *et al.,* (2007)
Nubian		P.H.S.	0.54	0.77		Ballal *et al.,* (2008)
Draa				0.077	0.11	Boujenane and El-Hazzab, (2008)
Sahelian	1010		0.41	0.45		Otuma and Osakwe, (2008)
Jamunapari	4301	RE.ML.	0.12	0.18	0.13	Roy *et al.,* (2008)
Red Sokoto	1000		0.59	0.78	0.70	Akpa *et al.,* (2009)
Local and Damascus	1202	RE.ML.	0.30	0.38	0.17	Hermiz *et al.,* (2009)
Osmanabadi	1297	P.H.S.	0.002	0.341	0.183	Jedhe *et al.,* (2009)
Chasmere			0.20	0.20		Maghsoudi *et al.,* (2009)
Tellicherry	566	RE.ML.	0.062	0.344	0.369	Murugan *et al.,* (2009)
Jamunapari	2759		0.275	0.362	0.297	Singh *et al.,* (2009)
Boer	1520		0.30	0.09		Zhang *et al.,* (2009)
Sirohi	2769	RE.ML.	0.39	0.09	0.06	Gowane *et al.,* (2011)
Jamunapari	2950		0.14	0.19	0.25	Roy *et al.,* (2011)
Thai Native, Boer, Saanen	791		0.25	0.38		Supakorn *et al.,*(2011)
Naeini		RE.ML.	0.25	0.07		Baneh *et al.,* (2012)
Raeini Cashmere	3022	RE.ML.	0.12	0.08		Barazandeh *et al.,*(2012)
Black Bengal	179	RE.ML.	0.49	0.54	0.62	Haque *et al.,* (2012)
Raeini Cashmere	4219	RE.ML.	0.22	0.25	0.29	Mohammadi *et al.,* (2012)
local and Shamy	465		0.24	0.35	0.36	Abdullah *et al.,* (2013)
Exotic		RE.ML.	0.33	0.39	0.45	Hassan *et al.,* (2013)
Black Bengal		RE.ML.	0.45	0.47	0.45	Mia *et al.,* (2013)
Zaraibi	10374		0.29	0.22	0.27	Osman, (2013)
Adani	1590	RE.ML.	0.54	0.33	0.35	Sadegh *et al.,* (2013)
Ettawa Grade		RE.ML.	0.54	0.35	0.37	Hasan *et al.,* (2014)
Shami	110	RE.ML.	0.49	0.38	0.25	Hermiz *et al.,* (2014)
Sirohi			0.318	0.693		Dudhe, (2015)
Zaraibi		RE.ML.	0.25	0.25	0.32	El-Moghazy *et al.,* (2015)
Teddy	1459	RE.ML.		0.19		Kuthu *et al.,* (2015)
Mehsana	585		0.16	0.29	0.77	Gupta *et al.,* (2016)
Khari	1260		0.37	0.42	0.46	Bhattarai *et al.,* (2017)
Teddy	18702	RE.ML.	0.28	0.23		Kuthu *et al.,* (2017)
Maraz		Mivqueo	0.04	0.01	0.03	Taher, (2017)
Ardi	754	MTDFREML	0.15	0.26	0.45	Mohammed *et al.,* (2018)
Damascus			0.41	0.35	0.18	

Table 1 Continue ...

Continue Table 1 ...

Jamunapari	5922		0.14	0.16	0.19	Rout *et al.,* (2018)
Ardi			0.41	0.33		Aljumaah, (2019)
Zaraibi	2998	RE.ML.	0.28	0.31	0.19	El-Awady *et al.,* (2019)
Kurdish Mountain		RE.ML.	0.41	0.61	0.79	Hermiz and Baper, (2019)
Pantja	906		0.25	0.38	0.30	Khadda *et al.,* (2019)
Nubian, Granadina, Saanen, Toggenburg Alpine	19887	RE.ML.	0.18			Meza-Herrera *et al.,* (2019)
Saanen	180		0.25			Irawati *et al.,* (2020)

* MEO= Method of estimation; P.H.S.= Paternal Half Sib; RE.ML.= Restricted Maximum Likelihood; MTDREML= Multiple Trait Derivative Restricted Maximum Likelihood; DFREML= Derivative Free Restricted Maximum Likelihood; A.M.= Animal Model; S.M.= Sire Model; BW=Birth Weight; WW=Weaning Weight; W6M=Six month weight.

Table 2: Heritability estimate for milk yield traits in several goat breeds/genetic groups.

Breeds/genetic groups	No.	MOE*	h^2	References
Test day milk yield				
Norwegian	3567	P.H.S.	0.40	Ronningen, (1965)
Damascus	1585		0.16	Constantinou *et al.,* (1985)
Damascus	829	P.H.S.	0.31	Mavrogenis *et al*., (1989)
Saanen and Alpine	7215	P.H.S.	0.30	Andonov *et al.,* (1998)
Local Crosses	451	RE.ML.	0.83	Hermiz *et al.,* (2002)
Damascus	1167	RE.ML.	0.17	Jawasreh, (2003)
Saanen	3548	RE.ML.	0.34	Morris *et al.,* (2006)
Saanen	404		0.82	Ishag *et al.,* (2012)
Black Bengal	62	RE.ML.	0.15	Mia *et al.,* (2014)
Anglo Nubian	80		0.71	Bondoc *et al.,* (2018)
Pre weaning milk yield				
Damascus	1585		0.35	Constantinou *et al.,* (1985)
Damascus	922		0.45	Mavrogenis and Constantinou, (1991)
Skopelos	1251	P.H.S.	0.15	Kominakis *et al*., (2000)
Damascus	1611		0.45	Mavrogenis and Papachristoforou, (2000)
Damascus	1167	RE.ML.	0.17	Jawasreh, (2003)
Zaraibi	2363	DFREML	0.27	Shaat *et al.,* (2007)
Dhofari	233	DFREML	0.05	El-Wakil and Fooda, (2013)
Post weaning milk yield				
Damascus	1774	P.H.S.	0.29	Mavrogenis *et al*., (1984 b)
Damascus	1585		0.31	Constantinou *et al.,* (1985)
Damascus	844		0.49	Constantinou, (1989)
Damascus	829	P.H.S.	0.52	Mavrogenis *et al*., (1989)
Local Crosses	451	RE.ML.	0.53	Hermiz *et al.,* (2002)
Damascus	1167	RE.ML.	0.17	Jawasreh, (2003)
Saanen	1413	RE.ML.	0.12	Valencia *et al.,* (2007)
Total milk yield				
Alpine	6452		0.49	Iloeje *et al.,* (1981)
LaMancha	745		0.61	
Nubian	6897		0.59	
Saanen	2759		0.53	
Toggenburg	4007		0.59	
Damascus	1585		0.29	Constantinou *et al.,* (1985)
Damascus	844		0.46	Constantinou, (1989)
Damascus	829	P.H.S.	0.46	Mavrogenis *et al.,* (1989)

Table 2 Continue ...

Continue Table 2 ...

Damascus	922		0.28	Mavrogenis and Constantinou, (1991)
Murciano Granadina	10289	RE.ML.	0.18	Analla *et al.,* (1996)
Alpine	2598	P.H.S.	0.53	Ilahi *et al.*, (1998)
Saanen	1203	P.H.S.	0.09	Ribeiro *et al.*, (1998)
Skopelos	1251	P.H.S.	0.14	Kominakis *et al.*, (2000)
Damascus	1611		0.49	Mavrogenis and Papachristoforou, (2000)
Local Crosses	345	RE.ML.	0.46	Hermiz *et al.,* (2002)
South African Saanen	1915	ASREML	0.23	Muller *et al.*, (2002)
Damascus	1167	RE.ML.	0.22	Jawasreh, (2003)
Zaraibi	2363	DFREML	0.35	Shaat *et al.,* (2007)
Saanen	1413	RE.ML.	0.22	Valencia *et al.*, (2007)
Saanen	1520		0.17	Torres-Vázquez *et al.,* (2009)
Saanen	49709		0.34	Rupp *et al.,* (2011)
Alpine	67882		0.30	
Alpine			0.36	García-Peniche *et al.,* (2012)
LaMancha			0.48	
Nubian			0.44	
Oberhasli			0.61	
Saanen			0.36	
Toggenburg			0.47	
Saanen	404		0.44	Ishag *et al.,* (2012)
Dhofari	233	DFREML	0.08	El-Wakil and Fooda, (2013)
Dhofari	190	DFREML	0.02	El-Wakil and Fooda, (2014)
Jonica	220	RE.ML.	0.22	Selvaggi and Dario, (2015)
Anglo Nubian	84		0.52	Bondoc *et al.,* (2018)
Saanen	180		0.32	Irawati *et al.,* (2020)

* MEO= Method of estimation; P.H.S.= Paternal Half Sib; RE.ML.= Restricted Maximum Likelihood; MTDREML= Multiple Trait Derivative Restricted Maximum Likelihood; DFREML= Derivative Free Restricted Maximum Likelihood; A.M.= Animal Model; S.M.= Sire Model; BW=Birth Weight; WW=Weaning Weight; W6M=Six month weight.

Table 3: Heritability estimates of reproductive traits in several goat breeds/genetic groups.

Breed/genetic groups	Traits	No.	MOE*	h^2	References
West African Dwarf	LSB	848		0.28	Odubote and Akinokun, (1992)
West African Dwarf	LSB	587		0.32	Odubote, (1996)
	KI	587		0.03	
Native	Fertility	95	RE.ML.	0.00	Al-Karmah, (1999)
	LSB	72		0.02	
	LSW	62		0.00	
Hill	LSB		RE.ML.	0.03	Neopane, (2000)
	LSW			0.03	
	LWB			0.21	
	LWW			0.16	
	GL			0.03	
	KI			0.03	
Polish	KI	9283	RE.ML.	0.015	Bagnicka *et al.,* (2007)
Norwegian	KI	68240		0.03	
Zaraibi	LSB	4784	MTDREML	0.08	Mabrouk *et al.,* (2009)
	LSW			0.05	
Egyptian Nubian	LSB	7298		0.08	Aboul-Naga *et al.,* (2012)
	LSW			0.05	

Table 3 Continue ...

Continue Table 3 ...

Arsi-Bale	KI	792	DFREML	0.13	Kebede *et al*., (2012)
	LSB			0.15	
	LSW			0.18	
	LWB			0.16	
	LWW			0.12	
Raeini cashmere	LSB	3473	RE.ML.	0.04	Mohammadi *et al.,* (2012)
	LSW			0.09	
	SR			0.16	
Thailand	LSB	2508		0.066	Thepparat, (2012)
	LSW	2508		0.031	
	KI	1525		0.040	
Black Bengal	AFK	251		0.21	Haque *et al*., (2013)
	WFK			0.18	
	LSB			0.14	
	LWB			0.12	
	GL			0.22	
	KI			0.17	
Black Bengal	LSB	63	RE.ML.	0.08	Mia *et al.,* (2013)
	LSW			0.13	
	LWB			0.10	
	GL			0.18	
Boer	KI	350	RE.ML.	0.37	Menezes *et al*., (2016)
	LSB			0.01	
	LSW			0.10	

RE.ML. = Restricted Maximum Likelihood; MTDREML = Multiple-trait derivative-free restricted maximum likelihood; LSB=Litter size at birth; LSW=Litter size at weaning; LWB=Litter weight at birth; LWW=Litter weight at weaning; GL=Gestation Length; AFK=Age at first kidding; WFK= Weight at fist kidding; KI=Kidding interval; SR= Survival rate.

Table 4: Genetic (Rg) and phenotypic (Rp) correlations among body weights at birth, weaning and 6-months of several goat breeds/genetic groups.

Breed/genetic groups	Rg	Rp	Correlated Traits		References
Ganjam	0.92	0.33	1	3	Madeli and Parro, (1984)
Damascus	0.34	0.43	1	2	Mavrogenis *et al.,* (1984 a)
	0.41	0.37	1	3	
	0.82	0.71	2	3	
Mali	-	0.88	2	3	Wilson, (1987)
Damascus	0.54	0.43	1	2	Mavrogenis, (1988)
	0.41	0.37	1	3	
	0.82	0.71	2	3	
Jamunapari	0.98	0.94	1	2	Roy *et al.,* (1989)
	0.91	0.66	1	3	
Jamunapari	-	0.25	1	2	Saxena *et al*., (1990)
Angora		0.23	1	2	Said and Al-Rawi, (1994)
		0.20	1	3	
		0.86	2	3	
Boer	0.356		1	2	Van Niekerk *et al.,* (1996)
Hill	0.59	0.43	1	2	Neopane, (2000)
	0.85	0.51	1	3	
	0.87	0.83	2	3	
Teddy	0.69	0.65	1	2	Hyder *et al.,* (2002)

Table 4 Continue ...

Continue Table 4 ...

Zaraibi	0.42	0.13	1	2	Shaat *et al.,* (2007)
	0.47	0.21	1	3	
	0.77	0.59	2	3	
Sudanese Nubian	0.72		1	2	Ballal *et al.,* (2008)
Draa	0.58	0.27	1	2	Boujenane and El-Hazzab, (2008)
	0.28	0.15	1	3	
	0.43	0.51	2	3	
Arsi-Bale		0.83	2	3	Dadi *et al.,* (2008)
Sahelian	0.42		1	2	Otuma and Osakwe, (2008)
Markhoz	0.47	0.33	1	2	Rashidi *et al.,* (2008)
	0.48	0.29	1	3	
Toggenburg	0.58	0.16	1	2	Ahuya *et al.,* (2009)
Local and Damascus	0.39	0.22	1	2	Hermiz *et al.,* (2009)
	0.10	0.18	1	3	
	0.19	0.66	2	3	
Tellichery	0.685	0.314	1	2	Murugan *et al.,* (2009)
	0.378	0.336	1	3	
	0.816	0.781	2	3	
Local	0.366	0.562	1	2	Alade *et al.,* (2010)
Sirohi	0.47	0.37	1	2	Gowane *et al*., (2011)
	0.41	0.27	1	3	
	0.81	0.68	2	3	
Naeini	0.61		1	2	Baneh *et al.,* (2012)
Raini Cashmere	0.55	0.10	1	2	Barazandeh *et al.,* (2012)
Black Bengal	0.67	0.62	1	2	Haque *et al.,* (2012)
	0.95	0.49	1	3	
	0.81	0.74	2	3	
Angora	0.36	0.29	1	2	Snyman, (2012)
Local & Shamy	0.32	0.41	1	3	Abdullah *et al.,* (2013)
West African Dwarf	0.68	0.46	1	2	Ayizanga *et al.,* (2013)
Arsi-Bale	0.70	0.17	1	2	Bedhane *et al.,* (2013)
	0.64	0.19	1	3	
	0.72	0.94	2	3	
Black Bengal	0.60	0.66	1	2	Mia *et al.,* (2013)
	0.51	0.49	1	3	
	0.79	0.75	2	3	
Adani	0.69	0.32	1	2	Sadegh *et al.,* (2013)
	0.36	0.21	1	3	
	0.84	0.48	2	3	
Ettawa Grade	0.349	0.169	1	2	Hasan *et al.,* (2014)
	0.044	0.298	1	3	
	0.689	0.644	2	3	
Shami	0.48	0.55	1	2	Hermiz *et al.,* (2014)
	0.36	0.55	1	3	
	0.61	0.68	2	3	
Black Bengal	0.60	0.66	1	2	Mia *et al.,* (2014)
	0.51	0.49	1	3	
	0.79	0.75	2	3	
Surti		0.266	1	2	Tyagi *et al.,* (2015)
		0.072	1	3	
		0.312	2	3	

Table 4 Continue ...

Continue Table 4 ...

Mehsana	0.34	0.18	1	2	Gupta *et al.,* (2016)
	-0.02	0.09	1	3	
	0. 90	0.73	2	3	
Khari	0.71	0.67	1	2	Bhattarai *et al.,* (2017)
	0.72	0.68	1	3	
	0.95	0.91	2	3	
Maraz	-0.61	0.29	1	2	Taher, (2017)
	0.29	0.42	1	3	
	-0.87	0.98	2	3	
Ardi	0.34	0.45	1	2	Aljumaah, (2019)
Kurdish Mountain	0.45	0.48	1	2	Hermiz and Baper, (2019)
	0.55	0.57	1	3	
	0.68	0.73	2	3	
Pantja	0.541	0.732	1	2	Khadda *et al.,* (2019)
	0.485	0.639	1	3	
	0.732	0.969	2	3	
1 = Birth weight; 2 = Weaning weight; 3 = 6 Month weight.					

0.15-0.83 for test-day, 0.05-0.45 for pre-weaning, 0.12-0.53 for post-weaning and 0.02-0.61 for total milk yield (Table 2). It appears from the table that in general the heritability estimates are considered modulate in most studies. Also, Jembere *et al.,* (2017) found that the unweighted average heritability estimates for daily milk yield, 90 day milk yield and total milk production were 0.26, 0.31 and 0.32, respectively in different breeds of goat.

- **Traits of reproductive:**

The overall efficiency in goat production depends on some components such as fertility, litter size and kids survival. It seems from table 3 that heritability estimates of these traits are rather low *and* reflect the generally small genetic variance for most reproductive traits with few exceptions such as litter size and litter weight at birth and age and weight at first kidding. However, analysis of reproduction traits present problems in devising adequate models, especially to account for the discrete or binomial nature of data, a combination of the full-sib and half-sib progeny and extended relationships amongst parents (Fogarty, 1995). A similar trend has been reported earlier in sheep (Fogarty, 1995; Juma and Alkass, 2006)

Table 5: Genetic (Rg) and Phenotypic (Rp) correlations among milk trait of different goat breeds/genetic groups.

Breed/genetic groups	Rg	Rp	Correlated Traits		References
Damascus	0.99	0.84	1	2	Mavrogenis, (1988)
	0.78	0.59	1	4	
	0.93	0.78	3	4	
Damascus	0.99	0.84	1	2	Mavrogenis *et al.,* (1989)
	0.78	0.59	4	1	
	0.93	0.78	4	3	
Local		0.30	2	3	Hermiz *et al.,* (1998)
		0.77	2	4	
		0.78	3	4	
Skopelos	0.95	0.80	3	4	Kominakis *et al.,* (2000)
Local crosses	0.26	0.46	1	3	Hermiz *et al.,* (2004)
	0.84	0.70	1	4	
	-0.09	0.80	3	4	
Damascus	0.79	0.75	1	2	Jawasreh, (2003)
	0.59	0.67	1	3	
	0.77	0.83	1	4	
	0.52	0.46	2	3	
	0.82	0.84	2	4	
	0.91	0.87	3	4	
1 = Test day milk yield; 2 = Pre weaning milk yield; 3 = Post weaning milk yield; 4 = Total milk yield					

and goats (Jembere *et al*., 2017).

Genetic and Phenotypic correlations:

• Live weight

Table 4 presented the genetic and phenotypic correlations between live body weights at different ages. The table clarified that the genetic correlation between birth and each of weaning and 6 months weights varied from -0.61 to 0.98 and -0.02 to 0.92, respectively. Whereas Rg between weaning and 6 months weights varied from -0.87 to 0.95. Estimates of Rp between birth and each of weaning and 6 months weights ranged between 0.10-0.94 and 0.072-0.68, respectively. While Rp between weights at weaning and at 6 months old ranged between 0.312-0.98. Similarly, Jembere *et al.,* (2017) found that the unweighted average rg among traits of growth ranged between 0.20 and 0.98 and rp ranged from 0.25 to 0.95. However, the cause of genetic correlations as stated by Falconer, (1989) are mainly due to pleotropic which expresses the property of genes affecting two or more traits, as well could be affected by the linkage between genes. Accordingly, selection for one trait can lead to an indirect genetic response in the other traits depending on genetic correlations estimated between any pairs of traits.

• Milk traits

The genetic and phenotypic correlations between traits of milk were ranged from -0.09 to 0.99 and 0.30 to 0.87, respectively (Table 5). Jembere *et al*., (2017) reported similar trends and found that the unweight Rp and Rg among traits of milk production ranged from 0.36 (90 milk yield with lactation length) to 0.94 (daily milk yield with total milk yield).

Conclusion

This review article indicated that a high genetic progress in growth rate and milk production can be achieved through selection in goats due to moderate to high heritability estimates. However, to improved litter size additional information on records of relatives and improved management practices such as flushing and hormonal therapy are required.

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