

## Morphometric Characterization and Genetic Distance among Four Breeds of Rabbit (*Oryctolagus cuniculus*)

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**Abstract.** An experiment was conducted to elucidate performance of body measurements and to estimate genetic distance among four breeds of rabbit; those were Flamish Giant, English Spot, Angora and Rex. Material of the experiment was 352 heads of four breeds of rabbit originating from three districts of Jambu, Sumowono and Ungaran in Semarang Regency-Central Java. Experiment material was determined by purposive sampling method on the basis of population density. Parameters observed were 1) head length, 2) head width, 3) ear length, 4) ear width, 5) chest circumference, 6) chest depth, 7) chest width, 8) humerus length, 9) radius-ulna length, 10) tibia length, 11) femoris length, 12) body length, and 13) hip width. SAS package program was used to analyze data. Phenogram tree was constructed using MEGA 5. Results showed that there was no difference on the morphometric performance between sexes within breed with exception in Flamish Giant. Rabbits in Jambu district tended to have similarity in body measurement with those in Sumowono, but differed from rabbits in Ungaran. Cumulative contribution ratio from the first principal component (PC1) to the third principal component (PC3) was 83.6%. The genetically closeness was shown among Flamish Giant, English Spot and Angora, while Rex had a much different character.

**Keywords:** morphometric, genetic distance, rabbit

**Abstrak.** Penelitian ini bertujuan mengetahui penampilan ukuran-ukuran tubuh dan menduga jarak genetik antar empat bangsa kelinci. Sebanyak 352 ekor kelinci dari 4 bangsa yaitu Flamish Giant, English Spot, Angora dan Rex digunakan sebagai materi, berasal dari Kecamatan Jambu, Sumowono dan Ungaran di Kabupaten Semarang, Jawa Tengah. Materi penelitian ditentukan dengan metode purposive sampling berdasarkan tingkat kepadatan populasi kelinci. Parameter yang diukur dan diamati meliputi morfometrik pada 1) panjang kepala, 2) lebar kepala, 3) panjang telinga, 4) lebar telinga, 5) lingkar dada, 6) dalam dada, 7) lebar dada, 8) panjang tulang humerus, 9) panjang tulang radius-ulna, 10) panjang tulang tibia, 11) panjang tulang femur, 12) panjang badan, dan 13) lebar pinggul. Data yang diperoleh dianalisis dengan program SAS. Hasil analisis diskriminan digunakan untuk menyusun pohon fenogram (filogeni) dengan menggunakan software MEGA 5. Hasil penelitian menunjukkan tidak adanya perbedaan penampilan morfometrik antar jenis kelamin pada bangsa yang sama kecuali pada Flamish Giant. Kelinci di Kecamatan Jambu cenderung mempunyai kesamaan ukuran tubuh dengan kelinci di Kecamatan Sumowono, tetapi berbeda dengan kelinci di Kecamatan Ungaran. Nisbah kontribusi kumulatif dari komponen utama pertama (PC1) sampai dengan komponen utama ketiga (PC3) sebesar 83,6%. Kedekatan secara genetik terlihat antara bangsa Flamish Giant, English Spot dan Angora, sedangkan Rex memiliki karakter yang jauh berbeda.

**Kata kunci:** morfometrik, jarak genetik, kelinci

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### Introduction

Indonesian farmers raise many rabbit breeds to meet protein deficit from ruminant meat. There is no doubt that the farmed rabbits have enormous potential to the need of protein especially the villagers. Other reasons of raising rabbits are its high prolificacy, fecundity,

profitability, short generation interval and high feed conversion efficiency. Farrell and Raharjo (1984) reported that the farmed rabbit had the greatest potential in terms of meat production. A doe weighing 3-4 kg could produce 80 kg of dressed rabbit carcass per year.

The American Rabbit Breeder Association (2011) grouped rabbits into 47 breeds, four of

which namely Flamish Giant, English Spot, Angora and Rex are raised by farmers in Semarang Regency-Central Java. Each breed has characteristics and differs in superior trait; however, morphometric characteristics assume similarity among breeds. Most researches were conducted on prediction of body weight from body measurement (Heinrichs et al., 1992; Rahim, 2006; Ozkaya and Bozkurt, 2009). Genetic distance analysis using body measurements was conducted in sheep (Suparyanto et al., 1999) and buffalo (Johari et al., 2009). To date, study on morphometric characteristics and genetic relationships among rabbit breeds are limited. This study was conducted to evaluate the morphometric performance in four breeds of rabbit and to estimate genetic distance among them existing in Semarang Regency.

## Materials and Methods

**Material.** Four rabbit breeds including Flamish Giant, English Spot, Angora and Rex of more than 12 months old were chosen based on popularity to be raised in Jambu, Sumowono and Ungaran districts of Semarang Regency-Central Java. Location of experiment was determined according to purposive sampling method based on population density of rabbits raised by farmers. Male rabbits (bucks) were to have capacity to copulate and the females (does) were to have more than two parities. The number of rabbits used is presented in Table 1.

Morphometric parameters measured (in cm) are presented in Figure 1, comprising 1) head length, 2) head width, 3) ear length, 4) ear width, 5) chest circumference, 6) chest depth, 7) chest width, 8) humerus length, 9) radius-ulna length, 10) tibia length, 11) femoris length, 12) body length, and 13) hip width.

**Data analysis.** SAS (1990) was used for analysing the data for univariate and multivariate analysis and the effect of location

and breed on body measurements was tested using General Linear Model (GLM). Difference between male and female body measurement was tested by t-test. PRINCOMP procedure was performed to determine discriminant variable among breeds and distribution mapping of breeds. DISCRIM procedure was performed to evaluate misclassified of breed and Mahalanobis distance among breeds. Squared root of Mahalanobis distance obtained was administered to MEGA 5 to construct phylogeny through UPGMA tree (Tamura et al., 2011).

## Results and Discussion

Preliminary analysis showed that there was no difference of body measurements between male and female within a breed. Flamish Giant showed significant difference between sex ( $P < 0.05$ ), while other three breeds did not show difference. Accordingly, analysis of morphometric of Flamish Giant was separated into different sex. Table 2 presents body measurement of Flamish Giant at different location. Body measurements of three breeds of rabbit measured are presented in Table 3.

Head length and width, ear length and width, chest circumference and depth, humerus length, radius-ulna length, tibia length and femoris length showed significant difference among district both in male and female. Chest depth in male just differed in male. Furthermore, body length and hip width were significantly different ( $P < 0.05$ ) in female. Flamish Giant in Jambu District tended to show similarity to those in Sumowono, but not similar to Ungaran. Body measurements of rabbit in Ungaran District tended to be similar to those in Sumowono. In fact, Sumowono is the center of genetic resource of rabbit to wide spread to other area. It was stated by Brahmaniyo et al. (2006) that phenotypic difference of rabbit at each area shows no exchange among areas.

Body measurements of rabbits (pooled sex)

Table 1. The number of rabbits used as the experiment material

District	Flamish Giant		English Spot		Angora		Rex		Total
	M	F	M	F	M	F	M	F	
Jambu	15	25	-	-	-	-	15	24	79
Sumowono	14	26	10	27	13	27	15	25	157
Ungaran	17	23	11	28	10	27	-	-	116
Total	46	74	21	45	26	54	30	29	352

M : male; F : female

Table 2. Body measurements (cm) of Flamish Giant at different location

Variable	Jambu		Sumowono		Ungaran	
	Male	Female	Male	Female	Male	Female
Head length	12.14±0.64 <sup>b</sup>	11.76±0.52 <sup>l</sup>	12.20±0.77 <sup>b</sup>	11.96±1.03 <sup>l</sup>	12.75±0.76 <sup>a</sup>	12.54±0.58 <sup>k</sup>
Head width	4.33±0.31 <sup>b</sup>	4.14±0.15 <sup>l</sup>	5.13±1.50 <sup>a</sup>	4.46±0.36 <sup>k</sup>	4.67±0.28 <sup>ab</sup>	4.31±0.25 <sup>k</sup>
Ear length	14.77±1.00 <sup>b</sup>	13.81±1.23 <sup>l</sup>	15.60±1.31 <sup>ab</sup>	15.02±0.82 <sup>k</sup>	15.80±1.25 <sup>a</sup>	15.30±1.08 <sup>k</sup>
Ear width	6.73±0.36 <sup>b</sup>	6.33±0.48 <sup>l</sup>	7.12±0.43 <sup>a</sup>	6.68±0.40 <sup>k</sup>	7.25±0.52 <sup>a</sup>	6.89±0.40 <sup>k</sup>
Chest circum- ference	27.04±1.48 <sup>b</sup>	26.84±1.63 <sup>l</sup>	29.58±2.02 <sup>a</sup>	27.93±1.21 <sup>k</sup>	28.44±1.61 <sup>a</sup>	27.17±1.43 <sup>kl</sup>
Chest depth	7.04±0.46 <sup>b</sup>	7.11±0.66	7.33±0.60 <sup>b</sup>	6.85±0.49	7.75±0.61 <sup>a</sup>	6.96±0.65
Chest width	6.51±0.54	6.43±0.85	6.39±0.96	6.49±0.57	6.46±0.53	6.39±0.61
Humerus length	9.51±0.66 <sup>b</sup>	9.52±0.84 <sup>l</sup>	9.56±0.86 <sup>b</sup>	9.20±0.82 <sup>l</sup>	10.45±0.69 <sup>a</sup>	10.00±0.67 <sup>k</sup>
Radius-ulna length	10.58±0.80 <sup>b</sup>	10.37±0.64 <sup>l</sup>	10.90±0.94 <sup>b</sup>	9.88±0.71 <sup>m</sup>	12.05±0.50 <sup>a</sup>	11.27±0.53 <sup>k</sup>
Tibia length	15.41±0.80 <sup>b</sup>	15.15±0.64 <sup>l</sup>	15.50±1.83 <sup>b</sup>	14.80±1.14 <sup>l</sup>	16.65±0.77 <sup>a</sup>	16.33±0.79 <sup>k</sup>
Femoris length	12.45±0.66 <sup>b</sup>	12.14±0.70 <sup>l</sup>	12.68±0.92 <sup>b</sup>	11.83±0.94 <sup>l</sup>	13.41±0.78 <sup>a</sup>	12.86±0.62 <sup>k</sup>
Body length	38.95±1.43	37.76±2.53 <sup>l</sup>	39.61±2.40	39.77±2.82 <sup>k</sup>	39.90±1.59 <sup>a</sup>	39.19±2.75 <sup>kl</sup>
Hip width	8.70±0.62	7.90±0.71 <sup>l</sup>	8.48±0.76	8.26±0.64 <sup>k</sup>	8.70±0.51	8.35±0.53 <sup>k</sup>

Values bearing different superscript at the same location between sex differ significantly (P&lt;0.05)

Table 3. Body measurements (cm) of three breeds of rabbit

Variabel	Jambu		Sumowono		Ungaran	
	Male	Female	Male	Female	Male	Female
Head length	11.23±0.66 <sup>b</sup>	11.74±0.56 <sup>a</sup>	12.15±0.71	12.09±0.73	10.97±0.78	10.92±0.49
Head width	4.01±0.38	4.15±0.27	4.37±0.43	4.27±0.28	4.18±0.35	4.09±0.26
Ear length	12.83±1.29 <sup>b</sup>	13.91±1.21 <sup>a</sup>	14.44±1.22	14.40±1.44	11.66±0.86	11.33±0.72
Ear width	6.10±0.52 <sup>b</sup>	6.46±0.48 <sup>a</sup>	6.62±0.53	6.57±0.52	5.73±0.34	5.64±0.31
Chest circumference	26.34±1.85	26.73±1.70	27.95±1.66 <sup>k</sup>	26.81±1.41 <sup>l</sup>	26.92±1.53 <sup>r</sup>	26.17±1.26 <sup>s</sup>
Chest depth	6.55±0.66	6.83±0.64	6.83±0.86	6.86±0.57	6.51±0.56	6.70±0.71
Chest width	5.74±0.61 <sup>b</sup>	6.38±0.47 <sup>a</sup>	6.30±0.72	6.46±0.74	6.10±0.54	5.98±0.56
Humerus length	9.00±0.67 <sup>b</sup>	9.79±0.71 <sup>a</sup>	10.07±0.57	9.82±0.77	8.82±0.55 <sup>s</sup>	9.20±0.56 <sup>r</sup>
Radius-ulna length	9.76±0.79 <sup>b</sup>	10.66±0.64 <sup>a</sup>	10.52±0.88 <sup>l</sup>	10.88±0.66 <sup>k</sup>	9.78±0.53 <sup>s</sup>	10.21±0.64 <sup>r</sup>
Tibia length	14.28±1.08 <sup>b</sup>	15.74±0.93 <sup>a</sup>	15.69±0.83	15.64±0.92	13.85±0.80 <sup>s</sup>	14.52±0.62 <sup>r</sup>
Femoris length	11.28±0.94 <sup>b</sup>	12.61±0.62 <sup>a</sup>	12.43±0.76	12.47±0.75	11.54±0.7 <sup>s</sup>	11.99±0.65 <sup>r</sup>
Body length	34.27±2.93 <sup>b</sup>	38.11±2.47 <sup>a</sup>	38.00±2.06	38.28±2.52	34.50±2.11	34.50±1.70
Hip width	7.04±0.73 <sup>b</sup>	8.09±0.63 <sup>a</sup>	7.53±0.69 <sup>l</sup>	8.17±0.74 <sup>k</sup>	6.99±0.64 <sup>s</sup>	7.35±0.54 <sup>r</sup>

Values bearing different superscript at the same location between sex differ significantly (P&lt;0.05)

for Angora at Sumowono tended to differ from those in Ungaran observed from the similarity

of body measurement was in head width, chest depth and chest circumference (P>0.05). The

performance of body measurements for English Spot at those two districts also tended to differ. There is evidence that handling management of rabbits were different among districts. Primary information showed that farmer crossed their rabbits among domesticated breeds, and between domesticated and local breeds. Rex at Sumowono and Jambu indicated difference in several body measurements. This is because of different environmental condition and different management conducted by the farmers. According to Suparyanto et al. (1999), breed crossing caused genetic mutation even produced new breed (Pattie et al., 1990).

**Principal component analysis.** Table 4 shows the eigenvalue and its contribution in each principal component (PC). Result indicated that cumulative contribution ratio from PC1 to the PC3 was 83.6%. This means that the first three PCs extracted account for more 83% of morphometrical variation information. Table 5

presents eigenvectors of the first principal component (PC1) and the second principal component (PC2). In PC1, all eigenvectors had positive values, while in PC2, three eigenvectors representing length showed negative values. According to Hayashi et al. (1982), in morphometrical application of the principal component analysis, the first component was acceptable as “size”, and the second one as a “shape”. The scattering diagram of 4 breeds of rabbits constructed by PC1 and PC2 is presented in Figure 1.

Figure 1 shows that some of body measurements of Flamish Giant tended to be similar to those of English Spot as well as Angora. Morphological similarity showed possibility of close relationships among breeds (Brahmantiyo et al., 2006). In this study, Rex located on left side showed the small size category, in which it differed from others.

Table 4. Eigenvalue and its contribution in each principal component

principal component	Eigenvalue	Contribution ratio	Cumulative contribution ratio
First	15.496	0.674	0.674
Second	2.176	0.095	0.768
Third	1.557	0.068	0.836

Table 5. Eigenvector of each principal component

Variable	PC 1	PC 2
Head length	0.166	0.104
Head width	0.062	0.091
Ear length	0.392	-0.025
Ear width	0.129	0.004
Chest circumference	0.263	0.866
Chest depth	0.075	0.156
Chest width	0.074	0.107
Humerus length	0.135	0.127
Radius-ulna length	0.147	0.107
Tibia length	0.221	-0.001
Femoris length	0.154	0.089
Body length	0.766	-0.383
Hip width	0.135	-0.106

PC1 : first principal component; PC2 : second principal component

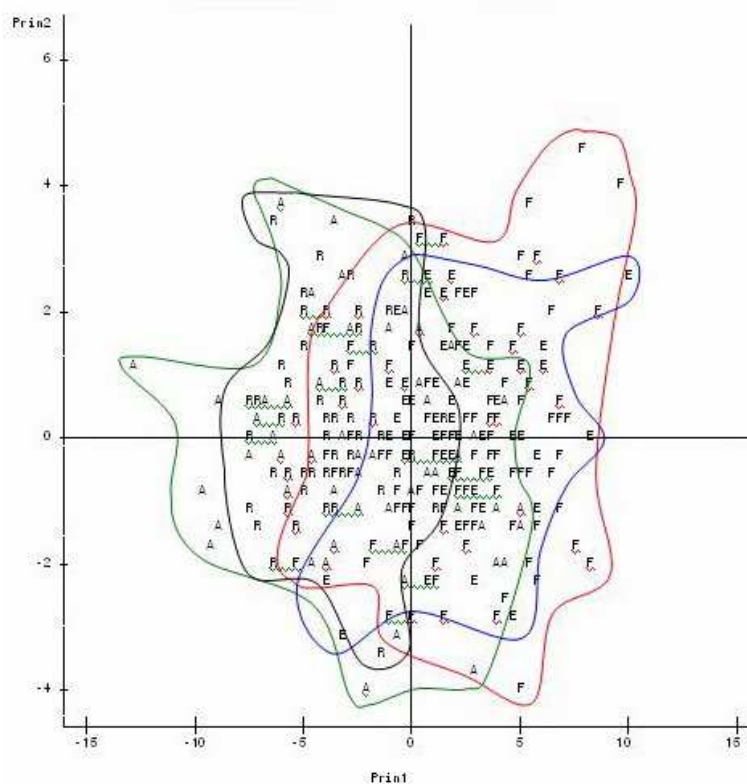


Figure 1. Scattering diagram of 4 breeds of rabbits was constructed by PC1 and PC2. A: Angora. F: Flamish Giant. E: English Spot. R: Rex

Table 6. Results of classification analysis by means of discriminant analysis

Breed		Angora	English Spot	Flamish Giant	Rex	Total
Angora	N	30	20	11	16	77
	%	38.96	25.97	14.29	20.78	100.00
English Spot	N	15	36	19	6	76
	%	19.79	47.37	25.00	7.89	100.00
Flamish Giant	N	10	27	77	6	120
	%	8.33	22.50	64.17	5.00	100.00
Rex	N	4	1	1	73	79
	%	5.06	1.27	1.27	92.41	100.00
Total	N	59	84	108	101	352
	%	16.76	23.86	30.68	28.69	100.00

N: the number of rabbit

Table 7. Mahalanobis squared distance to breed of rabbit in Semarang regency

Breed	Angora	English Spot	Flamish Giant	Rex
Angora	0	1.21590	2.79302	3.78866
English Spot	1.21590	0	1.36302	7.12179
Flamish Giant	2.79302	1.36302	0	10.22782
Rex	3.78866	7.12179	10.22782	0

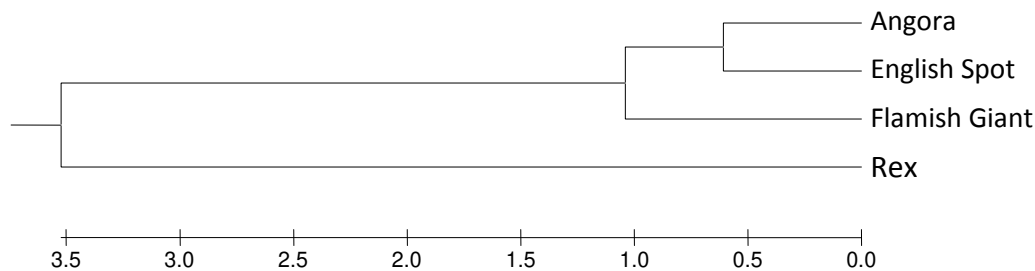


Figure 2. Phylogenetic tree for 4 breeds of rabbit in Semarang regency

**Discriminant analysis.** Breed identification appeared to be possible by the discriminant analysis. Table 6 shows result of classification analysis by means of discriminant analysis. It shows the correctness and its percentage of classification. Higher percentage in classification of breed shows more correct in grouping of individuals within breed. It can be seen in Table 6, that classification of Rex showed 92.41%, in which 7.59% of individuals spreads into other breeds. It was stated by ARBA (2011), Rex is a small size rabbit having specific of soft body hair. The three breeds of Angora, English Spot and Flamish Giant showed more misclassification because of several similarities of their body measurements. As obtained in previous quantitative analysis, that body measurements of Angora, English and Famish Giant had some similarities. This result was also true as provided by principal component analysis.

**Genetic distance analysis.** There are various kinds of molecular data or quantitative data that can be used for measuring genetic distance. According to Nei (1972), genetic distance is the degree of gene difference between populations. Mahalanobis distance is a distance measure (Mahalanobis, 1936), based on the correlation among variables by which different pattern can be analyzed (SAS, 1990). Mahalanobis squared distance to breed obtained in this study is presented in Table 7. Phenogram tree constructed by Mahalanobis

distance is presented Figure 2. The farthest genetic distance was shown between Flamish Giant and Rex rabbits, while the nearest distance was between Angora and English Spot rabbits. It was clear that the more similar linear body measurements between two breeds, the shorter distance it had, and *vice versa*. The far distance between Flamish Giant and Rex was due to extreme difference in phenotype (Brahmantiyo et al., 2008).

## Conclusions

Rex breed showed different characteristic in morphometric and was classified into small size category. The farthest of genetic distance was shown between Flamish Giant and Rex, while the nearest distance was between Angora and English Spot.

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