REFERENCES

Ayyat M S, Anous M R and Sadek M H. 1995a. Genetic parameters for meat production in rabbits. 1-Non carcass components. *World Rabbit Science* **2**: 93-99.

Ayyat M S, Marai I F M and EL-Sayiad GH A. 1995b. A trail to grade New Zealand White rabbits for broiler production at marketing and breeding. *World Rabbit Science* **3**: 75-84.

Berchiche M, Lebas F and Ouhayoun J. 1995. Utilization of field beans by growing rabbits 1. Effects of supplementation aimed at improving the sulphur amino acid supply. *World Rabbit Science* **3** : 75-84.

Blasco A, Ouhayoun J and Masoero G. 1992. Status of rabbit meat and carcass: Criteria and terminology. *Options Mediterranean's* **17**: 105-20.

El-Mahdy M R M. 1998. Evaluation of live body and carcass of broiler rabbits at marketing. *Egyptian Journal of Rabbit Science* **8**: 69-81.

Farghaly H M. 1996a. Analysis of incidence of pre- and post-mature gestations in rabbit populations. *Proceedings of the 6th World Rabbit Congress* **2**: 273-77.Toulouse, France.

Farghaly H M. 1996b. Genetic and maternal variance components of still births and pre-weaning mortality in purebred rabbits. *Indian Journal of Animal Sciences* **66**: 907-13.

Farghaly H M. 1996c. Performance of imported and locally born commercial rabbits population in Egypt. *Indian Journal of Animal Sciences* **66**: 634-40.

Harvey W R. 1990. *Users Guide for LSMLMW and MIXMDL*. Mimeo, Ohio State University, USA.

Khalil M H, Owen J B and Afifi E A. 1987. A genetic analysis of litter traits in Bauscat and Giza White rabbits. *Animal Production* **45**: 123-34.

Lopez M C, Sierra I and Lite M J. 1992. Carcass quality in Gigante de Espana purebred and commercial crossbred rabbits. Options *Mediterraneans* **17**: 75-80.

Lukefahr S D, Nwosu C V and Rao D R. 1989. Cholesterol level of rabbit meat and trait relationships among growth, carcass and lean yield performances. *Journal of Animal Science* 67: 2009-17.

Lukefahr S D and Ozimba C E. 1991. Prediction of carcass merit from live body measurements in rabbits of four breed-types. *Livestock Production Science* **29**: 323-34.

Lukefahr S D, Van Vleck L D and Roberts J D. 1992. Estimates of components of variance and covariance of carcass traits in rabbits using animal model. *Journal of Applied Rabbit Research* **15** : 259-73.

Moura A S A M T, Polastre R and Carmelo M J. 1991. Genetic study of individual performance from weaning to slaughter selected rabbits. *Journal of Applied Rabbit Research* **14**: 228-34.

Ozimba C E and Lukefahr S D. 1990. Evaluation of purebred and crossbred rabbits for carcass merit. *Journal of Applied Rabbit Research* **13**: 193-98.

Turabik S and Gurei F. 1997. Estimates of the genotype environment interactions on live weights in New Zealand White rabbits *Proceedings*. International Conference on Animal, Poultry and Rabbit Production and Health, held in Cairo, 2-3 September.

Varewyck H, Bouquet Y and Van Zeveren A. 1986. A progeny test for carcass quality in meat rabbits. *Arch. Gefluegelk* **50**: 26-31.

Table 6. Genetic ±SE and phenotypic correlations between live body measurements and each of carcass, technological cuts and % of dressing and meat/bone

Live traits and measurements	Carcass, technological cuts and % of dressing and meat/bone									
	HCW	RHCW	CCW	RCCW	HLW	LoW	FLW	FRCW	DP%	MBR%
WW	0.45±0.37	0.38±0.22	0.30±0.17	0.34±0.23	0.33±0.19	0.24±0.21	0.38±0.34	0.42±0.30	0.17±0.10	0.30±0.18
	0.20**	0.19**	0.19**	0.18**	0.17*	0.18**	0.21**	0.20**	0.03NS	0.18**
LBWB	0.73±0.19	0.68±0.24	0.68±0.22	0.61±0.29	0.61±0.29	0.69±0.22	0.78±0.18	0.67±0.22	0.36±0.51	0.70±0.53
	0.91***	0.91***	0.90***	0.91***	0.88**	0.89***	0.85***	0.90***	0.38***	0.45***
LBWA	0.78±0.17	0.73±0.19	0.74±0.19	0.68±0.25	0.69±0.29	0.75±0.19	0.79±0.18	0.73±0.22	0.43±0.35	0.74±0.53
	0.91***	0.92***	0.90***	0.91***	0.88***	0.89***	0.86***	0.90***	0.38***	0.45***
LBL	0.09±0.07	-0.02±0.07	-0.06±0.06	-0.11±0.16	-0.30±0.22	-0.10±0.09	0.42±0.29	0.03±0.07	0.50±0.40	0.57±0.37
	0.56***	0.55***	0.53***	0.55***	0.52***	0.51***	0.52***	0.56***	0.12NS	0.27***
LHG	0.73±0.19	0.67±0.22	0.67±0.21	0.65±0.22	0.67±0.24	0.69±0.22	0.70±0.19	0.71±0.20	0.06±0.23	0.24±0.14
	0.75***	0.74***	0.72***	0.74***	0.67***	0.74***	0.73***	0.75***	0.38***	0.44***
LPG	-0.15±0.12	-0.07±0.25	-0.13±0.12	0.20±0.31	-0.017±0.11	-0.15±0.17	-0.04±0.14	-0.10±0.16	0.73±0.27	0.84±0.25
	0.13NS	0.15*	0.12NS	0.15*	0.11NS	0.14*	0.05NS	0.14*	-0.33***	0.04NS
LHL	0.66±0.40	0.66±0.41	0.64±0.41	0.62±0.43	0.48±0.38	0.63±0.43	0.92±0.45	0.63±0.40	0.05±0.06	0.97±0.41
	0.62***	0.62***	0.61***	0.61***	0.58***	0.58***	0.62***	0.29***	0.29***	0.34***
LTL	-0.95±0.30	-0.93±0.28	-0.99±0.29	-0.99±0.32	-0.01±0.03	-0.95±0.29	0.99±0.27	-0.96±0.28	0.70±0.27	0.02±0.08
	0.11NS	0.13NS	0.10NS	0.14*	0.13NS	0.12NS	-0.01NS	0.11NS	-0.22**	-0.31***
LLC	0.20±0.12	0.27±0.16	0.19±0.19	0.17±0.15	0.19±0.13	0.13±0.13	0.30±0.21	0.25±0.17	0.73±0.43	0.62±0.38
	0.59***	0.58***	0.56***	0.58***	0.54***	0.57***	0.52***	0.58***	0.16*	0.30***

Key to abbreviation for traits are given in materials and methods and Table 1.
Genetic ±SE (rg) and phenotypic correlations (rp) are on 1st and 2nd line of each row, respectively.
***P<0.001, **P<0.01, *P<0.05, NS=nonsignificant.

GW and EOD ranged from 0.80 to 0.92, while BW, KW and HrW were moderately heritable (0.21 to 0.34) and remaining non-carcass components were low h^2 values with high standard error. In general, when h^2 is high, traits phenotype are good indicators of underlying breeding values, and phenotypic selection will be effective. If h^2 is low, traits phenotype reveal little about breeding values, and phenotypic selection will be ineffective.

Genetic and phenotypic correlations

Genetic (rG) and phenotypic (rP) correlations among various live measurements and some carcass components (Table 6) were high and positive. These results indicate that live weight (WW, LBWB, LBWA) before slaughter was involved in the HCW. Distinct and antagonistic rG of HCW with LTL. The same trends were obtained between each of RHCW, CCW, RCCW, HLW, LoW, FLW and FRCW with live measurements, except FLW was positive with LTL. Low rG (<0.30) between all carcass traits and LLC were obtained. In general, high rG between live measurements and carcass components indicate the synergistic control of the same additive genes, influencing the both measurement and weight variables. The rG between DP% and each of LBWA, LBWB, LBL, LTL and LLC were high and positive and varied widely from 0.38 to 0.73. Antagonistic high rG of DP% with LPG was observed. MBR% was high, and showed positive genetic correlations with LBWB, LBWA, LBL, LHL and LLC. DP and MBR% were high but with negative correlations witl LPG. Therefore, selection according to the considered mea surement traits would also improve the carcass and each o DP% and MBR%.

The rP between HCW, RHCW, CCW, RCCW, HLW LoW, FLW, FRCW and each of WW, LBWB, LBWA, LBL LHG, LHL and LLC were positive and significant (P<0.05 0.01 or 0.001) which confirms the above results and is simila to reports of Lukefahr and Ozimba (1991). The rP betweei DP% and MBR and each of LBWB, LBWA, LHG, LHL an LLC were significant and positive. The rP between LBW and DP% of 0.51 were obtained by Lukefahr *et al.* (1989).

In conclusion, the genetic variation of carcass and non carcass traits appears to include additive genetic component and play an important part in the phenotypic variation of man traits studied. The high values of $h^2 > 0.50$ for LPG or LTI (as indicator), and positively high genetic correlations be tween these live measurements and each of carcass form an technological cuts performance (HCW, RHCW, CCW RCCW, HLW, LoW, FLW and FRCW) and antagonistic re lationships with LTL measurement suggest that selectioi based on some live measurements (as predictors production would also improve the commercial carcass performance i commercial rabbit populations. In general, results from thi study suggest potential indirect selection to improvement car cass performance traits according to simple live measure ments.

distribution. High CV% were obtained for WW, KFW, CHL and SW. In general, CV% values ranged between 13.7 and 70% in live, carcass and non-carcass weight, suggesting improvement by selection according to phenotypic traits is possible. Estimates of CV% values ranged between 5.6 and 9.4% of measurements of live and carcass, which mean that measurements were better expressed than weight variables.

Genetic effects

Sire effects were significant for live body weight (WW, LBWB, LBWA), LHG, LPG, LTL and carcass CTL. Also, sire effects were significant for all carcass traits (HCW, RHCW, CCW, RCCW, HLW, LW, FLW, FRCW, MBR% and DP%). Sire effects were significant for BW, HW, LW, GW and EOW. Similar results on non-carcass component were in agreement with those reported by Ayyat *et al.* (1995a) who found that sire effects were significant on LW and non-significant on KW, HrW, SW and GTF. Accordingly, commercial carcass traits improvements could be made by selection of sires based on carcass performance of their progeny.

Dam effects were significant for LoW, DR%, BW, GW and all carcass measurements, except CCL and CHL suggesting importance of dam on some carcass traits and measurements. The sire and dam effects were significant (P<0.001, 0.01 and 0.05) for many carcass traits. These results were in agreement with those reported by Ayyat *et al.* (1995a). These results indicated the possibility of genetic improvement for some carcass traits by selection of sire. Sire selection really drives genetic changes, because the relative importance of sires selection can be seen in the advantages that sires have over dams in accuracy of selection and selection intensity.

Non-genetic effects

Least-squares means ± SE for live measurements, carcass and non-carcass traits as affected by sex and season of delivery are given in Table 2. Sex effects were not significant for all measurements and traits studied, except CTC, LW, GW, EOD and NEOW. CTC and NEOW were higher in male than that in female, while LW, GW and EOW were higher in female. Lopez *et al.* (1992) reported similar results about EOW. However, carcass studies (Moura *et al.* 1991 and Turabik and Gurei 1997) reported negligible differences due to sex of rabbits. Season effects were significant (P<0.01 or 0.001) for all traits studied except LBL, LHG, LPG, LHL, LTL, DP%, CHL, CTL, CTC, and SW. Weight of live, carcass traits and measurements were highest during winter. Depressed WW and growth during summer were observed (Farghaly 1996 a, b, c), which adversely influenced carcass traits (Ozimba and Lukefahr 1990, Moura *et al.* 1991 and Lukefahr and Ozimba 1991). In general, season appears to be the major non-genetic factor affecting weight of live and carcass traits. The 2-way interactions between sex and season were significant (P<0.05, 0.01 and 0.001) for weight greater than measurements variables and the reverse was true at other traits. The summer is more stressful due to extreme heat and relative humidity (Farghaly 1996 a, b) and both sexes produce at a lower level. But the loss in live and carcass performance is much less for male than that for female (Table 3).

Regressions

The partial linear regression coefficients (b) of carcass traits (dependent variables) on live body measurements traits (independent variables) into the base main effects model are given in Table 4. The (b) of carcass traits studied on WW were not significant. The (b) of carcass traits studied on LPG girth were nonsignificant, except DP%. The obtained results clarified non-importance of WW and LPG in predicting carcass traits. The (b) of carcass traits (HCW, RHCW, CCW, RCCW, HLW, LoW, FLW, FRCW, MBR% and DP%) on each of LBWB, LBWA, LHG and LHL were positive and highly significant (P<0.001). These results showed that each weight and measurement unit increase in independent variables (LBWB, LBWA, LHG and LHL) increased HCW, RHCW, CCW, RCCW, HLW, LoW, FLW, FRCW, MBR% and DP% as covariates. The same trend of (b) results were obtained for pervious dependent carcass form and technological cuts variables, except MBR% and DP% on LBL and DP% on LLC. Also all dependent variables on LTL were significant (P<0.05, 0.01), except FLW, MBR and DP%. These findings were in agreement with results reported by Lukefahr and Ozimba (1991).

Heritabilities

Paternal halfsib estimates of h^2 (Table 5) for live weight were moderately heritable and ranged from 0.18 to 0.30. Similar, h^2 estimates of weaning weight reported by Khalil *et al.* (1987) and for pre-slaughter weight presented by Lukefahr *et al.* (1992). The h^2 estimates for LHG, LPG and LTL were moderately and highly heritable (0.33, 0.54 and 0.62, respectively). The h^2 estimates for LBL, LHL and LLC were lowly heritable (below 0.2).

The h^2 for carcass form and technological cuts traits were moderate and high and ranged from 0.38 to 0.76. Varewyck *et al.* (1986) found that h^2 values for carcass traits were moderately to highly heritable on the same breeds. The high h^2 values of some carcass traits and measurements suggest that improvement of these traits could be realized by selection. The h^2 values of MBR% and DP% were lowly heritable (< 0.13). The low h^2 values in this study for MBR% and DP% were noted by Ayyat *et al.* (1995a).

The h^2 estimates of CTL, CTC and CLL were 0.79, 0.78 and 0.62, respectively, while remaining carcass measurements were small and ranged from 0.06 to 0.20. The low h^2 indicated a comparatively large influence of environmental effects, besides that improvement of these traits could be realized by improvement of management. The h^2 for HW, LW, fasting and complete bleeding), head weight (HW), liver weight (LW), kidneys weight (KW), kidney fat weight (KFW), lungs and trachea (LTW), heart weight (HrW), spleen weight (SW), giblets weight (GW, liver + kidneys + heart), edible offals weight (EOW, including kidneys+ heart+ liver + spleen+ lungs+ trachea), non-edible offals weight (NEOW, including skin+ ears+ feet+ tail) and gastrointestinal tract full (GTF, including stomach and intestinal content and empty urinary bladder).

Data were statistically analyzed by using mixed model least-squares and maximum likelihood method of Harvey (1990). The following mathematical model was used to describe the live, carcass and non-carcass traits:

$Y_{ijklm} = \mu + S_i + D_{ij} + X_k + A_l + X_{Akl} + e_{ijklm}$, where:

Y_{ijklm} = live body measurements, carcass and non-carcass components, μ= overall mean, S_i = a random effect associated with the ith sire assumed to be normally and independently distributed with expected mean zero and variance σ^2 s, D_{ij} = a random effect associated with the jth dam nested within ith sire assumed to be normally and independently distributed with expected mean zero and variance σ^2 d:s, X_k = effect due to kth sex (k, 1=male and 2=female) A^l= effect due to lth season of delivery l= (1=winter and 2=summer), XA_{kl} = interaction of kth sex and lth season, and e_{ijlkm}= a random residual component associated with the ijklmth observation assumed to be normally and independently distributed with expected mean zero and variance σ^2e.

Heritability (h^2), genetic and phenotypic correlations were calculated by using paternal half sib method. The regression analyses were carried out for live traits measured (WW, LBWB, LBWA, LBL, LHG, LPG, LHL, LTL and LLC) as linear covariates (independent variables) and carcass traits (HCW, RHCW, CCW, RCCW, HLW, LoW, FLW, FRCW, DP% and MBR%) as dependent variables by using another nine models including the same previous random and fixed effects. Regression was computed for each covariate source separately. Percentages of carcass traits were subjected to arcsin transformation.

RESULTS AND DISCUSSION

The overall means of WW (Table 1) in this study agree with Farghaly (1996 a, b, c) on the same breeds. LBWB, LBWA and HCW were lower than that recorded by Ayyat *et al.* (1995 a, b) using New Zealand White breed at the same age. Means of live and carcass measurements (LBL, LHG, LPG, CCL, CHL, CTL) agree with El-Mahdy (1998) and were not far from the values reported previously by Ayyat *et al.* (1995 a, b). CCW were lower than that reported by Berchiche *et al.* (1995) and El-Mahdy (1998). The same value of MBR% was reported by Berchiche *et al.* (1995). Similar values of DP% were reported by Ayyat *et al.* (1995a). Generally, the differences in live, and carcass measurements and component between values of this work and previous researches on the same breed may be because of the adverse non-genetic factors. Most environmental influences (unknown) are difficult to quantify. Then, researchers cannot mathematically adjust rabbit meat performance to account for them. A low R^2 were obtained for LHL, CHL, LTW and SW. However, these were minor differences in R^2 values within and between live, carcass, non-carcass measurements and weight variables. This may be to some extent depend on their more normal

Table 5. Heritability (h^2) and standard error for live, carcass and non-carcass traits

Items	Key#	h^2	SE±
Live body weight			
Weaning weight	(WW)	0.30	0.18
Live body weight	(LBWB)	0.18	0.12
Fast live body weight	(LBWA)	0.18	0.11
Live body measurements			
Body length	(LBL)	0.10	0.16
Heart girth	(LHG)	0.33	0.18
Pelvic girth	(LPG)	0.62	0.19
Humerus length	(LHL)	0.12	0.17
Thigh length	(LTL)	0.54	0.19
Lumbar circumference	(LLC)	0.17	0.16
Carcass and technological cuts			
Hot carcass weight	(HCW)	0.51	0.19
Reference hot carcass	(RHCW)	0.42	0.16
Commercial carcass weight	(CCW)	0.48	0.19
Reference cold carcass	(RCCW)	0.38	0.19
Hind legs weight	(HLW)	0.41	0.17
Loin weight	(LoW)	0.46	0.18
Fore legs weight	(FLW)	0.69	0.19
First retail cut	(FRCW)	0.50	0.19
Meat/bone ratio (%)	(MBR%)	0.12	0.10
Dressing (%)	(DP%)	0.10	0.08
Carcass measurements			
Carcass length	(CCL)	0.07	0.11
Humerus length	(CHL)	0.06	0.03
Thigh length	(CTL)	0.79	0.18
Thigh circumference	(CTC)	0.78	0.17
Lumbar circumference	(CLC)	0.20	0.16
Loin length	(CLL)	0.62	0.19
Non-carcass traits			
Blood weight	(BW)	0.26	0.15
Head weight	(HW)	0.92	0.18
Liver weight	(LW)	0.80	0.19
Kidneys weight	(KW)	0.34	0.18
Kidney fat weight	(KFW)	0.10	0.17
Lungs and trachea	(LTW)	0.06	0.16
Heart weight	(HrW)	0.21	0.18
Spleen weight	(SW)	0.02	0.03
Giblets weight	(GW)	0.80	0.19
Edible offals weight	(EOW)	0.81	0.19
Non-edible offals weight	(NEOW)	0.07	0.10
Gastrointestinal tract full	(GTF)	0.05	0.01

#Key to abbreviation is given in materials and methods.

Table 3. Least squares means ±SE of live, carcass and non-carcass traits as affected by sex and delivery season as fixed effects

Items	Winter		Summer	
	Male (76)	Female (80)	Male (108)	Female (46)
Live body weight (g)				
WW	532.4±18.83A	474.8±18.36B	423.5±15.80C	476.3±24.21ABC
Carcass and technological cuts (g)				
HCW	1353.5±36.13A	1251.3±35.22B	1055.4±30.31C	1154.9±46.44BC
RHCW	1124.1±31.99A	1034.6±31.18B	877.4±26.83C	948.9±41.11BC
CCW	1110.3±31.55A	1022.8±30.75B	871.3±26.46C	930.9±40.55BC
RCCW	1340.0±35.68A	1239.5±34.78B	1049.3±29.93C	1136.8±45.87BC
LoW	359.0±11.44A	326.3±11.15B	275.5±9.60C	298.5±14.70BC
FLW	175.5±5.20A	159.4±5.07B	128.1±4.36C	147.6±6.68B
FRCW	964.1±28.15A	884.9±27.44B	756.2±23.62C	815.8±36.19C
MBR%	6.0±0.17A	5.6±0.17AB	5.0±0.14C	5.5±0.22A
DP%	61.0±0.70A	59.1±0.68B	58.7±0.59BC	61.6±0.90A
Carcass measurements (cm)				
CTC	18.1±0.28A	18.1±0.27A	18.4±0.23A	17.2±0.35D
Non-carcass traits (g)				
HW	132.3±3.07A	121.3±2.99B	105.8±2.57C	118.8±3.94BC
LW	62.8±2.03A	62.8±1.98A	44.3±1.71C	56.3±2.61D
LTW	14.1±0.57A	13.2±0.55AB	10.7±0.48C	12.3±0.73BC
HrW	6.8±0.26A	6.1±0.25B	5.0±0.22C	5.9±0.33
GW	83.4±2.44A	82.3±2.38AB	61.5±2.05C	74.9±3.14B
EOD	98.7±2.69A	96.7±2.62AB	73.1±2.26C	88.4±3.46B

Key to abbreviation for traits are also given in materials and methods, and Table 1.
Within each row, mean bearing different letters, differed significantly at P<0.05, 0.01 or 0.001.

cuts (FRCW, including hind legs, lion and fore legs). Meat/bone ratio (MBR%) of the dissected hind legs and non-carcass components. Dressing percentage (DP%) was calculated as hot carcass weight (HCW) relatively to live body weight after fasting (LBWA). Non-carcass traits analyzed were blood weight (BW, the differences between live body weight after

Table 4. Regression analysis (b±SE) for carcass components on live body measurements

Live traits and measurements	Carcass, technological cuts and % of dressing and meat/bone (as dependent variables)									
	HCW	RHCW	CCW	RCCW	HLW	LoW	FLW	FRCW	DP%	MBR%
WW	NS 0.11±0.16	NS 0.08±0.14	NS 0.11±0.15	NS 0.08±0.14	NS 0.03±0.05	NS 0.03±0.05	NS 0.02±0.02	NS 0.08±0.12	NS 0.00001±0.0007	NS -0.002±0.003
LBWB	*** 0.69±0.02	*** 0.61±0.02	*** 0.68±0.02	*** 0.60±0.02	*** 0.23±0.01	*** 0.21±0.01	*** 0.09±0.004	*** 0.53±0.02	*** 0.001±0.003	*** 0.005±0.001
LBWA	*** 0.70±0.02	*** 0.62±0.02	*** 0.69±0.02	*** 0.61±0.02	*** 0.23±0.01	*** 0.21±0.01	*** 0.09±0.004	*** 0.54±0.02	*** 0.001±0.0003	*** 0.005±0.001
LBL	*** 50.06±7.31	*** 44.27±6.47	*** 49.43±7.21	*** 43.63±6.38	*** 16.19±2.51	*** 14.45±2.37	*** 6.48±1.08	*** 37.12±5.78	*** 0.07±0.04	*** 0.18±0.16
LHG	*** 81.70±6.06	*** 71.16±5.47	*** 80.85±5.97	*** 70.31±5.38	*** 24.80±2.28	*** 25.32±1.97	*** 11.32±0.91	*** 61.43±4.91	*** 0.15±0.04	*** 0.82±0.16
LPG	NS 9.05±7.13	NS 9.50±6.29	NS 8.88±7.03	NS 9.32±6.21	NS 2.49±2.42	NS 3.23±2.25	NS -0.03±1.03	NS 5.69±5.56	NS 0.01±0.03	*** -0.56±0.13
LHL	*** 187.32±20.37	*** 165.88±18.03	*** 185.39±20.09	*** 163.96±17.76	*** 63.79±6.87	*** 54.87±6.70	*** 24.22±3.08	*** 142.89±16.05	*** 0.32±0.12	*** 1.73±0.47
LTL	** 34.48±13.42	** 33.65±11.82	** 34.72±13.24	** 33.89±11.65	** 11.70±4.54	** 10.83±4.25	** 1.84±1.97	** 24.37±10.50	** -0.02±0.06	** -0.45±0.26
LLC	*** 57.38±7.93	*** 51.42±6.99	*** 55.67±7.88	*** 49.72±6.94	*** 18.54±2.73	*** 17.68±2.53	*** 6.97±1.20	*** 43.20±6.25	*** 0.10±0.04	NS 0.33±0.18

Key to abbreviation for traits are also given in materials and methods and Table 1; Genetic ±SE (rg) and phenotypic correlations (rp) are on 1st and 2nd line of each row, respectively; ***P<0.001, **P<0.01, *P<0.05, NS=nonsignificant.

vertebra, loin length (CLL), hot carcass weight (HCW, including the head+ liver+ heart+ kidneys + trachea + lungs) and reference hot carcass weight (RHCW, without any parts). After 1 hr of slaughtering carcasses were refrigerated for 24 hr between 0 and 4 °C and were hung in normal ventilation or sufficient air. Carcass was separated into 4 technological cuts according to the methods recommended by Blasco *et al.* (1992). Commercial carcass weight (CCW, including head + liver +heart + kidneys + trachea + lungs), reference cold carcass weight (RCCW, without any parts), hind legs (HLW, including the sacral bone and the lumbar vertebrae after the sixth lumbar vertebra), loin weight (LoW, including abdominal wall and the ribs after the seventh thoracic rib), fore legs (FLW, including thoracic insertion muscles) and first retail

Table 2. Least squares means ±SE of live, carcass and non-carcass traits as affected by sex and delivery season as fixed affects

Items	Sex		Season	
	Male (184)	Female (126)	Winter (156)	Summer (154)
Live body weight (g)				
WW	477.9±12.29A	475.5±15.19A	503.6±13.15A	449.9±14.45B
LBWB	2079.2±32.06A	2070.7±39.62A	2236.1±34.30A	1913.9±37.70B
LBWA	2004.0±31.7A	1984.3±39.18A	2153.6±33.92A	1834.7±37.28B
Live body measurements (cm)				
LBL	34.0±0.22A	34.2±0.27A	34.6±0.24A	33.6±0.26A
LHG	26.6±0.21A	27.3±0.26A	27.9±0.23A	26.0±0.25A
LPG	29.3±0.27A	28.5±0.33A	29.8±0.29A	28.0±0.32A
LHL	8.9±0.08A	9.0±0.09A	9.2±0.08A	8.7±0.09A
LTL	13.1±0.14A	12.8±0.17A	13.1±0.15A	12.8±0.17A
LLC	22.5±0.21A	22.9±0.26A	23.7±0.22A	21.7±0.25B
Carcass and technological cuts (g)				
HCW	1204.6±23.58A	1203.1±29.14A	1302.6±25.22A	1105.1±27.72B
RHCW	1000.7±20.88A	991.8±25.80A	1079.3±22.33A	913.2±24.55B
CCW	1194.7±23.29A	118.1±28.78A	1289.8±24.91A	1093.1±27.38B
RCCW	990.8±20.59A	976.8±25.44A	1066.5±22.03A	901.1±24.21B
HLW	391.1±7.98A	384.5±9.86A	414.4±8.54A	361.2±9.38B
LoW	317.2±7.47A	312.4±9.23A	342.6±7.99A	287.0±8.78B
FLW	151.8±3.39A	153.5±4.19A	167.5±3.63A	137.8±3.99B
FRCW	860.1±18.37A	850.3±22.71A	924.5±19.66A	786.0±21.61B
MBR%	0.5±0.11A	5.6±0.14A	55.8±0.12A	5.3±0.13B
DP%	59.8±0.54A	60.4±0.56A	60.0±0.49A	60.1±0.54A
Carcass measurements (cm)				
CCL	33.0±0.23A	33.6±0.28A	34.4±0.25A	32.1±0.27B
CHL	7.9±0.06A	8.0±0.07A	8.1±0.06A	7.8±0.07A
CTL	11.7±0.09A	11.4±0.11A	11.6±0.10A	11.5±0.11A
CTC	18.3±0.18A	17.6±0.22B	18.1±0.19A	17.8±0.21A
CLC	16.5±0.15A	16.2±0.19A	16.8±0.16A	15.9±0.18B
CLL	10.8±0.11A	11.0±0.14A	11.3±0.12A	10.6±0.13B
Non-carcass traits (g)				
BW	71.5±3.30A	70.6±4.07A	80.6±3.53A	61.5±3.88B
HW	119.1±2.00A	120.0±2.47A	126.8±2.14A	112.3±2.35B
LW	53.5±1.33A	59.5±1.64B	62.8±1.42A	50.3±1.56B
KW	13.0±0.29A	13.1±0.36A	13.7±0.31A	12.5±0.34B
KFW	4.9±0.37A	5.8±0.46A	6.2±0.39A	4.5±0.43B
LTW	12.4±0.37A	12.7±0.46A	13.6±0.40A	11.5±0.43B
HrW	5.9±0.17A	6.0±0.21A	6.5±0.18A	5.4±0.20B
SW	1.1±0.05A	1.3±0.06A	1.3±0.05A	1.1±0.05A
GW	72.4±1.59A	78.6±1.97B	82.9±1.71A	68.2±1.87B
EOW	85.9±1.76A	92.6±2.17B	97.7±1.88A	80.8±2.07B
NEOW	292.8±5.07A	267.4±6.26B	301.4±5.42A	258.8±5.95B
GTF	333.7±7.56A	340.0±9.34A	356.2±8.09A	317.4±8.89B

Key to abbreviation for traits are also given in materials and methods; ***P<0.001, **P<0.01, *P<0.05 and NS - not significant; With each classification, mean bearing different letters, differed significantly at P<0.05, 0.01 or 0.001.

ing winter and between 25.2 and 33.6 °C and 91.5 and 57.3 RH%, respectively, during summer.

Live traits and measurements analyzed were weaning weight (WW), live body weight before (LBWB) and after fasting by 12 hr (LBWA), body length (LBL), heart girth (LHG), pelvic girth (LPG), humerus length (LHL), thigh length (LTL) and lumbar circumference (LLC). Carcass measurements and traits analyzed were carcass length (CCL), humerus length (CHL), thigh length (CTL), thigh circumference (CTC), lumbar circumference (CLC), seventh lumbar

Table 1. Overall mean ±SE, coefficients of determination (R^2) and variation (CV%) and source of variations for live, carcass and non-carcass traits.

Traits	Key#	Overall mean	R^2	C V%	Source of variations				
					Sire	Dami-sire	Sex	Season	Sex × season interaction
Live body weight (g)									
Weaning weight	(WW)	471.3±9.82	0.56	24.1	*	NS	NS	**	***
Live body weight	(LBWB)	2067.4±27.87	0.49	16.6	**	NS	NS	***	NS
Fasted live body weight	(LBWA)	1987.2±27.57	0.49	17.1	**	NS	NS	***	NS
Live body measurements (cm)									
Body length	(LBL)	34.0±0.18	0.50	6.3	NS	NS	NS	NS	NS
Heart girth	(LHG)	26.8±0.19	0.55	8.1	**	NS	NS	NS	NS
Pelvic girth	(LPG)	29.1±0.21	0.62	8.1	***	NS	NS	NS	NS
Humerus length	(LHL)	8.9±0.06	0.47	8.7	NS	NS	NS	NS	NS
Thigh length	(LTL)	13.1±0.11	0.63	9.0	***	NS	NS	NS	NS
Lumbar circumference	(LTC)	22.7±0.18	0.53	9.4	NS	NS	NS	***	NS
Carcass and technological cuts (g)									
Hot carcass weight	(HCW)	1193.9±20.12	0.62	18.4	***	NS	NS	***	**
Reference hot carcass	(RHCW)	989.1±17.56	0.59	20.0	**	NS	NS	***	*
Commercial carcass weight	(CCW)	1182.6±19.83	0.60	18.6	**	NS	NS	***	*
Reference cold carcass	(RCCW)	977.8±17.27	0.58	20.1	*	NS	NS	***	*
Hind legs weight	(HLW)	386.1±6.48	0.59	19.0	**	NS	NS	***	NS
Loin weight	(LoW)	312.1±6.20	0.61	21.8	**	**	NS	***	*
Forelegs weight	(FLW)	150.7±2.96	0.66	20.5	**	NS	NS	***	***
First retail cut	(FRCW)	848.9±16.02	0.62	20.4	**	NS	NS	***	**
Meat/bone ratio (%)	(MBR%)	5.5±0.09	0.51	19.9	***	NS	NS	**	**
Dressing percentage (%)	(DP%)	59.8±0.36	0.83	4.9	**	**	NS	NS	***
Carcass measurements (cm)									
Carcass length	(CCL)	33.2±0.20	0.50	6.3	NS	NS	NS	**	NS
Humerus length	(CHL)	7.9±0.05	0.39	7.8	NS	NS	NS	NS	NS
Thigh length	(CTL)	11.6±0.07	0.78	5.6	*	***	NS	NS	NS
Thigh circumference	(CTC)	18.1±0.14	0.78	6.9	NS	***	*	NS	*
Lumbar circumference	(CLC)	16.3±0.12	0.54	8.9	NS	**	NS	***	NS
Loin length	(CLL)	10.9±0.09	0.62	9.4	NS	**	NS	***	NS
Non-carcass traits (g)									
Blood weight	(BW)	71.2±2.59	0.86	28.1	***	***	NS	***	NS
Head weight	(HW)	118.2±1.71	0.74	13.7	**	NS	NS	***	***
Liver weight	(LW)	55.4±1.20	0.71	21.5	**	NS	**	***	**
Kidneys weight	(KW)	13.0±0.23	0.58	19.7	NS	NS	NS	**	NS
Kidney- fat weight	(KFW)	5.2±0.29	0.48	70.0	NS	NS	NS	**	NS
Lungs and trachea	(LTW)	12.4±0.30	0.44	30.7	NS	NS	NS	***	*
Heart weight	(HrW)	5.8±0.14	0.50	28.9	NS	NS	NS	***	**
Spleen weight	(SW)	1.2±0.04	0.47	40.8	NS	NS	NS	NS	NS
Giblets weight	(GW)	74.2±1.43	0.71	19.0	**	*	*	***	**
Edible offals weight	(EOD)	87.8±1.60	0.71	18.0	**	NS	*	***	**
Non-edible offals weight	(NEOD)	282.9±4.20	0.49	18.2	NS	NS	**	***	NS
Gastrointestinal tract full	(GTF)	337.5±5.90	0.50	33.2	NS	NS	NS	**	NS

Key to abbreviation for traits are given also in materials and methods; R^2 = Model sum of squares/ total sum of squares; ***$P<0.001$, **$P<0.01$, *$P<0.05$ and NS = not significant.

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Genetic and non-genetic factors affecting live, carcass and non-carcass traits of New Zealand White rabbits in Egypt

H M FARGHALY [1] and M R M EL-MAHDY [2]

Zagazig University, Zagazig, Egypt

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ABSTRACT

Genetic and non-genetic factors that influence live, carcass and non-carcass traits of New Zealand White breed were evaluated by a basic model included sire and dam (as random effects), sex, delivery season and interaction between them (as fixed effects). The sire and dam effects on many carcass traits, were significant, but the sire effects were greater than dam. Sex insignificantly affected most traits, except thigh circumference and liver, giblets, edible and non-edible offals weights. Season appears to be the major non-genetic factor that affect live, carcass form and technological cuts traits. The highest live body weight, carcass traits and measurements were estimated during winter. The two-way interactions between sex and season were significant for weight greater than measurement variables. The losses in live and carcass performance traits were higher in males than in females, during summer. Regression coefficients (b) of all carcass traits, meat/bone ratio and dressing% (as dependents) on each of live body weight before and after fasting, heart girth and humerus length (as covariates) were positive and highly significant ($P<0.001$). Heritabilities (h^2) for heart girth, pelvic girth and thigh length of live body and carcass traits were high and ranged from 0.33 and 62. The h^2 estimates of carcass thigh length, thigh circumference, loin length, head, liver, giblets and edible offals weights were very high and ranged between 0.62 and 0.92. Genetic correlations (rG) between each of hot, reference hot, commercial and reference cold carcass and technological cuts and each of weaning, live body weight before and after fasting, heart girth and humerus length were high and positive. The rG between dressing% and each of live body weight before and after fasting, body and thigh length and lumbar circumference were high and positive. It was concluded that the h^2 and rG were sufficiently high to permit selection of commercial carcass traits on individual levels for some of the live traits in rabbits.

Key words: Carcass traits, Genetic and phenotypic correlations, Heritability, Live traits, Rabbits

Development of sound rabbit breeding programmes depends upon accurate knowledge of genetic and environmental parameters of the traits (Lukefahr *et al.* 1992).

The extent of incorporation of some easily assessed traits such as live weight and measurements into a selection programme is partly determined by the extent to which they are inherited (Ayyat *et al.* 1995a). To date, genetic parameter estimates of measurements and components of carcass and non-carcass traits in rabbit populations are scanty, especially under subtropical conditions.

The purpose of this study was to evaluate genetic and non-genetic factors affecting carcass and non-carcass components. Heritabilities, genetic and phenotypic correlations between live measurements and carcass traits were also estimated.

Present address : [1]Animal Production Department, Faculty of Agriculture.

[2]Animal Production Department, Faculty of Agriculture, Moshtohor, Banha Branch.

MATERIALS AND METHODS

Data of 310 fryers of San El-Hagar Agricultural Company Farm taken at random at 90 days of age from the offspring, 42 dams and 23 sires were used. The animals reared under similar environmental conditions and were fed *ad lib.* on a commercial pelleted rabbit ration. The digestible energy was 2 600 kcal/kg ration. Freshwater was provided all the time from automatic drinkers with nipples. The fryers were housed separately in individual cages of universal galvanized wire batteries. Cages for does were provided with external nest boxes for kindling and nursing the young. Does were allocated to the bucks at random at each mating period, avoiding closely related mating (fullsib, halfsib and parent-offspring matings). The bucks to does ratio was 1:6. The weaning age was 30 days. Fryers were slaughtered at 90 days of age after fasting by 12 hr (Lukefahr *et al.* 1992). Various live body measurements were taken and recorded before slaughter. The temperature and relative humidity (RH%) ranged between 16.9 and 21.3 °C and 96.2 and 81.5 RH%, respectively, dur-