A METHOD FOR OPTIMAL EVALUATION OF MEAT QUALITY AND STRESS SUSCEPTIBILITY

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1. INTRODUCTION

In the estimation of breeding values the performance of an animal is estimated linearily. The animal gets the more points the higher the performance in the trait is. This kind of evaluation is correct for characteristics as for example daily gain because each extra gain in performance trait produces additional economical profit.

For characteristics of meat quality and stress susceptibility however a linear approach is not valid because these traits have an optimum level. An increase in performance beyond the optimum does not produce additional profit but economical loss.

2. SQUARE APPROACH

2.1. CHOICE OF FUNCTION

Population means of most characteristics of meat quality and stress susceptibility are lower than the optimum for these traits. Therefore a square evaluation as squared deviation from the optimum (KEMPTHORNE and NORDSKOG, 1959) offers itself. The squared deviation from the optimum can be written:

$$z_i = (x_i - x_{opt})^2$$

Rebsamen (1980) proposes the mean of squared deviations as contemporary average and use of standardized deviations from average:

$$z_i = \frac{(x_i - x_{opt})^2 - \bar{z}}{s_z} \quad ; \quad \bar{z} = \frac{\sum (x_i - x_{opt})^2}{n}$$

In Switzerland a so called FQ-value (Meat Quality value) is created in this way. FQ is defined as sum of the traits meat colour and pH-value 30 minutes after slaughter. Aims of square evaluation are:

- Identical valuation of deviations on both sides of the optimum
- Higher weighting of extreme deviations by squaring
- Identical valuation of both traits by standardizing

Figure 1 shows the square evaluation of the trait meat colour as example for a square approach of characteristics.

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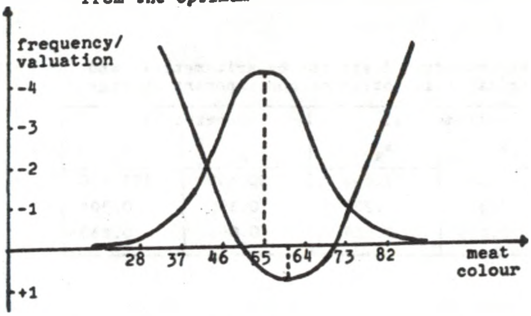
Fig.1: Evaluation of meat colour as squared deviation from the optimum



2.2. CRITICAL REFLECTION ON SQUARE PROCEDURES

While calculating the contemporary average (=mean of squared deviations from the optimum) the extreme deviations draw the mean in result of their higher weight to themselves. So they cancel a portion of their higher weighting. A geometrical calculation takes the higher weight of extreme deviations into account.

A second point of view is the common definition of the expression "optimum". In general optimum means "the best, the highest". Everything beside the optimum is worse. Therefore the contemporary average as absolute term of the square function is to be set to zero.

The following three functions to evaluate meat quality and stress susceptibility traits are discussed:

a) Arithmetical mean ($\bar{x}_a$) as contemporary average and standard deviation (s_a) by $\bar{x}_a$:

$$\Delta x_i = \frac{(x_i - x_{opt})^2 - \bar{x}_a}{s_a}$$

b) Geometrical mean ($\bar{x}_g$) as contemporary average and standard deviation (s_g) by $\bar{x}_g$:

$$\Delta x_i = \frac{(x_i - x_{opt})^2 - \bar{x}_g}{s_g}$$

c) without contemporary average, standard deviation (s_a) :

$$\Delta x_i = \frac{(x_i - x_{opt})^2}{s_a}$$

The effects of the definition of different means has been tested on 257 pigs from the litter testing station Achterwehr (Table 1).

Table 1: Mean and standard deviation by arithmetical and geometrical calculation of contemporary average

trait	arithmetical		geometrical	
	$\bar{x}_a$	s_a	$\bar{x}_g$	s_g
meat colour	106.000	131.600	30.600	151.400
pH_1	0.337	0.264	0.185	0.304
pH_{24}	0.128	0.114	0.066	0.130

3. RESULTS

Under the acceptance of equal weighting of one standard deviation in linear and square valuation the results are as follows: Choosing the arithmetical mean as contemporary average the square valuation leads for 135 pigs to a nearly similar, for 60 pigs to a better and for 62 to a worse breeding value than linear approach. By use of the geometrical contemporary average no animals are valuated better, 190 nearly similar and 67 worse. For the function without contemporary average only 75 pigs are evaluated almost similar and 182 worse. Detailed informations can be taken from Tables 2 - 4.

Table 2: Comparison of linear and square evaluation, arithmetical contemporary average for square approach

		Standardized deviation from mean (linear)								Σ
		≤-3s	≤-2s	≤-1s	< 0s	≥ 0s	≥ 1s	≥2s	≥3s	
Standardized deviation of squared deviation from optimum from contemporary average	≥0s				52	84	36			172
	<0s			8	34		4	4		50
	≤-1s			17				2		19
	≤-2s			9						9
	≤-3s		1	5					1	7
Σ			1	39	86	84	40	6	1	257

Table 3: Comparison of linear and square evaluation, geometrical contemporary average for square approach

		Standardized deviation from mean (linear)								Σ
		≤-3s	≤-2s	≤-1s	< 0s	≥ 0s	≥ 1s	≥2s	≥3s	
Standardized deviation of squared deviation from optimum from contemporary average	≥ 0s					84	18			102
	< 0s				83		22			107
	≤-1s			23	3			2		30
	≤-2s			11				4		15
	≤-3s		1	5					1	7
Σ			1	39	86	84	40	6	1	257

Table 4: Comparison of linear and square evaluation, without contemporary average for square approach

		Standardized deviation from mean (linear)								Σ
		<-3s	<-2s	<-1s	< 0s	> 0s	> 1s	> 2s	> 3s	
Standardized squared deviation from the optimum	> 0s									
	< 0s				63	84	39			186
	<-1s			12	23		1	5		41
	<-2s			13				1		14
	<-3s		1	14					1	16
Σ			1	39	86	84	40	6	1	257

3.1. COMPARISON OF EFFECTS OF ARITHMETICAL AND GEOMETRICAL CONTEMPORARY AVERAGE

As Table 5 shows 60 % of the pigs get extra charge by calculating the contemporary average arithmetically, while by geometrical calculation the part of pigs getting extra charge falls to 40 %. Through this constriction the expression "optimal" rather seems to be correct. For example the range for extra charge for the trait meat colour is constricted from 50-70 to 55-65 points. Therefore the geometrical calculation of the contemporary average stops extra charge for performances - especially in the traits pH_1- and pH_{24}-value - which are not satisfying.

Table 5: Portion and performance of animals getting extra charge by arithmetical and geometrical contemporary average

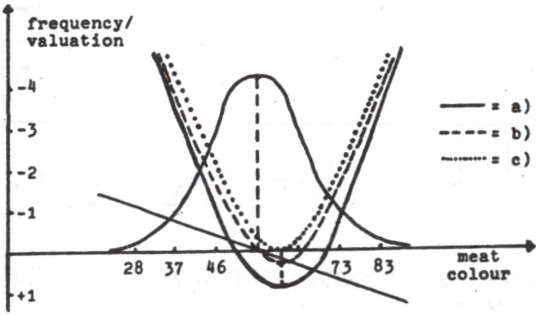
Trait	Contemp. average	Boundry for extra charge: points, upper	points, lower	standard deviation, upper	standard deviation, lower	Portion of animals with extra charge in %
Meat colour	arith.	49.70	70.30	-0.59	1.70	67.8
	geome.	54.40	65.60	-0.07	1.18	37.9
pH_1	arith.	5.62	6.78	-0.27	3.60	60.6
	geome.	5.77	6.63	+0.23	3.10	40.9
pH_{24}	arith.	5.24	5.96	-0.38	4.10	64.8
	geome.	5.43	5.86	+0.25	3.50	40.1

3.2. RELATIONS BETWEEN THE THREE SQUARE FUNCTIONS AS WELL AS SQUARE AND LINEAR VALUATION

Figure 2 illustrates three square functions compared to a linear one. Basically it can be seen that

- the vertex of the parabolic curves is in the optimum
- the contemporary average moves the vertex perpendicularily and effects the rise scarcely
- the choice of the contemporary average especially effects the valuation of pigs near the optimum, extreme deviations are valuated almost similar

Fig.2: Three square and a linear function to valuate the trait meat colour



- large differences between population mean and optimum effect a flattening of square valuation curves

The correlations between the different square functions are for all traits between 0.99 and 1.00. The correlation between linear and square function depends on the difference between optimum and population mean. As Table 6 shows the correlation rises with increasing difference to -1 or +1. If the population mean is near the optimum the correlation falls to zero.

Table 6: Correlations between linear and square evaluation depending on difference between population mean and optimum

Correlation between lin. and square evaluation	Difference between population mean and optimum in standard deviations						
	-3s	-2s	-1s	0s	+1s	+2s	+3s
arith. contemporary average	0.94	0.91	0.82	0.10	-0.77	-0.89	-0.93
geome. contemporary average	0.94	0.92	0.81	0.16	-0.74	-0.90	-0.93

4. DISCUSSION

The evaluation of traits as squared deviation from the optimum is a method to take the special demands of characteristics of meat quality and stress susceptibility into account. These characteristics show an optimum. Deviations to both sides are negativ.

Especially two aims are fulfilled by square evaluation: Deviations to both sides of the optimum are valuated similar and extreme deviations get higher weights. Thus square evaluation leads to a selection which excludes extreme deviations to both sides of the optimum.

A contemporary average is not nescessary as present examination shows. The efficiency of selection is not injured because the optimum is like a kind of constant contemporary average.

If there are large differences between optimum and population mean square evaluation becomes similar to linear approach. But in any case animals with performances near the optimum get extra charge by square evaluation, so that even in case of large differences square evaluation leads to optimal breeding values.

For practical application the standardized squared deviation from the optimum is considered to be the best of these three methods. Firstly is easy to understand, secondly is easier to calculate than the others and thirdly no disadvantages are to be found in comparison to functions with contemporary average.

An optimal method would be to combine standardized squared deviations from the optimum of some traits of meat quality and stress susceptibility to one value and include this value into selection indexes.

5. SUMMARY

Usually characteristics of meat quality and stress susceptibility show an optimum compared to other traits. Therefore a linear evaluation cannot fulfil the special demands of these characteristics. Positive deviations from the optimum get rising extra charge when practising a linear approach though they are as unwanted as negative deviations. To reach a correct evaluation, different possibilities of a square valuation were examined. Indeed there are possibilities to reach this aim. The evaluation as squared deviation from the optimum could be an alternative to linear approach. This makes it possible to select on both sides of the optimum. Deviations to both sides are of the same negative value by square valuation. Thus selection directs at extreme deviations to both sides of the optimum. In particular the effects of the choice of the contemporary average and the importance of the difference between population mean and optimum are discussed. The contemporary average has almost no influence on the ranking of the animals. With rising difference between population mean and optimum the square evaluation leads to almost similar results as a linear approach.

R E S U M E N

Generalmente, los caracteres de calidad de la carne y de susceptibilidad al stress demuestran un óptimo en comparación con otros caracteres. Los métodos de evaluación lineal no pueden cumplir con las demandas especiales de estos caracteres. Las desviaciones positivas desde el óptimo presentan una importancia superior cuando se practica un exámen lineal creyendose que se trata de desviaciones negativas. Para obtener una evaluación correcta, se examinaron diferentes posibilidades de una evaluación cuadrática. Ciertamente, existen posibilidades de alcanzar este logro. La evaluación como desviación cuadrática desde el óptimo podría ser la alternativa para la aproximación lineal. Ello hace posible seleccionar en ambos lados del óptimo. Lasdesviaciones a ambos lados son del mismo valor negativo por evaluación cuadrática. Por ello la selección se dirige a desviaciones extremas en ambos lados del óptimo. En particular, los efectos de la elección de una media contemporánea y la importancia de las diferencias entre la media de la población y el óptimo se discuten. La media contemporánea no tiene casi influencia sobre ~~el ordenamiento~~ la categorización del animal. Con diferencias entre la media de la población y el óptimo, la evaluación cuadrada tiende a resultados casi análogos a los de la investigación lineal.

6. LITERATURE

KEMPTHORNE, O. and A.W. NORDSKOG (1959) : Restricted selection indices, Biometrics 15: 10 - 19

REBSAMEN, A. (1980): Personal communication