Thesis

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Comparative results of beef cattle test farming in Hungary and Germany

A szarvasmarha-teszthizlalás összehasonlító eredményei Magyarországon és Németországban

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Abstract

A comparative review of the performance testing records of the central testing stations Lehr- und Versuchsanstalt für Tierzucht und Tierhaltung (LVAT) in Germany and Bos Genetic in Hungary was conducted. The records of 284 beef bulls were analysed to see the influence of breed but most importantly the influence the central testing station itself has on the test results. This revealed that the mean for average daily gain across the two testing stations was almost identical. It also identified that with regard to average daily gain, the Charolais breed was the highest performer at LVAT, while the Blonde d'Aquitaine breed was the highest performer at the Bos Genetic Central testing station. Furthermore, the effects of differences in starting age and weight of bulls on average daily gain were analysed, showing a negligible, statistically insignificant correlation.

Absztrakt

Összehasonlító elemzést végeztünk a németországi Lehr- und Versuchsanstalt für Tierzucht und Tierhaltung (LVAT) és a magyarországi Bos Genetic központi tesztállomások teljesítményvizsgálati adatai alapján. Összesen 284 húsmarhabika adatait elemeztük, hogy megvizsgáljuk a fajta, de leginkább magának a központi tesztállomásnak a hatását a kapott teszteredményekre. Az elemzés kimutatta, hogy az átlagos napi súlygyarapodás átlaga a két tesztállomás között szinte azonos volt. Emellett kiderült, hogy az átlagos napi súlygyarapodás tekintetében az LVAT állomáson a Charolais fajta teljesített a legjobban, míg a Bos Genetic központi tesztállomáson a Blonde d'Aquitaine fajta bizonyult a legjobbnak. Továbbá megvizsgáltuk a bikák kiinduló életkora és súlya közötti különbségek hatását az átlagos napi súlygyarapodásra, amely csekély, statisztikailag nem szignifikáns korrelációt mutatott

List of Abbreviations

ADG – avergae daily gain

AI – artifical insemination

DE – Germany

EU – European union

HU – Hungary

LVAT – Lehr- und Versuchsanstalt für Tierzucht und Tierhaltung

M – mean value

SD – standart deviation

TMR – Total mixed ration

1. Introduction

Cattle rearing has been a crucial part of European agriculture since the domestication of cattle about 10.000 years ago. In 2024, the European Union established itself as the fourth biggest producer of beef worldwide [1]. However, with growing competition from other major beef exporting nations, such as the United States, Brazil, and China, it is becoming increasingly vital to focus on improving the genetic traits of beef cattle to increase productivity, health, and economic gain. Performance testing allows for the prediction of factors such as the birth weight, rate of weight gain, feed efficiency, and general offspring potential of the beef cattle [2]. With the widespread use of artificial insemination, trait selection is not limited to regionality anymore, making the reliability of the breeding bull test much more critical. By evaluating these factors, the industry can select superior genetic traits, improving the weight per head of cattle and the quality of meat over time. Hungary and Germany share the same concept of performance testing but differ in the implementation of testing practices and goals for the results.

This paper examines the process of performance testing and compares the procedural differences between Germany and Hungary. It serves as an overview of the key performance indicators for beef cattle, the techniques used in performance testing, the impact of the farm environment on test results and the main objectives of testing and prospects for the future of beef cattle breeding. Additionally, it explores the differences in test results of the Limousin, Charolais, and Blonde d’Aquitaine beef cattle breeds.

2. Literature Review

2.1. Goals

Performance testing in beef cattle has proven to be essential in the selection and improvement of herd genetics [3]. It allows for the individual evaluation of animals to learn information about traits that would improve the herd productivity and efficiency. This is important in the decision-making process of livestock producers, as it can influence which breed and genetic line they choose to get the best results in optimizing their productivity and efficiency, and therefore their profitability [4]. The evaluation of young bull calves is the focus of performance testing. Bulls with promising traits could be utilised in artificial insemination (AI) all over Europe if their performance test proves their value as a breeding animal. This is especially vital given the beef industry is attempting to move more towards higher production with equal or lower stock count due to societal pressure and space restrictions [5].

Performance testing can be tailored to focus on different characteristics depending on the livestock's purpose. In beef cattle, the focus is on the evaluation of the growth performance from birth to slaughter. This form of testing helps to determine the performance of cattle by measuring the rate and efficiency of live weight gain in the form of body weight at different ages and a calculated average daily weight gain. It is also utilised for progeny testing, where the offspring of a bull with good characteristics is tested to see if these traits have been passed from sire to calf [6]. The testing is done for at least ten of the offspring and only bull calves are considered. Progeny testing is extremely important because the information gathered from this is used in the herdbook data of the siring bull.

This paper will review and contrast the performance testing methods available today. The focus will remain on the testing methods utilised at test farms in Hungary and Germany, whose data will be analysed in this paper.

2.2. Testing Parameters

The parameters tested and recorded in beef cattle performance testing have a direct impact on the economic returns for beef producers [7]. It is important for these measured traits to have a high degree of heritability to ensure that selection for these traits carries value for improving long term production of the herd. The heritability of production traits has been a widely researched topic and studies show that many of the traits relevant to beef cattle producers have a high enough genetic heritability to be considered as selection criteria [8].

Heritability in general refers to the proportion of traits in a population that is accounted for by genetic factors [9]. Variation from this is due to the interaction between the expression of genes and environmental influences. In practice, predominantly heritability estimates are utilised, which are expressed in a range from 0-1. They allow for the prediction of the effect of artificial selection for a particular trait in a given population [10]. For economically important traits, such as weight gain in beef cattle, it is advantageous to know if a new selective breeding program will result in the desired increase in herd performance [11]. The implementation of these programs is quite lengthy and expensive if they do not yield the desired improvement. It is possible to quite accurately predict the expression of specific traits in response to selection in early generations [12]. However, making predictions for subsequent generations tends to be more complex. The growth rate of beef cattle is at its highest during the first year of life, so the emphasis in performance testing is mostly placed on weaning and yearling traits. There is a large body of research reporting that heritability for these traits is moderate to high with some variations[13].

2.2.1. Birth Weight

Birth weight is the first parameter that can be recorded for any newborn calf. It sets a starting point for the weight gained in later life stages and allows for the evaluation of pre-weaning weight gain. It is a parameter that has a heritability of 0,46 and correlates with other values important for performance testing. For example, birth weight has a positive correlation of 0,66 with yearling weight [14]. It is also heavily influenced by maternal properties, with age of the dam having the biggest influence [15]. The birth weight of a calf is an indicator for birthing difficulties, as big calves often result in the dams requiring assistance during calving [7]. An increase in birth weight was shown to significantly increase calving difficulty, with an estimated genetic correlation of 0,83 [16]. The same paper also highlighted that an increase in birth weight increases the percentage of perinatal mortality and gestation length, with an estimated genetic correlation of 0,55 and 0,54, respectively. Studies indicate the anticipated genetic variation in yearling and birth weights resulting from varying degrees of selection aimed at achieving greater yearling weight while simultaneously reducing birth weight [17]. Specifically, pursuing heavier yearling weights alongside lighter birth weights may enhance yearling weight by approximately 86%, while birth weight would rise by only 52% compared to an equally rigorous selection focused solely on increasing yearling weight [14].

More investigation is required to identify the optimal selection method. It appears that prioritizing post-natal growth up to weaning or yearling stages is preferable over focusing on final weights at slaughter, as this could help reduce direct selection pressures for increased birth weight [14]. While a definitive selection method for birth weight cannot be proposed, it is advisable to monitor birth weights and refrain from utilizing sires that exhibit high birth weights in their progeny.

2.2.2. Weaning Weight

Weaning weight is a particularly important parameter to differentiate if the recorded gains are due to genetic potential or dependent on the maternal ability of the dam [18]. The heritability of this trait was described in various papers with moderate to high heritability. One paper set the heritability at 0,58 and was one of the higher estimates of this trait [19]. Others have described the heritability as a more moderate 0,39 [20] and 0,27 [13]. Weaning weight demonstrates significant positive genetic correlations with yearling weight, often exceeding 0,60 [21]. This suggests that enhancements in weaning weight typically result in increased yearling weight [22]. Such correlations are crucial for breeders aiming to optimize both early and later growth stages.

For instance, average daily gain (ADG) shows a strong correlation with weaning weight. The genetic correlations between weaning weight and average daily gain have been reported to range from 0,40 to 0,65, highlighting a shared genetic basis for growth occurring before and after weaning [23]. This high heritability and correlation with important economic traits make average daily gain a good selection criterion for herd improvement. Research described the selection for weaning weight as highly effective in improving the overall growth performance of the herd only being outperformed by the selection for yearling weight trait [19].

The maternal ability of the dam has a strong influence on weaning weight. It was reported that calves of dams aged under two and over four years old at the time of parturition have lower weaning weights compared to calves of dams between two and four years old [15, 24]. Furthermore, the weight of the dam at parturition, gains during the nursing period, and the dam’s inherent milk production ability have strong influences on the pre-weaning gains of the calf [25]. The sex of the calf also influences its gains during the pre- and post-weaning period, with male calves having a significant advantage over female calves [15]. Therefore, weaning weight is also described as a trait reflecting the growth potential of the calf and the maternal ability of the mother [18]. Another notable study found that the calf's gender, the dam's age, geographical location, birth month, and management practices, significantly impact weaning weight, with each factor contributing over five percent to the overall variance [26].

The age of the calve at which the weaning weight is recorded is never uniform in a group. Due to these differences, a standardized age range of 160 to 250 days was suggested. The optimal age to record the weaning weight was determined as 205 days old [27]. After the data collection, the weight data must be standardised to the age of 205 days. This is calculated with the following formula:

$$205\ day\ weaning\ weight = 205\ \frac{weaning\ weight - birth\ weight}{age\ at\ weaning\ in\ days} + birth\ weight$$

Since birth weight is not always available in every herd, a standardised birth weight according to the breed can be used in the 205-day weaning weight equation. To accommodate the variation in weaning weight that stems from the age of the dam, correction factors for dam age should be calculated [15]. There has been research focused on whether additive or multiplicative adjustment factors would have the required standardising effect [28]. It was determined that additive adjustments for age of dam and multiplicative adjustments for sex of calf had the most reliable effect on standardising weaning weight. These adjustment factors are expected to change as new advances in herd genetics are made and should also be further developed into breed-specific adjustment factors [29].

2.2.3. Yearling Weight

Yearling weight is measured in the post weaning growth period. It is also often described as 365-day weight in the literature. Yearling weight holds a significant economic value, as it serves as an indicator of the genetic potential in growth rates and exhibits a strong genetic correlation with feed efficiency [30]. Animals that gain weight rapidly typically require a lower quantity of feed for each kilogram of weight increase. This correlation allows for simultaneous improvement in growth rates in early and later life stages through selection. As with weaning weight, previous research has described yearling weight as a parameter that is influenced by the age of dam [31]. Therefore, the adjusted 205-day weight is required for its calculation:

$$365\ day\ weight = 160\ \frac{yearling\ weight - weaning\ weight}{days\ between\ weighing} + 205\ day\ weight$$

The adjustment for age of dam influence makes it possible to compare individual calves with others in their group and farm based on yearling weight. The yearling weight has to be recorded between 320 and 410 days of age and requires at least 160 days to have passed between weaning weight and yearling weight recording [27]. Studies have shown that if a herd is selected for yearling weight over a long time frame, large improvements can be made [32, 33]. This particular study had selected for yearling weight for 10 years and showed regular advancements of 11-12 kg in males and 7-9kg in females for yearling weight, in the last 6 years of the experiment [32]. The heritability of yearling weight in this case was described at around 0,50. A similar study selected for low birth weight but high yearling weight and reported a positive potential for selection [33]. These studies show the potential of yearling weight as a selection criterion in beef cattle performance testing. The selection for such a highly economically beneficial trait is an opportunity for producers, especially since it has been shown that there can be an antagonistic selection between birth weight and yearling weight, combining high returns with a lower risk of birthing difficulties [33]. This fast growth also requires the producers to feed for a shorter amount of time, reducing feeding cost substantially. Therefore, it has been recommended that adjusted yearling weight be the main selection criterion for beef cattle producers [19].

2.2.4. Average Daily Gain

ADG is defined as the amount of gain an animal has made per day in a specific time period [34]. It can be calculated for a wide range of growth phases and therefore adjusted to measure pre- and post-weaning gain, but also to measure the gain during testing periods. The pre-weaning stage is largely influenced by maternal nutrition, milk yield, and environmental conditions [35]. The post-weaning period benefits from regulated feeding practices and management interventions resulting in post-weaning ADG having a strong genetic impact on final weight gain with reduced environmental variability [36]. Heritability estimates for ADG differ between the pre- and post-weaning phases but typically fall within the range of 0,27-0,42 for pre-weaning ADG and 0,30-0,47 for post weaning ADG, suggesting a moderate genetic influence [31]. The heritability is generally more pronounced in post-weaning ADG due to better-controlled conditions during this phase [14]. In contrast, pre-weaning ADG is significantly affected by maternal influences and environmental variability, resulting in lower heritability figures [13].

ADG demonstrates positive correlations with various traits such as weaning weight and yearling weight. The genetic correlation between ADG and weaning weight averages around 0,14, while post-weaning ADG exhibits robust correlations with yearling weight, with a correlation of 0,33. This underscores yearling weight's significance for improved growth and economic viability of the selection process [37].

Being deliberate with the selection methods, through multi-trait indices, can help alleviate adverse consequences [14].

2.2.5. Efficiency of Feed

The amount of feed required is high when raising beef cattle and the associated feed cost is a big factor when evaluating the economic viability of a beef cattle producer [38]. The main factors evaluated regarding feed are the feed conversion ratio and the residual feed intake. The feed conversion ratio is the amount of feed consumed per unit of weight gain, whereas the residual feed intake represents the difference between an animal's actual feed intake and the expected intake based on its weight and size [38].

A recent study has found the heritability of feed conversion to be 0,29 and the heritability of residual feed intake to be 0,39 in beef cattle [39]. This shows that the traits are heritable enough to be selected for and have an impact on the herd. The correlation between the two was described as 0,66, showing that improvement of either trait affects the other as well. The same study investigated the correlation between the feed conversion ratio and other performance traits. It was found that the correlation between feed conversion ratio and ADG was –0,62 [39]. This negative correlation reflects that a lower feed conversion ratio is linked with a higher ADG. In simple terms, the less feed required to increase an animal's weight by one kilogram, the higher the animals ADG. An improvement to the ADG while decreasing the required amount of feed is a very desired development for beef cattle producers, as this means a decrease in cost for their production. There was no notable correlation between feed conversion ratio and post weaning traits such as weaning and yearling weight, making feed conversion a good additional parameter for which to select.

Testing for feed conversion ratio and residual feed intake is difficult and costly. The testing at central testing stations allows for a low amount of environmental influence on the results, allowing for increased reliability, but the cost associated with central testing stations cannot be overlooked. In order to decrease the cost, research was initiated to evaluate if the standard testing duration of 112 days for feed conversion ratio and residual feed intake could be decreased [40]. It was shown that even when the testing duration was decreased from 112 days to 70-84 days, there was no decrease in accuracy for the resulting feed conversion ratios and residual feed intake values. This shortened testing period decreases the testing cost by a substantial amount and would decrease the financial burden on the farmer. It would also benefit the central testing stations by allowing them to perform more tests per year, increasing revenue and decreasing operating costs [40].

Another possibility to test for these traits would be during on-farm testing. There were various implementation methods discussed in studies, ranging from manual weighing of feed in individual bull pens, to automated feeding and weighing systems [3]. On-farm testing of feed conversion ratio and residual feed intake would allow for a larger population of the herd to be tested instead of just the selected groups of bulls being sent to central testing stations. However, on-farm testing has a higher variance in records results due to the influence of environmental factors and it would be almost impossible for producers to implement a feeding plan that stays consistent throughout the year while producing under commercial conditions [3]. Another hurdle for the implementation of such testing is the high upfront cost of installing these systems and the increase in labour required to facilitate the manual carrying out of the testing process.

One of the automated feed intake measurements has had multiple studies about its utilisation and reliability. The GrowSafe® system, that is based around a radio frequency identification collar or ear tag, allows for the measurement of frequency at the feeding bunker, amount of feed intake, watering behavior, and tracking of body weight [41]. This particular study showed that feed intake, required for the calculation of feed conversion ratio and residual feed intake, could be measured reliably with the GrowSafe® system and only had an error rate of 6% [41]. The possibility for incorrect installation of the system or interference with the radio frequency identification ear tag were also mentioned as sources of error to be considered.

A different study used the same automated system to analyse a further reduction of testing duration for feed conversion ratio and residual feed intake [42]. It demonstrated that automated feed intake and body weight measurements, which should be measured at least weekly, would allow the testing duration for feed conversion ratio to be shortened to 42 days and the testing duration for residual feed intake to be shortened to 63 days.

Research indicates that enhancing feed efficiency leads to a direct reduction in both feed cost and greenhouse gas emissions per head of cattle [43]. This outcome supports the industry's commitment to evolving sustainable production practices. For example, breeding for lower residual feed intake has demonstrated a decrease in methane emissions [43].

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2.3. Process and Techniques

To collect the data required for performance testing, two main methods are available, on-farm testing and central testing stations. Both methods come with benefits and challenges catering to specific needs in the cattle husbandry sector. In the European Union (EU), the ‘Commission Decision 2006/427/EC’ (2006) states that all pure breed beef bulls must undergo a form of performance testing to be eligible for any form of breeding, whether by AI or natural cover. This furthermore accentuates the importance of performance testing and the widespread need for it.

2.3.1. On-Farm Testing

On-farm testing is a simple process that can easily implemented into farms of any size [2]. The setup can be as simple or elaborate as the circumstances require it to be. The set-up process only requires an accessible scale on the farm and training of staff on the relevant procedures [44]. On-farm testing is used to monitor the development of herd production characteristics and allows for the implementation of selection and culling programs [45]. It is also valuable for the evaluation of real-world performance in the herd. This type of testing shows the effect that management practices, environment, and herd composition have on the performance metrics of cattle [46]. In on-farm testing, the calf is evaluated from birth up until either weaning age or until the final feedlot weight [7]. Therefore, bulls showing promising results on-farm can be preselected after weaning for further testing at a central testing station [47].

The EU 'Commission Decision 2006/427/EC' (2006) states that in the case of on-farm testing, at minimum the live weight and age must be recorded. The important growth stages of birth, weaning, and yearling should be included. Another parameter that is often collected, but is not mandatory, is the number of offspring sired by a particular bull. This allows for the assessment of the reproductive capability of this bull during progeny testing.

The challenge with the data collected from on-farm testing is that there are too many variables to accurately compare each farm's results to those from other testing programs. Several pre- and post-weaning environmental factors influence on-farm testing results and make it difficult to rely only on this data for the selection of new bull genetics to be introduced into the herd [48]. These include the location and therefore the climate conditions, such as humidity, rainfall, vegetation, and soil influencing the composition and availability of feed. Another important factor mentioned is the animal and herd management which includes heat detection, technique of insemination, weaning age, and calf treatments during the pre-weaning phase.

Besides the environmental factors that influence the pre-weaning weight gain of the calves, there is also a strong genetic component influencing the calves in the pre-weaning phase of rearing [49]. Environmental factors, such as the season in which the calf was born, were significant only in cases where grazing systems were in place and cattle were subject to seasonal changes in nutrition on pasture without supplementation [49, 50]. The age at weaning was described as a possible factor influencing the weight gain during the post-weaning phase as well [51]. These can collectively be referred to as herd of origin factors.

2.3.2. Central Testing Stations

Testing at a central testing station has been widely utilised around the world since the 1950s, as it allows selection for genetic improvement that is permanent and cumulative [52, 53]. Central testing stations allow the control of influential environmental and management variables that are not possible to control in an on-farm setting, such as diet and housing. Here young bull calves are gathered from varying herds to ascertain their performance potential in a way that is standardised [53].

It is important to note that the herd of origin still accounts for an important part of the phenotypic variance of ADG over the testing period [36, 54]. It has been the standard that there be an adjustment period of at least 28 days but it was recommended to increase this to 56 days to further eliminate the effect environment and herd of origin has on the testing performance [55]. This period also doubles as the quarantine period to prevent or minimise the introduction of infectious diseases into the herd during testing. Studies have also shown that variation in age and weight at the start of testing has minimal to no effect on the ADG during testing [34, 56]. Consequently, it is more important to give the herd time to acclimatise to their surroundings than to have a testing herd with uniform age.

Under EU ‘Commission Decision 2006/427/EC’ (2006), central testing stations play a vital role in the collection of data relevant to the assessment of cattle breeding value and is the testing method of choice for bull selection used in AI.

An important difference between the process of on-farm testing and central testing stations is that the on-farm testing can be applied to an entire herd of cattle, while at a central testing station, only individual bull calves will be evaluated. One of the reasons for this is that it is much easier to implement new herd genetics through a change in sire, as he can produce a lot more offspring than a dam could [12]. Therefore, the change of dams simply for genetic growth improvement is not recommended for the efficiency of selection.

2.4. Environmental Factors

The environmental factors influencing the performance of beef calves can be general or just influencing one growth period. For example, the influence of the maternal environment that the dam provides in the pre-weaning period has a notable influence on weaning weight and development of the calf [24]. The influence of the dam is one of the biggest factors of the variance associated with the pre-test environment. As mentioned previously, the age of the dam is the most influential factor, but it should be noted that the parity of the dam also has an impact on the performance of calves [15]. It has been found that the weaning weight in beef cattle tends to be decreased during the first two pregnancies of a dam. This is most likely because the maternal ability of the dam has not properly developed yet and therefore the calves are not getting the amount of milk needed for optimal growth. The timing of a calf's birth also has an impact on birth weights [15]. This research has shown that calves born earlier in the calving season were lighter in birth weight and calves born later into the calving season were heavier at birth.

Another important factor influencing the calves and bulls throughout life is their housing facilities. One study shows that the climate conditions in calf housing have an influence on calf health and growth development [57]. Factors such as high variations in temperature and relative humidity or increases in wind speed could contribute to thermic stress influencing the calf. This could lead to reduced weight gain, general growth performance, or even death during testing or in the pre-testing phase [57]. Proper housing is therefore vital for uniform testing and providing the best possible environment to showcase growth performance.

Nutrition is another source of variation between farms of origin or on-farm testing programs. Due to the constraints of managing a beef cattle operation under commercial circumstances, it is not feasible to have uniform nutrition throughout the year, as feed is dependent on the ground composition from which it was harvested. Beef producers who pasture-raise their animals cannot control the provided nutrition apart from proper grazing rotation. A study in this field of research has demonstrated the effectiveness of supplying a yearly or seasonal long-acting trace mineral rumen bolus [58]. It showed success in promoting growth in pasture-raised animals and should be studied further to assess the impact that nutrition and especially deficiencies have on the growth performance of calves. Further research is also warranted into the mitigation of these environmental and herd of origin influences on the results of especially central performance testing.

2.5. Overview of Beef Breed Characteristics

The three cattle breeds selected for this paper are in correlation with the cattle breeds tested in the German and Hungarian testing stations. The Charolais, Blonde d'Aquitaine, and Limousin beef cattle breeds are known for their prominence in the industry.

The Charolais is a French cattle breed that is typically white with a pink muzzle, and a long, medium to large body [59]. The birth weight, weaning weight, and yearling weight were described as 35,79±4,90 kg, 271,98±33,05 kg, and 415,59±152,73 kg, respectively [60]. The ADG for pre-weaning, post-weaning, and lifetime were reported as 1,125±0,156 kg, 0,926±0,265 kg, and 1,041±0,143 kg.

The Blonde d'Aquitaine is a famous French cattle breed as well. Its coat can range from white to red but the typical colour is golden wheat colouring with distinct rings around the eyes and muzzle [61]. The birth weight, weaning weight, and yearling weight were described as 35,09±4,61 kg, 275,08±34,66 kg, and 424,38±58,55 kg, respectively[60]. The ADG for pre-weaning, post-weaning, and lifetime were reported as 1,143±0,163 kg, 1,028±0,280 kg, and 1,094±0,159 kg.

The Limousin cattle breed, also known as the "butcher's animal" in France, has a large, well-muscled frame with a small and broad forehead [62]. The coat is golden-red or black, which is lighter on the underbelly. The birth weight, weaning weight, and yearling weight were described as 29,19±3,39 kg, 216,06±29,01 kg, and 348,16±42,38 kg, respectively [60]. The ADG for pre-weaning, post-weaning, and lifetime were reported as 0,890±0,138 kg, 0,852±0,223 kg, and 0,874±0,123 kg.

Comparing these three breeds shows their similarities and differences. The Charolais calves generally exhibit the highest birth weight, followed by the Blonde d'Aquitaine calves, then the Limousin calves. High birth weight may allow for faster growth during the pre-weaning phase but also carries the risk of dystocia during parturition [16].

The Blonde d’Aquitaine breed shows the highest weaning weight and weaning ADG, with the Charolais following closely [60]. These can be seen as indicators for good maternal traits and early growth potential. The maternal influence can again be identified when comparing the weaning ADG and yearling ADG. The difference of up to 0,2 kg per day in Charolais in the pre-weaning phase compared to the post-weaning ADG points towards the good maternal ability of this breed In Limousin cattle, the difference in pre- to post-weaning gains indicate a more moderate growth that could indicate a better feed efficiency in this breed.

This breed-specific reference data allows for comparison during the testing process and gives a general idea of the potential a cattle breed possesses. Having a good knowledge of the potential in each breed allows for different crossbreeding focuses to be developed during the process of selection.

3. Material and Methods

The data for this review was collected from “Bos Genetic” in Hungary and “Lehr- und Versuchsanstalt für Tierzucht und Tierhaltung (LVAT)” in Germany. LVAT is a cooperation between the testing centre, the beef breeding organisation in Berlin-Brandenburg, and the municipal department of agriculture and rural development. The LVAT was founded in 1992 and opened its doors as an experimental farm in 1993. It has facilities to perform performance testing in sheep, pigs, dairy, and beef cattle. The facilities have been constantly expanded with EU funding. Since 2005, not only progeny testing and origin testing for fattening bulls was offered, but also a stationary own performance test for future beef cattle breeding bulls. Bos Genetic, on the other hand, was a central testing and AI station since its opening in 1985. It was partly owned by the German “Osnabrücker Herdbook Cooperation”. Because of restructuring and challenges in the Hungarian AI station environment, the facilities were acquired by the University of Veterinary Medicine Budapest in 2022 to provide teaching opportunities for veterinary students in AI and general cattle management. Today, they still facilitate the central testing, the subsequent production of AI straws, and progeny testing of beef cattle in Hungary.

3.1. The Testing Stations

Bos Genetic has its facility in Martonvásár, near Budapest, and has a maximum capacity for about 140 bulls. Due to the size of the facility, there can be multiple simultaneous performance tests conducted at the same time. Therefore, testing is initiated at multiple dates throughout the year. The bulls are housed in boxes with deep straw and in groups of 4-6 bulls. Each enclosure has an indoor area and outdoor area of the same size, with a feeding area included indoors. The adjustment period is 21 days but can be longer depending on the arrival of calves for one testing group. A unique difference compared to the German farm is that Bos Genetic has the ability to produce AI straws in-house and therefore offers the service of housing promising bulls for semen collection and later their offspring for progeny testing.

LVAT is situated in Groß Kreutz, near Potsdam, and has a limited capacity to test about 50 bulls per year, which is divided into two testing periods. The bulls are combined into groups of 4-8 per cubicle and are housed in an outdoor stable. These cubicles are covered and bedded with straw. The feeding area at the front is not covered by the roof and not bedded, allowing for easy cleaning. Arriving bulls must be between 184 and 240 days of age to be considered. Testing starts with the arrival in the stable and has a duration of 183 days. There is no adjustment period or quarantine considered in this testing. Another service that can be offered at this test farm is the evaluation of additional performance characteristics in meat. An ultrasound assessment performed at the conclusion of the testing period provides critical insights into both lean muscle area and fat thickness. At the end of testing, it is possible for the breeders' association to perform an evaluation of the bulls' external traits, which will then be recorded in the stud book. Once the evaluation is complete, the bulls are either returned to their breeder or sold directly from the testing premises.

3.2. Feed

The feeding practices in both facilities are very similar. At Bos Genetic, feeding is done twice a day with a total mixed ration (TMR) and three supplementary feedings of concentrate with an ad libitum supply of hay. At LVAT, the animals receive a TMR once a day with the addition of receiving a weighed amount of concentrate twice a day with manual feeding. Both feed their TMR and add concentrate to facilitate best possible growth for these beef bulls. In addition, vitamin and mineral lick stones are provided to balance nutritional requirements. The proved TMR is based on a mixture of either grass or corn silage, straw, and concentrate. These rations are mixed for the entire testing group at once to ensure uniformity in the provided feed.

3.3. Performance test data

This paper will compare and discuss the results of central performance testing from LVAT in Germany (DE) and Bos Genetic in Hungary (HU). The records from LVAT are from 2014-2023 and include 76 beef bulls. The records for Bos Genetic are from 2018-2023 and include 208 bulls in total. For each farm, the recorded parameters were breed, age at start of test, weight at start of test, weight at end of test, and ADG during testing.

At LVAT, these young beef bulls were kept at the testing station for a test duration of 183 days. Bos Genetic had a variable test duration, with a range between 125 and 195 days. In addition, the Bos Genetic station had a 21-day quarantine and adjustment period to eliminate the introduction of debilitating diseases. This period also allows them to get acquainted with the new surroundings, therefore limiting the influence of transport stress and herd of origin on growth.

Both test farms require the bulls to be unvaccinated for and free of bovine herpes virus 1, have a negative bovine viral diarrhoea virus antigen test, and a health certificate signed by a state veterinarian that the bull is free of notifiable diseases such as tuberculosis, brucellosis, and enzootic bovine leukosis. Every tested bull is also required to have a single nucleotide polymorphism test to determine the parentage in accordance with herdbook regulations. An added criteria of LVAT is the requirement for bulls to be above the national average for their breed in post-weaning ADG, acquired previously in on-farm testing. This criterion is in place because of space limitations, so that only bulls with promising growth traits will be admitted for station testing.

4. Results and Discussions

The selected stations are both central testing stations used to evaluate the growth of promising bull calves after weaning until about 400-450 days of age. These records are vital for the use of selection programs or in the search for new sires for herd genetics. A good performance on test is also of economic importance to the breeder, since a promising bull maybe sold at a high price directly from the testing premises to AI stations for them to start semen collection for AI. The data gathered from these two central testing stations were evaluated to assess for differences in performance results between facilities in Hungary and Germany.

4.1. Breed

At LVAT, out of the total amount of bulls in their records (n = 76), 24 are Charolais, 42 are Limousin, and 10 are Blonde d'Aquitaine. This correlates to a breed distribution of 31,58%, 55,26%, and 13,16%, respectively, in the performance test records (Figure 1). Bos Genetic's records reflect that of the bulls tested (n = 208), 22 are Charolais, 71 are Limousin, and 115 are Blonde d'Aquitaine. The breed distribution in the performance test records at this station is 10,58%, 34,13%, and 55,29%, respectively (Figure 1).

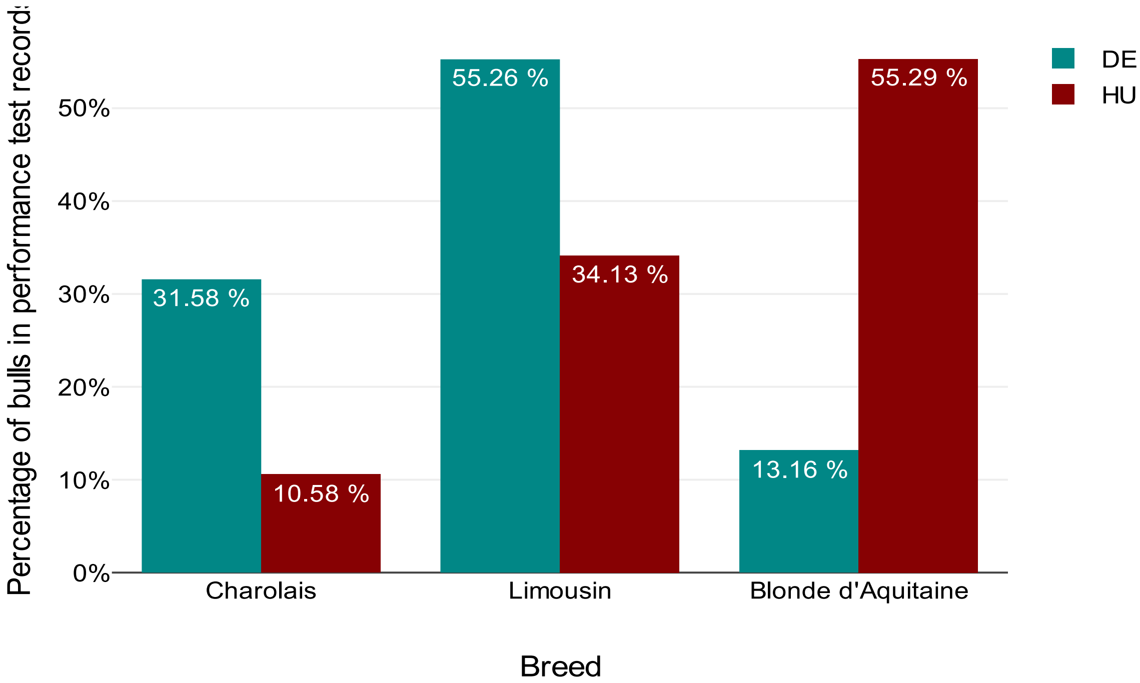

Figure 1: Percentage of Charolais, Limousin, and Blonde d'Aquitaine bulls in performance test records from Hungarian (n = 208) and German (n = 76) central testing stations.

At LVAT, the Limousin breed is predominant, amounting to 55,25% of the total performance test records at the testing station. The Charolais breed, making up 31,58% of the records, still represents a significant number of bulls tested at LVAT. The Blonde d'Aquitaine breed is the least represented in the records, with only 13,16%. This indicates that Germany does not have a large population of Blonde d'Aquitaine cattle utilised as sires for breeding. This conclusion drawn from the LVAT testing station might not be representative for Germany, as the sample size of performance test records is too small.

At Bos Genetic, the Blonde d'Aquitaine breed is the most prevalent, with 55,29% of the tested bulls being of this breed. The Limousin breed is the second most common, making up 34,13% of the performance test records. The Charolais breed makes up only 10,58% of the testing records, which could maybe indicate that it may not be as utilised in Hungarian breeding programmes.

4.2. Age at Start of Testing

The age at the start of testing in correlation to breed and country is presented in Table 1. The starting age at LVAT is on average 40 days younger than the one at Bos Genetic, where the maximum age at the start of testing was as high as 339 days old. This can be the result of much higher capacity and more frequent testing at Bos Genetic, allowing them to not be as restrictive in the selection of bulls for testing.

Table 1: Age of bulls at the start of performance testing at central testing stations in Hungary(n=208) and Germany(n=76).

		n	Mean	Std. Deviation	Minimum	Maximum
Age at start of test (days)	HU	208	264.95	22.34	195	339
	DE	76	225.75	21.89	181	251

When analysing the age at the start of testing in correlation to the three breeds and the performing central testing station, it was found that the Charolais breeds in both central testing stations were on average higher in starting age compared to the other two breeds (Table 2)

Table 2 : Age of bulls at the start of performance testing in correlation to the country in which it was performed and the breed of the bull

			n	Mean	Std. Deviation
Age at start of test (days)	DE	Charolais	24	235.04	14.65
		Limousin	42	222.86	22.74
		Blonde d'Aquitaine	10	215.6	26.54
	HU	Charolais	22	289.18	20.98
		Limousin	71	263.44	23.27
		Blonde d'Aquitaine	115	261.25	19.09

This correlation of age at the start of testing between records from LVAT and Bos Genetic can also be seen in the other two breeds. The Blonde d'Aquitaine starting age at both testing stations, on average, is the lowest of the breeds. It is interesting that this can be seen in the records of both stations, hinting at the possibilities that breed-specific later weaning could lead to a higher age at the start of testing.

To test if a higher age at the start of testing would influence the other recorded parameters of performance testing, Pearson correlation tests were conducted. This method evaluates the correlation between the testing parameters and their significance.
The correlation between the age at the start of testing and the weight at the start of testing showed that there was a high, positive correlation, which was statistically significant, $r(282) = 0{,}54$, $p = <0{,}001$. This is not unexpected as older bulls have had more time to mature and gain weight compared to younger bulls in the performance test.

For the relationship between the age at the start of testing and final testing weight, the test showed that there was a moderate, positive correlation that was statistically significant, r(282) = 0,35, p = <0,001. This correlation is also not surprising as a higher starting weight and an equal daily weight gain during the test would result in a higher final weight. For this test to show only a moderate correlation might be because of the time that passed over the course of the testing period, allowing the bull to show his real genetic potential and not that of the pretest environment.

In the case of age at the start of testing and ADG during the testing period, a negligible, positive correlation was described that was not statistically significant, r(282) = 0,08, p = 0,187. Due to the lack of statistical significance, the negligible positive relationship can likely be attributed to chance. This is also an important relationship between testing parameters because a high influence would mean that the limitation of entry age would have to be stricter. Especially because the ADG of the testing period is very important in the final evaluation scores of the central performance test of bulls.

4.3. Weight at the start of testing

When looking at the weight at the start of testing, the averages at LVAT and Bos Genetic are comparable (Table 3). The average is the same, but there is a wider range of weights at the start of testing at the Bos Genetic testing station.

Table 3: Weight at start of performance test in beef bulls in German (n = 76) and Hungarian (n = 208) central testing stations.

		n	Minimum	Maximum	Mean ± Std.
Weight at start of test (kg)	HU	208	188	482	319.48 ± 55.7
	DE	76	237.36	402.91	311.55 ± 35.74

The breed-specific differences in the starting weight were visualised in Figure 2, showing that at both testing locations, the Charolais breed had the higest starting weight. It also shows that the Charolais bulls starting their performance test at Bos Genetic had a much higher starting weight compared to those tested at LVAT. This could again be because of the higher average starting weight at the beginning of the testing period and the generally higher age at Bos Genetic. It might also be attributed to the breed difference between the Limousin and Blonde d'Aquitaine breeds, who were quite similar in starting weight at both testing stations.

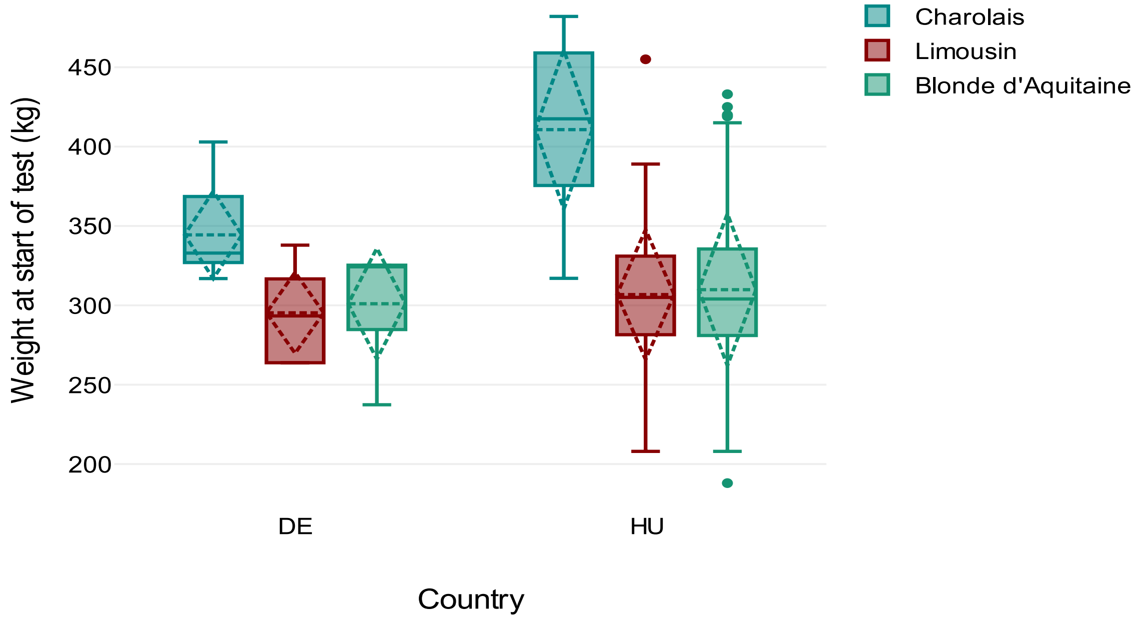

Figure 2: Weight of bulls at start of test in correlation to country and breed

4.4. Weight at the End of Testing

The final weight taken during the central performance test shows how much the bulls have grown and is a vital measurement for calculating the average daily gain. The performance records for Bos Genetic and LVAT show that the final weight is very breed-specific (Table 4).

Table 4: Weight at the end of performance testing in correlation to the breed and central testing station

			n	Mean	Std. Deviation	Minimum	Maximum
Weight at end of test (kg)	DE	Charolais	24	669.88	41.17	606	740
		Limousin	42	583.19	47.56	529	646
		Blonde d'Aquitaine	10	584.3	33.67	517	608
	HU	Charolais	22	606.68	49.67	492	675
		Limousin	71	572.75	56.59	450	764
		Blonde d'Aquitaine	115	611.99	55.5	479	774

Comparing the records of the two testing stations shows that Charolais bulls and Limousin bulls on average achieved a higher final weight at LVAT than at Bos Genetic. The Blonde d'Aquitaine breed, on the other hand, on average achieved higher final testing weights at Bos Genetic.

For the evaluation of the final testing weight, it might also be beneficial to look at the individuals that have achieved the highest final weight (Figure 3). In performance testing, the goal is to assess the potential but also to identify individuals which perform far better than average.

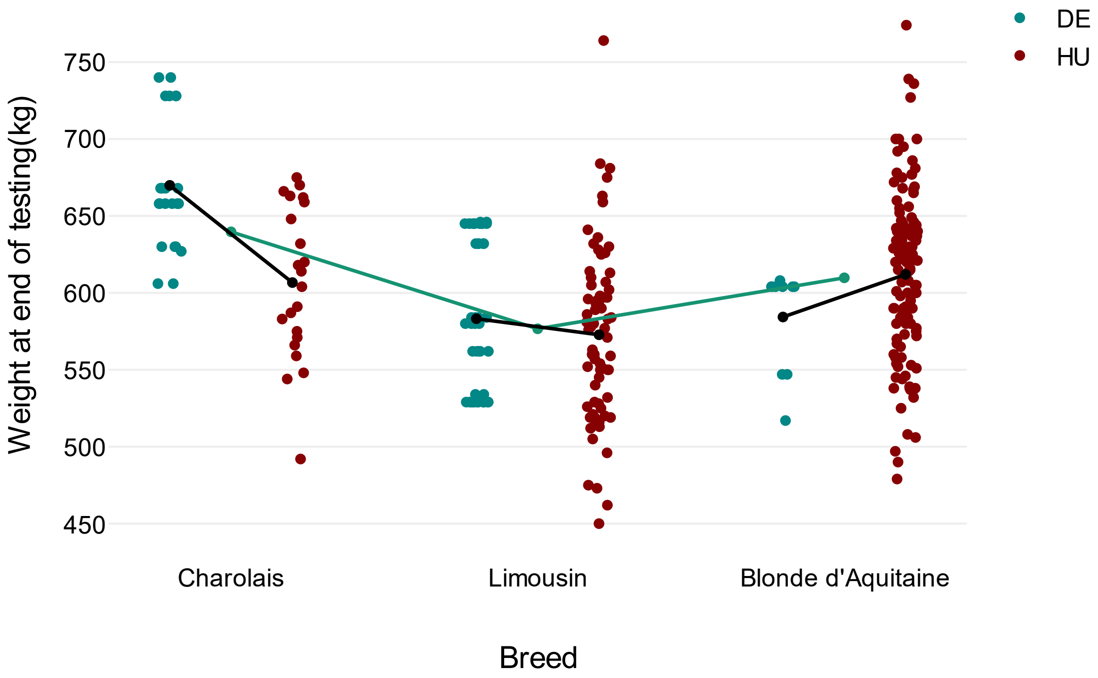

Figure 3: Weight of bulls at the end of performance testing in correlation to breed and testing station

When looking at the maximum, the Blonde d'Aquitaine breed at Bos Genetic produced the individual with the highest final weight in the entire record collection (Table 4, Figure 3). This could not have been identified from only analysing the averages calculated from these data. When looking at the data visualised on a Multi-Vari Chart, it can be observed that the Blonde d'Aquitaine breed especially had multiple high-performing individuals identified at the Bos Genetic testing station. Also, the previously identified bulls with high final weights from the Charolais breed at LVAT can be found in this visualisation. This comparison is again limited in reliability due to the small sample size of records from LVAT.

4.5. Average Daily Gain While Testing

The evaluation of the ADG during the test is one of the most important parameters collected during testing, as it is a crucial decision criterion in the sire selection process for beef producers. As this is also permanently recorded in the herdbook, a high ADG during testing correlates directly with a higher economic evaluation of this bull.

Looking at the results from central performance testing at Bos Genetic and LVAT, a direct evaluation of the mean ADG in correlation to the country they were tested in shows that they are equal, at an average of 1,63 kg of daily gain during the testing period. (Figure 4).

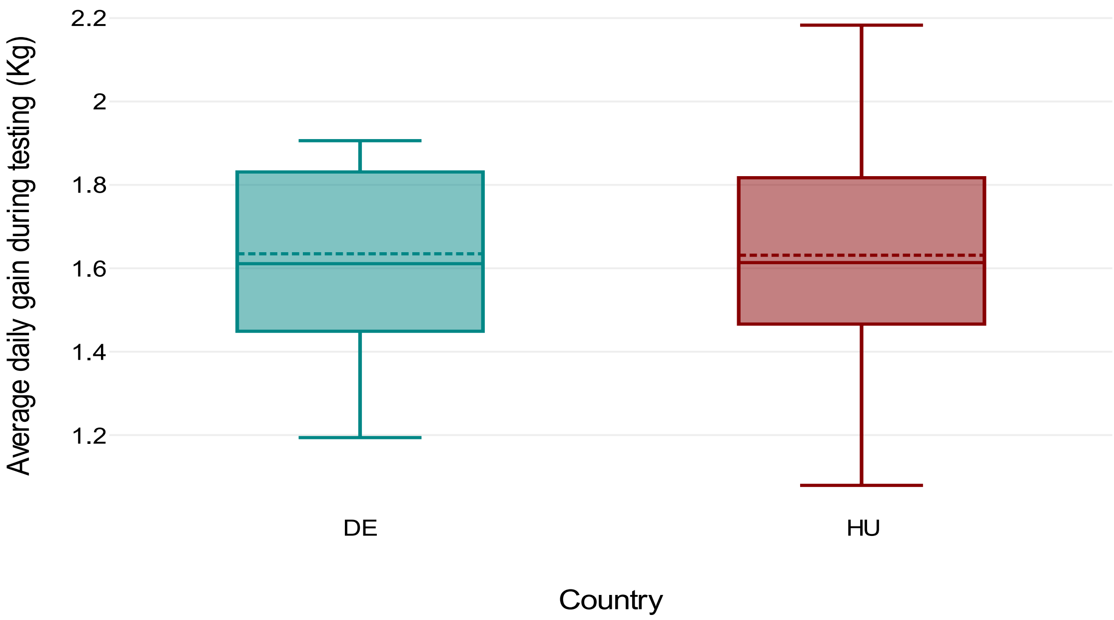

Figure 4: Average daily gain of bulls during central performance testing in correlation to the performing testing station

The main difference between the testing stations is the standard deviation from the mean average, where Bos Genetic has a wider spread of the ADG. This can most likely be attributed to the much larger pool of performance data supplied by Bos Genetic compared to LVAT. Statistical analysis also concluded that the correlation between ADG and the individual performing testing station, was identical. LVAT (M = 1,63, SD = 0,19) and Bos Genetic (M = 1,63, SD = 0,23). The only differences were the standard deviation, which can be most likely attributed to the much larger set of records from Bos Genetic. When evaluating the ADG of each breed for both testing stations, inter-breed differences can be evaluated. The records indicate that at LVAT, the Charolais breed had the highest mean

ADG during testing. At Bos Genetic, the cattle breed showing the highest mean ADG was the Blonde d'Aquitaine (Table 5).

Table 5: Average daily gain of bulls during performance testing in correlation to breed and testing station

			n	Mean	Std. Deviation	Minimum	Maximum
ADG test (kg)	DE	Charolais	24	1.78	0.12	1.44	1.89
		Limousin	42	1.57	0.19	1.19	1.91
		Blonde d'Aquitaine	10	1.55	0.11	1.31	1.69
	HU	Charolais	22	1.55	0.2	1.24	1.89
		Limousin	71	1.54	0.21	1.08	2.18
		Blonde d'Aquitaine	115	1.7	0.21	1.1	2.11

Interestingly, at both testing stations the highest average daily gains belonged to bulls of the Limousin breed, who are normally considered slower growers compared to the other two breeds[60]. The lower averages of the Limousin and Blonde d'Aquitaine breeds at Bos Genetic can probably be attributed to the much larger records and less selective entry requirements compared to LVAT. This is also reflected when looking at the minimum values of Bos Genetic records.

When comparing the results with a study from 2001 looking at the growth rate of beef bulls, the averages achieved at both testing stations far outperform their reported values[63]. The Charolais bulls had an average of 1,27 kg daily gain, the Limousin bulls had an average daily gain of 1,07 kg and the Blonde d'Aquitaine bulls had an average daily gain of about 1,12 kg. These differences show the differences that can be achieved during an on-farm testing study and the performance testing done at the central testing stations of Bos Genetic and LVAT.

To analyse the influence that central testing stations could potentially have on the ADG of the breeds, a two-way ANOVA test was conducted. It showed that there was no significant difference between the testing station, in relation to ADG (p=0,898). Furthermore, a significant difference between breed in relation to ADG, was discovered (p=<0,001). The interaction between testing station and breed, in relation to ADG was shown to be significant (p=<0,001). This is an interesting finding that requires further investigation in future work.

The independence from the place where testing was administered was also shown in a point-biserial correlation, run to determine the relationship between testing station and ADG during testing. It showed a negative correlation, which was not statistically significant (rpb = -0,01, n = 284, p = 0,906), indicating that there is no correlation between ADG and testing station.

Another correlation that should be investigated is that between the weight at start of testing and the ADG of bulls during the testing period (Figure 5).

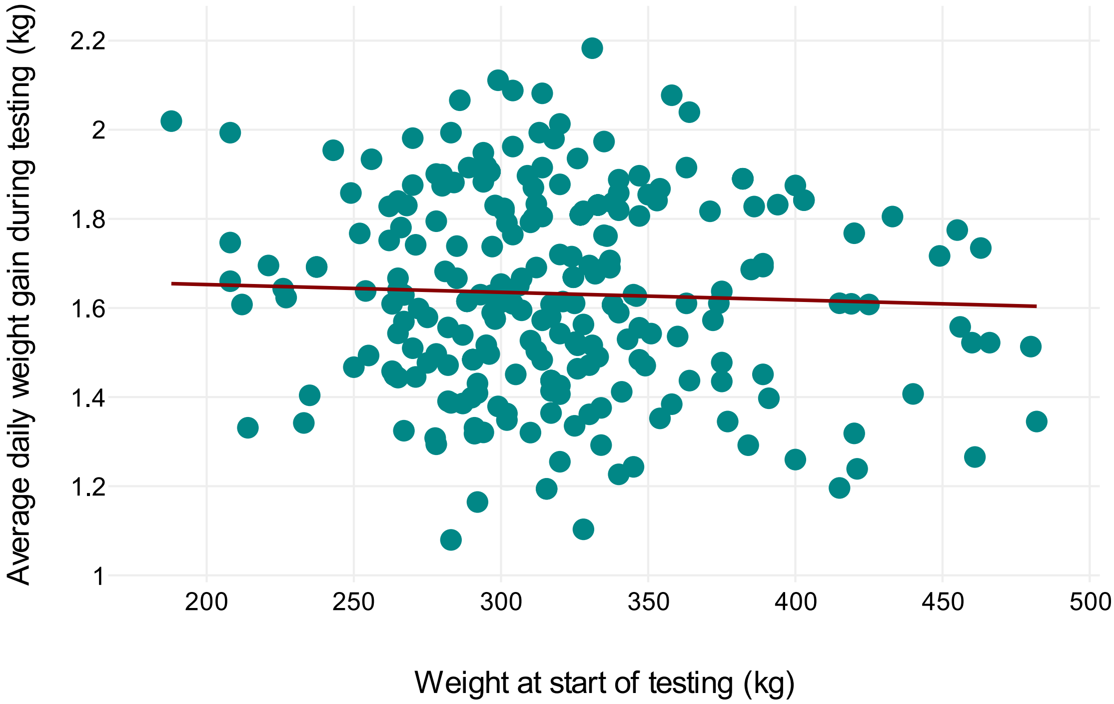

Figure 5: Scatterplot showing the relationship between the average daily weight gain of bulls and the weight at the start of testing

The result of the Pearson correlation showed that there was a negligible, negative correlation between the weight at start of testing and the ADG of bulls during testing. The correlation was not statistically significant, r(282) = -0,04, p = 0,492. This is important information for producers and performance testers, as a significant correlation would mean that the entry weight should be a limiting criterion for bulls to be accepted to the central testing stations. Determining when and which bulls are allowed to be tested is an area in which further investigation is warranted.

After evaluation, the test records of the central testing stations, LVAT and Bos Genetic, show that it is not important which testing station is used for central performance testing in beef cattle of the Limousin, Charolais, and Blonde d'Aquitaine breeds. The results showed that the testing processes in Germany and Hungary are comparable and can be treated as such.

This comparison also has shown opportunities for research regarding central performance testing of beef cattle. Future research should focus on and deepen knowledge on the comparability of testing stations and practices around the globe. This would allow for an international exchange of performance data and widen the possibility of genomic selection even further. The exchange of data might even be able to identify opportunities for growth trait improvement from cattle breed on other continents, for example cattle that would be more heat tolerant without reduced performance, an important trait in the face of global warming. The establishment of central testing stations in countries exhibiting these extreme environments could provide for further research opportunities in this area.

Research on how performance traits develop over a long period of time, especially in relation to the breeds, would allow for a deeper insight into the consequences of selection processes. This requires the expansion of standardised testing protocols to be used in on-farm and central testing stations. In addition, the development of advanced methods to evaluate the feed efficiency of bulls more readily would allow the beef industry to come one step closer to sustainable practices, especially since the public view on livestock is constantly changing and pressure to be environmentally sustainable is rising.

5. Conclusion

Performance testing in beef cattle is a crucial tool in the development of genetic enhancement and economic viability. The assessment of various traits, including weaning weight, yearling weight, feed efficiency, and ADG, yields essential insights into both the genetic and phenotypic capabilities of individual animals as well as the herd. These attributes act as benchmarks for breeders, facilitating informed selection choices that directly impact the productivity of subsequent generations.

Heritability estimates for economically important characteristics, such as ADG and feed efficiency, typically range from moderate to high, highlighting the potential of these traits to be passed on to the next generation and indicate the potential for systematic selection processes for productivity improvements [31, 39]. Furthermore, the relationships between growth traits and reproductive outcomes, such as calving difficulty, emphasizes the importance for the implementation of balanced selection strategies [16]. Such practices ensure that while enhancing growth and productivity, other factors limiting health and reproduction are not overlooked.

A significant factor in performance testing is the differentiation between central testing stations and on-farm testing. Central testing stations evaluate animals within a standardised environment, which reduces environmental variability and provides a controlled setting for comparing genetic potential among bulls. This approach is particularly beneficial for economically important traits like ADG, where accurate data is paramount for breeding selection. Central testing facilities also generate valuable information for national or breed-specific assessments, contributing to the improvement of breed performance.

In contrast, on-farm testing takes place in the cattle's own herd setting, reflecting the utilised conditions and management practices. This method provides insights into how well animals adapt to specific environments, making it especially important for assessing resilience against environmental stressors, reproductive capability, and maternal performance. Although it may introduce additional variability due to differences in environment and management and herd of origin, this can be partially mitigated by the usage of adjustment factors and standardisation.

The choice between central versus on-farm testing often hinges on the objectives of the breeding program. A synergistic approach that incorporates both methodologies can yield a more comprehensive understanding of genetic potential: centralized testing supplies precise data on high-heritability traits in bulls, while on-farm assessments capture real-world performance metrics of the entire beef herd.

Despite its advantages, performance testing encounters hurdles in its implementation. High costs associated with data collection and the necessity for advanced technologies capable of measuring intricate traits, like residual feed intake, creates a hurdle for smaller scale farmers to take advantage of these testing practices.

The comparison between the central testing stations in Germany and Hungary, LVAT and Bos Genetic, has also shown the comparability of the resulting records. Not just regarding the Charolais, Limousin, and Blonde d'Aquitaine breeds that were analysed, but also the respective performance metrics were shown to be of comparable informative value. It also identified that the Charolais breed was the highest performer at LVAT, while the Blonde d'Aquitaine breed performed best at the Bos Genetic central testing station. The much stricter entry requirement that the LVAT central testing station had for bull calves to be accepted for testing, was reflected in a smaller deviation from the mean of performance metrics. The further development of analysis between testing stations would allow for data bases to be established and breed traits would be able to be better evaluated.

Performance testing remains an evolving but essential tool for the beef cattle industry. It creates possibilities toward improved herd genetics and economic efficiency. By harnessing both central and on-farm testing methodologies, breeders can achieve a comprehensive perspective on animal performance, ensuring that selection strategies are robust enough to apply across different production systems. In the long run, the beef cattle husbandry sector will have to explore new technologies to addressing sustainability challenges and especially to uphold efficacy, reliability, and importance of the performance testing of beef cattle. This will allow the industry to become more profitable and increase production capabilities, maybe even allowing the European beef exports to regain their former ranking in worldwide exports of beef.

6. Summary

This Thesis explores the differences and similarities of beef cattle performance testing in Hungary and Germany, highlighting the vital importance of such testing in improving genetic traits, productivity, and economic sustainability within the beef sector. It furthermore examines essential performance metrics, such as birth weight, weaning weight, yearling weight, average daily gain, and feed efficiency, while highlighting their genetic heritability and economic significance of these traits. In contrasting on-farm testing with central testing stations, the strengths and challenges of both methods are analysed and reviewed. The breed specific differences of Charolais, Blonde d'Aquitaine, and Limousin cattle are compared in their growth performance data. A comparative review of the performance testing records of the central testing stations LVAT in Germany and Bos Genetic in Hungary was conducted. The records of 284 beef bulls were analysed to see the influence breed but most importantly the influence the central testing station itself has on the resulting test results. This revealed that the mean for average daily gain across the two testing stations was almost identical. It also identified that with regards to average daily gain, the Charolais breed was the highest performer at LVAT, while the Blonde d'Aquitaine breed was the highest performer at the Bos Genetic central testing station. Furthermore, the effects of differences in starting age and weight of bulls on average daily gain were analysed, showing a negligible, not statistically significant correlation.

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Thesis progress report for veterinary students

Name of student: **Tim Christopher Wieschhoff**

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Name and title of the supervisor: **Dr. Rátky József**

Department: **Department of Reproduction and Farm Animal Clinic**

Thesis title: **The comparative results of beef cattle test farms in Hungary and Germany**

Consultation – 1st semester

	Timing			Topic / Remarks of the supervisor	Signature of the supervisor
	year	month	day		
1.	2023	08	31	First meeting about Topic, goals, & 1st visit to Bos Genetic	
2.	2023	10	03	Introduction & Structure	
3.	2023	10	25	2nd visit Bos Genetic to gather testresults, Housing & Food composition	
4.	2023	11	14	Progress Report	
5.	2023	12	06	3rd visit to Bos Genetic	

Grade achieved at the end of the first semester: 5

Consultation – 2nd semester

	Timing			Topic / Remarks of the supervisor	Signature of the supervisor
	year	month	day		
1.	2024	03	11	Progress Report & Semendata aquisition	
2.	2024	06	21	Setting Goals for Summer period & timeline	
3.	2024	11	27	Application for Thesis deadline extension	
4.					
5.					

Grade achieved at the end of the second semester: 4

1

The thesis meets the requirements of the Study and Examination Rules of the University and the Guide to Thesis Writing.

I accept the thesis and found suitable to defence,

....

signature of the supervisor

Signature of the student: ....

Signature of the secretary of the department: ....

Date of handing the thesis in 2024 '12. 13.