Journal of Agriculture and Rural Development in the Tropics and Subtropics
Volume 105, No. 1, 2004, pages 71–82

Productivity and Breeding Strategies of Sheep in Indonesia: A Review

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Abstract

There are two distinct types of sheep in Indonesia: thin-tailed and fat-tailed, with some strain differentiation within each. The most important sheep breeds of Indonesia are the Javanese Thin Tail (JTT) and Javanese Fat Tail (JFT) sheep of West and East Java, respectively. Included are strains of thin tailed sheep Sumatra Thin Tailed (STT), Semarang, Garut and the Priangan sheep. The government also introduced some temperate sheep breeds (such as: Merino, Suffolk, Dorset, Suffas, Dormer, St.Croix and Barbados Blackbelly sheep).

The purposes of this paper are to review the potential of productivity for local sheep and their crosses with some imported sheep breeds. The concepts of breeding strategies for sheep in Indonesia are also discussed in three parts: (1) evaluation and improvement of local breeds (2) nucleus structure, and (3) gene migration (crossbreeding).

Keywords: sheep, breeds, breeding, Indonesia

1 Origin and Development of Indonesian Sheep

The breeds of sheep are classified according to fleece and tail type and roughly described in term of colour, horn, ears and product (Masson, 1991; Gatenby, 1995). There are 4 basic tail types in domestic sheep (Devendra and McLeroy, 1982): long-tailed, short-tailed, fat-tailed, and fat-rumped. Gatenby *et al.* (1994) reported that there are three general types of the sheep native to Southeast Asia: Small coarse-wooled sheep, fat-tail sheep of Eastern Indonesia, and long-tail wooled sheep of Thailand. In Indonesia, there are two distinct types: thin-tailed and fat-tailed, with some strain differentiation within each, particularly the thin-tailed group (Edey, 1983; Iniguez *et al.*, 1993; Bradford and Inounu, 1996). In the past some temperate sheep breeds such as Merino, Suffolk, Suffas, Dorset and, more recently, the Barbados Blackbelly, St.Croix-Virgin Island white hair sheep were introduced to Indonesia (RIAP and SRCRSP, 1990; Utoyo, 1995).

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1.1 Thin-tailed Types

The most numerous group in this class is the Javanese Thin-tail (JTT), the predominant type in West Java, which is the province with the largest sheep population (Merkens and Soemirat, 1979; RIAP and SRCRSP, 1990). The JTT sheep has some strains or local sub populations that are named after the local regions where they are prevalent, such as Garut and the Priangan sheep (Iniguez *et al.*, 1993). The Garut is popular as a fighting sheep and differs from the common thin-tailed sheep in its larger size and convex facial profile (Edey, 1983).
Other strains of thin-tailed sheep in Indonesia include the Semarang, from Central Java and the Sumatra Thin-tail (STT) from the island of that name. The JTT sheep is a small animal, usually white but commonly has black patches around the eyes and nose and sometimes elsewhere (Edey, 1983). The tail shows no sign of fat and does not reach the hocks. The ram has closely curled horns and the ewe is usually polled.

1.2 Fat-tailed Types

The Javanese Fat-tail (JFT) is a white, polled breed found predominantly in East Java (Sutama, 1990). Their tails range from rather modest-sized fat to extremely large tails. Among the fat-tailed populations the island of Madura has on average the most extreme fat tails (Iniguez *et al.*, 1993; Edey, 1983).
The JFT sheep are the largest sheep breed of Indonesia. JFT are mostly white and relatively free of wool and some totally free. Both sexes are polled (Iniguez, 1990; Iniguez *et al.*, 1993). The typical fat-tailed sheep is completely white and is hornless in both sexes. Occasionally rams carry small horns. Fat-tailed sheep are larger than the thin-tailed (Edey, 1983). Merkens and Soemirat (1979) noted a difference in disposition between JFT and JFT types with the JFT being much more docile.

2 Productivity of Sheep in Indonesia

There are many ways of changing the productivity of livestock (Wiener, 1994) and utilisation of genotypes based only on their performance within environments distinctly from those where they will be introduced can have devastating consequences (Iniguez *et al.*, 1993). The factors limiting the rearing of animals from temperate zones in the tropics are summarised by Tawfik (2001): very little acclimatisation to adverse conditions, exposure to numerous diseases and the high demand of good feeding and rearing conditions.

As a result of a long process of adaptation, the action of natural and artificial selection and gene migration, Indonesia possesses three different indigenous sheep breeds that are distributed throughout its different tropical environments and are well suited for intensive and extensive exploitation (Iniguez *et al.*, 1993). Fewer animals have been selected for increased productivity in the humid tropics. In this part the production and reproduction performance of indigenous sheep and their crosses with imported breeds are presented.

INIGUEZ *et al.* (1991) have summarised the comparison for birth and weaning weights of Indonesian sheep (Table 1). Table 2 presents ewe weights at different parity. The STT ewe weight is considered to be the lightest and JFT sheep the heaviest. (SODIQ *et al.*, 1999) reported the weaning weights of JTT under the village management system which were improved by 7.03 ± 1.06 and 8.83 ± 0.58kg, respectively. INOUNU *et al.* (1993) showed that litter weaning weights were influenced significantly by prolificacy-year, parity and ewe weight gain. Lamb birth weight and weaning weight were heavier in male offspring and in small litters (INIGUEZ *et al.*, 1991).

Table 1: Birth and weaning weight of JTT, JFT and STT sheep.

Breed	*Birth weight (kg)*		*Weaning weight (kg)*	
	single	*multiple*	*single*	*multiple*
JTT	2.64	1.68	10.0	7.6
JFT	2.28	1.52	9.7	7.2
STT	2.13	1.50	10.8	7.0

Table 2: Ewe weight of JTT, JFT and STT sheep under different parities.

Breed	*Ewe weight (kg)*				
	Parity 1	*Parity 2*	*Parity 3*	*Parity 4*	*Parity 5*
JTT	22.8	25.0	26.9	28.6	29.9
JFT	22.9	25.8	27.1	27.1	26.9
STT	19.5	21.3	22.5	24.2	23.4

Performance of body weight of JFT and crosses with Dormer and Suffas at birth and weaning (SURYAPRATAMA, 1990) and at puberty (DARMOWIJONO, 1990) are presented in Table 3 and 4, respectively.

Table 3: Birth and weaning weight and daily gain in JFT, JFT×Dormer and JFT×Suffas

Breed	*Weight (kg)*		*Daily gain (g)*
	at birth	*at weaning*	
JFT	1.92 ± 0.13	6.92 ± 0.18	47.7 ± 6
JFT×Dormer	2.31 ± 0.28	9.94 ± 0.27	77.6 ± 9
JFT×Suffas	1.97 ± 0.20	8.85 ± 0.22	76.2 ± 8

Table 4: Weight at puberty of JFT, JFT×Dormer and JFT×Suffas

Breed	*Weight at puberty (kg)*			
	Males[1]	*Females*[1]	*Males*[2]	*Females*[2]
JFT	21.9	21.1	16.1	13.8
JFT×Dormer	24.9	21.9	-	-
JFT×Suffas	21.0	18.9	-	-

[1] DARMOWIJONO (1990), [2] SIRAIT (1990),

WIJONO (1990) studied the effect of crossbreeding on birth and weaning weight, weight at 7 months and at 10 months in JFT crossed with Dormas and Suffas sheep. In all cases crossbred animals were heavier than JFT (Table 5).

Table 5: Birth and weaning weight, weight at 7 and 10 months of JFT, JFT×Dormer and JFT×Suffas

Characteristics	*JFT*	*JFT x Dormas*	*JFT x Suffas*
Birth	2.40 ± 0.06	2.88 ± 0.01	2.79 ± 0.02
Weaning	7.21 ± 0.14	8.00 ± 0.14	8.24 ± 0.28
7 months	9.65 ± 0.17	11.73 ± 0.20	12.66 ± 0.31
10 months	12.7 ± 0.3	14.90 ± 0.41	16.50 ± 0.48

SANTIARSA (1990) and SURYAPRATAMA (1990) reported birth and weaning weights and daily gains till weaning of an F_2 population. Their results are summarised in Table 6. The overall productivity of ewes per lambing (Table 7) were reported by SETIADI and INIGUEZ (1993). The JTT and JFT ewes weaned comparatively fewer kg lambs compared with the STT ewes which weaned up to 95 percent of lambs born.

The prolific Javanese ewes have been documented by some researchers (INOUNU *et al.*, 1993; ROBERTS, 2000; SUMARYADI and MANALU, 1999). SUBANDRIYO *et al.* (1996) and GATENBY *et al.* (1997) reported the productivity of Sumatra sheep and crosses with imported breeds St.Croix, Barbados Blackbelly (Table 8).

The carcass yield of JFT was lower than that of crossbreeds and comparable to the yield of the JTT (KOMARUDIN, 1990). Table 9 presents carcass average for JFT and JFT (HERMAN, 1993). The data confirm a higher total fat content in carcasses of JFT than JTT. Carcass percentage of JTT ranged between 44 - 56 percent (SODIQ *et al.*, 1998a,b) and depend on the body weight at slaughter (SODIQ *et al.*, 1999).

Table 6: Average of birth and weaning weight and average daily gain from birth to weaning in F_1 and F_2 crossbreds.

Traits and breeds	F_1	F_2
Birth weight (kg)		
JFT	1.92 ± 0.13	2.15 ± 0.12
JFT×Dormer	2.31 ± 0.28	2.26 ± 0.16
JFT×Suffas	1.97 ± 0.24	1.66 ± 0.27
Weaning weight (kg)		
JFT	6.92 ± 0.18	9.34 ± 0.53
JFT×Dormer	9.94 ± 0.27	8.80 ± 0.96
JFT×Suffas	8.85 ± 0.68	6.98 ± 1.15
Daily gain (g)		
JFT	47.7 ± 6.00	67.90 ± 7.00
JFT×Dormer	77.60 ± 9.00	63.90 ± 9.00
JFT×Suffas	76.20 ± 8.00	50.30 ± 10.00

Table 7: Mean weight of lambs weaned per ewe per lambing from JTT, JFT and STT sheep

	Average (kg)	*% Ewe body weight*
JTT	9.29	35
JFT	9.04	35
STT	11.4	52

3 Breeding Strategies for Sheep in Indonesia

Research to generate new small ruminant technologies should cover various aspects including genetic improvement (Soedjana, 1993; Subandriyo and Djajanegara, 1995). A great number of studies have been dedicated to the possibilities of improving the efficiency of genetic programmes (Flamant, 1991). The general breeding strategy for any production environment is to match genetic potential to the feeding and management system (Bradford, 1993). In pursuing these goals, one needs to address questions such as: What are the ideal forages for those conditions; what are the most suitable animals breeds or crosses? (Iniguez *et al.*, 1993).

The genetic improvement should not be considered in isolation from the aspects of the environment (Wiener, 1994). Methods available for genetic improvement are: (a) selection between and within local available breeds, (b) development of improved

Table 8: Productivity of Sumatra sheep and crosses

Characteristic	*STT*	*STT × St.Croix*	*STT × Barbados Blackbelly*	*Composit* [1] *STT × St. Croix × Barbados Blackbelly*
Birth weight (kg)	1.88	2.23	2.15	2.45
Weaning weight (kg)	8.67	11.67	11.73	13.14
Litter size	1.5	1.49	1.67	1.46
Pre weaning growth (g/h)	81.50	97.4	108.2	101.5
Survival rate till weaning (%)	86.24	84.75	90.91	98.21
Productivity index (kg/ewe/y)	16.0	21.5	24.3	22.34

[1] 50% STT, 25% St. Croix and 25% Barbados Blackbelly

Table 9: Carcass characteristics of JTT and JFT

Characteristics	*JTT sheep*	*JFT sheep*
Slaughter weight (kg)	36.7	38.3
Carcass (kg)	20.2	21.4
Carcass (%) of slaughter weight	55.1	55.9
Muscle (%) of carcass	57.7	49.3
Fat (%) of carcass	26.8	36.2

type of animals by crossbreeding or gene migration (EDEY, 1983; INIGUEZ *et al.*, 1993; WIENER, 1994; SAKUL *et al.*, 1994). Breeding strategies for sheep production systems in the humid tropics such as Indonesia have been reported by some researchers: BRADFORD (1993), (INIGUEZ, 1990), (INIGUEZ *et al.*, 1993), SUBANDRIYO and DJAJANEGARA (1995), HARDJOSUBROTO (1995), ADJISOEDARMO (1997), ADJISOEDARMO *et al.* (1997). In general, their concept of breeding plan is summarised in three parts: (1) evaluation and improvement of local breeds, (2) nucleus structure, and (3) gene migration (crossbreeding).

3.1 Evaluation and Improvement of Local Breeds

Evaluation and improvement of local breeds is the first step to follow in a breeding program (INIGUEZ *et al.*, 1993; ADJISOEDARMO, 1997). Usually local breeds display considerable variation for most production traits so there is good potential for selection. The selection programs was been applied by ADJISOEDARMO *et al.* (1997) to create genetically improved Javanese Thin Tailed sheep. Noor *et al.* (2001) studied the selection to improve birth and weaning weight of Javanese Fat Tailed sheep.

The evaluation should then be made simultaneously with a selection program, for instance in a ram breeding nucleus plan. The flock should be established with a wide genetic base comprising a genetic pool of individuals from the local breeds. This sub population should represent a random sample of the whole population. However since the objective is also to raise production, screening of the local population for outstanding males and females could be useful and provide a one-step improvement of 10 to 15 percent in production (Iniguez *et al.*, 1993).

The screening should consider some traits: (a) selection of wool-free animals, (b) selection of twin-producing ewes if the environment allows for this level of prolificacy, for instance by selection of ewes that have produced at least five lambs in three lambings in two years, and (c) selection for desirable characteristics and against undesirable defects. The measurements should include: (a) lambing dates, (b) litter size, born and weaned, (c) ewe body weight at mating, lambing and weaning, (d) wool scores at birth and at adult age, (e) lamb birth and weaning weights, (f) lamb mortality, and (g) post weaning growth up to three months after weaning.

The adoption of the best mating system is mainly dictated by availability of labour and the need to group or synchronise lambings as well as other flock activities. The simplest system is continuous breeding which implies permanent presence of rams in the ewe flock except during late pregnancy and early lactation. Production under this system has proved to be effective for STT sheep. A non-continuous system could also be implemented. However, it increases lambing intervals. For instance, mating the ewes for a one month's period preceded and was followed by two months without exposure to rams, increased the lambing interval of STT from 201 to 232 days (Iniguez *et al.*, 1991).

3.2 Nucleus Structure

Fundamentally, a selection (evaluation) program involving direct participation of producers (end-users) would consist of: (a) A *central nucleus flock* to produce selected rams for breeding, preferably located at a research centre or government multiplication centre, and (b) *base flocks* where rams from the nucleus will be distributed. These would consist of smallholder flocks, commercial producers or government multiplication centres; with both types of flocks under performance monitoring.

The nucleus would require intensive recording of performance of the individual ewes as well as rams with identification of all animals. It should produce sufficient rams to be distributed among the base flocks for breeding purposes.

The number of animals in the nucleus will be defined on the basis of the number of participants, or, more properly, the number of animals in the total program. For instance, a nucleus flock of 400 STT ewes with an average litter size of 1.54 and with a capacity to lamb at a rate of three lambings in two years can produce at least 260 ram lambs per lambing (assuming 0.85 fertility). Of those there will be a reduction of 20 percent due to pre weaning mortality and culling for defects, leaving about 210 rams to be tested for post weaning growth (until three to four months after weaning). Here a culling rate of 40 percent could be applied resulting in about 125 faster growing ram lambs. The top ten best ram lambs will be kept, while 60 to 80 could be distributed as ram lambs to be sold. If two rams are to be used on each farm comprising 20 to 30 breeding ewes, than 30 to 40 farmers could be part of the breeding program. The nucleus will produce its own breeding rams and replacement ewes.

The top 60 females will be kept as a replacement nucleus flock. However, outstanding females from the base flock could be introduced into the nucleus central flock during the program to minimise development of inbreeding in the flock. These ewes should be obtained throughout a fair agreement with participants. The nucleus females, by top rams produced at each lambing should be kept for breeds in the nucleus flock for no more than two years or three lambing seasons.

The participating (base) flocks would comprise performance-monitored farms, involving mainly groups of farmers such as those of the Outreach Research Project (ORP) of the Small Ruminants Collaborative Research Support Program (SR-CRSP) in North Sumatra. In this project, farmers participate in an on-farm research framework aimed at testing different technologies to improve sheep productivity. Initially, the farmers with four to six heads (flock) were preferable for the project. In the new breeding scheme for the Outreach Research Project (ORP) an increase of the flock size up to 20 to 30 ewes to be raised under a combination of cut and carry and grazing in the rubber plantations is being considered. A simple system of identification has been proven is to be implemented. Important (minimum) variables to record are: (1) Litter size, born and weaning, (2) lambing dates, (3) wool scores and (4) dam and lamb weaning weights (so that weight of lamb produced/ewe/year can be calculated).

3.3 Gene Migration (Crossbreeding)

Crossbreeding as a means of utilising differences between breeds has been widely used in sheep breeding in many countries (Rae, 1982). In order to avoid losses in adaptation present in the local breed, crossbreeding should be aimed at introducing desirable genes utilisation of local adaptability. The substitution of the local genes by upgrading to exotic breeds should only be practised where there is clear evidence that the resulting animals are more productive on a lifetime basis than the types they replace. Crossbreeding increases the heterozygote of a population, permitting the exploitation of heterosis. It may also be used for the formation of a new type of animal, a synthetic or new breed, which will combine desirable features of the parental breeds.

Some researchers apply the crossbreeding program for improvement of the Indonesian sheep. Merkel *et al.* (1999) concluded that the Sei Putih Hair sheep have relative growth potential and can contribute to increased sheep production in Indonesia. Gatenby *et al.* (1997) showed that the hair sheep crossbreds were more productive. Crossing the native Sumatra sheep with the two Caribbean breeds resulted in a increase in mature size and growth rate (Doloksaribu *et al.*, 2000).

The collaborative program between SR-CRSP has recently established a crossbreeding evaluation program involving the Saint Croix hair sheep from the Virgin Islands and STT sheep. The objectives are to assess the suitability of hair sheep for improvement of STT in the production systems such as those integrating sheep and under rubber plantations.

Concerning the optimum versus maximum genetic performance and tools for genetic improvement, there are several points to be noted (Subandriyo and Kevin, 1996) in the breeding strategies of sheep production:

(a) Breeds introduction or evaluation (selected breeds developed in a similar environment and look at full cycle)

(b) Records to keep (lambing dates, percentage and weaning weight)

(c) Selection criteria (post weaning growth of ram lambs and weight of lamb weaned per ewe)

(d) Role of government (professionally staffed breeding farm, selected for appropriate traits, selected breeding stock, provide information and service).

4 Zusammenfassung

Der Schafbestand in Indonesien besteht aus zwei Haupttypen: das Dünnschwanz- und das Fettschwanzschaf. Innerhalb der Schaftypen sind mehrere Schläge vorhanden.
Die wichtigsten Schafrassen in Indonesien sind das „Javanese Thin Tail (JTT)"- in Westjava und das „Javanese Fat Tail (JFT)" - Schaf in Ostjava. Weitere Dünnschwanzschafrassen sind „Sumatra Thin Tailed (STT)", „Semarang", „Garut" und „Priangan". Die Regierung in Indonesien importierte einige Schafrassen aus dem gemäßigten Klimabereich, wie Merino, Suffolk, Dorset, Suffas, Dormer, St. Croix und Barbados Blackbelly.

Das Ziel der vorliegenden Arbeit ist eine Zusammenstellung des Produktionspotentials der Lokalrassen und ihrer Kreuzungen mit den importierten Schafrassen in Indonesien. Das Zuchtkonzept beim Schaf wird in drei Abschnitten erläutert: Entwicklung und Verbesserung der Lokalrassen, Struktur der Zuchtherde und Kreuzungsprogramme.

References

Adjisoedarmo, S.; Sistem perbibitan ternak Nasional ruang lingkup ternak ruminansia kecil ditinjau dari aspek mutu genetis, budidaya, standar dan pengawasan mutu [National breeding program for small ruminant, View on aspects: genetic, keeping, quality standard and evaluation]; Univ. of Jenderal Soedirman, Purwokerto, 31pp.; 1997; [Indonesian].

Adjisoedarmo, S., Purnomo, B., Sudewo, A. T. A., Marmono, E. and Santosa, S. A.; Santosa Mrnciptakan bibit unggul domba lokal menggunakan seleksi [Creating genetically improved local sheep by selection]; Research Report, Univ. of Jenderal Soedirman, Purwokerto, 31pp.; 1997; [Indonesian].

Bradford, G. E.; Small Ruminants Breeding Strategies for Indonesia; Proceedings of a Workshop held at the Research Institute for Animal Production, August 3-4; pp. 83-94; 1993.

Bradford, G. E. and Inounu, I.; Prolific breeds of Indonesia; in: *Prolific Sheep*, edited by Fahmy, M. H.; pages 137–145; CAB International, Wallingford, U.K.; 1996.

Darmowijono, S. A.; Pertumbuhan bobot badan DEG dan persilangnnya dengan Dormer dan Suffas [Growth of Fat Tailed sheep and crosses with Dormer and Suffas]; in: *Research on Javanese Fat tail Sheep at Gadjah Mada University*, edited by Astuti, M.; 1990; [Indonesian].

Devendra, C. and McLeroy, G. B.; *Goat and Sheep Production in the Tropics*; Intermediate Tropical Agriculture Series; Longman Group Limited, Essex, UK; 1982; 271pp.

Doloksaribu, M., Gatenby, R. M., Subandriyo and Bradford, G. E.; Comparison of Sumatra sheep and hair sheep crossbreds. III. Reproductive performance of F_2 ewes and weight of lambs; *Small Ruminant Research*; 38(2):115–121; 2000.

Edey, T. N.; The genetic pool of sheep and goats; in: *Tropical Sheep and Goat Production*; pages 3–5; Australian Universities' International Development Program (AUIDP), Canberra; 1983.

Flamant, J. C.; Considering the Social Aspects of Sheep Breeding Programmes; in: *Genetic Resources of Pig, Sheep and Goat*, edited by Maijala, K.; World Animal Science Series; pages 379–390; Elsevier Science Publishers; 1991.

Gatenby, R. M.; *Sheep*; The Tropical Agriculturalist Series; CTA, Macmillan Education Ltd., London; 1995; 153pp.

Gatenby, R. M., Doloksaribu, M., Bradford, G. E. and Romjali, E.; The potential of hair sheep for the humid tropics of Southeast Asia; in: Proceedings of a Symposium on Strategic Development for Small Ruminant Production in Asia and the Pacific; Bali, July 11-16, pages 25-36; 1994.

Gatenby, R. M., Doloksaribu, M., Bradford, G. E., Romjali, E., Batubara, A. and Mirza, I.; Comparison of hairsheep and their crossbreeds II. Reproductive performance of F_1 ewes; *Small Ruminants Research*; 25(2):161–167; 1997.

Hardjosubroto, W.; Pola pemuliabiakan untuk peningkatan productivitas ternak lokal di Indonesia [Breeding strategy for livestock improvement in Indonesia]; Proceedings of the National Seminar of the Livestock and Veterinary, Nop 7-8, pages 51-59, Bogor; 1995; [Indonesian].

Herman, R.; Pertumbuhan dan komposisi tubuh dan karkas komparasi antara domba Priangan dan Domba Jawa Ekor Gemuk [Growth, body composition and carcass comparison between Priangan and Javanese Fat-tail sheep]; Dissertation, Institute of Agriculture, Bogor; 1993; [Indonesian].

Iniguez, L.; Towards the conservation and improvement of the Javanese Fat Tail sheep; in: Proceedings of a workshop on Production Aspects of Javanese fat tail sheep in Indonesia, Surabaya, August 10-11, pages 79-83; 1990.

Iniguez, L., Pattie, W. A. and Gunawan, B.; *Aspek-aspek pemuliabiakan domba pada lingkungan tropis basah [Aspects of sheep breeding with particular emphasis on humid tropical environments]*; pages 80–141; Sebelas Maret University Press; 1993; [Indonesian].

INIGUEZ, L., SANCHEZ, M. and GINTING, S. P.; Productivity of Sumatran sheep in a system integrated with rubber plantation; *Small Ruminant Research*; 5(4):303–317; 1991.

INOUNU, I., INIGUEZ, L., BRADFORD, G. E., SUBANDRIYO and TIESNAMURTI, B.; Production performance of prolific Javanese ewes; *Small Ruminant Research*; 12(3):243–257; 1993.

KOMARUDIN; Hubungan antara persentase karkas dengan bagian-bagian karkas domba lokal [Relation between the percentage of carcass and the carcass cut in local sheep]; Research Report. Gadjah Mada University; 1990; [Indonesian].

MASSON, I. L.; Classification and Distribution of Sheep Breeds; in: *Genetic Resources of Pig, Sheep and Goat*, edited by MAIJALA, K.; World Animal Science Series; pages 179–193; Elsevier Science Publishers B.V.; 1991.

MERKEL, R. C., SIMANIHURUK, K., GINTING, S. P., SIANIPAR, J., BATUBARA, L. P. and POND, K. R.; Growth potential of five sheep genotypes in Indonesia; *Small Ruminant Research*; 34(1):11–14; 1999.

MERKENS, J. and SOEMIRAT, R.; Sumbangan pengetahuan tentang pemulianbiakan domba di Indonesia [Contribution to the knowledge of sheep breeding in Dutch East Indies]; Translation by LIPI, Bogor, pages 7-24; 1979; [Indonesian].

NOOR, R. R., DJAJANEGARA, A. and SCHULER, L.; Selection to improve birth and weaning weight of Javanese Fat Tailed; *Archiv für Tierzucht - Archives of Animal Breeding*; 44(6):649–659; 2001.

RAE, A.; Breeding; in: *Sheep and Goat Production*, edited by COOP, I. E.; World Animal Science Series C1; pages 15–55; Elsevier Science Publishers; 1982.

RIAP and SRCRSP; Research Institute for Animal Production (RIAP) and Small Ruminant Collaborative Research Support Program (SRCRSP); Indonesian Small Ruminants Directory, ISRN, Bogor, 52pp.; 1990.

ROBERTS, J. A.; Frequency of the prolificacy gene in flocks of Indonesian Thin Tail sheep: A Review; *Small Ruminant Research*; 36(3):215–226; 2000.

SAKUL, H., BRADFORD, G. E. and SUBANDRIYO; Prospects for genetic improvement of small ruminants in Asia; in: Proceedings of a symposium on Strategic Development for Small Ruminant Production in Asia and the Pacific, July 11-16, pages 3-14, Bali; 1994.

SANTIARSA, I. G.; Pertumbuhan cempe F_2 persilangan DEG dengan Domer dan Suffas [Growth rate till weaning of F_2 lambs crossing Fat Tailed sheep with Dormer and Suffas sheep]; in: *Research on Javanese Fat Tail Sheep at Gadjah Mada University*, edited by ASTUTI, M.; 1990; [Indonesian].

SETIADI, B. and INIGUEZ, L.; Reproduction performance of small ruminants in an on-farm research program with village farms in West Java; *Small Ruminant Research*; 12(1); 1993.

SIRAIT, M.; Rata-rata pertambahan bobot badan Domba Ekor Gemuk sejak disapih sampai pubertas [Averages body weight of Fat Tailed sheep from weaning till puberty]; in: *Research on Javanese Fat Tail Sheep at Gadjah Mada University*, edited by ASTUTI, M.; 1990; [Indonesian].

Sodiq, A., Priyono, A., Sugiyatno, Soedjadi and Marmono, E. A.; Produktivitas domba pada sistem pedesaan dan ditingkatkan [Ewe reproduction index under village and improved management systems]; Research Report, Univ. of Jenderal Soedirman, 66pp.; 1999; [Indonesian].

Sodiq, A., Setyaningrum, A. and Haryoko, I.; Study tentang Komparasi Karkas Domba dan Kambing di Banyumas. [Study on Comparison of the Sheep and Goats Carcasses in Banyumas]; *Scientific Publication, Univ. of Jenderal Soedirman*; 18(1):41–51; 1998a; [Indonesian].

Sodiq, A., Soedjadi and Priyono, A.; Karakteristik karkas Domba Ekor Tipis di Banyumas [Carcass characteristics from Thin Tail Sheep in Banyumas]; Research Report; Univ. of Jenderal Soedirman, 42pp.; 1998b; [Indonesian].

Soedjana, T. J.; Direction of Future Small Ruminants Research and Development in Indonesia; in: Proceedings of a Workshop Held at the Research Institute for Animal Production, August 3-4, pages 3-64, Bogor; 1993.

Subandriyo and Djajanegara, A.; Potensi produktivitas ternak domba di Indonesia [The potential of productivity for sheep in Indonesia]; Proceedings of a National Veterinary Seminar, Nov. 7-8, Bogor; 1995; [Indonesian].

Subandriyo and Kevin, R. P.; Small Ruminants Production: Recommendations for Southeast Asia; *Indonesian Small Ruminant Network Newsletter*; 6(2):17–19; 1996.

Subandriyo, Setyadi, B., Rangkuti, M., Dwiyanto, K. and Batubara, L. P.; Pemuliaa Bangsa Domba Sintetis Hasil Persilangan Domba Lokal Sumatra dengan Domba Bulu [Breeding Synthetic Sheep Crossing between Local Sumatra Sheep and Hair Sheep]; Centre of Research and Development of Livestock, Bogor; 1996; [Indonesian].

Sumaryadi, Y. M. and Manalu, W.; Prediction of litter size based on hormones and blood metabolites concentrations during pregnancy in Javanese Thin Tail ewes; *Asian Australian Journal of Animal Sciences*; 12(5):682–688; 1999.

Suryapratama, W.; Perbandingan pertumbuhan cempe DEG dengan persilangan DEG dengan Domer dan Suffas [Comparison of growth rate till weaning between Fat Tailed sheep and crossing with Dormer and Suffas sheep]; in: *Research on Javanese Fat Tail Sheep at Gadjah Mada University*, edited by Astuti, M.; 1990; [Indonesian].

Sutama, K.; Production and reproductive performance of Javanese Fat Tail sheep; in: Proceedings of a workshop on Production Aspects of Javanese Fat Tail Sheep in Indonesia, Surabaya, August 10-11, pages 69-77; 1990.

Tawfik, E. T.; Basic Concept of Animal Breeding; Paper presented at a General Lecture in Jenderal Soedirman University, Purwokerto, Indonesia, September 29; 2001.

Utoyo, D. P.; Animal Genetic Resources in Indonesia; in: Proceedings of the First National Co-ordinators Meeting, FAO, Bangkok, January, pages 86-107; 1995.

Wiener, G.; *Animal Breeding*; Macmillan Education Ltd., London; 1994; 208pp.

Wijono, D. B.; Parameter fenotipik pertumbuhan DEG dan silangan Dormas dan Suffas [Phenotypic parameters of growth in Fat Tailed Sheep and Crosses with Dormer and Suffas sheep]; Thesis, Gadjah Mada University; 1990; [Indonesian].