Arch. Tierz., Dummerstorf 43 (2000) 1, 5-15

Department of Animal and Wildlife Sciences[1], University of Pretoria, Pretoria, South Africa and ARC-Animal Improvement Institute[2], Irene, South Africa

ESTÉ VAN MARLE-KÖSTER[1], BERNICE E. MOSTERT[2] and JAPIE VAN DER WESTHUIZEN[2]

Body measurements as selection criteria for growth in South African hereford cattle

Summary

Birth weight (BW), weaning weight (WW), yearling weight (YW) and seven body measurements (cannon bone length at birth (CB); hip height at weaning (HHW); hip height at yearling (HHY); body length at weaning (BLW); body length at yearling (BLY); scrotum circumference at weaning (SCW) and scrotum circumference at yearling (SCY), measured in a Hereford stud (1497 animals) over a period of 19 years, were used in estimating genetic (co)variances, heritabilities and correlations. Nine different multitrait animal model evaluations were carried out whereby (co)variance components were estimated using the REML VCE 3.0 package. Estimates from different evaluations were pooled, weighing each estimate by the inverse of the sampling variance to calculate weighted mean variance ratios among the different traits. Generally, structural traits tended to have lower heritability estimates (CB = 0.24; HHW = 0.28; HHY = 0.33; BLW = 0.22; BLY= 0.14) when compared with literature values , while estimates for production traits compared well with estimates reported for the South African National Evaluation. Weights and linear body measurements were positively correlated (0.4 - 0.9). Negative correlations were found for scrotum, circumference at weaning and yearling with BW and CB respectively. SCW and BW: -0.54; SCY and BW: -0.65; SCW and CB: -0.66; SCY and CB: -.58. It is concluded that CB could serve as an early indicator of mature size and weights at different ages.

Key Words: body measurements, cannon bone, genetic evaluation, Hereford cattle, REML, selection

Zusammenfassung

Titel der Arbeit: **Körpermaße als Selektionskriterium für das Wachstum von Herefordrindern in Südafrika**

In einer Hereford - Rinderzuchtherde wurden über einen Zeitraum von 19 Jahren bei 1497 Individuen Körpermessungen durchgeführt und für die Kriterien:
Geburtsgewicht (BW); Absatzgewicht (WW); Jährlingsgewicht (YW); Röhrbeinlänge bei Geburt (CB); Hüfthöhe beim Absetzen (HHW) und bei Jährlingen (HHW); Körperlänge beim Absetzen (BLW) und bei Jährlingen (BLY) sowie Hodenumfang beim Absetzen (SCW) und bei Jährlingen (SCY) genetische Parameter, wie (Co)Varianzen, Heritabilitäten und Korrelationen geschätzt. Neun verschiedene Analysen nach dem Mehrmerkmals-Tiermodell wurden ausgeführt, wobei (Co)Varianz-Komponenten mit Hilfe des REML VCE 3.0 Pakets berechnet wurden. Schätzwerte der verschiedenen Analysen wurden gepoolt und, nach Wichtung jedes Schätzwertes durch die Inverse der Stichprobenvarianz, die gewogenen mittleren Varianzverhältnisse zwischen den verschiedenen Merkmalen ermittelt. Im Vergleich zu den Werten aus der Literatur tendieren die strukturellen Merkmale im allgemeinen zu niedrigen Heritabilitätsschätzwerten (CB = 0,24; HHW = 0,28; HHY = 0,33; BLW = 0,22; BLY = 0,14), während die Schätzwerte für die Produktionseigenschaften gut mit denen des Berichtes der South African National Evaluation übereinstimmen. Körpergewichte und lineare Körpermaße sind positiv korreliert (0,4 bis 0,9). Negative Korrelationen wurden zwischen dem Körpergewicht sowie der Röhrbeinlänge bei Geburt und dem Hodenumfang sowohl bei der Geburt als auch bei Jährlingen gefunden (SCW:BW = 0,54; SCY:BW = -0,65; SCW:CB = -0,66; SCY:CB = -0,58). Es wird geschlussfolgert, dass die Röhrbeinlänge bei Geburt als frühzeitiger Indikator für die Grössenentwicklung und die Körpergewichte zu den verschiedenen Altersstufen dienen kann.

Schlüsselwörter: Körpermaße, Mittelfussknochen, Zuchtwertschätzung, Hereford, REML, Selektion

Introduction

Herefords in South Africa increased in size from an average Frame Score 3 (119.38 cm) to an average of 5 (129.54 cm) at 15 months of age over a period of approximately 15 years (Hereford Breeders Society of Southern Africa, 1997). The past fifteen years of Hereford cattle breeding in South Africa were directed towards selection for larger framed animals with a higher growth rate. Hereford breeders used hip height as an additional measurement to weight in assisting them in the selection process (Hereford Breeders Society of Southern Africa, 1983) .

Body measurements have been of recurring interest in beef cattle selection and breeding programmes. Measurements such as hip height or wither height were used to study skeletal development. BROWN et al. (1983) and GOSEY (1984) reported that hip height is a trait indicating maturity at an early age, followed by height at withers and width of shoulders. Skeletal growth in growing animals takes priority for nutrients over muscle growth and fat deposition (BERG and BUTTERFIELD, 1976). Regardless of plane of nutrition, frame size of animals of the same age and sex should increase according to their genetic potential.

Studies indicate that length of the cannon bone (MEYER, 1995) and hip height (GILBERT et al., 1993) could be used as indication of maturity at an early age. Reports on genetic parameters for body length and height are limited.

Scrotal circumference and its relationship with fertility, has been studied extensively (NEELY et al., 1982; SMITH and BRINKS, 1989; MORRIS et al., 1992). Scrotal circumference is favourably related to both fertility in the male and its female offspring. Therefore it is of interest to evaluate the relationship of scrotal circumference, as indicator of reproduction, with other linear body measurements and weights.

Hereford breeders are taking body measurements and weights at different ages and production stadia. It should therefore be established which measurements provide the most accurate and best information for effective selection. The aim of this study was therefore to estimate the heritabilities and genetic correlations for the different measurements in order to evaluate these as selection criteria for growth and reproduction in Hereford cattle in South Africa.

Material and Method

Data for this study were obtained from a registered polled Hereford stud near Vryburg in the North-West Province of South Africa. The herd was established in 1978 and participated in the South African National Beef Cattle Performance Testing Scheme (KÖSTER, 1992).

Herd management

The herd numbers were maintained at an average of 250 breeding cows. Cows and calves were kept on natural pastures throughout the year. Natural pastures consist of a semi-arid Bush Savanna, classified by ACOCKS (1988) as the eastern Kalahari Thornveld Proper. Summer and winter supplementation of minerals, protein and energy were provided. The mating seasons were between mid-December to March and again from June to July. Approximately one third of the cows were artificially inseminated. Calves were weaned at an average age of 205 days. Bull and heifer calves were separated after weaning. Young bulls received a growth meal (14% protein, 72% TDN, one percent of live weight) from weaning to year old, while heifers were kept on natural pasture with supplementation.

Calves with physical defects were culled at weaning. Cows were evaluated on reproductive and calf performance. Emphasis was placed on selection for a leaner type of Hereford with an average Frame Score between 6 and 7 (137.16 cm - 142.24 cm at eighteen months of age). For this purpose Hereford semen was imported from the USA, since 1982.

Measurements

The herd participated in Phases A, B, C and D of the South African National Beef Cattle Performance Testing Scheme. Measurements recorded on the farm included birth weight (BW), 100 days weight, weaning weight (WW), yearling weight (YW) and 18 months weight (bulls only). Body measurements recorded were cannon bone length at birth (CB), body length at weaning and yearling (BLW and BLY), hip height at weaning and yearling (HHW and HHY) and scrotal circumference at weaning and 12 months of age (SCW and SCY). Weights were recorded over a period of 19 years (1978-1996) and heights and lengths for 13 years (1983-1996). The same manager was responsible for taking all measurements.

Cannon bone length was measured within 24 hours after birth, from the calcaneus (point of hock) to the trochlea, which articulates with the proximal phalanx to form the pastern joint. Body length was measured from the *Regio interscapularis* (withers) to the caudal *Tuber ischii* (pin bones). The height of the animal was measured directly over the *Tuber coxae* (hooks), with the animal standing on a level surface.

Data description

Including all pedigrees the data set consisted of 1497 records. A total of 51 sires and 376 dams were represented. The data were edited to eliminate incomplete records and outliers. The twinning rate was low, 1.5% of the data, and were excluded. All pedigrees were checked to ensure parents were born at appropriate times before their offspring.

Statistical methods

The GLM (General Linear Model) procedure of SAS (1995) was used to determine which fixed effects had a significant influence on the data. Age of dam was classified into three categories, i.e. dams younger than 30 months; dams 31 - 92 months of age and dams older than 92 months. As calves received creep feeding that could have had a cannulation effect it is expected that age of dam had little effect after birth. Animals were grouped according to the number born per month over the 19 years namely: January to April, May to August and September to December. A year-season concatenation was established and fitted as a fixed effect in the model for all traits, to account for possible interactions. Sex and age when weighed were also considered as fixed effects. A series of univariate REML estimations (MEYER, 1991) fitting animal models with full relationships, were carried out. The appropriate mixed models, with the best likelihood fits, were decided upon for multitrait analyses, therefore in all analyses the direct-maternal covariance was ignored. Due to the data structure a multiple trait analysis, including all the traits, could not be performed, therefore the following nine analysis were carried out:

1. BW, WW, YW and CB
2. BW, WW, YW, HHW and HHY
3. BW, WW, YW, BLW and BLY
4. BW, WW, YW, SCW and SCY
5. CB, HHW, HHY, BLW and BLY
6. BLW, BLY, SCW and SCY
7. CB, SCW and SCY
8. HHW, SCW and SCY
9. HHY, CSW and CSY

Multitrait analyses were consequently performed to obtain heritabilities and genetic correlations between traits.
Variance components were estimated with the REML VCE 3.0 package (GROENEVELD, 1994), approximating the first derivatives by finite differences. Optimization was done using the UNCMIN optimizer on the Cholesky factor. In Table 1 the final model fitted for variance component estimation for each trait is indicated.
Since a series of (co)variance components and variance component ratios were obtained from different multitrait analyses, these (co) variances and ratios were pooled, weighing each estimate by the inverse of its sampling variance (SE^2) (KOOTS et al., 1994), as follows :

$$h^2 \text{pooled} = \sum_{I=1}^{n} h_i^2 / \left(SE_{h^2_i}\right)^2 / \sum_{i=1}^{n} 1 / \left(SE_{h^2_i}\right)^2$$

Results and Discussion

Characteristics of the data for all traits with phenotypic means and standard deviations are summarised in Table 2.

Table 1
Final model used for variance component estimation for each trait (Modell der Varianzkomponentenschätzung für jedes Merkmal)

Factor	Type	BW	WW	YW	CB	HHW	HHY	BLW	BLY	SCW	SCY
Yr-seas	F	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0001
Sex	F	0.0001	0.0001	0.0001	0.027	0.0001	0.0001	0.0001	0.0001	-	-
Age of dam	F	0.0008	0.29	0.48	0.0001	0.0869	0.0723	0.6981	0.4914	0.6023	0.3692
Age at WW	C	-	0.0001	-	-	0.3529	-	0.0134	-	0.7381	-
Age at YW	C	-	-	0.0001	-	-	0.4785	-	0.0001	-	0.0001
Mat. Env.	R	x	x	x	-	x	-	x	x	x	-
Mat. Gen.	A	x	x	x	x	x	x	x	x	-	-
Direct Gen.	A	x	x	x	x	x	x	x	x	x	x

Yr-seas = Year-season
Mat. Env. = Maternal environmental effect
Mat. Gen. = Maternal Genetic effect
Direct Gen. = Direct Genetic effect
F = Fixed effect
C = Covariable
R = Random effect
A = Random effect, using the full relationship matrix

Table 2
Data structure for birth weight (BW), weaning weight (WW), yearling weight (YW), cannon bone length at birth (CB), hip height at weaning (HHW), hip height at yearling (HHY), body length at weaning (BLW), body length at yearling (BLY), scrotal circumference at weaning (SCW) and at yearling (SCY) (Strukturangaben für Geburtsgewicht, Absetzgewicht, Jährlingsgewicht, Mittelfußknochenlänge bei Geburt, Hüfthöhe beim Absetzen und als Jährling, Körperlänge beim Absetzen und als Jährling, Hodenumfang beim Absetzen und als Jährling)

Description	**Traits**									
	BW (kg)	**WW (kg)**	**YW (kg)**	**CB (cm)**	**HHW (cm)**	**HHY (cm)**	**BLW (cm)**	**BLY (cm)**	**SCW (cm)**	**SCY (cm)**
Number of records	1147	1122	1005	1092	1183	1131	996	894	241	475
Number of animals	1497	1497	1497	1497	1497	1497	1497	1497	1497	1497
Mean	37.7	212.9	315.2	29.4	110.3	122.7	107.9	120.4	30.3	32.0
SD	4.2	36.3	61.4	1.6	4.5	5.5	6.5	8.4	4.5	3.3

SD - Standard deviation

Weighted heritabilities and genetic correlations for all traits are presented in Table 3.

Table 3

Weighted heritabilities (on diagonal) and genetic correlations (above diagonal) for all the traits (Gewogene Heribilität und genetische Korrelationen für alle Merkmale)

	BW	WW	YW	CB	HHW	HHY	BLW	BLY	SCW	SCBW
DIRECT HERITABILITIES AND CORRELATIONS										
BW	0.302	0.33	0.50	0.84	0.48	0.50	0.40	0.59	-0.54	-0.65
WW		0.10	0.931	0.52	0.79	0.81	0.76	0.66	0.29	0.37
YW			0.11	0.49	0.73	0.82	0.84	0.80	0.16	0.17
CB				0.22	0.92	0.91	0.61	0.83	-0.66	-0.58
HHW					0.28	0.97	0.92	0.79	0.25	0.38
HHY						0.33	0.94	0.82	-0.02	-0.01
BLW							0.22	0.96	0.06	0.31
BLY								0.14	-0.10	0.21
SCW									0.29	0.99
SCY										0.25
MATERNAL GENETIC HERITABILITIES AND CORRELATIONS										
BW	0.076	0.72	0.51	0.91	0.48	0.50	0.31	0.16	-	-
WW		0.05	0.96	0.77	0.79	0.81	0.10	0.04	-	-
YW			0.06	0.49	0.73	0.82	0.04	0.007	-	-
CB				0.04	0.88	0.87	0.80	0.87	-	-
HHW					0.99	0.99	0.98	-0.99	-	-
HHY						0.15	0.98	0.99	-	-
BLW							0.02	0.96	-	-
BLY								0.06	-	-
SCW									-	-
SCY										-
MATERNAL ENVIRONMENTAL HERITABILITIES AND CORRELATIONS										
BW	0.055	0.855	0.859	-	0.780	-	0.668	0.942	-0.997	-
WW		0.268	0.999	-	0.977	-	0.984	0.843	--0.958	-
YW			0.133	-	0.979	-	0.987	0.835	--0.958	-
CB				-	-	-	-	-	-	-
HHW					0.005	-	0.885	-0.11	0.474	-
HHY						-	-	-	-	-
BLW							0.07	0.897	0.989	-
BLY								0.04	0.679	-
SCW									0.03	-
SCY										-

„----" effect was not included in the model for the specific trait.

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Table 4
Variances and co-variances for all traits (Varianzen und Co-Varianzen für alle Merkmale)

	BW	WW	YW	CB	HHW	HHY	BLW	BLY	SCW	SCY
RESIDUAL VARIANCES AND CO-VARIANCES										
BW	**8.39**	21.20	28.27	1.21	3.61	3.70	1.30	1.17	1.56	2.65
WW		**364.06**	364.63	3.28	34.59	30.93	28.57	37.78	2.87	13.85
YW			**950.74**	7.08	41.65	48.08	45.45	79.86	47.61	44.78
CB				**1.67**	0.76	0.80	0.51	0.39	-0.00	1.03
HHW					**1.57**	5.36	4.52	5.10	0.40	0.31
HHY						**1.70**	3.44	5.47	5.49	3.70
BLW							**20.76**	6.42	0.78	0.44
BLY								**32.78**	0.75	0.58
SCW									**10.42**	7.27
SCY										**7.05**
DIRECT GENETIC VARIANCES AND CO-VARIANCES										
BW	**4.57**	5.05	13.46	1.21	2.13	2.85	2.12	2.89	-2.82	2.18
WW		**59.94**	87.82	2.68	13.00	16.95	13.81	10.92	5.80	4.83
YW			**155.57**	4.10	22.32	31.86	25.77	22.43	4.66	3.10
CB				**0.49**	1.32	1.64	1.16	1.50	-1.28	-0.74
HHW					**4.40**	5.50	4.64	5.19	1.01	1.22
HHY						**6.45**	5.99	6.82	-0.06	-0.04
BLW							**7.02**	6.10	0.34	1.29
BLY								**5.96**	-0.52	0.80
SCW									**4.28**	2.78
SCY										**2.37**

Table 4 (continued)

	BW	WW	YW	CB	HHW	HHY	BLW	BLY	SCW	SCY
MATERNAL GENETIC VARIANCES AND CO-VARIANCES										
BW	**1.66**	6.23	6.86	0.40	1.75	1.84	0.24	0.70	-	-
WW		**40.52**	52.17	1.76	19.72	18.91	3.77	9.27	-	-
YW			**84.44**	1.47	26.15	24.91	6.28	14.83	-	-
CB				**0.001**	0.45	0.45	0.32	0.52	-	-
HHW					**0.94**	3.25	2.45	3.80	-	-
HHY						**2.74**	2.47	3.83	-	-
BLW							**0.07**	0.15	-	-
BLY								**0.49**	-	-
SCW									-	-
SCY										-
MATERNAL ENVIRONMENTAL VARIANCES AND CO-VARIANCES										
BW	**0.70**	9.06	9.00	-	0.05	-	1.52	1.83	-0.88	-
WW		**148.38**	139.93	-	1.10	-	25.46	18.55	-10.78	-
YW			**131.88**	-	0.96	-	27.34	19.67	-10.82	-
CB				-	0.09	-	-	-	-	-
HHW					**0.09**	-	0.35	-0.03	0.38	-
HHY						-	-	-	-	-
BLW							**2.19**	1.71	1.37	-
BLY								**1.88**	1.077	-
SCW									**0.50**	-
SCY										-

„—" effect was not included in the model for the specific trait. *Heritability estimates are presented on the diagonals and genetic correlations on the off diagonals.

Heritability estimates of the growth traits (Table 3) compared well with the National Genetic Evaluation of the South African Hereford (BW: $h^2 = 0.283$, $m^2 = 0.108$; WW: $h^2 = 0.109$, $m^2 = 0.111$ and YW: $h^2 = 0.109$, $m^2 = 0.093$) (MOSTERT, 1997 - unpublished data). Except for the direct heritability of BW, estimates found in this study were lower than the average estimates found in the literature (KOOTS et al., 1994). Contrary to the results of MEYER (1995), CB was not subjected to maternal effects. The direct heritability of CB compared well with that estimated by MEYER (1995) of 0.30 on Australian Polled Herefords. Literature estimates varied from 0.08 and 0.11 for length of rear and fore cannon in live animals to 0.48 for length of metacarpal bone of cattle slaughtered at fixed weight (WILSON et al., 1976). GILBERT et al. (1993) reported a heritability of 0.3 for CB measured at weaning.

Structural traits tended to be highly heritable. Estimates reported in the literature for height varied from 0.36 at weaning (MEYER, 1995) to 0.43 and 0.57 for Angus and Hereford at one year of age (GILBERT et al., 1993). The direct heritability found in this study at weaning for height was lower than most estimates, but still indicates moderate heritability. The estimate for hip height at yearling in this study was 0.33, also lower than the 0.59 reported by BULLOCK and BERTRAND (1993). Maternal heritabilities for hip height at weaning (0.10) and yearling (0.15) were low. This supports the findings of MEYER (1995) who indicated that maternal effects have little influence on hip height (0.04).

Length of body, at weaning and yearling, had lower direct heritabilities than that for hip height at the same ages, while the estimates for maternal genetic effects were low. The maternal environmental effect had a greater influence on BLW ($c^2 = 0.07$) than the maternal genetic effect ($m^2 = 0.02$), while at yearling the reverse was found ($c^2 = 0.04$ and $m^2 = 0.06$) (Table 3).

Direct heritabilities for yearling scrotal circumference of 0.53 for Hereford and 0.16 for Brangus were reported by KRIESE et al. (1990). TOELLE and ROBISON (1985) estimated heritabilities of 0.08 and 0.44 at weaning and yearling respectively. KEETON et al. (1996) found heritabilities of 0.46 for SC at weaning. Direct heritabilities estimated in this study were lower for SC at both weaning (0.29) and yearling (0.25).

Positive genetic correlations were found between BW and hip height (0.48 with HHW; 0.5 with HHY) and BW and body length (0.4 with BLW; 0.59 with BLY). The genetic correlation estimates of weight (WW and YW) with body length and height were highly positive. Estimates for weights with body length ranged from 0.66 (WW x BLW) to 0.84 (YW x BLY) and for weights with hip height ranging from 0.73 (YW x HHW) to 0.82 (YW x HHY). This suggests that selection for weight should favour taller and longer animals.

A higher correlation was found (0.9) between CB and hip height, than between BW and hip height at weaning and year old. Cannon bone should therefore be a good early predictor of the height of the animal at both ages. Cannon bone was also highly correlated (0.88) with BW, but only moderately correlated with WW (0.53) and YW (0.48). The results of this study confirmed the findings of MEYER (1995) that showed CB as a good predictor of mature size. According to MEYER (1995) genetic correlations between CB and mature size ranged from 0.6 to 0.7.

Scrotal circumferences at weaning and year old were negatively correlated (- 0.54 and -0.65) with BW. Low positive correlations were found for SC with WW (0.29) and YW (0.37). KNIGHTS et al. (1984) reported low, but positive genetic correlations between weight at birth, at weaning and at year old with SC, suggesting that bulls superior for growth should sire sons with a larger scrotal circumference. High negative correlations were found between SC at weaning (-0.66) and yearling (-.58) with cannon bone. This indicates that selection for fast maturing animals will not necessarily lead to larger SC. COULTER and FOOTE (1977) reported a curvilinear relationship between SC and body weight and that the testes tend to reach mature size more rapidly. It is therefore not possible to conclude that selection for heavier animals will necessarily result in change in scrotal circumference. Body height and length at weaning and year old seem to have little effect on scrotal circumference. As scrotal circumference is recognized as a good indicator of fertility, it is important to pay more attention to possible negative and or positive correlations between scrotal circumference and body weight in long term selection for heavier bulls.

Conclusion

Maternal effects were evident in body measurements, even after weaning. As expected, ample evidence was found of positive genetic correlations among traits associated with skeletal development. Maturity height end-points had a negative genetic correlation with SC (CB, HHY) whereas height pre-weaning had no detrimental effect. Pre-weaning growth had no detrimental effect on SC, but there is reason for concern if selection is based on growth end-points.

Body measurements such as CB at birth can be used by Hereford breeders in conjunction with selection for growth. This study indicates that CB, if measured accurately could receive more emphasis as an early indicator of mature size and weights at different ages.

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Received: 28.04.1998

Accepted: 15.11.1999

Authors' addresses

ESTÉ VAN MARLE-KÖSTER, BSc (Agric) Honns. MSc (Agric) Animal Science/Breeding
Department of Animal and Wildlife Sciences
Faculty of Biological and Agricultural Sciences
University of Pretoria
Pretoria 0002, South Africa

B.E. MOSTERT, BSc (Agric) Honns. MSc (Agric) Animal Science
J. VAN DER WESTHUIZEN, Ph.D Animal Breeding
ARC-Animal
Improvement Institute
Irene 0062, South Africa

Arch. Tierz., Dummerstorf 43 (2000) 1, 16

Buchbesprechung

Qualität von Fleisch und Fleischwaren (Bd. 1 und 2)

WOLFGANG BRANSCHEID, KARL-OTTO HONIKEL, GERHARD von LENGERKEN, KLAUS TROEGER (Hrsg.)

921 Seiten, 239 Tabellen, 225 Abbildungen (68 farb.), Deutscher Fachverlag, Frankfurt/M., 1998,
ISBN 3-87150-513-7, 248,00 DM; 1810,00 ÖS; 220,00 SFr

Mit dem zweibändigen Titel zur Qualität von Fleisch- und Fleischwaren haben die Herausgeber und weitere kompetente Autoren einem dringenden Bedürfnis nach einem Fachbuch entsprochen, das sowohl Erzeuger und Verarbeiter als auch Verbraucher gleichermaßen interessiert. Im Gegensatz zum umfangreich vorliegenden Schrifttum zu einzelnen Teilgebieten, war es das Ziel, ein gesamtheitliches System der Qualitätssicherung bei Fleisch- und Fleischwaren von der tierischen Erzeugung, über Transport und Vermarktung, Schlachtung bis zur Verarbeitung darzustellen. Dies ist mit hohem wissenschaftlichen Anspruch gelungen.
Die zwei Bände gliedern sich in 20 Hauptabschnitte, die übersichtlich und detailliert untergliedert sind. Der erste Buchteil des 1. Bandes wird u.a. durch Informationen zur Fleischproduktion, Verbrauch und Vermarktung, Marketing von Fleisch sowie das Qualitätsmanagement, die Komponenten des Schlachttierwertes, die Erfassung der Schlachtkörperzusammensetzung und die Einstufung in Handelsklassen eingeleitet. Es folgen die speziellen Fragen des Schlachttierwertes und seiner Beeinflußbarkeit bei Rind, Kalb, Schwein, Schaf, Ziege, Gehegewild, Kaninchen und Geflügel. Mit dem Schlachtprozeß befassen sich die Abschnitte Schlachttiertransport, Fleischgewinnung und Behandlung sowie Schlachtnebenprodukte und Schlachtabfälle. Der zweite Band wird eingeleitet mit dem Komplex Fleischhygiene sowie der Rückstandsproblematik, ihrer Untersuchung und Bewertung. Es folgen die anatomisch-physiologischen Grundlagen der Fleischqualität, die biotechnischen Prozesse der Fleischbildung, die ernährungsphysiologische Bedeutung von Fleisch- und Fleischerzeugnissen, die Bestimmung der Komponenten und Eigenschaften von Fleisch- und Fleischwaren und das umfangreiche Kapitel Fleischwaren. Jedem Abschnitt bzw. Unterabschnitt sind ein weiterführendes Literaturverzeichnis und wo notwendig, gesetzliche Regelungen aus deutschem bzw. EU-Recht angefügt.
Bei dem vorliegenden Fachbuch handelt es sich um ein auf dem neuesten Wissensstand beruhendes, sorgfältiges und kenntnisreich aufgebautes, erschöpfendes Werk. Es ist didaktisch gut aufbereitet, was auch durch drucktechnische Texthervorhebungen, viele Tabellen, Abbildungen und Übersichten wirkungsvoll unterstützt wird. Darüber hinaus ist es in einer sehr verständlichen Sprache geschrieben.
Für das Lebensmittel Fleisch und Fleischwaren ist Qualität von eminenter Bedeutung. Dieses Buch leistet in der gegenwärtigen Argumentationssituation zum Qualitätsstreben bei tierischen Nahrungsmitteln einen wesentlichen Beitrag und demonstriert anschaulich mit welcher hohen Verantwortung sich Wissenschaft und Praxis, alle an der Fleischkette Beteiligten, dieser Problematik stellen. Es ist ein Fachbuch, ein unverzichtbares Nachschlagewerk, das für den Tierproduzenten und den in Schlachtung oder Verarbeitung Tätigen ebenso hilfreich ist, wie für den in der Landwirtschaft, Veterinärmedizin oder der Nahrungsgüterwirtschaft wissenschaftlich Arbeitenden. In gleicher Weise kann es für die Weiterbildung, aber auch Auszubildenden und Studierenden der genannten Disziplinen und anderer biologischen Fachrichtungen sehr empfohlen werden.

ERNST RITTER, Dummerstorf