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Study on Growth Performance and Carcass Quality of Apparently Healthy Female Rabbits as Affected by Breed

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Running Title: Breed Effects on Growth and Carcass Traits in Female Rabbits

ABSTRACT

Rabbits have being considered as the best alternative meat source especially for underdeveloped/developing countries. The study assesses growth performance and carcass quality attributes of female weanling rabbits of five different rabbit breeds (Dutch, New Zealand White Rabbit, American Black, Wild and Dwarf Brown) being reared in Pakistan under conventional housing system. Female weanling rabbits (n=50; 10 per breed), weaned at about 4 weeks of age were studied for growth performance and carcass quality attributes at 19th week of experimentation. The initial and slaughter weight, and daily weight gain per animal was significantly (P≤0.05) different for all breeds with highest values noticed for wild rabbits and lowest for Dwarf Brown. The body length, trunk length, fur length, forelimb length and hind limb length was significantly (P≤0.05) higher for wild rabbits, whereas, tail length and head length were significantly (P≤0.05) higher in Dwarf Brown breed of rabbits. All the studied carcass attributes viz. live weight, chilled carcass weight, reference carcass weight, dressing out % and dressing fat % were significantly (P≤0.05) higher for wild rabbits being 2140±505.0g, 2190.0±451.0g, 69.0±3.1%, 49.0±1.6% and 3.2±1.1%, respectively. The wild breed of rabbits revealed significantly (P≤0.05) higher values for meat to bone ratio (5.4±0.2), hind limb % (39.0±1.7%) and bone % (13.0±0.8%) whereas forelimb % was significantly (P≤0.05) higher for New Zealand White rabbits (13.0±0.8%) as compared to other study breeds. The study concludes that genotype is true determinant of growth and carcass attributes in rabbits. Heavier genotypes (wild indigenous and New Zealand White) are recommended for commercial purposes in Pakistan.

Keywords: Dutch, Wild and Dwarf Brown Rabbit, Carcass, genotype

INTRODUCTION

The soaring global population, rapid urbanization and elevated meat consumption have led to the dilemma of a shortage of meat, especially for developing countries. It is now estimated that the prevalent global trends will further alter the dietary patterns of humanity towards more meat consumption, and by 2050, the global meat demand will have increased by 75% (Rahman, 2016). The developing and underdeveloped countries of the world are largely to be hit by this acute shortage owing to their sole dependency upon conventional livestock such as buffalo, cattle, sheep, goats, pigs, and camels (Purwin *et al*., 2019). Apart from its nutritional value as a main animal protein, the importance of eating meat in perspective to traditions, cultures, and socio-economic profiles cannot be underestimated (Bogueva *et al*., 2017).

The research trends have lately diverted towards finding alternate meat sources that may be low-cost, easy to yield, high quality, low in saturated fatty acids, and high in unsaturated fatty acids. Micro livestock are hence, being studied as a potential source of quick delivery of meat for humans, especially in European and African countries (Assan, 2014; Behera *et al*., 2019; Thakkar *et al*., 2019).

Typically, micro livestock comprise rabbits, bush rodents, bees, sables, guinea pigs, and certain reptiles (Gibbons, 1991; Assan, 2014). Among these, the domestic rabbit (*Oryctolagus cuniculus*) is emerging as a potential alternate meat source throughout the world because of its better meat quality attributes, ease of maintenance, high prolificacy and fecundity, earlier sexual maturity, and short generation cycles (Paci *et al*., 2012; Saleh *et al*., 2013; Papadomichelakis *et al*., 2017).

Pakistan is mainly an agro-livestock-based country in which the livestock sector shared 60.54% of agriculture and 11.22% of the national Gross Domestic Product (GDP) during 2018–2019, as per the Economic Survey of Pakistan (Khan, 2023). Though the livestock population in Pakistan is at a constant rise, catering to the meat demand for all and sundry is still an unaddressed issue. Rabbit farming at a small-scale backyard rearing is being carried out mainly in Khyber Pakhtunkhwa province, yet its elevation to commercial scale has not yet been attained.

The research work conducted on rabbits in Pakistan has mostly been directed towards their production, morphometric attributes (Khan *et al*., 2017), and meat quality parameters under specific feeding

patterns (Khan *et al*., 2016). However, there is a dearth of knowledge regarding growth performance and meat quality/carcass attributes of healthy rabbits being reared under a conventional rearing system in Pakistan. These physiological indices may be of prime importance in strengthening rabbit meat as a large-scale meat source. These parameters for healthy male rabbits of five different breeds have been published elsewhere (Suleman *et al*., 2020). The present work on rabbit meat is being presented with an objective to assess growth performance and carcass quality attributes of female weanling rabbits of five different rabbit breeds (Dutch, New Zealand White, American Black, Wild, and Dwarf Brown) being reared in Pakistan under a conventional housing system.

MATERIALS AND METHODS

Experimental animals and housing

The duration of the study was 19 weeks, and was carried out at the Wildlife and Ecology Animal Housing Facility of the University of Veterinary and Animal Sciences (UVAS), Lahore, Pakistan (Ravi Campus). The accommodation, care, and management of study animals were conducted as per the ethical approval of the Office of Research, Innovation, and Commercialization of UVAs, Lahore, Pakistan.

Female weanling rabbits (n=50; 10 per breed for Dutch, New Zealand White, American Black, Wild, and Dwarf Brown), weaned at about 4 weeks of age, and belonging to homogenous litters, were obtained from the local vendor. Identification of breed for these animals was attained through their morphometric attributes and colour (Setiaji *et al*., 2012; Dalle Zotte *et al*., 2013). These breeds are already being reared on a small-scale basis in Pakistan. The rabbits were reared under a conventional housing system as detailed earlier in our work (Suleman *et al*., 2020). Briefly, they were caged in colony cages (65×40×32 cm) at the stocking density of 0.06 m² per rabbit. Acclimatization to housing and feeding patterns prior to the initiation of the experimental trial was attained in 1 week. An appropriate and similar diet pattern was maintained throughout the trial with pelleted feed (17.7 CP, 12.13 MJ/kg DE) and ad libitum alfalfa hay from the second week until slaughter at the 19th week of the experiment.

Growth performance and carcass attributes

The growth attributes (body weight, head length, body length, tail length, trunk length, ear length, fur length, forelimb length, and hind limb length) of animals were recorded weekly at post-weaning age (4 weeks) until slaughter at the 19th week. All the animals were slaughtered, and carcasses were prepared as per the protocols levied down by the World Rabbit Science Association (Belabbas *et al*., 2019; Suleman *et al*., 2020). The skin, distal parts of tail, hind limbs, forelimbs, digestive tract, and urogenital organs were removed. Hot carcasses were suspended in a ventilated area for 30 minutes and later chilled at 3-4ºC. Accordingly, the live weight (LW), chilled carcass weight (CCW), reference carcass weight (RCW), dressing-out percentage (DOP), and dissectible fat (DFaP) were calculated. The DOP was calculated as (Blasco & Ouhayoun., 1993): Carcass weight/live body weight×100

The RCW was a carcass without a head and organs but included only meat, fat, and bone.

The weight percentages of various tissues/organs (head, meat-to-bone ratio, loin, forelimb, hind limb, thoracic viscera, liver, kidney, stomach, small intestine, large intestine, bone, and thoracic cage) were deduced from the total percentage of CCW at the time of slaughter (19th week) (Saleh *et al*., 2013; Suleman *et al*., 2020).

Statistical analysis

Statistical Package for the Social Sciences (SPSS for Windows Version 13, SPSS Inc., and Chicago, IL, USA) was used for all statistical analyses. Results were expressed as mean (±SE), and the differences of the study attributes (growth performance and carcass quality attributes) within the five breeds of rabbits were deduced through ANOVA, followed by post-hoc Duncan's Multiple Range test. Significance level was fixed at P≤0.05.

RESULTS

The initial (at the time of weaning) and slaughter weight of animals was significantly (P≤0.05) different for all breeds, with the highest values noticed for wild rabbits (934.0±30.0 g and 1924.0±609.0 g) and the lowest for Dwarf Brown (514.0±27.0 and 1117.0±384.0 g), respectively. A similar trend was observed for slaughter weight and daily weight gain per animal in five breeds of the present study, being highest for wild rabbits and lowest in Dwarf Brown rabbits (Table 1).

Table 1: Mean (±SE) values for body weight of five breeds of female rabbits as recorded on 19 weeks at slaughter*

Breeds	Initial Body Weight (g)	Slaughter Weight (g)	Daily Weight Gain Per Rabbit (g)
Dutch	664.0 ±32.0^{c}	1341.0±250.0^{c}	5.0± 0.8^{c}
N Z W	819.0±27.0^{b}	1596.0±463.0^{b}	5.8±1.2^{b}
A Black	575.0±39.0^{c}	1161.0 ± 368.0^{d}	4.4±0.6^{d}
Wild	934.0±30.0^{a}	1924.0±609.0^{a}	7.4±1.3^{a}
D Brown	514.0±27.0^{e}	1117.0±384.0^{d}	4.5±0.6^{d}

*Different superscripts within columns differ at P≤0.05

The overall mean (± SE) values for various growth performance attributes of five breeds of female rabbits, viz., head length, body length, tail length, trunk length, ear length, fur length, forelimb length, and hind limb length, as recorded at the 19th week, are presented in Table 2. All the parameters were significantly (P≤0.05) different for females of all five rabbit breeds under study. The body length, trunk length, fur length, forelimb length, and hind limb length were significantly (P≤0.05) higher for wild rabbits, whereas tail length and head length were significantly (P≤0.05) higher in the Dwarf Brown breed of rabbits.

The overall mean (±SE) values for carcass characteristics have been presented in Table 3. It was noticed that all the studied parameters were significantly (P≤0.05) different within the breeds. All the studied carcass attributes, viz. LW, CCW, RCW, DOP, and DFap were significantly (P≤0.05) higher for wild rabbits, being 2140±505.0g, 2190.0±451.0g, 69.0±3.1%, 49.0±1.6%, and 3.2±1.1%, respectively, as compared to the counterpart breeds under study.

The overall mean values (±SE) for weight percentages of tissues as calculated from the percentage of CCW at slaughter are given in Table 4. Amongst all studied parameters, meat-to-bone ratio, forelimb %, hind limb %, and bone% % were significantly (P≤0.05) different within the five study breeds. The wild breed of rabbits revealed significantly (P≤0.05) higher values for meat-to-bone ratio (5.4±0.2), hind limb% (39.0±1.7%), and bone % (13.0±0.8%), whereas forelimb % was significantly (P≤0.05) higher for New Zealand White rabbits (13.0±0.8%) as compared to other study breeds. All the studied carcass attributes, viz. LW, CCW, RCW, DOP, and DFap were significantly (P≤0.05) higher for wild rabbits, being 2140±505.0g, 2190.0±451.0g, 69.0±3.1%, 49.0±1.6%, and 3.2±1.1%, respectively, as compared to the counterpart breeds under study.

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Table 2: Mean (±SE) values for growth attributes of five breeds of female rabbits as recorded on 19 weeks at slaughter*

Breed	HL (g)	BL (g)	TL (g)	TrL (g)	EL (g)	FL (g)	FLL (g)	HLL (g)
Dutch	13.6±0.3^{b}	46.5±2.8^{c}	6.4±0.3^{b}	32.8±2.4^{c}	8.2±0.3^{a}	1.7±0.2^{a}	17.9±2.4^{b}	25.3±2.6^{c}
N Z W	13.5±0.3^{b}	49.2±3.8^{b}	6.3±0.3^{b}	35.6±3.4^{b}	6.6±0.3^{c}	1.7±0.2^{a}	19.7±3.1^{a}	34.0±3.7^{b}
A Black	13.8±0.6^{b}	43.7±4.6^{d}	6.3±0.4^{b}	29.8±4.0^{d}	6.7±0.5^{c}	1.5±0.1^{b}	14.8±1.3^{c}	22.0±1.2^{d}
Wild	13.6±0.2^{b}	54.4±3.4^{a}	6.6±0.2^{b}	41.1±2.9^{a}	6.6±0.2^{c}	1.8±0.2^{a}	19.9±2.9^{a}	36.5±3.0^{a}
D Brown	14.2±0.4^{a}	46.1±5.4^{c}	7.2±0.3^{a}	31.8±4.9^{c}	7.5±0.3^{b}	1.7±0.1^{a}	15.9±1.5^{c}	22.7±1.7^{d}

*Different superscripts within columns differ at P≤0.05

HL = Head Length; BL = Body Length; TL = Tail Length; TrL = Trunk Length; EL = Ear Length; FL = Fur Length; FLL = Forelimb Length; HLL = Hindlimb Length

Table 3: Mean (±SE) values for carcass characteristics of five breeds of female rabbits as recorded on

Breed	LW (g)	CCW (g)	RCW (%)	DOP (%)	DFap (%)
Dutch	1733±402.0^{c}	1100.0±242.1^{d}	63.0±2.2^{b}	40.0±1.0^{c}	2.8±1.1^{b}
New Zealand White	1700±512.0^{c}	1270.0±213.0^{c}	66.0±1.9^{a}	45.0±2.0^{b}	3.1±1.1^{a}
American Black	1505±321.0^{d}	1040.0±100.0^{d}	55.0±1.9^{d}	37.0±1.1^{d}	3.2± 1.0^{a}
Wild	2140±505.0^{a}	2190.0± 451.0^{a}	69.0±3.1^{a}	49.0±1.6^{a}	3.2±1.1^{a}
Dwarf Brown	1860±411.0^{b}	1520.0±321.2^{b}	59.0±2.7^{c}	46.0±1.9^{b}	2.8±1.0^{b}

19 weeks at slaughter
LW= Live Weight; CCW= Chilled Carcass Weight; RCW= Reference Carcass Weight; DOP= Dressing Out %; DFaP= Dissectible Fat
*Different superscripts within columns differ at P ≤ 0.05.

Table 4: Mean (±SE) values for weight percentages of tissues from five breeds of female rabbits as calculated from total percentage of Chilled Carcass Weight at 19 weeks of age at slaughter

Breed	HP %	M/B	LP %	FLP %	HLP %	LHP %	LvWP %	KvW %	SP %	SIP %	LIP %	GITP %	BP %	TCP %
Dutch	8.0 ± 0.8	4.9 ± 0.1^{b}	24.0 ± 1.3	12.0 ± 0.7^{b}	36.0 ± 2.6^{b}	2.5 ± 0.2	7.3 ± 0.6	1.3 ± 0.2	3.6 ± 0.2	3.3 ± 0.2	76.2 ± 3.2	16.2 ± 1.5	10 ± 0.7^{c}	9.3 ± 0.8
N.Z.W	9.0 ± 0.5	4.9 ± 0.1^{b}	24.0 ± 1.3	13.0 ± 0.8^{a}	38.0 ± 2.7^{a}	2.7 ± 0.2	7.6 ± 0.5	1.4 ± 0.1	3.6 ± 0.2	3.5 ± 0.2	76.4 ± 3.0	15.7 ± 1.7	11.0 ± 0.7^{b}	9.4 ± 0.8
A.Black	8.0 ± 0.7	4.9 ± 0.2^{b}	23.0 ± 1.1	12.0 ± 0.6^{b}	34.0 ± 1.5^{c}	2.4 ± 0.2	7.3 ± 0.5	1.2 ± 0.1	3.5 ± 0.1	3.1 ± 0.1	76.0 ± 3.0	15.2 ± 1.1	11.9 ± 0.6^{b}	9.2 ± 0.6
Wild	9.0 ± 0.5	5.4 ± 0.2^{a}	23.7 ± 0.8	12.0 ± 0.6^{b}	39.0 ± 1.7^{a}	2.5 ± 0.1	7.4 ± 0.5	1.2 ± 0.1	3.5 ± 0.2	3.7 ± 0.2	76.0 ± 3.0	16.2 ± 1.4	13.0 ± 0.8^{a}	9.2 ± 0.7
D.Brown	8.0 ± 0.9	4.8 ± 0.1^{b}	23.0 ± 1.0	10.0 ± 0.6^{c}	36.0 ± 1.6^{b}	2.4 ± 0.1	7.6 ± 0.6	1.2 ± 0.1	3.5 ± 0.2	3.5 ± 0.2	76.0 ± 2.6	15.2 ± 1.6	10.0 ± 0.5^{c}	9.0 ± 0.6

New Zealand White= N.Z.W; American Black= A.Black; Dutch Brown= D. Brown; KyWP= Kidney Weight %; SP= Stomach %; SIP= Small Intestine %; LIP= Large Intestine %; GITP= Gastrointestinal Tract %; BP= Bone %; TCP= Thoracic Cage %
*Different superscripts within columns differ at P≤0.05

DISCUSSION

The present study has incorporated five different rabbit breeds (Dutch, New Zealand White, American Black, Wild, and Dwarf Brown) being reared in Pakistan under a conventional housing system at a small scale. Their usage for meat purposes in Pakistan is quite scanty; however, they are substantially being used for academic/research purposes in various educational institutes of Pakistan. This work on these breeds tends to target the female rabbits in respect to their growth and carcass attributes. The comparisons have been discussed with previous work reported for male rabbits of these breeds and with other global prior reports on similar aspects.

The initial body weight of all female rabbits (at the time of weaning) belonging to five different breeds was significantly different for each breed, being highest for wild rabbits and lowest for Dwarf Brown. It has been well expounded through earlier studies that at weaning, the rabbits have a different body weight owing to their different genetic make-up. Though environment, nutrition, and health status play a vital role in the attainment of the final weight at weaning, the role of genetic difference is always superseding (Paci *et al*., 2012; Belabbas *et al*., 2019).

In the present study, the initial (at the time of weaning), slaughter weight, and daily weight gain per animal were significantly different for all breeds, with the highest values noticed for wild rabbits and the lowest for Dwarf Browns. This trend of results is in line with work conducted on male rabbits of the same breeds. However, the values are slightly lower than those reported earlier on males (Suleman *et al*., 2020). Males of almost every mammal species tend to have a higher weight as compared to females owing to a different genetic make-up and presence of testosterone as an additional anabolic hormone (Yalçın *et al*., 2006; Yakubu & Ayoade, 2009). Comparing the results with earlier published reports, it was noticed that the wild indigenous rabbits occupying various habitats of the world have higher daily weight gain and hence earlier maturity, weight gain, and body size (Yakubu & Ayoade, 2009;

Papadomichelakis *et al*., 2017). Results on New Zealand White rabbits are also in accordance with prior studies (Dal Bosco *et al*., 2002; Trocino *et al*., 2002). Higher (1700-1730 g) and lower (1400-1450 g) slaughter weights than our results have, however, also been reported for New Zealand White rabbits (Yalçın *et al*., 2006; Njidda & Isidahomen, 2011). The differences could be because of differences in slaughter age, timing of experimentation, age at weaning, and housing/feeding patterns (Dalle Zotte *et al*., 2013; Khan *et al*., 2017).

All the growth performance attributes of the present study were significantly different for females of all five rabbit breeds. Similar results were seen in a report conducted on male rabbits of these breeds (Suleman *et al*., 2020). The body length, trunk length, fur length, forelimb length, and hindlimb length were significantly higher for wild rabbits, whereas tail length and head length were significantly higher in the Dwarf Brown breed of rabbits. These results are in line with various other reports conducted on wild and Dwarf Brown rabbits and have been attributed to the genetic makeup of individual animals (Dalle Zotte *et al*., 2013; Papadomichelakis *et al*., 2017). All values were within physiological ranges reported elsewhere (Elamin *et al*., 2012; Papadomichelakis *et al*., 2017).

Regarding the carcass characteristics, the results of the present study showed that all the studied parameters were significantly different among the breeds. Comparing these results with those reported on male rabbits of these breeds (Suleman *et al*., 2020), it was seen that females in this study had lower DOP as compared to males. It has already been proven that female rabbits show lower DOP as compared to males (Trocino *et al*., 2002). All the studied carcass attributes, viz. LW, CCW, RCW, DOP, and DFap were significantly higher for wild rabbits as compared to the counterpart breeds under study, as reported earlier (Papadomichelakis *et al*., 2017). Higher values of DOP have been reported for African rabbits (Belabbas *et al*., 2019), which could be due to differences in breed, climate, and management/feeding protocols.

Amongst the studied parameters of weight percentages of tissues, meat-to-bone ratio, forelimb %, hind limb %, and bone % were significantly different within the five study breeds. The wild breed of rabbits revealed significantly higher values for meat-to-bone ratio, hind limb %, and bone %, whereas forelimb % was significantly higher for New Zealand White rabbits as compared to other study breeds. The results are in line with previous reports, and all the values were within the physiological range presented earlier (Trocino *et al*., 2002; Yalçın *et al*., 2006; Papadomichelakis *et al*., 2017). Algerian local rabbits have revealed a higher meat-to-bone ratio of 7.25 (Belabbas *et al*., 2019), which is quite higher than our values. However, genetic variation and differences in climatic conditions could be the cause of this difference.

CONCLUSIONS

The present study clearly demonstrates that wild indigenous and New Zealand White rabbits have a higher potential for growth and resultant weight gain. Hence, these heavier genotypes could be used for commercial farming in order to reduce the meat supply gap in Pakistan. Apart from genotype, a delay in slaughter time may also prove beneficial in terms of meat yield. It is also evident from the present study that carcass attributes vary markedly within various breeds and are true determinants of a typical breed. Future research needs to be directed towards the effect of various feed additives/supplements not only on carcass quality but also on oxidant/antioxidant levels.

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