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# The efficacy of crossbreeding on reproductive and productive performance in New Zealand White and Flemish Giant rabbits

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**Abstract:** Crossbreeding is a well-established practice in livestock production aimed at improving reproductive and productive traits. This study evaluated the effects of crossbreeding on rabbits, focusing on comparisons between purebred Flemish Giant (n = 10), New Zealand White (n = 23), and their crossbred offspring (n = 27). Various parameters, including litter size, body weight, growth rate, and mortality, were assessed. The results demonstrated that crossbred rabbits presented a 15% faster growth rate than purebred rabbits, along with the lowest mortality rate and highest total meat output. This phenomenon, attributed to hybrid vigour, effectively blends the large frame of the Flemish Giant with the good litter size of the New Zealand White. Furthermore, statistical analyses, including ANOVA and Tukey–Kramer's honestly significant test, confirmed the significant effects of breed class on productivity, body weight, and carcass yield. Growth curves estimated using the Gompertz model highlighted the superior performance of crossbred rabbits under semiarid conditions. Notably, crossbreeding resulted in offspring with the highest dressing percentage and overall improved performance, offering potential advantages for rabbit producers worldwide.

**Keywords**: Semiarid region; rabbit breeding; hybrid vigour (heterosis); carcass weight; growth rate

## INTRODUCTION

Rabbit meat production is increasing in Africa, with countries such as Zimbabwe, Kenya, South Africa, and Egypt contributing significantly (Gerbil *et al*., 2023; Sibanda *et al*., 2024). Globally, this protein source, valued for its health benefits and low environmental impact, estimated at over one million tons, is worth more than US$6.5 billion (Parisi *et al*., 2020). China leads consumption, followed by the Democratic Republic of Korea and Egypt (Trocino *et al*., 2019). This trend is expected to continue due to the health and economic advantages of rabbit meat, including its status as a sought-after organic white meat (Mondin *et al*., 2021). However, rabbit production faces several constraints. These include high prenatal and postnatal mortality and overall mortality between birth and marketing, which are estimated at 40% and are highest in young rabbits. The productive and reproductive performances of rabbits are generally low in Zimbabwe (Tembachako and Mrema, 2016; Sibanda *et al*., 2024). This consequently affects the supply of rabbit meat. Low productivity has been attributed to several factors, some of which include poor management practices, the use of breeds with low genetic potential and a lack of information, which leads to practices without documentation or guidelines. Most importantly, the negative effects of climate change have led to reduced growth performance of livestock, including rabbits, due to depressed rainfall and high temperatures, which ultimately results in disease and poor pasture provision (Mugoti *et al*., 2022). Most farmers keep rabbits in a colony system, where there is limited or no control over mating (Patton 1994; Verga *et al*., 2007; Cherwon *et al*., 2020). This promotes inbreeding and hence low productivity. Consequently, there is a need to develop a breed that excels in nutrient utilization efficiency, while surpassing current standards for meat production and reproductive performance. One way to improve production and reproductive traits in animals is through crossbreeding.

Crossbreeding aims to leverage the potential for improved performance in offspring, exceeding that of parent rabbits in terms of genetic diversity, litter size, and overall vitality (Kumar *et al*, 2023). In Zimbabwe, commercial rabbit farms utilize various breeds, including Californian White, New Zealand White (known for their docile temperament and efficient feed conversion), New Zealand Red, Chinchilla Grey, Flemish Giant (renowned for large litter size and rapid early growth), and the indigenous Zika breed (Startupbiz 2017). Flemish giant is a large breed (adult weight 5–7 kg) with various coat colours (black, light grey, tan, fawn). By crossing these breeds, farmers can combine favourable traits. This study specifically investigated the effects of crossbreeding New Zealand White and Flemish Giant on the reproductive and productive performance of their offspring. We compared the performance of crossbred offspring to that of purebred rabbits to assess the effectiveness of this crossbreeding strategy.

## MATERIALS AND METHODS

The study was conducted at the Vusanani Cooperative Farm in Umguza District, Matabeleland North Province, Zimbabwe, and ran from June, 2022 to May, 2023. This area experiences a temperate climate with an average maximum temperature range of 23–26°C, a minimum temperature range of 11–15°C, and an annual temperature range of 18–22°C. Three rabbit breeds were used: purebred New Zealand White (n = 23), pure Flemish Giant offspring (n = 10), and crossbred Flemish Giant and New Zealand White (n = 27). Each breed class originated from three does. For the crossbreeds, New Zealand White does were mated with a Flemish Giant buck. The data were collected from the second litter (parity) of each doe.

All rabbits underwent a three-month acclimation period before the experiment began. Does with eight teats were selected for breeding. All groups received the same management practices with weekly measurements. The evaluated traits included litter size, individual birth and weaning weight, preweaning and postweaning mortality, growth rate, and gestation period. Prior to introducing the rabbits, the metal housing system (a three-tier structure with four compartments per row) was thoroughly disinfected. Cages were sized appropriately for does (90 cm × 100 cm × 45 cm) and bucks (90 cm × 65 cm × 45 cm). This design provided adequate shade, ventilation, and air circulation. The bedding was changed weekly. The rabbits received a combination of feed: rabbit pellets (120 g per animal, offered mornings) and ad libitum hay throughout the day. Water was continuously available (ad libitum) during the experiment. Weaning occurred at 8 weeks, when does were separated from their litters.

### *Data analysis*

Data normality was assessed using the Shapiro-Wilk test, and homogeneity of variance was evaluated using Levene's test. A mixed statistical approach was employed, utilizing two-way analysis of variance (ANOVA) to examine the effects of breed and sex on rabbit growth and carcass yield, and one-way ANOVA to compare productivity among the three rabbit breed groups. Post-hoc tests (Tukey's HSD) were conducted for pairwise comparisons among breed groups, with significant differences considered at $P < 0.05$. Growth curves for the three rabbit groups were modelled using the Gompertz growth model in SAS Proc NLIN, enabling prediction of future growth patterns. All statistical analyses were performed using IBM SPSS version 21**.**

## RESULTS AND DISCUSSION

The ANOVA results revealed that there was a significant difference in the mean weight of the rabbits from birth to slaughter ($p < 0.05$) (Table 1). The sex of the rabbits had a significant effect on the live weight from birth to 4 weeks ($p < 0.05$), after which it did not have an effect. During all the stages of growth, the crosses of the New Zealand White and Flemish Giant (FgxNzw) generally had intermediate weights, often ranking second-lowest, with the purebred New Zealand White breed consistently having the lowest weights. At 16 weeks, Flemish giant rabbits had the highest mean body weight. Notably, the crossbred group presented the highest dressing percentage. Flemish giant rabbits were observed to have greater body weights during the experimental period. This is because it was bred or developed specifically for high growth rates and frame sizes (Lukefahr *et al*., 1982). Moreover, the Flemish giant rabbit is an example of a large breed of rabbit that grows quickly but matures slowly. The crosses between New Zealand White and Flemish Giant performed exceptionally well in terms of carcass yield and dressing percentage, exceeding the average expected values for either parent breed. This phenomenon, known as heterosis or hybrid vigour, often leads to improved performance in offspring from crosses between genetically distinct lines. Our findings support similar observations by Assan (2017), who reported enhanced carcass traits in crossbred rabbits.

Carcass traits are influenced by adult mature weight and the maturity of rabbits at the time of slaughter. Late-maturing rabbit breeds produce carcasses with more muscle tissue and less fat at a corresponding slaughter weight than early-maturing rabbit breeds do (Blasco *et al*., 2018). The lower dressing percentage in Flemish Giant might be attributed to a lower degree of maturity at slaughter (Table 1). Generally, a lower dressing percentage is characteristic of the Flemish Giant breed, whereas the New Zealand breed has a higher dressing percentage (Lukefahr *et al*, 1982; Palka *et al*, 2023).

The growth rate was estimated by the Gompertz growth curve model. The growth curves of the female rabbits revealed that the Flemish giant crosses presented the highest growth rate, followed by the New Zealand White and New Zealand White–Flemish Giant crosses. According to the model, the growth rate was high in the first 40 days. The estimated weights of the Flemish giant females were 5061 g at 121 days, 2553 g for New Zealand White rabbits, and 2448 g for the crossbred rabbits. The growth of the crossbred rabbits continued even after 121 days of age, whereas the growth of the New Zealand white hybrids plateaued (Figure 1).

According to the male growth curve (Figure 2), the Flemish giant–New Zealand hybrids had the highest growth rate from birth, followed by the Flemish giant pure breed. The New Zealand White breed had the lowest growth rate. The Flemish giant had the highest live weight at 121 days (2821 g), followed by the crossbreeds (2788 g). At 121 days, New Zealand white had the lowest live weight, at 1873 g.

The size of the New Zealand White rabbits observed in the present study was similar to that reported by Maj *et al*. (2009). Derewicka *et al*. (2021) reported that Flemish giants were 3193 g heavier than New Zealand White giants were at 2520 g, and 2801 g heavier for the cross breed of the two giants, which concurs with the results of the present study. In support of these results, Hagan and Opuka-Mensah (2019) suggested that crosses can exploit the high growth rate of the paternal breed and exceptional prolificacy, good maternal instinct and tolerance of the production conditions of the maternal breed. This finding is also in agreement with the results observed by Fayeye (2013), who concluded that crosses from distantly related genotypes may express more hybrid vigour in crossbreeding schemes, as seen in the New Zealand White and Flemish Giant crosses.

The productivity levels of the two breeds and their crosses were also assessed, as is shown in Table 2. The crossbred group presented the highest productivity, as it produced offspring with a total carcass weight of 14358 g per doe. The cross-

**Table 1.** Comparison of mean weight (g) (±SE) carcass yield (g) and dressing percentage between the sexes of three breeds of rabbits at different growth stages

| | Sex | Breed | | Three crosses of rabbits | | |
|---|---|---|---|---|---|---|
| Age(weeks) | | | Sex | FgxFg (n=10) | NzxNz (n=23) | FgxNz (n=27) |
| 0 | ** | *** | M | $50.75^a \pm 1.28$ | $32.88^c \pm 0.62$ | $41.58^b \pm 0.73$ |
| | | | F | $54.33^a \pm 1.04$ | $36.50^c \pm 1.04$ | $42.80^b \pm 0.66$ |
| 2 | ** | *** | M | $258.25^a \pm 1.65$ | $243.18^b \pm 0.80$ | $250.92^b \pm 0.95$ |
| | | | F | $265.83^a \pm 1.35$ | $245.67^c \pm 1.35$ | $251.53^b \pm 0.85$ |
| 4 | * | *** | M | $469.75^a \pm 1.70$ | $453.24^c \pm 0.82$ | $459.92^b \pm 0.98$ |
| | | | F | $475.17^a \pm 1.39$ | $456.33^b \pm 1.39$ | $460.40^b \pm 0.88$ |
| 6 | ns | *** | M | $800.50^a \pm 9.08$ | $735.47^c \pm 4.40$ | $784.08^b \pm 7.42$ |
| | | | F | $771.00^a \pm 7.42$ | $738.50^b \pm 7.42$ | $783.80^c \pm 4.69$ |
| 8 | ns | *** | M | $1126^a \pm 17.62$ | $1013^a \pm 8.56$ | $1222^b \pm 10.18$ |
| | | | F | $1066^a \pm 14.40$ | $1017^b \pm 14.40$ | $1222^c \pm 9.12$ |
| 10 | ns | *** | M | $1687^a \pm 34.60$ | $1317^c \pm 16.79$ | $1589^b \pm 19.98$ |
| | | | F | $1730^a \pm 28.25$ | $1319^c \pm 28.25$ | $1583^b \pm 17.87$ |
| 12 | ns | *** | M | $2142^a \pm 42.78$ | $1614^c \pm 20.75$ | $2112^a \pm 24.70$ |
| | | | F | $2190^a \pm 34.93$ | $1614^c \pm 34.93$ | $2118^b \pm 22.09$ |
| 14 | ns | *** | M | $2642^a \pm 30.14$ | $1914^c \pm 14.62$ | $2340^b \pm 17.03$ |
| | | | F | $2656^a \pm 24.61$ | $1915^b \pm 24.66$ | $2338^c \pm 15.56$ |
| 16 | ns | *** | M | $3118^a \pm 35.23$ | $2214^c \pm 17.09$ | $2627^b \pm 20.34$ |
| | | | F | $3115^a \pm 28.77$ | $2216^c \pm 28.0$ | $2636^b \pm 18.19$ |
| Carcass weight | ns | *** | M | $1714^a \pm 24.74$ | $1246^c \pm 12.00$ | $1597^b \pm 14.92$ |
| | | | F | $1714^a \pm 23.16$ | $1240^c \pm 23.16$ | $1594^b \pm 12.78$ |
| Dressing out % | ns | *** | M | $54.98^b \pm 0.79$ | $56.28^b \pm 0.39$ | $60.80^a \pm 0.46$ |
| | | | F | $55.03^b \pm 0.73$ | $55.96^b \pm 0.73$ | $60.50^a \pm 0.46$ |

*Notes: [abc]Mean values within a row are significantly different if superscripts differ (*p < 0.05, ** p < 0.001 ***p < 0.0001, ns=not significant), M-male; F-females, Fg is the Flemish giant breed, Nzw is the New Zealand White breed and FgxNzw is the cross between the Flemish giant breed and the New Zealand White breed. n= is the number of kits from each breed class.*

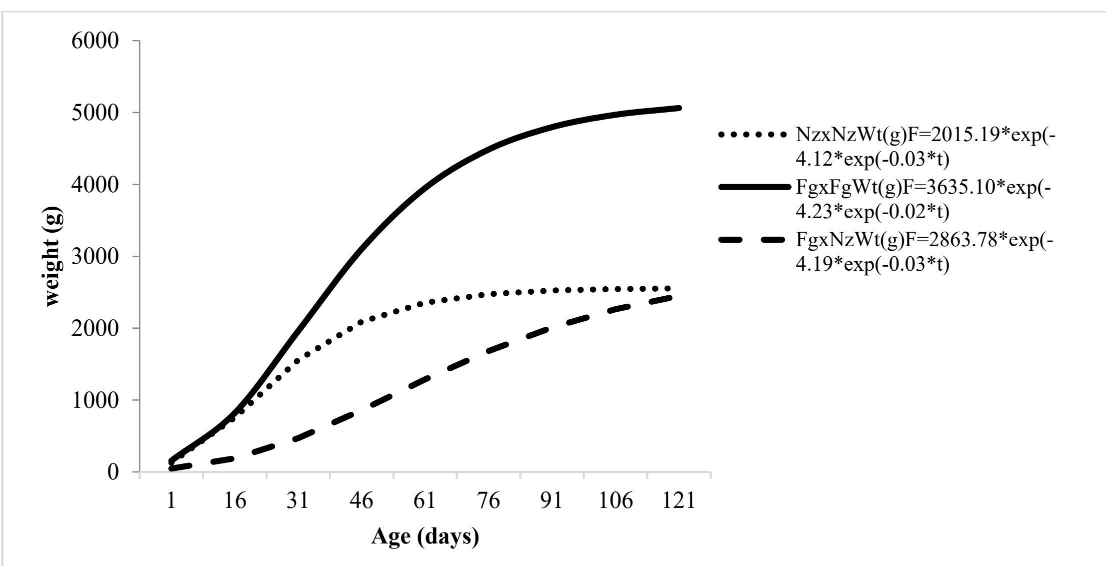


**Figure 1**. Female growth curves of three classes of rabbits estimated using the Gompertz model

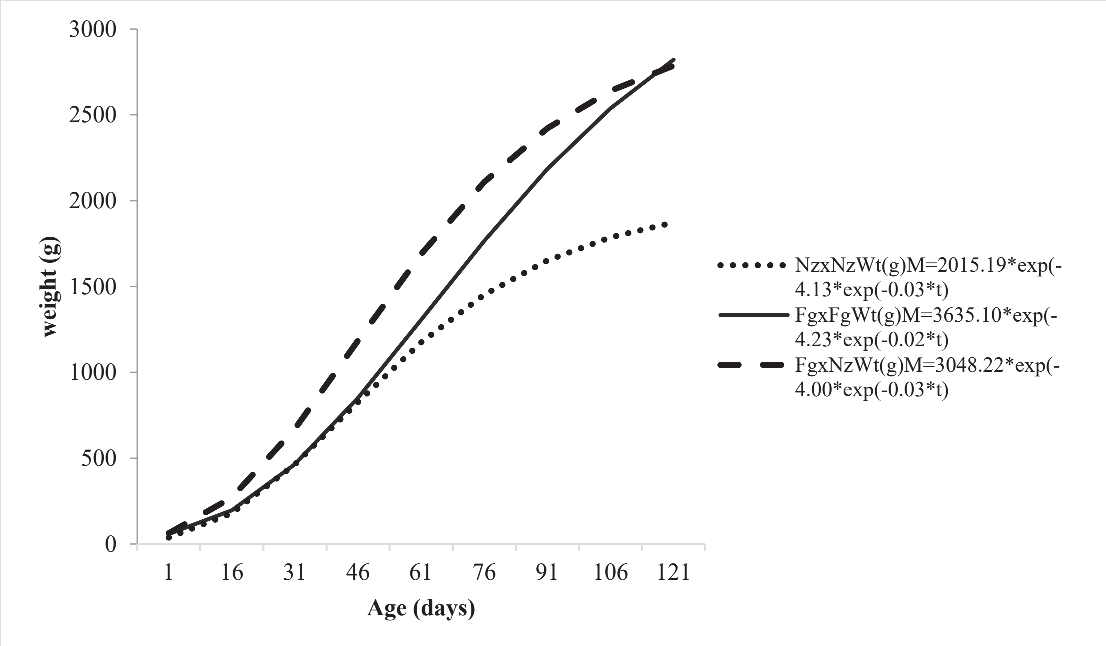


**Figure 2**. Male growth curves of three classes of rabbits estimated using the Gompertz model

**Table 2.** Productivity of different rabbit breed groups (g)

| Doe class (Breed) | Rabbits produced | ACW (g) | Sum of ACW (g) | Productivity per doe (g) |
|---|---|---|---|---|
| Fg x Fg | 10 | 1714[a] | 17136 | 5712 |
| Nzw x Nzw | 25 | 1243[c] | 31084 | 10361 |
| Fg x Nzw | 27 | 1595[b] | 43075 | 14358 |
| | | | | |
| SE | 143 | | | |
| F value | 4.53 | | | |
| P value | 0.021 | Significance | * | |

*Notes: [abc]Mean values within a row are significantly different if superscripts differ (*p < 0.05, ** p < 0.001 ***p < 0.0001, ns=not significant). The mean number of offspring produced by three does in three breed classes; ACW=average carcass weight. Fg is the Flemish giant breed, Nzw is the New Zealand White breed, and FgxNzw is the cross between the Flemish giant and the New Zealand White.*

breeds were New Zealand White (10361 g) versus Flemish giant (5712 g). The high productivity observed in the crossbreed is attributed to improved litter size and carcass weight. Litter size is the most important economic characteristic in rabbit breeding. Essentially, most crossbreeding studies in Egypt on the New Zealand White breed involving males of indigenous rabbit breeds have shown that this breed has considerable heterosis effects on most litter traits (Akinsola *et al.,* 2014).

## CONCLUSION

This study suggested that crossbreeding New Zealand White and Flemish Giant rabbits could be a successful strategy for improving rabbit meat production. Compared to those of purebred rabbits, crossbred rabbits presented potentially favourable traits, such as increased litter size and growth rates. These findings offer promise for enhancing rabbit production efficiency and farmer livelihoods. However, further research with a larger sample size could provide more conclusive evidence and explore the impact of crossbreeding on other commercially relevant traits, such as meat quality.

### *Data availability*

The data for this research can be made available upon reasonable request.

### *Conflict of interest*

All the authors declare that there are no conflicts of interest surrounding the publication of this research.

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