



Special Issue: Agricultural Productivity and Sustainability Improvement in Tropical Region

Phenotypic and Morphometric Characterization of Hycole, Hyla and New Zealand White Rabbits for KUAT Hybrid (Tropical Adaptive and Superior Rabbit)

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Abstract | Hycole and Hyla rabbits were imported in 2012 and 2013. Hycole and Hyla rabbits were known as best broiler rabbit and had potentiality as genetic resources to develop Indonesian broiler rabbit. The aim of this study was to characterize phenotype of Hycole and Hyla rabbits to evaluate their adaptability in tropical environments. Research were held at Indonesian Research Institute for Animal Production, Ciawi, Bogor, Indonesia using 79 adult rabbits (20 does and 20 bucks of Hycole, 14 does and 12 bucks of Hyla, and five does and eight bucks of New Zealand white). The age of the rabbits evaluated in this experiment was rabbits with age 20 wk old. The mean birth weight for Hyla was 53.6 g + 7.5 g, Hycole was 51.6 g + 9.9 g, and NZW was 54.4 g + 10.7 g. This experiment was carried out for 3 mo. The feed used during the experiment was commercial feed. A complete randomized design with unbalanced data analysis was used for quantitative traits and descriptive analysis for qualitative traits. Qualitative characteristics of hair color variation of Hyla rabbit was different than other with 7.7 % pointed on their white hair color, and hip type compact of Hycole, Hyla and New Zealand White were 90 %, 84.6 % and 76.9 %, respectively. Quantitative characteristics of chest depth of Hycole and Hyla rabbits were higher than New Zealand White. Hycole and Hyla rabbits showed high body size at Head height, Ear length, Ear width, Chest depth, Radius Ulna, Femoris, Length of the spine. Crossing of these rabbits with New Zealand White rabbit have potential to develop broiler rabbits that adapted in tropic.

Received | January 08, 2021; **Accepted** | February 03, 2021; **Published** | May 20, 2021

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Citation | Brahmantiyo, B., H. Nuraini, A.W. Putri, M. Mel and C. Hidayat. 2021. Phenotypic and morphometric characterization of hycole, hyla and New Zealand white rabbits for KUAT hybrid (tropical adaptive and superior rabbit). *Sarhad Journal of Agriculture*, 37(Special issue 1): 09-15.

DOI | <https://dx.doi.org/10.17582/journal.sja/2021/37.s1.09.15>

Keywords | Breeding, Broiler rabbit, Hybrid crossing, Increase qualitative and quantitative, *Oryctolagus cuniculus* Linnaeus 1758.

Introduction

Hycole, Hyla rabbits were imported by the Indonesian Research Institute for Animal Production (IRIAP) in 2012 and 2013, respectively.

Importations were done to overcome raising demand on broiler rabbit. Hycole, Hyla and New Zealand White rabbits have a superiority on high growth rate and proliferation rate. The body weight of Hyla's rabbit in the age of 70 d can reach 2 160 g (de la

Fuente and Rosell, 2012), Hycole's rabbit can reach 2 400 g to 2 500 g (Brahmantiyo *et al.*, 2017) and New Zealand White rabbit can reach 1 998.30 g (Chodová *et al.*, 2014). The three breeds of rabbit will be used in the program to develop a tropical adaptive superior rabbit [KUAT = *kelinci unggul adaptif tropis* (tropical adaptive and superior rabbit)].

Characterization of quantitative traits has been performed on Hycole, Hyla rabbits for litter size, growth rate, and morphometrics of the body (Setiaji *et al.*, 2012). Crosses Hycole rabbit with NZW and their reciprocal has been done with the crossed Hycole sire and NZW dam (P_AN) (Brahmantiyo *et al.*, 2017). The rabbit has potential to be developed as the genetic resources of dam adaptive to tropical climate due to its good heterosity (hybrid vigor) in litter size and growth rate (Khan *et al.*, 2017a, 2017b; Tariq *et al.*, 2015).

Besides, evaluating quantitative characteristic, this study also evaluating qualitative characteristic of Hycole, Hyla and New Zealand white rabbits in the context of developing KUAT. This study aimed to evaluate phenotypic and morphometric characterization of Hycole, Hyla and New Zealand white rabbits for KUAT hybrid.

Materials and Methods

The research was conducted at Rabbit Facility Unit, Indonesian Research Institute for Animal Production, Ciawi, Bogor, West Java. The materials used in the study include of Hycole (PP) rabbits of 14 does and 12 bucks, Hyla (CC) rabbits of 20 does and 20 bucks, and New Zealand White (NN) rabbits of five does and eight bucks. The age of the rabbits evaluated in this experiment was rabbits with age 20 wk (weeks) old. The mean birth weight for Hyla was 53.6 g + 7.5 g, Hycole was 51.6 g + 9.9 g, and NZW was 54.4 g + 10.7 g. This experiment was carried out for 3 mo (months). The feed used during the experiment was commercial feed with the nutritional content, *i.e.*, 18 % of crude protein, 4.0 % of crude

fat, 16 % crude fiber, and 2 500 Kcal kg⁻¹ metabolic energy. The feed used was in the form of pellets.

Quantitative observation performed by measuring the morphometrics of each rabbit breed, *ie.* head (length, width, and height), chest (circumference, depth and width), length of front leg, rear leg, backbone, and ear, also the width of hip. Observation on qualitative properties include: (i) head type (oval elongate, oval, and rounded oval) was determined based on the index value of the width-size division to the head length was < 0.45 then the head shape is oval elongated, the value of 0.45 to 0.50 oval head shape and > 0.50 head shape is oval rounded; (ii) body type seen from the body shape while in a stationary, quiet position and the body of the rabbit is on a flat medium, there is a commercial body type, arc, semi-arc, compact and cylinder (Fig. 1; Hassan *et al.*, 2012); (iii) eye color consisting of red and black; (iv) dominant body color is determined by looking at the colors that dominate the whole body of a rabbit; (v) hair color variations are categorized when the rabbit has only one hair color the same on the whole body then the rabbit has a single color variation. The rabbits with three or more mixtures of color on each hair shaft then the rabbit has an agouti color variation. The rabbit with variation of broken colors that rabbit has a combination of white hair color and other colors. The rabbit has a white hair color in most areas of the body and different hair color in the nose, ears, legs and tail then the rabbit has a variety of pointed white color. Variety of shaded colors were rabbits that has a darker hair color on the back, head, ears, tail and legs that graded the colors become lighter on the body. Rabbit with contrasting hair color on the eye circumference, nostrils, chest, abdomen, inner legs, lower tail, and inner edges of the ear then the rabbit has tan color variations, and rabbit has a protective hair color that is different from hair color on the skin surface then the rabbit has a variety of colors ticked (ARBA, 2011; Taha *et al.*, 2017); (vi) Hair type is categorized when the rabbit has hair with a short size and a smooth texture then the rabbit has a normal hair type. Rex hair type expressed of short and straight hair on the skin and fine texture.



Figure 1: Commercial body type, arc, semi-arc, compact, and cylinder (ARBA, 2011).



Figure 2: *Hycle (PP), Hyla (CC) and New Zealand white (NN).*

The rabbit has long hair, thin and smooth then the rabbit has angora hair type. Smaller diameter and the outer layer is transparent, shiny and slick then the rabbit has a satin hair type; (vii) Hip type is determined by palpation and see the shape of the hip surface from behind (Filho *et al.*, 2012).

The complete randomized design factorial was applied for quantitative properties data (Jatoi *et al.* 2015), while the qualitative characteristic data is described descriptively based on the percentage.

Results and Discussion

Qualitative characteristics

Qualitative characteristics are individual traits that can be classified into groups based on apparent and definitely distinct traits for each group. Color variations, hair color patterns and eye color are qualitative traits influenced by color-coding genes, fur quality and softness are qualitative properties of commercial value (Mancini *et al.*, 2017). Hycle, Hyla and New Zealand White rabbits shown at Figure 2.

The proportion of each qualitative traits of Hycle, Hyla and New Zealand White rabbits can be seen in Table 1. Qualitative characteristics are characteristics that can be seen only existence, not measured value or degree. There is a clear distinction between one characteristic with another characteristic and can not be made gradation (discontinuous).

According to their head index, PP, CC and NN had oval head type because they had the index value of the width-size division to the head length > 0.50 , and their body type are commercial (ARBA, 2011). Commercial body type of rabbits were expression of broiler rabbit that has a larger body size and shape (Abo-Eid *et al.*, 2016). Eye color of three breeds of rabbit were red, that eye color is determined by the

distribution and pigment content of melanocytes and melanosomes in the iris of eye. Covrig *et al.* (2013) reported that the red eyes that appear in white-haired rabbits are the expression of cc genes that cause albino on the surface of the body and red on the eyes. The absence of pigment on the skin, white-haired rabbits usually have red eyes (Covrig *et al.* 2013).

Table 1: *Qualitative characteristics of Hycle (PP), Hyla (CC), and New Zealand white (NN) rabbit.*

Traits	Phenotype	Rabbit breed (%)		
		PP	CC	NN
Head type	Oval	100	100	100
Body type	Commercial	100	100	100
Eyes color	Red	100	100	100
Dominant hair color	White	100	100	100
Hair color variation	Single	100	92.3	100
	Pointed white	-	7.7	-
Hair type	Normal	100	100	100
Hip type	Compact	90	84.6	76.9
	Slim	10	15.4	23.1

There were four type of hair, normal, angora, rex and satin. PP, CC and NN rabbits have normal hair type because of short size and a smooth texture of hair. According to Neirurerová *et al.* (2019), normal hair type is owned by many strains of rabbits with various body sizes. Normal hair has a size of about 2.5 cm with a thin texture, smooth and compact. The most common hair color of rabbits is single hair color, agouti, broken, pointed white, shaded, tan, and ticked (Kabir, 2013). The dominant hair color of the three rabbit lines (PP, CC and NN) is single and white. CC rabbit has a normal hair color variation of 92.3 % and there are 7.7 % have a variation of pointed white hair color. In addition to white, the dominant body color patterned rabbit pointed white can also be other colors (Kozioł *et al.*, 2015). Variations of pointed white patterns on CC rabbits are black on the nose, ears, legs and tail.

Table 2: *Body size of rabbits based on breed and sex of rabbit.*

	Hycole (PP)		Hyla (CC)		New zealand white (NN)	
	Doe	Buck	Doe	Buck	Doe	Buck
Head length (cm)	12.98 ± 0.64	13.27 ± 0.81	13.16 ± 0.42	13.77 ± 0.60	12.86 ± 0.69	12.85 ± 0.56
Head width (cm)	4.87 ± 0.26	5.30 ± 0.42	4.57 ± 0.14	5.15 ± 0.37	4.50 ± 0.09	5.11 ± 0.25
Head height (cm)	6.34 ± 0.39 ^a	5.30 ± 0.42 ^c	5.93 ± 0.38 ^b	6.34 ± 0.40 ^a	6.14 ± 0.32 ^{ab}	6.44 ± 0.28 ^a
Chest circumference (cm)	33.21 ± 2.64	31.88 ± 2.26	33.24 ± 1.63	33.21 ± 1.85	31.74 ± 0.37	32.78 ± 1.24
Ear length (cm)	13.70 ± 0.78 ^{ab}	13.77 ± 0.76 ^{ab}	13.13 ± 0.61 ^b	13.88 ± 0.55 ^a	14.22 ± 0.81 ^a	13.58 ± 0.85 ^{ab}
Ear width (cm)	8.42 ± 0.62 ^a	8.30 ± 0.55 ^a	8.37 ± 0.44 ^a	7.90 ± 0.51 ^a	7.28 ± 0.46 ^b	8.05 ± 0.48 ^a
Chest depth (cm)	10.81 ± 0.87 ^a	10.50 ± 0.10 ^a	10.92 ± 0.63 ^a	10.41 ± 0.10 ^a	8.57 ± 0.48 ^b	10.10 ± 1.47 ^a
Chest width (cm)	9.69 ± 0.80	9.32 ± 0.94	8.76 ± 0.45	8.95 ± 0.73	8.35 ± 0.78	8.50 ± 0.65
Radius Ulna (cm)	10.83 ± 0.54 ^{ab}	11.11 ± 0.86 ^a	11.17 ± 0.52 ^a	10.60 ± 0.79 ^{ab}	10.30 ± 0.40 ^b	10.71 ± 0.49 ^{ab}
Humerus (cm)	9.97 ± 0.51	9.95 ± 0.82	9.98 ± 0.39	10.16 ± 0.65	9.80 ± 0.50	10.00 ± 0.19
Tibia (cm)	15.10 ± 0.63	15.11 ± 0.61	15.16 ± 0.53	15.58 ± 0.46	15.18 ± 0.40	15.04 ± 0.41
Femoris (cm)	12.93 ± 0.23 ^a	12.75 ± 0.30 ^a	12.84 ± 0.28 ^a	12.75 ± 0.33 ^a	12.42 ± 0.28 ^b	12.94 ± 0.23 ^a
Length of the spine (cm)	41.25 ± 1.96 ^a	39.68 ± 2.17 ^{ab}	38.51 ± 2.17 ^{bc}	38.26 ± 2.61 ^{bc}	37.26 ± 1.48 ^c	39.15 ± 1.12 ^{bc}
Width of the spine (cm)	9.85 ± 0.76	9.78 ± 1.00	8.97 ± 0.55	9.34 ± 0.56	9.19 ± 0.63	9.12 ± 0.80

Different superscript letters on the same line, significantly different ($P < 0.05$).

Hip type of PP, CC and NN rabbits with compact hip type were 90 %, 84.6 %, and 76. 9 %, respectively and slim hip type were 10 %, 15.4 %, dan 23.1 %, respectively. Rabbits that have a solid rounded hip shape show good muscle distribution ([Asamoah et al., 2019](#); [Bivolarski et al., 2011](#); [Guo et al., 2016](#); [Papadomichelakis et al., 2017](#); [Suleman et al., 2020](#)). According to [ARBA \(2011\)](#) the hip showed the condition of the rabbit's body. Rabbits that have a rounded or solid hip reflect that the rabbit also has a rounded and solid body. This suggests that the physical state of the rabbit is prime and has a good meat content.

Quantitative characteristics

Quantitative nature is the properties of production and reproduction or measurable properties, such as body weight and body size or morphological characteristics ([Andronikov et al., 2019](#); [Belabbas et al., 2019](#); [Kadi et al., 2018](#); [Petracci et al., 2018](#)). Morphological characteristic is a structural form of organism that is the main source of characteristic of most organism groups. The size and shape of the body is a comprehensive predictor of the typical form and description of various body images that prove useful in analyzing many organism. Body weight that were expression of body size and body shape very important for breeding rabbits in commercial units ([Fuente and Rosell, 2012](#)). [Hassan et al. \(2012\)](#) reported that morphometric traits were highly correlated with body weight. Accordingly, the morphometric traits of rabbits can be used as a tool for selection in genetic

improvement of rabbits, as well as to predict their body weight.

The three breed rabbits have similarities in head length, head width, chest circumference, chest width, humerus length, tibia length, femoris length, and hip width ([Table 2](#)). The interaction between breed and sex has a significant effect ($P < 0.05$) on head height, length and width of the ear, chest depth, radius ulna length, and the length of the spine.

The chest circumference and the length of the spine reflect the productivity of the rabbit ([Abdel-Kafy et al., 2018](#)). The chest circumference of buck and doe rabbit's were 31.88 cm ± 2.26 cm and 33.21 cm ± 2.64 cm of PP, 33.21 cm ± 1.85 cm and 33.24 cm ± 1.63 cm of CC, and 32.78 cm ± 1.28 cm and 31.74 cm ± 0.37 cm of NN, respectively. The length of the buck and doe rabbit's spine is as follows 39.68 cm ± 2.17 cm and 41.25 cm ± 1.96 cm of PP, 38.20 cm ± 2.61 cm and 38.52 cm ± 2.17 cm of CC, and 39.15 cm ± 1.12 cm and 37.24 cm ± 1.48 cm of NN.

The size of chest circumference and the length of the spine of this study obtained CC rabbits have chest circumference (32.21 cm ± 1.85 cm) and the length of spine of PP (41.25 cm ± 1.96 cm) the highest and it's different from the results of [Brahmantiyo et al. \(2017\)](#) which obtained the highest chest circumference (33.32 cm) on the PP rabbit and the highest length of spine (42.41 cm) on the NN rabbit. This difference is influenced to several factors such as individual

differences measured, the process of adaptation to the environment, and the difference in rabbit generation measured. This study are agreement with Hassan *et al.* (2012) that said linear measurement or a combination of it can be used to predict live body weight or another linear trait and also can be use for genetic improvement.

Adaptation in the tropics, with ambient temperature and feeds availability, unplanned mating program were influence performance changes in the rabbit and may lead to inconsistent performance of its filial, which is very different from the performance of pure breed in the country of its origin. Imported rabbits that raised in Indonesia will adaptation to different climates resulting in changes in the rabbit body in both shape and performance when compared to their origin country (Cherwon *et al.*, 2020; Pei *et al.*, 2012; Sakr *et al.*, 2019).

Conclusions and Recommendations

This study shows that the Hycle, Hyla and New Zealand White rabbits have body size that express their genetic potential in the tropics of Indonesia. Hycle and Hyla Rabbits have the potential genetics to develop broiler rabbits in Indonesia that can be crossed with New Zealand White rabbits. This crossbred were expected to produce adaptive tropical broiler rabbits with high productivity.

Acknowledgment

The authors wish thank to Head of Indonesian Research Institute for Animal Production as facilitator of this study.

Novelty Statement

Research related to broiler rabbits is still very rare in tropical countries, especially in Indonesia. This study shows novelty that phenotypic characteristics are very important to determine the adaptability and genetic expression of rabbits originated from subtropics that are kept in tropical climates for the development of rabbit breeding.

Author's Contributions

BB conceived and designed the study, and performed definition of intellectual content, literature search,

experimental studies, data acquisition, data analysis, statistical analysis, manuscripts preparation. HN, AWP and CH elaborated the intellectual content, carried out literature search, experimental studies and manuscripts review. MM elaborated and carried out literature search, manuscripts editing, manuscripts review and guarantor.

Conflict of interest

The authors declares that there is no conflict of interests regarding the publication of this article

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