Egyptian Journal of Rabbit Science, 32(2): 121-139 (2022)

CONSEQUENCES OF SELECTION FOR POST-WEANING GROWTH PERFORMANCE ON CARCASS AND TISSUE WEIGHT DISTRIBUTION TRAITS IN RABBITS

G.F. Gouda and Shemeis, A.R.
Animal Production Department, Faculty of Agriculture, Ain Shams University, Shoubra El-Kheima, 11241 Cairo, Egypt
Corresponding Email: *gfgouda@agr.asu.edu.eg & gouda_fathi@yahoo.com*

ABSTRACT

This study aimed to investigate the consequences of selection for post-weaning growth performance on carcass and tissue weight distribution traits using selection indices in rabbits through the multi-trait animal model. The experimental material involved 218 New Zealand White (NZW) rabbits, the progeny of 24 bucks and 93 adult does. The aggregate genotype of weaning weight (WW), slaughter weight (SW), and average daily gain (DG) from weaning to slaughter were included. The same three traits were used with different combinations as a source of information.

The cut percentage of hind leg (HLW), fore leg (FLW), loin (LOW), and thoracic cage (TCW) were the carcass weight distribution traits. While carcass tissue weight distribution traits were represented as a percentage of meat and bone in each cut, respectively occurring in the hind leg (HLM and HLB), fore leg (FLM and FLB), loin (LOM and LOB), and thoracic cage cut (TCM, TCB). The full index (I_1) including all sources of information: I_1 =23.5WW –18.0SW +1212.8DG had the highest correlation with the aggregate genotype traits (r_{TI} =0.84). Dropping DG from the full index to construct I_2 or SW to construct I_3 or WW to construct I_4 did not affect the accuracy of selection (r_{TI} =0.83). The index included weaning weight alone (I_5) was the most accurate single trait index (r_{TI} =0.73). Among all reduced indices, which had the same accuracy, the index I_2 was the best for being easy to measure. Applying the best accurate indices (I_1, I_2, and I_5) are expected to produce rabbits characterized by heavier body weight at weaning (88.80 to 108.10gm) and slaughtering (111.50 to 146.65 gm) with faster daily gain from weaning to slaughter (0.03 to 0.92 gm/day). This improvement would be coupled with changes in the distribution of carcass weight (decrease by -0.41 to -0.43% in HLW and by -0.05 to -0.01% in TCW and increase by 0.18 to 0.20% in FLW and by 0.11 to 0.14% in LOW), carcass meat weight distribution (decrease by -0.01 to -0.26% in HLM, -0.91 to -1.41% in FLM and increase by 0.13 to 0.64% in LOM and 0.45 to 0.58% in TCM) and in bone weight distribution (decrease by -0.07 to -0.08% in

FLB and by -0.12 in TCB% and increase by 0.11 to 0.15% in LOB with fluctuated change in HLB by -0.09 to 0.07%).

As compared with their unrestricted forms, the restricted indices $I_{8(HLM)}$ and $I_{9(HLM)}$ would entail an only a slight reduction in accuracy of selection (r_{TI}= 0.76 and 0.72, respectively) with acceptable improvement in WW (+104.7 and 108.2gm, respectively) and SW (+119.8 and 108.1gm, respectively) with an unfavorable increase in HLB by 0.37 and 0.07%, respectively.

***Conclusively**, Use of weaning weight (WW) and slaughter weight (SW) as sources of information (I_2) in the following index: **I_2= 3.8 WW + 1.5 SW (r_{TI} = 0.83)** would be recommended to maximize the post-weaning growth traits regardless of the deterioration in carcass tissue weight distribution. However, the following restricted index:*

$$I_{8(HLM)} = -29.4\ WW + 34.5\ SW - 2110.4\ DG\ (r_{TI} = 0.76)$$

would be a preferred choice to the breeder, taking into consideration the expected deterioration in carcass tissue weight distribution, for biological and rabbit meat consumer desires reasons.

Keywords: Rabbits – Selection indices – post-weaning growth traits – carcass weight distribution – carcass tissue weight distribution

---

INTRODUCTION

Meat consumers are focusing on getting lower protein costs with high quality (Mostafa *et al*., 2020). Rabbit meat is characterized by higher protein source, poly-unsaturated fatty acids, and little fat content with lower cholesterol levels (Dalle Zotte and Szendro, 2011). The preference of consumers in purchasing rabbit meat form varies depend on the country. For example, the most rabbit consumers in France and Mexico prefer the whale carcass as fresh meat, especially the loin and thigh cuts for its higher content of muscles (Szendrő *et al*., 2020). So, the commercial rabbit industries need breeds with a fast rate of growth and more lean meat (Sam *et al*., 2020). Pla (1996) reported that the carcass traits of rabbits affected by the adult weight and the degree of maturity. The effects of selection for post-weaning growth performance traits on fat partition and carcass composition traits were previously discussed (Gouda, 2022; Gouda and Shemeis, 2022; Belabbas *et al*, 2019; Michalik *et al*., 2009; Pascual and Blasco, 2008 and Piles *et al*., 2000). However, scarce information about the consequences of selection for post-weaning growth performance traits on the distribution of carcass weight and its tissues were noticed in rabbits.

Improving of live performance and carcass traits in the animal should not negatively affect the carcass tissues weight distribution, which in turn will affect the functional requirements of each tissue, resulting in a biological defect in the long term for this animal.

The goal of this study is to examine the consequences of selection for post-weaning growth traits via selection indices on the distribution of weights of carcass and its tissues in New Zealand White rabbits with an attempt to prevent any expected deterioration in the tissue weight distribution.

MATERIALS AND METHODS

Source of data and animal management

The data of the present study were obtained and previously described by Gouda and Shemeis (2022) in which a total of 218 weaned New Zealand white (NZW) rabbits (progeny of 24 bucks and 93 mature does) were used. At weaning on 28 days of age, the rabbits were earmarked and weighted (WW) and separated in rearing cages for fattening under natural environmental circumstances. They fed *ad libitum* a commercial diet containing 2800 kcal of digestible energy/kg up to slaughter at 90 days.

Traits to be considered

At slaughtering, rabbits are weighted (SW) and the daily gain from weaning to slaughter was calculated (DG). After that, the rabbits were transported to the Meat Laboratory in Faculty of Agriculture -Ain Shams University where the rabbits were slaughtered and dressed out. Then, the carcasses were split into two halves where the right side was jointed and weighted according to Blasco *et al*. (1993) into the hind leg (HLW), the fore leg (FLW), the loin (LOW), and the thoracic cage (TCW). All cuts were summed to give jointed side weight, where the carcass weight distribution was calculated as a percentage of each cut to the jointed side weight. Each cut was dissected into the meat (muscle + fat) and bone. Weights of meat and bone from each joint were summed up to give, respectively, the total side meat and total side bone.

The sum of these totals gives dissected side weight. The traits describing post-weaning growth traits and carcass distribution traits considered in the present study are presented in Table 1.

Table 1. Definitions and symbols used for traits considered in the present study

Trait	Symbol	definition
i. Post-weaning growth performance trait		
Weaning weight (gm)	WW	Body weight at 28-day of age recorded just after the separation of kids from their mother
Slaughter weight (gm)	SW	Body weight at 90-days of age, recorded at slaughter
Daily gain (gm/day)	DG	The differences between SW and WW divided by 60
ii. Carcass weight distribution traits		
Hind leg (%)	HLW	100*[Hind leg cut weight/ Jointed side weight]
Loin (%)	LOW	100*[Loin cut weight/ Jointed side weight]
Fore leg (%)	FLW	100*[Fore leg cut weight/ Jointed side weight]
Thoracic cage (%)	TCW	100*[Thoracic cage cut weight/ Jointed side weight]
iii. carcass tissue weight distribution traits		
a. *Meat weight distribution*		
Hind leg meat (%)	HLM	100*[Hind leg meat weight/ Total dissected meat weight]
Loin meat (%)	LOM	100*[Loin meat weight/ Total dissected meat weight]
Fore leg meat (%)	FLM	100*[Fore leg meat weight/ Total dissected meat weight]
Thoracic cage meat (%)	TCM	100*[Thoracic cage meat weight/ Total dissected meat weight]
b. *Bone weight distribution*		
Hind leg bones (%)	HLB	100*[Hind leg bones weight/ Total dissected bones weight]
Loin bones (%)	LOB	100*[Loin bones weight/ Total dissected bones weight]
Fore leg bones (%)	FLB	100*[Fore leg bones weight/ Total dissected bones weight]
Thoracic cage bones (%)	TCB	100*[Thoracic cage bones weight/ Total dissected bones weight]

Statistical analysis

The genetic and phenotypic parameters were estimated (VCE-6 software package, Kovač *et al*., 2002) according to the Multitrait -animal model:

$$y = Xb + Za + e$$

Where:

y = is the vector of observations traits,

b = is the vector of fixed effects,

a = is the vector of random additive genetic direct effects,
X and Z = known as incidence matrices relating observations to the respective fixed and random effects with Z augmented with columns of zeros for animals without records, and
e = is the vector of random residual effects.

Aggregate genotype traits (True breeding values)

To maximize the net income of the rabbit breeders through selection for post-weaning growth traits including WW, SW, and DG. The true breeding value (T) was defined as:

$$T = a_1\, g_{WW} + a_2\, g_{SW} + a_3\, g_{DG},$$

Where:

g_{ww} = the additive genetic value of weaning weight (WW)
g_{SW} = the additive genetic value of slaughter weight (SW),
g_{DG} = the additive genetic value of daily gain (DG) between weaning and slaughter, and
a_1, a_2, a_3 = the relative economic weights for WW, SW, and DG, respectively.

Calculation of economic values for aggregate genotype traits

The economic values of aggregate genotype traits were determined using the method described by Lamont (1991), depending on the heritability estimates of the aggregate genotype traits as follows:

$$a_i = \frac{\sum_i^n h_i^2}{h_i^2}$$, where

a_i : defined as the economic value of the i^{th} trait included in the aggregate genotype.

h_i^2 : defined as the heritability estimate of the i^{th} trait included in the aggregate genotype.

Construction of Selection indices

Nine selection indices (Cunningham et.al, 1970) including different combinations of WW, SW, and DG were constructed under the following three alternatives:

i: Selection based on the full index (comprising all sources of information).
ii: Selection based on reduced indices (comprising a combination of one source of information with the other; and
iii: Selection based on a single index (comprising one source of information).

Restraining change in hind leg meat percentage (HMW) to zero was carried out in two indices, as improvement in post-weaning growth traits would decrease HMW, which, in turn, would affect the biological state of the rabbit in jumping in addition to a consequent decrease in the rabbit breeders net income due to reluctance of the consumers to buy rabbits with less meat in the thigh.

RESULTS AND DISCUSSION

Variability and heritability

Overall means, heritability estimates (h^2), phenotypic coefficient of variations (CV), and economic values (a) of considered traits are given in Table 2. Post-weaning growth traits were more variable (CV = 16.9 to 24.4%) than those of carcass weight distribution (CV = 4.2 to 13.8%) and carcass tissue weight distribution traits (CV = 5.3 to 16.6%), except for percentage of meat in thoracic cage (CV = 33.2%). A comparable trend of variability for post-weaning growth traits was reported in previous studies (Peiró *et al*., 2019 & 2021; Ezzeroug *et al*., 2020; and Sakthivel *et al*., 2017).

The h^2 estimates for post-weaning growth traits were high (0.96, 0.53, and 0.46 for WW, SW, and DG, respectively). The higher h^2 estimate for WW was comparable to the values of 0.78 and 0.70 obtained by Castellini and Panella (1988) and Valderrama de Diaz and Varela-Avarez (1975), respectively, and much higher than the estimates of 0.03 to 0.26 reported by Peiró *et al.* (2021), Montes-Vergara *et al*. (2021), Ezzeroug *et al*. (2020), Sakthivel *et al*. (2017), Drouilhet *et al*. (2013) and Iraqi (2008). The present h^2 estimates for SW (0.53, Table 1) and those of 0.63 (Shemeis and Abdallah, 2000); 0.53 (Ferraz *et al*., 1991); and 0.42 (Gebriel *et al*., 1989) were higher than the estimates obtained by Montes-Vergara *et al*. (2021); Peiró *et al*. (2021); Sakthivel *et al*. (2017); Dige *et al.* (2012); Garreau *et al*. (2008); Moura *et al*. (2001); Akanno and Ibe (2005); and Lukefahr *et al*. (1996).

The heritability estimates for carcass weight and its tissue distribution traits were low to moderate (0.19 to 0.42) except for the estimate of 0.64 for carcass weight occurring in the fore leg. Due to its higher cost, a lack of information about genetic parameters for carcass weight and carcass tissue distribution was remarked. However, previous literature reported low heritability estimates for the thigh muscle volume measured in vivo by Computer Tomography (Nagy *et al*., 2013; Gyovai *et al*., 2008 & 2012).

It is worth noting that the high heritability estimates of post-weaning growth traits are the cornerstone of any breeding selection program. Moreover, regardless of all other genetic and environmental factors (Garcia and Argente, 2020), the differences in heritability estimates from one research to another, for the same post-weaning growth traits in the same herd (Table 1; Gouda 2022; and Gouda and Shemeis, 2022) may be due to the amount of covariances between these traits and the other traits under study in addition to the number of iterations needed for achieving analysis.

Economic values

According to the formula described by Lamont (1991) and depending on the heritability estimates illustrated in Table 2, the economic values for WW, SW, and DG were 2.03, 3.68, and 4.24, respectively.

Correlations

The Genetic (r_G) and phenotypic (r_P) correlations for the post-weaning growth traits, carcass weight distribution, and carcass tissue weight distribution are presented in Table 3. The strength and direction of genetic and phenotypic correlations between variables play an important role in its selection program. Since the phenotypic correlation is not a trustworthy estimate for exiting of environmental effect (Khalil *et al*., 1986), the genetic correlations between the considered traits in the present study will discuss.

From the genetic point of view, rabbits with a heavier weight at weaning are expected to have a heavier weight at slaughter (r_G= +0.59) with negligible effect on daily gain (r_G= +0.01). In agreement with the present study, previous literature reported higher genetic correlations for slaughter weight with weaning weight (Ezzeroug *et al*. 2020; Hanaa *et al*. 2014) contrary to the estimate of 0.08 documented by Iraqi (2008). However, the rabbits with faster daily gain are expected to finish the fattening period at a heavier slaughter weight (r_G= +0.81; Table 3; 0.95, Drouilhet *et al*., 2013; 0.56, Iraqi, 2008; 0.98, Lukefahr *et al*., 1996; 0.96, Polastre *et al*., 1992).

Genetic correlation between post-weaning growth traits and carcass weight distributional traits indicates that selection for heavier body weight at weaning or at slaughtering with faster gain from weaning to slaughter is expected to develop rabbits with low carcass weight occurring in hind leg (r_G= -0.13 to -0.32) and higher carcass weight occurring in the fore leg (r_G= 0.12 to 0.20), low meat weight occurring in the fore leg (r_G= -0.15 to -0.31) and higher meat weight occurring in loin (r_G= 0.03 to 0.29) and the thoracic cage (r_G= 0.16 to 0.26).

Table 2. Overall means with standard errors ($\bar{x} \pm$ SE), phenotypic coefficient of variations (CV), heritability estimates with standard errors (h^2±SE) and economic values (a) of post-weaning growth traits and carcass distribution traits

Trait	$\bar{x}$ ±SE	CV	h^2	a
i. Post-weaning growth traits				
• Weaning weight, gm (WW)	406.15 ±6.72	24.4	0.96	2.03
• Slaughter weight, gm (SW)	1746.81 ±20.10	16.9	0.53	3.68
• Daily gain, gm/day (DG)	21.28 ±0.29	20.6	0.46	4.24
ii. Carcass weight distribution as % in:				
• Hind leg cut (HLW)	38.93±0.11	4.2	0.40	-
• Fore leg cut (FLW)	17.62±0.12	10.2	0.64	-
• Loin cut (LOW)	33.41±0.11	5.2	0.35	-
• Thoracic cage cut (TCW)	10.04±0.09	13.8	0.27	-
iii. Carcass tissues weight distribution as:				
Percentage of meat occurring in:				
• Hind leg (HLM)	65.31±0.51	11.6	0.21	-
• Fore leg (FLM)	63.96±0.72	16.6	0.20	-
• Loin (LOM)	54.36±0.45	12.3	0.31	-
• Thoracic cage (TCM)	16.37±0.36	33.2	0.19	-
Percentage of bone occurring in:				
• Hind leg (HLB)	42.69±0.15	5.3	0.42	-
• Fore leg (FLB)	16.69±0.07	6.7	0.35	-
• Loin (LOB)	21.95±0.17	11.7	0.33	-
• Thoracic cage (TCB)	18.67±0.12	9.8	0.33	-

These figures of relationships mean that any improvement in post-weaning growth traits, through selection programs, would lead to undesirable deterioration in some carcass tissue weight distribution traits.

Genetically, rabbits that have a higher meat percentage occurring in hind leg cut tended to have lower meat percentage occurring in the fore leg and loin cuts (r_G= -0.73 and -0.63, respectively) with higher meat percentage occurring in the thoracic cage (r_G= +0.40). Moreover, negative genetic correlations were reported in the present study for LOM with HLM and FLM (r_G= -0.56 and -0.30, respectively).

Table 3. Genetic (above diagonal) and phenotypic (below) correlations for post-weaning growth traits and carcass distribution traits

Trait	WW	SW	DG	HLW	FLW	LOW	TCW	HLM	FLM	LOM	TCM	HLB	FLB	LOB	TCB
i. Post-weaning growth traits															
• Weaning weight (WW)	-	0.59	0.01	-0.32	0.17	0.11	-0.07	0.00	-0.15	0.03	0.16	0.03	-0.09	0.10	-0.10
• Slaughter weight (SW)	0.50	-	0.81	-0.29	0.20	0.06	0.04	-0.08	-0.31	0.25	0.26	0.03	-0.08	0.04	-0.09
• Daily gain (DG)	0.08	0.90	-	-0.13	0.12	0.01	0.10	-0.10	-0.28	0.29	0.21	0.01	-0.03	-0.01	-0.04
ii. Carcass weight distribution as % in:															
• Hind leg cut (HLW)	-0.21	-0.21	-0.13	-	-0.18	-0.59	-0.32	0.52	0.00	-0.49	-0.22	0.37	0.26	-0.43	-0.21
• Fore leg cut (FLW)	0.04	-0.19	-0.24	-0.24	-	-0.34	-0.31	-0.10	0.28	-0.14	-0.07	0.00	0.04	0.04	-0.12
• Loin cut (LOW)	0.12	0.29	0.28	-0.66	-0.26	-	-0.14	-0.38	-0.09	0.61	0.00	-0.43	-0.26	0.56	0.15
• Thoracic cage cut (TCW)	-0.02	-0.01	0.00	-0.10	-0.23	0.02	-	-0.06	-0.28	0.06	0.56	-0.03	-0.07	-0.18	0.35
iii. Carcass tissues weight distribution as:															
a. Percentage of meat occurring in:															
• Hind leg (HLM)	0.01	-0.03	-0.04	0.41	-0.20	-0.11	0.45	-	-0.47	-0.56	-0.04	0.21	0.21	-0.29	-0.13
• Fore leg (FLM)	-0.08	-0.13	-0.11	-0.02	0.20	-0.27	-0.51	-0.73	-	-0.30	-0.61	0.06	0.01	0.06	-0.14
• Loin (LOM)	0.01	0.13	0.14	-0.48	0.07	0.47	-0.31	-0.63	0.06	-	0.17	-0.32	-0.24	0.37	0.16
• Thoracic cage (TCM)	0.09	0.12	0.10	-0.13	-0.11	0.22	0.62	0.40	-0.71	-0.21	-	-0.17	0.07	-0.11	0.36
b. Percentage of bone occurring in:															
• Hind leg (HLB)	0.01	-0.04	-0.05	0.41	-0.02	-0.50	-0.07	0.01	0.25	-0.27	-0.23	-	-0.04	-0.71	-0.66
• Fore leg (FLB)	-0.06	-0.03	-0.01	0.12	0.08	-0.34	-0.33	-0.26	0.40	0.00	-0.34	0.15	-	-0.41	-0.04
• Loin (LOB)	0.08	0.08	0.05	-0.36	-0.02	0.60	0.07	0.08	-0.31	0.27	0.19	-0.72	-0.50	-	0.09
• Thoracic cage (TCB)	-0.07	-0.04	-0.02	-0.19	-0.03	0.20	0.35	0.17	-0.32	-0.02	0.37	-0.64	-0.29	0.14	-

It is noticeable that there is a negative relationship between LOB and each of HLB (r_G= -0.71) and FLB (r_G= -0.41). So, it could be concluded that any change in one of carcass tissue weight distribution components would influence its other components positively or negatively.

In agreement with present results, Michalik *et al*. (2009) concluded that the higher slaughter weight in French Lop rabbits would accompany by a decline in the proportion of hind part with an increase in the front part of the carcass with negligible effect on the proportion of the middle part.

Selection indices

Using the calculated estimates of genetic and phenotypic parameters and the economic values presented in Tables 2 and 3, seven unrestricted and two restricted selection indices were constructed. The weighing factors of the indices, accuracy of selection, the standard deviation of indices, and the relative efficiency to the full index were presented in Table 4.

Table 4. Weighing factors, indices standard deviation (σ_I), the accuracy of selection (r_{TI}) estimated from each index (*I*), and relative efficiency (RE) to the full index (I_1 =100)

Selection strategy	**Index (*I*)**	**Index trait**	**Weighing factors [a]** WW	SW	DG	σ_I	r_{TI}	**RE %**
Without restriction on HM								
i. Full index	I_1	WW, SW, DG	23.5	-18.0	1212.8	722.3	0.84	100
ii. Reduced index	I_2	WW, SW	3.8	1.5	-	717.5	0.83	98.8
	I_3	WW, DG	5.3	-	94.8	718.3	0.83	98.8
	I_4	SW, DG	-	5.2	-232.9	715.5	0.83	98.8
iii. Single index	I_5	WW	5.6	-	-	628.7	0.73	86.9
	I_6	SW	-	2.3	-	613.4	0.71	84.5
	I_7	DG	-	-	107.6	395.5	0.45	53.6
With restriction on HM								
	$I_{8(HLM)}$	WW, SW, DG	-29.4	34.5	-2110.4	653.3	0.76	90.5
	$I_{9(HLM)}$	WW, SW	5.60	-0.09	-	616.6	0.72	85.7

a: WW=Weaning weight; SW= Slaughter weight, DG= Daily gain

The unrestricted full index (I_1) including all sources of information gives the highest accuracy of selection (r_{TI} = 0.84). The three reduced indexes (I_2, $I_{3,}$ and I_4) were found to have similar accuracy of selection (r_{TI} = 0.83, RE = 98.8%). In this case, the preference of one index over another depends on the cost of data collection and their consequences on the carcass tissue weight distribution traits. On the other hand, selection based on weaning weight alone (I_5) appeared to be more valuable than SW alone (I_6) and DG alone (I_7) with selection accuracy of 0.73, 0.71, and 0.45, respectively.

Expected genetic response

Table 5 showed the results of the expected genetic response per generation in the considered traits for the unrestricted indices.

Post-weaning growth traits

From the selection accuracy and cost of data collection point of view, the unrestricted indices I_1, $I_{2,}$ and I_5 were found to be the best indexes. However, selection based on the best three unrestricted indices (I_1, $I_{2,}$ and I_5), is expected to improve the post-weaning growth traits by +88.8 to 108.1gm in WW, +111.5 to 146.7 gm in SW, and +0.03 to +0.92 gm/day in DG.

Carcass and carcass tissue weight distribution

Whereas the selection based on I_1, $I_{2,}$ and I_5 would upset the distribution of weights of carcass and its tissues through the increase in the share of for leg (0.18 to 0.20%) and loin (0.11 to 0.14% units) and the decrease in the share of hind leg (-0.41 to -0.43%) and thoracic cage -0.01 to -0.05% units). However, the selection on the same three indices would also upset the distribution of meat weight by increasing the share of loin (+0.56 to +0.64%) and thoracic cage (+0.56 to +0.58%) percentage and decreasing the share of hind (-0.20 to -0.26%) and the fore legs (-1.30 to -1.41%) percentage. Therefore, applying the restricted indices for HML to zero change were inevitable.

Restricted indices

According to the upset of the distribution of weights of carcass and its tissues specially in the percentage of meat in hind leg cut, restricted selection indices were applied to prevent the deterioration in this tissue for biological and rabbit consumer desire reasons.

Table 6 exhibit the effect of restricted indices and their expected genetic change on the considered traits. As compared with their unrestricted forms (($I_{8(HLM)}$ and $I_{9(HLM)}$ vs I_1 and I_2, respectively), the restricted forms would expect

Table 5. Expected genetic change to selection (per generation) based on unrestricted indices in post-weaning growth traits and carcass distribution traits (selection intensity = 1)

Expected genetic changes in:	Unit	Full index	Reduced index			Single index		
		I_1	I_2	I_3	I_4	I_5	I_6	I_7
		WW, SW, DG	WW, SW	WW, DG	SW, DG	WW	SW	DG
i. Post-weaning growth traits								
• Weaning weight (WW)	gm	88.80	91.20	90.95	91.2	108.10	47.64	0.92
• Slaughter weight (SW)	gm	146.65	144.11	144.43	143.5	111.50	139.11	105.31
• Daily gain (DG)	gm/day	0.92	0.83	0.85	0.82	0.03	1.47	1.69
ii. Carcass weight distribution as % in:								
• Hind leg cut (HLW)	%	-0.42	-0.41	-0.41	-0.41	-0.43	-0.28	-0.12
• Fore leg cut (FLW)	%	0.20	0.19	0.19	0.19	0.18	0.15	0.09
• Loin cut (LOW)	%	0.11	0.12	0.12	0.12	0.14	0.06	-0.01
• Thoracic cage cut (TCW)	%	-0.0٢	-0.01	-0.01	-0.01	-0.05	0.02	0.05
iii. Carcass tissues weight distribution as:								
a. Percentage of meat occurring in:								
1. Hind leg (HLM)	%	-0.26	-0.21	-0.21	-0.20	-0.01	-0.36	-0.42
2. Fore leg (FLM)	%	-1.41	-1.32	-1.32	-1.30	-0.91	-1.39	-1.17
3. Loin (LOM)	%	0.64	0.57	0.58	0.56	0.13	0.89	0.97
4. Thoracic cage (TCM)	%	0.58	0.57	0.57	0.56	0.45	0.54	0.40
b. Percentage of bone occurring in:								
1. Hind leg (HLB)	%	-0.09	0.06	0.05	0.09	0.07	0.04	-0.01
2. Fore leg (FLB)	%	-0.07	-0.08	-0.07	-0.07	-0.08	-0.05	-0.02
3. Loin (LOB)	%	0.11	0.12	0.12	0.12	0.15	0.05	-0.01
4. Thoracic cage (TCB)	%	-0.12	-0.12	-0.12	-0.12	-0.12	-0.08	-0.03

Table 6. Effect of restriction to zero genetic change in percent of total side meat occurring in hind leg cut as compared to unrestricted forms

Items	***I*$_{8(HLM)}$** WW, SW, DG	***I*$_{9(HLM)}$** WW, SW	$100 * (\frac{I_{8(HLM)}}{I_1})$	$100 * (\frac{I_{9(HLM)}}{I_2})$
Weighting factors for:				
• Weaning weight	-29.4	5.60	…	…
• Slaughter weight	34.5	-0.09	…	…
• Daily gain	-2110.4	…	…	…
Index standard deviation	653.3	616.6	90	86
Accuracy of selection	0.76	0.72	90	87
Expected changes in:				
i. Post-weaning growth traits				
• Weaning weight (WW)	104.76	108.28	118	119
• Slaughter weight (SW)	119.82	108.16	82	75
• Daily gain (DG)	0.20	-0.02	22	-2
ii. Carcass weight distribution as % in:				
• Hind leg cut (HLW)	-0.41	-0.42	98	102
• Fore leg cut (FLW)	0.17	0.18	85	95
• Loin cut (LOW)	0.15	0.15	136	125
• Thoracic cage cut (TCW)	-0.03	-0.05	150	500
iii. Carcass tissues weight distribution as:				
a. ***Percentage of meat occurring in:***				
• Hind leg (HLM)	0.00	0.00	0.00	0.00
• Fore leg (FLM)	-0.88	-0.87	62	66
• Loin (LOM)	0.19	0.09	30	16
• Thoracic cage (TCM)	0.47	0.43	81	75
b. ***Percentage of bone occurring in:***				
• Hind leg (HLB)	0.37	0.07	-411	117
• Fore leg (FLB)	-0.08	-0.08	114	100
• Loin (LOB)	0.14	0.15	127	125
• Thoracic cage (TCB)	-0.12	-0.12	100	100

to be lower in the accuracy of selection by 10 and 13%, respectively. However, applied of restricted indices would enhance the weaning weight by 18 and 19% compared to the unrestricted form. This increase in WW would be associated with a reduction in SW by 18 and 25%, respectively. Whereas the hind leg meat percentage (HLM) is a valuable trait for the rabbit consumer desire and the rabbit breeders because of biological reasons, it is possible to prevent the deterioration in the share of hind leg meat percentage by applying the restricted index $I_{8(HLM)}$ and $I_{9(HLM)}$. However, $I_{8(HLM)}$ is better than $I_{9(HLM)}$ for its higher selection accuracy and expected genetic change in aggregate genotype traits.

Conclusion

Use of weaning weight (WW) and slaughter weight (SW) as sources of information in the following index (I_2):

$$\boldsymbol{I_2 = 3.8\ WW + 1.5\ SW\ (r_{TI} = 0.83)}$$

would be recommended to maximize the post-weaning growth traits regardless of the deterioration in carcass tissue weight distribution.

However, the following restricted index $I_{8(HLM)}$:

$$\boldsymbol{I_{8(HLM)} = -29.4\ WW + 34.5\ SW - 2110.4\ DG\ (r_{TI} = 0.76)}$$

would be a preferred choice to the breeder, taking into consideration the deterioration in carcass tissue weight distribution.

REFERENCES

Akanno, E.C. and Ibe, S.N. (2005). Estimates of genetic parameters for growth traits of domestic rabbits in the humid tropics. *Livestock Research for Rural Development*. Volume 17, Article #86. Retrieved May 12, 2022, from *http://www.lrrd.org/lrrd17/7/akan17086.htm*

Belabbas, R.; de la Luz García, M.L.; Ainbaziz, H.; Benali, N.; Berbar, A.; Boumahdi, Z. and Argente, M.J. (2019). Growth performances, carcass traits, meat quality, and blood metabolic parameters in rabbits of local Algerian population and synthetic line. *Veterinary World*, 12: 55-62. *https://doi.org/ 10.14202/vetworld.2019.55-62.*

Blasco, A.; Ouhayoun, J. and Maseoro, G. (1993). Harmonization of criteria and terminology in rabbit meat research a review. *World Rabbit Science*, 1: 3-10. *https://doi.org/10.4995/wrs.1996.278.*

Castellini, C. and Panella, F. (1988). Heritability of pre and post weaning weights in rabbits. *4th World Rabbit Congress*. Budapest, Hungary, 10-14, October, 1988.

Cunnigham, E.P., Moe, R.A. and Gjedrem, T. (1970). Restriction of selection indexes. *Biometrics*, 23: 67-74.

Dalle Zotte, A. and Szendro, Z. (2011). The role of rabbit meat as functional food. *Meat Science*, 88: 319–331. *https:// doi.org/ 10.1016/j. meatsci.2011. 02.017.*

Dige, M.S.; Kumar, A.; Kumar, P.; Dubey, P.P. and Bhushan, B. (2012). Estimation of variance components and genetic parameters for growth traits in New Zealand White rabbit (Oryctolagus cuniculus). *Journal of Applied Animal Research*, 40: 167-172. *https://doi: 10.1080/09712119.2011.645037.*

Drouilhet, L.; Gilbert, H.; Balmisse, E.; Ruesche, J.; Tircazes, A.; Larzul, C. and Garreau H. (2013). Genetic parameters for two selection criteria for feed efficiency in rabbits. *Journal Animal Science*, 91: 3121– 3128. *https://doi: 10.2527/jas.2012-6176.*

Ezzeroug, R.; Belabbas, R.; Argente, M.J.; Berbar, A.; Diss, S.; Boudjella, Z.; Talaziza, D.; Boudahdir, N.; and García, M.L. (2020). Genetic correlations for reproductive and growth traits in rabbits. Canadian Journal of Animal Science 100: 317–322. *https://doi.org/10.1139/cjas-2019-0049.*

Ferraz, J.B.S.; Johnson, R.K. and Eler, J.P. (1991). Genetic parameters for growth and carcass traits of rabbits. *Journal of Applied Rabbit Research*, 14: 187–192.

Garcia, M.L. and Argente, M.J. (2020). The genetic improvement in meat rabbits. *IntechOpen*, Available via https://www.intechopen.com/online-first/the-genetic-improvement-in-meat-rabbits. *https://doi:10.5772/intechopen.93896*.

Garreau, H.; Eady, S.J.; Hurtaud, J. and Legarra, A. (2008). Genetic parameters of production traits and resistance to digestive disorders in a commercial rabbit population. *Proceedings of the 9th World Rabbit Congress*, Verona, Italy, 10-13 June 2008.

Gebriel, M.G.; Soltan, E.M. and Yamani, K.A.O. (1989). Early Prediction for heavy body weight and good carcass traits in rabbits. *Egyptian Poultry Science, 9: 193-204.*

Gouda G.F. and Shemeis, A.R. (2022). Consequences of selection for post-weaning growth performance traits on carcass attributes in rabbits. Egyptian *Journal of Rabbit Science*, 32: 59-75. *https://doi.org/10.21608/ejrs.2022.238413.*

Gouda, G.F. (2022). Consequences of selection for post-weaning growth performance traits on fat partition traits in rabbits. *International Journal of Veterinary Science*, 11(4): 461-466. *https://doi.org/10.47278/journal. ijvs/2022.136.*

Gyovai, P.; Nagy, I.; Gerencsér, Z.; Matics, Z.; Radnai, I.; Donkó, T.; Bokor, Á.; Farkas, J.; and Szendrő, Z. (2012). Genetic parameters for litter weight, average daily gain and thigh muscle volume measured by in vivo Computer Tomography technique in Pannon White rabbits. *Livestock Science*, 144: 119-123.

Gyovai, P.; Nagy, I.; Gerencsér, Z.; Metzger, S.; Radnai, I.; and Szendrő, Z. (2008). Genetic parameters and trends of the thigh muscle volume in Pannon White rabbits. *Proceeding of the 9th World Rabbit Congress, Verona,* Italy (pp: 115-120).

Hanaa, A.M.; El-Raffa, A.; Shebl, M.K., El-Delebshany, A.; and El-Sayed, N.A. (2014). Genetic evaluation of some economic traits in a maternal line of rabbits. *Egyptian Poultry Science*, 34: 85–98. *https://doi:10.21608/ epsj.2014.5308*.

Iraqi, M.M. (2008). Estimation of Genetic parameters for post-weaning growth traits of Gabali rabbits in Egypt. *Livestock Research for Rural Development,* 20 (5). http://www.lrrd.org/lrrd20/5/iraq20069.htm.

Khalil, M.H.; Owen, J.B.; and Afifi, E.A. (1986). A review of phenotypic and genetic parameters associated with meat production traits in rabbits. *Animal Breeding Abstract,* 54: 725-749.

Kovač, M.; Groeneveld, E. and Garcia Cortes, L.A. (2002). VCE-5 User's a package for the estimation of dispersion parameters. *7th World Congress on Genetics Applied to Livestock Production,* Montpellier, France 28-30 Aug: 19-23.

Lamont, S.J. (1991). Selection for immune response in chickens. *Presented at the 40th Annual National Breeder Round Table*, May 2-3. St. Louis, Missouri.

Lukefahr, S.D.; Odi, H.B. and Atakora, J.K.A. (1996). Mass selection for 70-day body weight in rabbits. *Journal of Animal Science*, 74: 1481-1489. *https://doi.org/10.2527/1996.7471481x*.

Michalik, D.; Lewczuk, A.; Brzozowski, W. and Wawro, K. (2009). Effect of body weight on the carcass composition of French Lop rabbits. *Canadian Journal of Animal Science*, 89: 47-51. *https://doi.org/10.4141/CJAS08060*.

Montes-Vergara, D.E.; Hernndez-Herrera, D.Y. and Hurtado-Lugo, N.A. (2021). Genetic parameters of growth traits and carcass weight of New Zealand white rabbits in a tropical dry forest area. *Journal of Advanced Veterinary and Animal Research, 20:471-478. https://doi.org/10.5455/javar.2021.h536. PMID: 34722746; PMCID: PMC8520158.*

Mostafa, A.R.; Dorina, M.; Mohamed, S.; Ayman, A. and Monica M. (2020). Rabbits Meat Production in Egypt and its Impact on Food Security, Small Holders Income and Economy. *Agricultural Research & Technology*, 24: 81-85. *https://doi.org/10.19080/ARTOAJ.2020.24.5556251*.

Moura, A.S.M.T.; Costa, A.R.C. and Polastre, R. (2001). Variance component and response to selection for reproductive, litter and growth traits through a multipurpose index. *World Rabbit Science*, 9:77-86. *https://doi: 10.4995/ wrs.2001.449.*

Nagy, I.; Petra, G.; Istvan, R.; Henrietta, K.; Janos, and F.; Zsolt, S. (2013). Genetic parameters, genetic trends and inbreeding depression of growth and carcass traits in Pannon terminal line rabbits. *Archiv fur Tierzucht*, 56: 191-199. *https://doi: 10.7482/0003-9438-56-018.*

Pascual, M.; Pla, M. and Blasco, A. (2008). Effect of selection for growth rate on relative growth in rabbits. *Journal of Animal Science*, 86: 3409–3417. *https://doi.org/10.2527/jas.2008-0976.*

Peiró, R.; Badawy, A.; Blasco, A. and Santacreu, M. (2019). Correlated responses on growth traits after two-stage selection for ovulation rate and litter size in rabbits. *Animal*, 13(11): 2457-2462. *https://doi: 10.1017/ S 1751731119001423.*

Peiró, R.; Quirino, C.; Blasco, A. and Santacreu, M.A. (2021). Correlated Response on Growth Traits and their variabilities to selection for ovulation rate in rabbits using genetic trends and a cryopreserved control population. *Animals*, 11: 2591. *https://doi.org/10.3390/ani11092591*.

Piles, M.; Blasco, A. and Pla, M. (2000). The effect of selection for growth rate on carcass composition and meat characteristic of rabbits. *Meat Science*, 54: 347-355. *https://doi.org/10.1016/s0309-1740(99)00109-6.*

Pla, M. (1996). Carcass composition and meat quality of rabbits selected from different criteria. *In Proc: 6th World Rabbit Congress*, Toulouse, 2. 347-350.

Polastre, R.; Moura, A.S.A.M.T. and Pons, S.B. (1992). Expectations from a mass selection programme for growth rate in selecta rabbits. *Revista da Sociedade Brasileira de Zootecnia,* 21: 45-56.

Sakthivel, M.; Balasubramanyam, D.; Kumarasamy, P. Gopi, H.; Raja; A; Anilkumar, R. and Devaki, A. (2017). Estimates of (co)variance components and genetic parameters for body weights and growth efficiency traits in the New Zealand White rabbit. *World Rabbit Science*. 2017, 25: 329-338. *https://doi.org/10.4995/wrs.2017.7057.*

Sam, I.M.; Essien, C.A. and Ekpo, J.S. (2020). Phenotypic correlation and carcass traits prediction using live body weight in four genetic groups of rabbit raised in tropical rain – forest zone of Nigeria. *Nigerian Journal of Animal Science*, 22:48-56. *https://www.ajol.info/index.php/tjas/ article/ view/200507.*

Shemeis, A.R. and Abdallah, O.Y. (2000). Possibilities of developing favourable body fat partition via selection indexes - application on rabbits. *Archiv fur Tierzucht*, 43(2): 193-201. *https://doi: 10.5194/aab-43-193-2000.*

Szendrő, K.; Szabó-Szentgróti, E. and Szigeti, O. (2020). Consumers' Attitude to Consumption of Rabbit Meat in Eight Countries Depending on the Production Method and Its Purchase Form. *Foods*. 19, 9: 654-669. *https://doi.org/10.3390/foods9050654.*

Valderrama de Diaz, G. and Varela-Alvarez, H. (1975). Genetic study on the improvement of some production characters in rabbits. *Agrociencia, Mixico*, 21: 115-124.

توابع الانتخاب لأداء النمو بعد الفطام على توزيع وزن الذبيحة وانسجتها في الأرانب

جوده فتحي، أحمد راغب شميس
قسم الإنتاج الحيواني، كلية الزراعة، جامعة عين شمس،شبرا الخيمة ١١٢٤١ القاهرة، مصر.

استهدفت هذه الدراسة بحث توابع الانتخاب لأداء النمو بعد الفطام في الارانب على توزيع وزن الذبيحة وأنسجتها باستخدام الأدلة الانتخابية معتمدا على المعالم الوراثية المقدرة بالنموذج الخطى المتعدد الصفات. استخدم في هذه الدراسة عدد ٢١٨ أرنب نيوزيلندى أبيض أبناء ٢٤ ذكر و ٩٣ أم ناضجة. اشتملت صفات الوراثة الكلية على وزن الفطام (WW) ، وزن الذبح (SW) ومعدل النمو اليومى من الفطام للذبح (DG). كانت صفات توزيع وزن الذبيحة هي نسبة كل من الرجل الخلفية (HLW) ، الرجل الأمامية (FLW) ، القطن (LOW) ، القفص الصدرى (TCW). في حين كانت صفات توزيع وزن أنسجة الذبيحة هي نسبة اللحم والعظام، على التوالي في كل من الرجل الخلفية (HLM, HLB)، والرجل الأمامية (FLM, FLB)، والقطن (LOM, FLB)، والقفص الصدرى (TCM, TCB). أظهرت النتائج أن الدليل الكامل التالى المحتوى على كل مصادر المعلومات (I_1) كان الأكبر ارتباطاً بصفات الوراثة الكلية: (I_1=23.5 WW–18.0SW+1212.8 DG (r_{TI}=0.84).

استبعاد صفة DG من الدليل الكامل لتكوين الدليل I_2 او صفة SW لتكوين الدليل I_3 أو صفة WW لبناء الدليل I_4 لم يكن له تأثير يذكر على دقة الانتخاب (r_{TI} =0.83). أظهر الدليل الفردى المحتوى على صفة WW أنه هو أفضل دليل فردى بين بقية الأدلة الفردية فى دقة الانتخاب (r_{TI} =0.73). بالرغم من تساوى دقة الانتخاب في الأدلة المخفضة ، فإن الدليل I_2 الذى يحتوى على WW ، SW يعتبر أفضل دليل مخفض لكونه سهل القياس. عند تطبيق أفضل أدلة انتخابية مخفضة (I_1, I_2 and I_5) فأنه يتوقع أن تعمل على انتاج أرانب تتسم بوزن ثقيل عند الفطام (٨٨.٠ إلى ١٠٨.١٠جم) وعند الذبح (١١١.٥ إلى ١٤٦.٦٥جم) وبمعدل نمو يومى أعلى (٠.٠٣ إلى ٠.٩٢ جم/يوم). هذا التحسين في أداء النمو بعد الفطام يستتبعه تغيرات في توزيع وزن الذبيحة على قطعياتها المختلفة (انخفاض بمقدار -٠.٤١ إلى -٠.٤٣% في صفة HLW ، وبمقدار -٠.٠٥ إلى -٠.٠١% في TCW وزيادة مقدارها ٠.١٨ إلى ٠.٢٠% في صفة FLW ، و بمقدار ٠.١١ إلى ٠.١٤% في LOW) ، وفى توزيع وزن النسيج اللحمى في الذبيحة (انخفاض بمقدار -٠.٠١ إلى -٠.٢٦% في HLM ، -٠.٩١ إلى -١.٤١% في FLM ، و زيادة مقدارها ٠.١٣ إلى ٠.٦٤% في LOM، ٠.٤٥ إلى ٠.٥٨% في TCM) ، وفى توزيع وزن النسيج العظمى (انخفاض بمقدار -٠.٠٧ إلى -٠.٠٨% في FLB ، -٠.١٢% في TCB ، وزيادة مقدارها ٠.١١ إلى ٠.١٥% في LOB مع تغيرات متذبذبة في صفة HLB مقدارها -٠.٠٩ إلى +٠.٠٧%).

مقارنة بصورها غير المقيدة ، فإن تطبيق الأدلة المقيدة $I_{8(HLM)}$ ، $I_{9(HLM)}$ سوف يؤدى الى انخفاض طفيف في دقة الانتخاب (r_{TI}= ٠.٧٦ و ٠.٧٢، على التوالى) مع تحسين مقبول في WW (+١٠٤.٧ و ١٠٨.٢جم ، على التوالى)، في SW (+١١٩.٨ و ١٠٨.١، على التوالى) مع زيادة غير مرغوبة في HLB بمقدار ٠.٣٧ و ٠.٠٧% ، على التوالي.

التوصية : يوصى للمربى باستخدام الدليل غير المقيد (I_2) التالى:

$$I_2 = 3.8\ WW + 1.5\ SW\ (r_{TI} = 0.83)$$

عند الرغبة في تحسين صفات أداء النمو بعد الفطام بغض النمو عن أي تدهور قد يحدث في توزيع وزن أنسجة الذبيحة. بينما يوصى للمربى باستخدام الدليل المقيد ($I_{8(HLM)}$) التالى :

$$I_{8(HLM)} = -29.4WW + 34.5SW - 2110.4DG$$

عند الرغبة في تحسين أداء النمو بعد الفطام مع مراعاة التدهور المحتمل في توزيع وزن أنسجة الذبيحة نتيجة للانتخاب، لأسباب تتعلق بالناحية البيولوجية للأرانب وأخرى تتعلق برغبات مستهلكى لحوم الأرانب.

الكلمات المفتاحية: أرانب – أدلة انتخابية – صفات النمو بعد الفطام – توزيع وزن الذبيحة – توزيع وزن أنسجة الذبيحة.