Arch. Tierz., Dummerstorf 44 (2001) 6, 649-659

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Selection to improve birth and weaning weight of Javanese Fat Tailed Sheep

Dedicated to Prof. Dr. Dr. h. c. Hans Joachim Schwark on the occasion of his 75th birthday

Summary

In Indonesia, the Javanese Fat Tailed Sheep is a very popular domestic animal for its meat production. However, selection to increase body weight has never been done by local farmers. As a result the variability of body weight is high, and expected that application of a selection program can improve this trait Two steps of selection were done in order to improve birth and body weight. In the first selection, the elite group was established by selecting the best 40 females and 3 males from 12500 sheep reared by local farmers based on their mature body weight and tail length. The control group was established by randomly selecting 40 females and 4 males. In the second step of selection, the best 50% females and 5% males of the progeny of the elite group was selected based on their weaning weight and tail size. The first selection results indicate that there was a positive genetic progress in both birth and weaning weight. Selection had increased 7.17% and 5.48% of male and female birth weight respectively and 9.48% and 9.78% of male and female weaning weight, respectively. Positive genetic progresses of birth and body weight were also found after the second selection. Birth weights of males and females were 6.75% and 7.20% higher than those in the control group. Male and female weaning weights were 5.60 % and 8.19% higher than those in the control group, however, selection for weaning weight did not affect reproductive traits.

Key Words: sheep, genetic, selection, weight, heritability

Zusammenfassung

Titel der Arbeit: **Selektion auf Erhöhung des Geburts- und Absetzgewichtes beim Javanischen Fettschwanzschaf**

Das Javanische Fettschwanzschaf spielt in Indonesien eine große Rolle in der Versorgung der Bevölkerung mit Fleisch. Eine Selektion auf Erhöhung der Körpermasse durch die Züchter ist nicht erfolgt. Diese Rasse ist durch eine hohe Variabilität der Körpermasse charakterisiert, die eine Selektion ermöglicht. In zwei Stufen wurde zur Verbesserung der Geburts- und Körpergewichte ein Selektionsprogramm realisiert.. In der ersten Stufe wurde eine Elitepopulation gebildet, die aus 40 weiblichen und 3 männlichen Tieren bestand und aus einer Gesamtpopulation von 12.500 Schafen selektiert wurde. Die zufällig selektierte Kontrollgruppe bestand aus 40 weiblichen und 4 männlichen Tieren.

Im zweiten Schritt wurden 50% der besten weiblichen und 5% der besten männlichen Nachkommen dieser Elitetiere auf der Grundlage ihrer Absetzgewichte und der Schwanzlänge selektiert. Diese Selektion erhöhte sowohl das Geburts- als auch das Absetzgewicht. So erhöhten sich die Geburtsgewichte um 7,17% ♂ und 5,48% ♀ und im Absetzgewicht um 9,48% ♂ bzw. 9,78% ♀. Ein positiver züchterischer Erfolg in beiden Merkmalen wurde auch im zweiten Selektionsschritt erhalten. So war das Geburtsgewicht der männlichen und weiblichen Tiere um 6,75% und 7,20 % höher als die der Kontrolle und im Absetzgwicht um 5,60% bzw. 8,19% überlegen. Diese Form der Selektion nach Absetzmasse und Schwanzlänge hatte keinen negativen Effekt auf die Fruchtbarkeitsmerkmale.

Schlüsselwörter: Schaf, Selektionsexperiment, Geburts- und Absetzgewicht, Heritabilität

Introduction

The sheep population in Indonesia is the largest when compared to that in other South East Asian countries. In 1992, the number of sheep in Indonesia was 5,750,000 with 49.97% of them concentrated in West Java.

There are two types of sheep, i.e. thin tailed sheep and fat tailed sheep. Thin tailed sheep can be found in the wet areas, e.g. West Java. On the other hand fat tailed sheep can mostly be found in dry areas, e.g. East Java and the eastern parts of Indonesia (SUTAMA, 1992). The sheep are relatively small, with mean mature ewe weight of 20 to 39 kg under traditional management. However, they are well adapted to the warm, humid climate of the country. They breed all year around and can have a mean lambing intervals of as low as 200 days (BRADFORD and INOUNU, 1996). DEVENDRA and McLEROY (1982) suggested that the javanese fat tailed sheep originated from West Asia and/or East Asia and were introduced by Arab traders hundred years ago. EDEY (1983) stated that after the introduction, the Indonesian fat tailed sheep were concentrated at Madura Island and then spread out to different parts of East Java and Nusa Tenggara Islands. The original fat tailed sheep have been crossed with some local sheep resulting in the fat tailed sheep that are found at present. MASON (1980), DEVENDRA and McLEROY (1982), SUTAMA and INIGUEZ (1990), SAKUL et al. (1994), and BRADFORD and INOUNU (1996) described the characteristics of fat tailed sheep as follows: hornless, white coat colour, medium size ear, sigmoid shaped tail with 15-18 vertebral bones, birth weight of 1.6 kg, weaning weight of 8.6 kg; mature weight is 43 and 40 kg for male and female respectively, and prolific ewes with high frequency of litters of three, four or more than can be expected for populations with mean litter size of generally between 1.3 and 1.9. SABRANI et al. (1993) found that lamb survival of this type of sheep is low (51.4%), coefficient of variation of weaning weight is high (26.60%) and coefficient of variation of mature weight is even higher (45.45%). With these high phenotypic variabilities, the breeder can select them in order to get significant improvements in birth and weaning weight. Selection on birth and weaning weight of javanese fat tailed sheep has not been done (Noor et al., 1998). Therefore, the main objective of this experiment was to evaluate birth and weaning weight through selection.

Material and Methods

An intensive survey was conducted to collect important data from 12500 sheep reared by local farmers in areas of East Java (in six districts, i.e. Situbondo, Sumenep, Bondowoso, Pasuruan, Pamekasan, and Probolinggo). The data collected were sex, age, birth type, number of sheep at weaning (3 months old), mature body weight (the age estimated based on the formation of permanent teeth), body length, body height, heart girth, tail length, tail width, coat colour.

Units of measurement were (i) body weight (kg): animal weight before eating in the morning, (ii) body length (cm): distance between *Tuber ischii* to *Tuberositas humeri,* (iii) body height (cm): vertical distance between the highest point of *scapula* to the ground, (iv) heart girth (cm): heart girth behind scapula (also known as chest circumference behind scapula), (v) tail length (cm): distance between the top of the tail to the end of the tail, (vi) tail width (cm): the widest tail width, (vii) coat colour: categorised into two classes, white and non-white.

Correlation among traits

In order to study the relationship among the body measurements and the relationship between body weight and linear body measurements, coefficients of correlation were estimated.

First Step of Selection

The elite group was established by selecting the best of 40 females and 3 males based on their mature weight from the 12,500 sheep that were measured independent from age, birth type and lactation (Fig. 1). Besides the mature weight, the selected sheep should have white colour coat, free from any exterior abnormalities, have large and sigmoid shaped tail. The size and shape of tail are the second selection criteria, because the traits are highly correlated to the ability of animals survive in dry areas. The selection method used in this experiment was independent culling level.
The control group was established by randomly selecting 40 females and 4 males. It should be noted that in the elite group only three males have mated the selection criteria. Both groups then were maintained at Garahan Research Centre, at Jember, East Java . Both groups were given the same type and quality of feed.

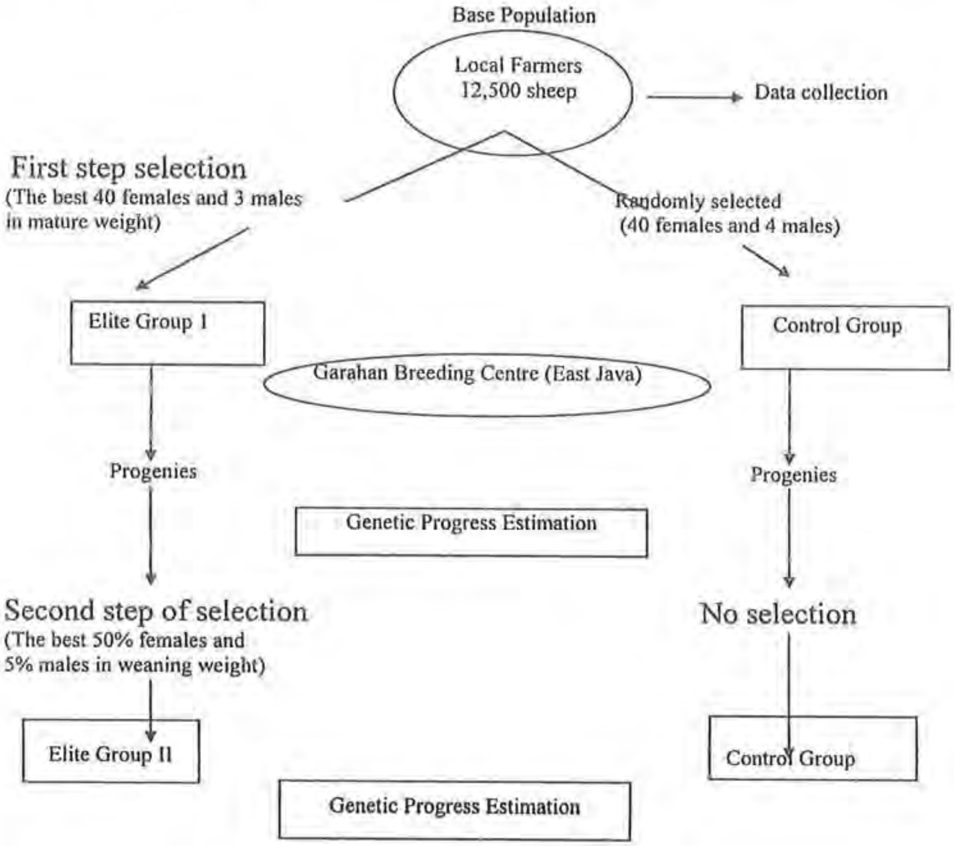

Fig. 1: Selection Scheme (Selektionsschema)

Second Step of Selection.

The progenies of both groups were maintained until they were weaned.

The best 50% females and 5% males of the progeny of the elite I group were selected based on their weaning weight and used for the parent for the next generation. There was no selection in the control group.

Heritability Estimation

The heritability of birth and weaning weight was estimated using 'Animal Model' of DFREML (MEYER, 1993). The heritability values were estimated from lambs which were born from the elite and control groups. Both sex and birth types were treated as fixed effects. Differential Selection (DS) was calculated using the following formula (NOOR, 1996):

$$DS = \overline{Xe} - \overline{Xc}$$

where:

DS : differential selection

$\overline{Xe}$: means of birth or weaning weight at the elite group

$\overline{Xc}$: means of birth or weaning weight at the control group

Genetic progress per generation (per selection cycle) was calculated using the following formula:

$$\Delta G = h^2 \times DS$$

where,

ΔG : genetic progress

h^2 : heritability of birth or weaning weight

DS : differential selection

Results

Means of Body Measurement Traits

In general, the javanese fat tailed sheep originating from Pasuruan, Situbondo and Probolinggo were significantly larger than those of other districts (Fig. 2). The variations in mean body measurement traits among district were high.

Coefficient of correlation among body measurement traits in the six different districts at the base population is presented in Table 1.

Body weight was highly correlated with body height, heart girth, tail length and tail width ($r = 0.45$ to 0.85) (Table 1). Animals that had high body weight tended to have larger tail. Some negative correlation was observed between traits other than body weight (body length, body height and heart girth) and tail length or tail width, especially in female sheep.

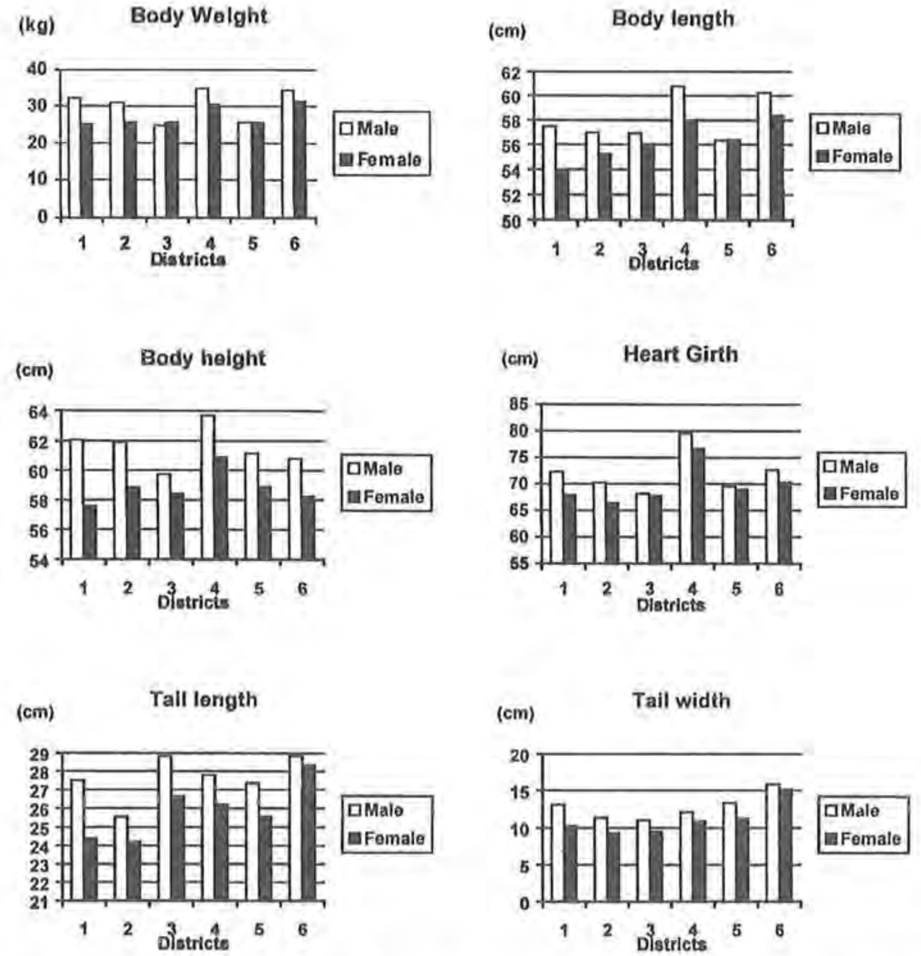

Fig. 2: The body weight, body length, body height, heart girth, tail length and tail width of male and female javanese fat tailed sheep in six districts in East Java (Note: 1. Situbondo, 2. Sumenep, 3. Bondowoso, 4. Pasuruan, 5, Pamekasan and 6. Probolinggo) (Körpergewicht, Körperlänge, Körperhöhe, Herzumfang, Schwanzlänge, Schwanzbreite von männlichen und weiblichen Javanesischen Fettschwanzschafen in 6 Regionen von Ostjava (Region 1. Situbondo, 2. Sumenep, 3. Bondowoso, 4. Pasuruan, 5. Pamekasan und 6. Probolinggo))

Table 1
Coefficients of correlation among body measurement traits of male (lower diagonal) and female (upper diagonal) javanese fat tailed sheep in Situbondo, Sumenep, Bondowoso, Pasuruan, Pamekasan, and Probolinggo (Korrelationskoeffizienten zwischen den Merkmalen der Körperkonformation in männlichen (unter der Diagonalen) und weiblichen (über der Diagonalen) Javanischen Fettschwanzschafen in 6 Regionen)

Groups		Traits					
Situbondo		BW	BL	BH	HG	TL	TW
	BW	*	0.429	0.534	0.692	0.373	0.452
	BL	0.286	*	0.671	0.370	0.334	0.153
	BH	0.727	0.673	*	0.554	0.367	0.268
	HG	0.740	0.341	0.627	*	0.356	0.362
	TL	0.463	0.530	0.598	0.455	*	0.280
	TW	0.744	0.272	0.615	0.584	0.532	*

Table 1 (continuation)

Sumenep		BW	BL	BH	HG	TL	TW
	BW	*	0.440	0.549	0.759	0.193	0.551
	BL	0.642	*	0.491	0.332	0.421	0.460
	BH	0.547	0.508	*	0.554	0.229	0.430
	HG	0.799	0.534	0.497	*	0.116	0.456
	TL	0.479	0.530	0.420	0.264	*	0.504
	TW	0.632	0.551	0.490	0.425	0.738	*
Bondowoso		BW	BL	BH	HG	TL	TW
	BW	*	0.536	0.511	0.755	0.315	0.474
	BL	0.743	*	0.670	0.582	0.317	0.414
	BH	0.749	0.783	*	0.602	0.304	0.299
	HG	0.838	0.673	0.770	*	0.452	0.599
	TL	0.558	0.616	0.494	0.756	*	0.392
	TW	0.478	0.393	0.496	0.689	0.702	*
Pasuruan		BW	BL	BH	HG	TL	TW
	BW	*	0.106	0.458	0.737	0.335	0.560
	BL	0.403	*	0.634	0.262	-0.098	0.002
	BH	0.547	0.756	*	0.458	0.034	-0.049
	HG	0.647	0.590	0.594	*	0.098	0.550
	TL	0.711	0.078	0.260	0.502	*	0.223
	TW	0.539	0.118	0.191	0.431	0.659	*
Pamekasan		BW	BL	BH	HG	TL	TW
	BW	*	0.372	0.530	0.645	0.433	0.391
	BL	0.637	*	0.439	0.347	0.155	0.402
	BH	0.649	0.604	*	0.518	0.353	0.444
	HG	0.738	0.547	0.763	*	0.377	0.500
	TL	0.633	0.412	0.448	0.508	*	0.271
	TW	0.647	0.505	0.615	0.685	0.610	*
Probolinggo		BW	BL	BH	HG	TL	TW
	BW	*	0.107	0.309	0.077	0.517	0.462
	BL	0.088	*	0.755	0.642	-0.101	0.040
	BH	0.243	0.799	*	0.623	-0.375	-0.162
	HG	0.190	0.433	0.416	*	-0.106	0.102
	TL	0.435	-0.210	-0.410	-0.020	*	0.403
	TW	0.437	-0.109	-0.269	0.110	0.281	*

Note : BW : body weight; BL : body length; BH : body height; HG : heart girth; TL : tail length; TW : tail width

Selection Experiment Results

Birth and body weight of sheep in the elite I and control groups are presented in Table 2.

Table 2
Birth and weaning weight of male and female javanese fat tailed progenies sheep in the elite I and control groups after the first selection (Geburts- und Absetzgewichte von männlichen und weiblichen Nachkommen in der Elite (I) und Kontrollgruppe im 1. Selektionsschritt)

Traits	Groups	Male		Female	
		n	Mean ± SD	n	Mean ± SD
Birth Weight (kg)	Control	32	2.12 ± 0.49	34	2.00 ± 0.46
	Elite I	36	2.51 ± 0.52	43	2.30 ± 0.45
Weaning Weight (kg)	Control	29	9.04 ± 2.56	30	8.12 ± 2.23
	Elite I	34	10.80 . ± 2.76	40	9.75 ± 2.38

Note : SD : Standard Deviation, n: number of observation

The first selection had improved birth and weaning weights of males and females (Table 2). This is indicated by the larger birth and weaning weight in the elite I group when compared to those in the control group. The selection also significantly increased the male tail width, however selection on mature weight did significantly increased body length, body height, heart girth and tail length of both male and female animals (Table 3).

Table 3
The t-test result between the means of body weight, body length, body height, heart girth, tail length and tail width in the elite I and control groups (Ergebnisse des t-Tests für die Merkmale der Körperkonformation in der Elite (I) und Kontrollgruppe)

Traits	Male		Female	
	t-value	P-value	t-value	P-value
Body weight	-1.99	0.049	-4.53	0.000
Body length	0.63	0.530	0.16	0.870
Body height	-1.39	0.160	-0.30	0.760
Heart girth	-1.35	0.180	-0.80	0.420
Tail length	-0.89	0.370	0.21	0.840
Tail width	-2.14	0.034	0.55	0.590

The estimated heritability values at all ages were moderate to high (Table 4), however, due to the small number of animals used, the standard errors of heritability values were relatively high. As the animals were getting older, the additive genetic (V_A), environmental (V_E) and phenotypic (V_P) variances were also getting larger (Table 4).

Table 4
Estimated heritability values (h^2) and standard error (SE) of body weight of javanese fat tailed sheep at different ages, Additive Genetic (V_A), environmental (V_E) and phenotypic (V_P) variances, phenotypic standard deviation (SD_P) and phenotypic coefficient of variation (CV_P) (Heritabilitäten (h^2) und Standardfehler (SE) des Körpergewichtes in verschiedenen Altersstufen und deren Varianzkomponenten (V_A – additiv-genetische Varianzen, V_E – Umweltvarianzen, V_P – phänotypische Varianzen, SD_P – phänotypische Standardabweichungen, CV_P – phänotypische Variationskoeffizienten))

Body Weight at week	Number of Animals	$h^2 \pm SE$	V_A	V_E	V_P	SD_P	CV_P (%)
1	73	0.385 ± 0.282	0.082	0.131	0.212	0.461	21.27
2	73	0.259 ± 0.239	0.171	0.493	0.775	0.816	25.55
3	73	0.122 ± 0.152	0.144	1.032	0.176	1.085	24.07
5	73	0.403 ± 0.131	1.017	0.151	2.525	1.589	23.75
6	73	0.390 ± 0.315	1.465	2.291	3.756	1.938	25.48
7	73	0.276 ± 0.278	1.366	3.584	5.950	2.225	26.02
8	72	0.357 ± 0.323	1.402	4.050	5.452	2.335	24.70
9	72	0.257 ± 0.323	1.403	4.045	5.448	2.334	24.12
10	72	0.445 ± 0.450	2.263	2.827	5.090	2.256	22.21
11	71	0.647 ± 0.432	3.669	1.994	5.663	2.374	22.60
13	71	0.487 ± 0.322	2.843	2.993	5.836	2.416	20.64
14	71	0.173 ± 0.144	0.888	4.244	5.132	2.265	18.90

Table 5
The differential selection and genetic progress of birth and weaning weight of males and females javanese fat tailed sheep after the first selection (Selektionsdifferenz und Selektionserfolg im Geburts- und Absetzgewicht nach dem 1. Selektionsschritt)

	Traits	Male	Female
Differential Selection (kg)	Birth Weight (kg)	0.3927	0.303
	Weaning Weight (kg)	1.76	1.63
Genetic Progress (kg)	Birth Weight (kg)	0.1520	0.1169
	Weaning Weight (kg)	0.8571	0.7938

The differential selection and the genetic progress summarised in Table 5 indicate first selection results that there was a positive genetic progress in both birth and weaning weight. Selection had increased 7.17% and 5.48% of male and female birth weight, respectively, and 9.48% and 9.78% of male and female weaning weight, respectively.

The female reproductive performance in the elite I and control groups are (Table 6), showed that selection on mature weight did not significantly affect reproductive traits.

Table 6
Pregnancy rate, birth rate, prolification and reproduction rate of sheep in elite I and control group progenies (Fruchtbarkeitsdaten in der Elite I und Kontrollgruppe)

Traits	Elite I Group	Control Group	P value
Pregnancy rate[1]	99.67 ± 1.05	95.74 ± 7.10	0.073
Birth rate[2]	98.80 ± 2.83	94.53 ± 7.94	0.093
Prolification[3]	1.54 ± 0.19	1.66 ± 0.34	0.290
Reproduction rate[4]	1.18 ± 0.08	1.12 ± 0.12	0.200

Note
1 Number of pregnant ewes divided by number of mated ewes x 100 %
2 Number of ewes giving birth divided by number of mated ewes x 100 %
3 Number of born sheep divided by number of pregnant ewes
4.Number of weaned sheep divided by number of mated ewes
P-Value Probability value of the t-test

Positive genetic progresses of birth and body weight were also found after the second selection. Birth weights of males and females were 6.75% and 7.20% higher than those in the control group. Male and female weaning weights were 5.60 % and 8.19% higher than those in the control group (Tables 7 and 8).

Table 7
Birth and weaning weight of male and female javanese fat tailed sheep progenies at elite II and control group after the second selection (Geburts- und Absetzgewichte der Nachkommen der Elite (II) und Kontrollgruppe)

Traits	Groups	Male		Female	
		N	Mean ± SD	N	Mean ± SD
Birth Weight (kg)	Control	32	2.32 ± 0.43	39	2.20 ± 0.43
	Elite II	48	2.72 ± 0.24	50	2.61 ± 0.17
Weaning Weight (kg)	Control	29	10.88 ± 1.87	33	9.40 ± 2.22
	Elite II	42	12.13 . ± 1.49	46	10.98 ± 1.19

Note : SD : Standard Deviation, n: number of observation

Table 8
The differential selection and genetic progress of birth and weaning weight of males and females javanese fat tailed sheep after the second selection (Selektionsdifferenz und Selektionserfolg im Geburts- und Absetzgewicht nach dem 2. Selektionsschritt)

	Traits	Male	Female
Differential Selection (kg)	Birth Weight (kg)	0.40	0.41
	Weaning Weight (kg)	1.25	1.58
Genetic Progress (kg)	Birth Weight (kg)	0.1548	0.15867
	Weaning Weight (kg)	0.6088	0.7695

Discussion

The variation of body measurement traits between districts were high (Fig. 2). Considering that the feed quality and management system in those districts are almost similar, it was suggested that this high variation is caused by the genetic variation due to the fact that no selection had been done before.

The significant test results between male and female in all traits indicate a distinct sexual dimorphism, where body measurement traits of male are significantly larger than those of females.

The javanese fat tailed sheep is a prolific breed. They produce single (34.41%), twins (42.16%), and triplets and quadruplets (23.43%), however, the mortality rate of twins, triplets and quadruplets are higher than singles (9.89% for twins, 12.49% for triplets and quadruplets vs. 0.01% for single). The causes of this high mortality of twins, triplets and quadruplets were due to low birth weight and lack of milk. This high mortality at birth may be significantly reduced by providing better feeding to pregnant ewes at the last quarter of the pregnancy period and by giving sufficient milk to the new-born sheep. Considering the available facilities and knowledge of local farmers, it is recommended that selection should also be aimed at producing twins rather than triplets or quadruplets. In most cases, farmers can still manage twin born sheep properly, hence, the mortality can be kept low.

Fig. 3: Male javanese fat tailed sheep (Bock des Javanischen Fettschwanzschafes)

Fig. 4: Male (left) and female (right) Javanese fat tailed sheep (Bock (links) und Mutterschaf (rechts) des Javanischen Fettschwanzschafes)

The first selection results indicated that positive genetic progress in both birth and weaning weight. Selection had increased 7.17% and 5.48% of male and female birth weight, respectively, and 9.48% and 9.78% of male and female weaning weight, respectively. It should be noted that if the genetic progress is calculated using the formula $\Delta G = h^2 \times i\,\sigma_P$ where, ΔG is the genetic progress, h^2 is heritability values, i is selection intensity and σ_P is phenotypic variance, then the genetic progress must be higher because of high selection intensity. As, in this experiment it was decided to reduce the environmental effects by maintaining both selected and control group under the same environmental condition. The small genetic progresses found in this experiment suggest a larger environmental impact in the districts or probably among farmers.

The results indicate that local sheep can be improved genetically using a conventional selection method. Occasionally black and brown spot colour still appeared in the elite group. However, the percentage of this occurrence was very low. During the experiment no abnormalities are apparent in the elite group.
Tail shape is also an important trait in this experiment. The tail size is closely related to the ability of the animal survive in the dry area. The fat deposit in the tail may function as a body reserve and utilized when the environmental conditions and feed quality are poor. The tail size will appear small in this condition, however, when the environmental condition is returned to normal, the tail size become large. INIGUEZ et al. (1991) found that among the fat-tailed populations in Indonesia, those on the island of Madura had on the average the most extreme fat tails. Under good feeding conditions, fat mass of the tails interfered substantially with the ability of the rams to serve ewes (OBST et al., 1980).
Selection also improved the size of tail (Figures 3 and 4) and the large size of the tail made it difficult to mate naturally. The tail has to be lifted up during the mating. In order to solve this problem several females were docked. The docking result indicate that males do not want to mate if the tail of the female is too short. The male tend to mate female animals with normal tail. Based on these results it is recommended that selection should aim to produce sheep with large body size and optimum tail size so they still could mate naturally.

Conclusion

Selection on weaning weight of javanese fat tailed sheep substantially improved birth and weaning weights, however, this selection did not significantly affect reproductive traits. Further improvement could still be expected if the selection is continued. Considering the high mortality rate in triplets and quadruplet lambs, under the present local farmer management condition in Indonesia, it is recommended to select ewes towards producing singles and twins.

Acknowledgements

This research was supported by ARMP II project funds from The World Bank. This paper was written while R.R. Noor on study visit at Marthin Luther University, Halle-Wittenberg Germany supported by DAAD. Special thank to Grahan Sheep and Goat Breeding Centre research group for making this experiment possible.

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Received: 1998-12-02

Accepted: 2001-10-12

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Arch. Tierz., Dummerstorf 44 (2001) 6, 660

Umweltbedingte Rückstände in Fleisch - Abnahme der Gehalte in den vergangenen 25 Jahren

H. HECHT, Kulmbach, Kurzfassung eines Fachvortrages anläßlich der 36. Kulmbacher Woche, 8. - 9. Mai 2001, Kulmbach

Anfang der 70er Jahre des vorigen Jahrhunderts fing man während des auf Hochtouren laufenden Wirtschaftswunders allmählich an, sich über die Schwermetallemissionen und die dadurch bedingten Immissionen auf Nutz- und Futterpflanzen Gedanken zu machen. Das Hauptinteresse galt damals dem Blei, zu dem schnell Arsen, Cadmium und Quecksilber kamen. Da die Höchst- bzw. Richtwerte für die Futter- und Lebensmittel nicht aufeinander abgestimmt festgelegt wurden, musste ihre gegenseitige Verträglichkeit durch Carry-over-Experimente überprüft werden.

Man stellte schnell fest, dass die Schwermetellbelastungen einiger Lebens- und Futtermittel aus toxikologischer Sicht recht hoch waren und man Maßnahmen ergreifen musste, die Immissionen als ihre Quellen zu reduzieren. Einige Änderungen der technischen Anleitung Luft zusammen mit stufenweisen Reduzierungen der Bleigehalte in Vergaserkraftstoffen waren die Folge. Die dort festgelegten Höchstwertregelungen wurden laufend verschärft mit der Folge, dass die Schwermetallbelastung vor allem bei Blei, Cadmium und Quecksilber in den Folgejahren bis zum heutigen Tage laufend abnimmt. Heute sind z. B. die Bleigehalte der Lebern und Nieren, also in den Akkumulationsorganen der Tiere für diese Elemente niedriger als sie es damals im Fleisch waren. Im Fleisch sind die Blei-, Cadmium und Quecksilbergehalte mittlerweile so niedrig, dass sie mit den modernsten Spurenelement-Nachweismethoden nicht mehr oder gerade noch nachgewiesen werden können. Die fallenden Trends der Umweltbelastung können mit Hilfe standorttreuer Wildtiere gezeigt werden.

Nach den Schwermetallen traten bald auch die persistenten Organochlorverbindungen, meist waren es Pestizide, als Umweltkontaminanten in Erscheinung. Es begann mit dem DDT und seinen Metaboliten, β-HCH folgte und endet heute bei polychlorierten Dibenzodioxinen und -furanen, Toxaphenen und planaren PCB. Auch hier konnten in den meisten Fällen die Akkumulationserscheinungen geklärt und durch Verbote oder Höchstwertregelungen erreicht werden, dass die Kontamination der vom Tier stammenden Lebensmittel laufend deutlich zurückgeht, was ihren quantitativen Nachweis und die Auswertung der Analysenergebnisse trotz modernster Nachweisverfahren immer mehr erschwert. Viele der Organochlorverbindungen haben heute als Rückstände bei uns keine Bedeutung mehr. Das gilt z. B. für DDT und seine Metaboliten und eine Reihe von Pestiziden auf Organochlorbasis wie Heptachlor, Aldrin oder auch Lindan.

Der Unfall von Tschernobyl belastete die Umwelt sehr heterogen, aber örtlich ganz erheblich mit künstlichen Radioisotopen, von denen zum Glück über lange Zeiträume nur die Cäsium-Isotope und vor allem das CS-137 Bedeutung besitzen. Aufgrund der physikalischen Eigenschaften des Cäsiums im Boden spielte das Radiocäsium aber auf landwirtschaftlichen Nutzflächen und damit in den dort erzeugten Futter- und Lebensmittel schon ein Jahr nach dem Unfall keine Rolle mehr. Anders sah und sieht noch heute die Situation bei einigen geschlossenen Moor- und Waldökosystemen aus, in denen wahrscheinlich noch viele Jahre lang bei Reh- und besonders beim Schwarzwild erhebliche Kontaminationen weit über dem als Grenzwert benutzten eigentlich von der EU nur für die Einfuhr aus Drittländern definierten Höchstwert von 600Bq/kg frische Muskelmasse liegen. Die Folgen des Unfalls von Tschernobyl sind ein Beispiel, das zeigt, wie kritisch Schadstoff-Immissionen sein und wie lange ökologische Halbwertszeiten sie besitzen können. Die Untersuchungen des Verhaltens des Radiocäsiums in Ökosystemen ließen erkennen, wo letzten Endes der Hauptteil der in die Luft emittierten persistenten Substanzen verblieb und welche Folgen das für das Ökosystem Wald und die dort lebenden Tiere haben kann.

Die Rückstandsuntersuchungen der letzten 30 Jahre haben gezeigt, dass die Gehalte an Schwermetallen und vielen der bekannten Organochlorverbindungen in unseren Lebensmitteln deutlich abgenommen haben und sich also gesetzliche Maßnahmen zur Reduzierung ihres Eintrags in die Nahrungsketten als erfolgreich erwiesen haben. Leider kommen immer noch neue bisher unbekannte oder unbeachtete Verbindungen zu den schon jetzt langen Listen potentieller Schadstoffe hinzu, wie etwa neuerdings die Chlorparaffine oder Stoffe mit hormonartigen Wirkungen, so dass die Erforschung des Verhaltens der unerwünschten Rückstände immer wieder aufs Neue gefordert und damit auch weiter entwickelt werden.