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Original Research

Morphometric characterization and genetic distance of rabbits (*Oryctolagus cuniculus*) in several region in Indonesia

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Abstract

Rabbits are a group of animals that are very popular and enjoyed by the community. Rabbits, in general, have the high biological and economic potential to produce quality meat, skin, and hair, as well as pets (ornamental) and modern business farming. Rabbits are well known in Indonesia and developed mostly for farming. This literature study discusses morphometric characteristics and genetic distances among rabbits. The parameters used were head length (PK), head width (LK), ear length (PTL), ear width (LTL), chest circumference (LKD), chest width (LD), humerus bone length (PH), radius-ulna bone length (PRU), tibial bone length (PT), and body length (PB). The results of body variables measurement in FG rabbits had a higher mean for body size, including PK (12.64 cm), PTL (13.59 cm), LTL (6.47 cm), PH (9.52 cm), PRU (8, 95 cm), and PB (41.97 cm) compared to other families. Genetic distance shows that it has a close genetic distance (0.63106), while the farthest genetic distance is found between Rexb rabbits and ES rabbits, which is 6.96749. The genetic distances and tree phenogram construction are useful for estimating kinship between Rabbits clumps.

Introduction

Providing meat from livestock to meet food adequacy standards is synonymous with efforts to increase livestock productivity. Cattle, buffalo, sheep, goats, pigs, and poultry are livestock commodities whose productivity continues to be boosted to meet the need for animal protein. However, so far, it has not been able to live up to expectations. One effort that should be developed to answer this challenge is to increase the diversity of meat-producing livestock commodities. Types of livestock that can be developed must have high biological and economic potential. One type of livestock that can meet these requirements is rabbit livestock.

Rabbits' livestock, when compared with other livestock commodities, has not received much attention, both in terms of management, productivity, and reproduction. This causes the Rabbit's livestock development program to be directed and planned. Most of the Rabbits owned by the community are not intended as meat-producing livestock. Rabbits are kept as pet animals (ornamental), for leather production and fertilizer. Rabbits are livestock with a high potential to produce quality meat, leather, pets (*ornamental animals*), and research objects in laboratories (Raharjo *et al*., 2001). The demand for meat today is increasing along with the introduction of

Rabbits farming, either through demonstration plots or pilot farming, information transfer, and technology. One of the advantages of Rabbits farming is its potential to be developed on a household/small scale and being able to breed based on local wisdom in conjunction with community farms.

Rabbits (*Oryctolagus cuniculus*) are herbivorous animals that in systematic zoology, are classified in the phylum Chordata, class Mammalia, order Logomorpha, family Leporidae, genus *Orcytolagus* (Lebas *et al*., 1997). Rabbits or rabbits widely cultivated in Indonesia are imported from various countries in Europe and America. In the field of animal husbandry, Rabbit farming is an industrial activity that until now has been operating commercially for meat and leather. In addition, rabbits are used as laboratory animals. Rabbits commonly found in people's farms today come from wild rabbits. However, because crossbreeding and domestication have been carried out between local and imported rabbits, therefore, Rabbits are kept as meat producers for human consumption. It was stated by Brahmantiyo & Raharjo (2009) that the high productivity of Rabbits' carcasses made the Rex Rabbits var start to be farmed for their meat. Besides being known as a meat producer, Rex Rabbits is also known for producing smooth and shiny hair with high productivity of hair and meat.

Rabbits that exist and widely cultivated in Indonesia, except for the Sylvilagus type originating from Sumatra, are imported rabbits from various countries in Europe and America. At present it is difficult to obtain rabbits from pure breeds because the existing rabbits are crosses of various types. Therefore, information is needed regarding the inventory and characterization of the various existing clumps. In general, rabbits are developed according to production goals, namely as a producer of meat (New Zealand White, Flemish Giant, and Californian), meat, leather, and hair (Rex and Satin), and ornamental (Hotot, Dwarf, Lop, and Lion) purposes. Rabbit breeders in Magelang Regency develop varieties of rabbits as meat producers, including Flemish Giant, English Spot, and New Zealand White.

Most of the rabbits currently being cultivated in Indonesia are imported from various countries in Europe and America. To introduce a new breed of rabbit to Indonesia to produce leather and hair, the Rex rabbit was imported from America in 1988. The types of rabbits currently being cultivated by breeders in Indonesia are the result of crosses, so it is difficult to obtain offspring of rabbits. pure. Differences in the location of origin of rabbits and the tropics in Indonesia cause the different results in performance from that of its pure breeds. Therefore, information is needed regarding the inventory and characterization of the various existing clumps. The New Zealand White rabbit (*Oryctolagus cuniculus*) is often used for meat production and laboratory animals (Curnin & Bessert, 1985). Rabbits of this breed have an average weight of between 8 to 12 pounds. The characteristics of the New Zealand rabbit are white, and sometimes red to black. It has long, erect, medium-sized ears, (Santoso & Sutarno, 2010).

Limited information and lack of attention to the breeding of rabbits impact the unavailability of breeds specifically for meat production. Rabbit breeds that are cultivated as meat-producing livestock are the result of crosses from existing rabbit breeds. Basic information that can be obtained simply as one of the prerequisites for improving genetic quality is the morphological characteristics of rabbits from different breeds and populations (Ajayi & Oseni, 2012). Morphometric analysis is an easy and inexpensive method for characterizing body size and estimating livestock genetic distances (Handiwirawan *et al*., 2011). Based on these needs, we carried out an assessment through related literature studies regarding morphometrics in rabbit livestock and to estimate genetic distance. These results are expected to be used as basic information for consideration in determining rabbit breeding policies.

Methode

The method used is a literature study examining scientific articles or related studies. The data obtained in the articles is secondary data in the form of a qualitative descriptive approach.

Results and Discussion

Morphometrics Characteristics

The variables observed were morphometric observations carried out by following the method to measure the head length (PK), head width (LK), ear length (PTL), ear width (LTL), chest width (LD), inside chest (DD), circumference chest (LKD), body length (PB), hip width (LP), scapular bone length (PS), humerus (PH), radius-ulna (PRU), femur (PF) and tibia (PT). Observations were done with digital calipers (mm) and measuring tape (cm). Observations of rabbit morphometrics were carried out on the size and body shape of the rabbit. The results of the observations showed that there were rabbit clumps that breeders commonly kept. The rabbit families are Angora (AG), Dutch (DT), Flemish Giant (FG), Loop (LP), Netherland Dwarf (ND), Cross (PX), Satin (ST), Reza (XA), and New Zealand White. (ZW). Brahmantiyo *et al*. (2007) revealed that in Lembang, West Bandung eight breeds of rabbits are commonly kept, namely Flemish Giant, Lion, Loop, New Zealand White, Silang, Rex, Satin, and Tan. The breed of rabbits kept by breeders highly depends on interest or market demand for certain breeds.

The measurement results for body variables in FG rabbits had the highest average (P<0.01) compared to other families for PK (12.64 cm); PTL (13.59cm); LTL (6.47cm); PH(9.52cm); PRU (8.95 cm) and PB (41.97 cm), except for LK, DD, LKD, LD, PS, PF, PT and LPL. FG rabbits had a relatively high average body size for DD, PT, and LPL compared to other breeds. The mean chest depth (DD) of FG and XA rabbits were 8.50 cm and 8.37 cm, respectively. These two sizes did not differ from the average size of ST rabbits (8.13 cm), but they were taller (P<0.01) when compared to the seven other rabbit families. The mean length of the tibia (PT) of FG rabbits (12.69 cm) and ST (12.62 cm) did not differ from the average size of ZW rabbits (12.21cm) but were longer (P<0.01) compared to the other seven families. The mean hip width (LPL) of FG rabbits was 8.48 cm. This size did not differ from the size of the XA rabbit (8.23 cm) but was taller (P<0.01) compared to the eight other rabbit families.

ST rabbits have relatively high averages for sizes LK, LKD, LD, PS, and PF compared to other rabbit breeds. The size of the head width (LK) of the ST (3.30 cm) and FG (3.29 cm) rabbits did not differ from that of the RX rabbit (3.14 cm); ZW (3.12 cm), and XA (3.10 cm), but broader (P<0.01) than the LP, AG, PX, ND and DT rabbits. The mean chest circumference (LKD) of ST rabbits was 29.01 cm. This size did not differ from the XA rabbit (28.49 cm) but was taller (P<0.01) when compared to the other eight families. The mean chest width (LD) of the ST rabbits (7.30 cm) did not differ from that of the RX rabbits (6.86 cm). However, it was wider (P<0.01) than the other eight families. The mean length of the scapular bone (PS) of ST rabbits was 8.43 cm. This size did not differ from the size of the FG rabbit (8.35 cm) but was longer (P<0.01) compared to the other eight families. The mean femur length (PF) of ST and FG rabbits were 10.47 cm and 10.44 cm. Both sizes did not differ from the ZW rabbit (10.24 cm) but were longer (P<0.01) compared to the other seven families.

ND rabbits had the smallest average (P<0.01) for almost all body sizes, such as PK (9.29 cm); PTL (8.15cm); LTL (3.86cm); LKD (22.61 cm); PS (6.21cm); PH (6.81cm); PRU (6.48 cm); PF (7.93cm); PT (9.08cm); PB (31.06cm); LPL (7.08 cm), except for LK, LD, and DD sizes. The mean size of LK rabbits ND and DT are 2.82 cm and 2.80 cm. Both of these sizes were the same as the PX (2.95 cm), AG (2.98 cm), and LP (3.03 cm) rabbits, but they were smaller (P<0.01) when compared to the XA, ZW, RX, FG, and ST rabbits. The ND rabbit has a DD body size of 6.72 cm. This size was the same as the body size of the DT rabbits (7.14 cm), but smaller (P<0.01) when compared to the eight other rabbit families. The average LD body size of ND rabbits is 5.75 cm. This size does not differ from the size of DT (5.87 cm), LP (5.88 cm), and PX (6.03 cm), but is smaller (P<0.01) when compared to the other six rabbit breeds.

Observation of the body sizes of the rabbits showed a significant difference. In general, the FG and ST breeds of rabbits showed a larger body size compared to the other breeds. FG rabbits, as stated by McNitt *et al*. (2013), are rabbits that has a large body stature with an adult weight above 5.9 kg. The large adult weight requires body support through a large skeleton and bones. ST rabbits are medium-type rabbits with adult weights ranging from 4.3 to 4.5 kg (McNitt *et al*., 2013). The mating process of ST rabbits, which was relatively controlled by breeders, resulted in the maintained and bigger performance of ST rabbits' size and body shape than other breeds. The ND rabbit is the rabbit family with the smallest body size compared to other breeds. ND rabbits are rabbits with stunted body conditions. McNitt *et al*. (2013) stated that stunting is a qualitative trait influenced by one or several pairs of genes. The Dw allele expression influences dwarf conditions in ND rabbits, while the dw allele expresses normal body conditions.

Based on the results of body measurement, data calculations only provide information about the differences and similarities in the size of the head length, head width, ear length, ear width, chest circumference, chest depth, chest width, humeral bone length, radius-ulna bone length, tibia bone length, and body length. (Brahmatiyo, *et al*., 2006). ES, FG, and NZW rabbits originating from Magelang have head sizes (length and width), ears (length and width), radius-ulna bone length, and body lengths that are larger than Rex rabbits and rabbits kept in Balitnak (Rex, Satin, RS, and NZW). The chest size (circumference, depth, and width) and length of the humerus bone in rabbits from Magelang were lower than those from Balitnak. These body measurements show that the ES, FG, and NZW rabbits in Magelang Regency are relatively longer and larger, with a narrow chest than the Rex, Satin, RS, and NZW rabbits from Balitnak. So that even though the ES, FG, and NZW rabbits have a large body appearance, they look thin and slender. In contrast to the Rex, Satin, RS, and NZW rabbits, which have a larger chest size and long humerus bone, they give a compact and proportional appearance to look fat and have dense flesh. This demand has encouraged breeders to cultivate rabbits to be traded as meat producers so that rabbits with large body sizes such as ES, FG, and NZW are highly preferred. Meanwhile, at Balitnak, the maintenance of Rex, Satin, and RS rabbits is intended to produce leather and hair as well as meat (dual purpose) and NZW rabbits as a meat-producing rabbit and research animal.

Genetic Distance Analysis

Genetic distance is the degree of gene difference between populations or species (Nei, 1987). In understanding the process of genetic evolution of a herd, research on genetic characteristics has been carried out using morphometric analysis (Taylor *et al*., 1977) and DNA analysis (Zhu *et al*., 2004). The genetic distance matrix values between each rabbit family are presented in Table 1. The genetic distance matrix values are used to construct a phenogram tree, as shown in Figure 1. The phenogram tree describes the genetic distance of the entire rabbit family.

Based on the value of genetic distance, rabbits originating from Magelang had small genetic distance values between clumps, each of 0.63416 (ES-FG), 1.18191 (ES-NZWm), 2.89715 (ES- Rexm), 1.14730 (FG-NZWm), 2.68643 (FG-Rexm) and 2.03481 (NZWm-Rexm). Likewise with rabbits originating from Balitnak, namely 1.93800 (NZWb -Rexb), 2.61792 (NZWb -Satin), 3.17606 (NZWb -

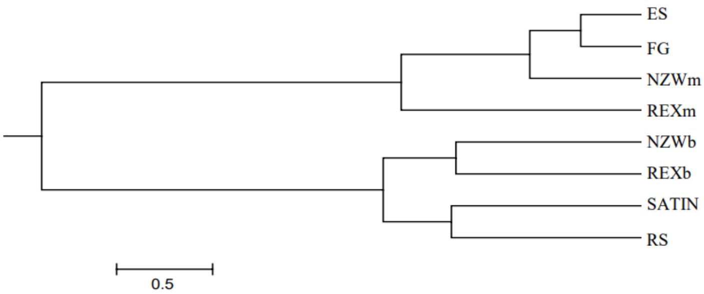
RS), 2.21582 (Rexb -Satin), 2.276784 (Rexb -RS) and 1.98507 (Satin-RS). The genetic distance between regions is very large, ranging from 5.25190 (Rexm-Satin) to 7.51063 (ES-Rex).

Table 1.

Genetic distance matrix for Mahalanobis rabbits in Magelang and rabbits in Balitnak

Clumps	ES	FG	NZW^m	NZW^b	Rex^m	Rexb	Satin	RS
ES		0.63106	1.08744	6.16218	2.30937	6.96749	5.35021	6.07806
FG			1.08059	5.93191	2.21681	6.71421	5.07849	5.84157
NZW^m				5.89139	1.69098	6.57295	4.89426	5.61904
NZW^b					6.37094	1.72604	2.39461	3.32332
Rexm						6.75571	5.06693	5.38507
Rex^b							2.20911	2.85719
Satin								2.06171
RS								

^{m} = Magelang. ^{b} = Balitnak. ES = English Spot. FG = Flemish Giant. NZW = New Zealand White. RS = Persilangan Rex dan Satin



^{m} = Magelang. ^{b} = Balitnak. ES = English Spot. FG = Flemish Giant. NZW = New Zealand White. RS = Persilangan Rex dan Satin.

The construction of the phenogram tree shows that ES and FG rabbits have relatively close genetic distance measurements (0.63106). Based on this value. a cross between ES and FG rabbit families will not get impressive quantitative size progress if it is not accompanied by strict selection. This is due to the heterosis obtained only from the diversity within the clump. For other breeds of rabbits. one can still expect an increase in body size due to the considerable genetic distance. The farthest genetic distance is found in Rexb and ES rabbits. which is 6.96749. In general. rabbits from Balitnak have a far genetic distance from rabbits from Magelang.

The process of genetic evolution of a livestock breed has been widely observed and studied using a morphometric analysis approach. According to Zhu *et al*. (2004). genetic characteristics can be examined using a DNA analysis approach. Meanwhile. genetic evolution can be measured using a genetic distance analysis approach. The function of the phenogram tree is to describe the overall genetic distance of the rabbit family. Based on their genetic distance values. Hyla. Hycole. New Zealand White (NZW). and FN rabbits had small genetic distance values between families. Each genetic distance value is 1.92 (CC-FF); 2.17 (CCFN); 2.77 (CC-NN); 2.11 (FF-FN); 2.47 (FF-NN); and 1.77 (FN-NN). The genetic distance of the Hyla. Hycole. NZW. and FN rabbits with the rex and satin rabbits has a fairly large genetic distance. which is 4.28 (CC-RR); 4.23 (CC-SS); 4.36 (FF-RR); 4.13 (FF-SS); 4.25 (FN-RR); 4.11 (FN-SS); 3.77 (NN-RR); and 3.54 (NN-SS).

Based on the construction of the phenogram tree. it shows that the CC (Hyla) and FF (Hycole) rabbits. as well as the FN and NN rabbits. have relatively close genetic distance measurements of 1.92 and 1.77. respectively. This indicates that it is suspected that there has been a cross between these rabbits. The research results of Mariandayani *et al*. (2013) showed that the existence of mixed values and close genetic distance through morphometric analysis between kedu chickens. free-range chickens. and Sentul chickens was thought to be the result of crossing between these chickens. The farthest genetic distance was found in FF (Hycole) and RR (Rex) rabbits. namely 4.36. According to Keliang *et al*. (2008); Galal *et al*. (2013). phenogram tree analysis can be used to measure genetic variation and phylogenetic relationships among rabbit genotypes. Furthermore. according to Yang et al. (2013). tree phenogram analysis can be used to measure genetic variation in horses. buffaloes. cows. rabbits. and kangaroos. Based on the phenogram tree. CC (Hyla). FF (Hycole). FN. and New Zealand White (NZW) rabbits (almost the same genetic distance) have the potential to cross with RR (Rex) and SS (Satin) rabbits (almost the same genetic distance) to produce rabbits with an optimal quantitative size which is impressive because of their considerable genetic distance.

Estimation of genetic distance and construction of phenogram trees resulting from the estimation of kinship relationships between rabbit breeds using the Mahalanobis genetic distance data and the genetic distance data are then used to construct the phenogram trees. The genetic distance of the 10 rabbit breeds observed ranged from 1.53-6.62. explaining that the kinship of rabbits varies greatly from one breed to another. The smallest genetic distance was obtained from the PX and ZW rabbit breeds. while the largest was from the FG and ND breeds. The PX family has a very close genetic distance to ZW. LP. and AG. Hence. the PX phenotype that develops in the community is a partial reflection or a combination of these adjacent families. The same pattern also occurs in the ZW rabbits. the closest genetic distance is to the PX and AG rabbit families. while the other four families. namely FG. ST. DT. and ND. have quite a long genetic distance from the other families. So they appear separated and different on phenogram tree construction.

The construction of the phenogram tree shows that the rabbit families with close genetic distances appear to be clustered not far apart. In contrast. some of the other families appear to be separated. Herrera *et al*. (1996) stated that the distribution of clump groupings on phenogram trees is likely to be influenced by two factors. namely differences in production capacity (production objectives) and differences in the origins of clump formation (origins).

Conclusion

Based on the results of the literature studies. it can be concluded that the morphometric observations in FG rabbits had a higher average for body sizes. including PK (12.64 cm). PTL (13.59 cm). LTL (6.47 cm). PH (9.52 cm). PRU (8. 95 cm) and PB (41.97 cm) compared to other families. The overall genetic distance between clumps is quite close (0.63106). The farthest genetic distance is found between the Rexb and ES Rabbits. which is 6.96749. Estimation of genetic distance and construction of the phenogram tree resulting from the estimation of kinship among other rabbit families.

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