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BIOLOGICAL CHARACTERISTICS AND GENE POLYMORPHISMS ASSOCIATED WITH SOME GROWTH AND REPRODUCTIVE TRAITS OF HUNG AND MEO INDIGENOUS PIGS

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SUMMARY OF PHD. DISSERTATION

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INTRODUCTION

1. RATIONALE

Vietnam is considered as one of the countries with rich and diversely indigenous swine genetic resources. The Hung pig in Ha Giang and the Meo pig in Nghe An provinces are two distintively indigenous pig races in the East-northern and Northern mountainous regions of Vietnam. Previously, there were researches on Hung pigs (Nguyen Van Duc, 2012; Hoang Thanh Hai, 2015; Dang Hoang Bien, 2016a) and studies on Meo pigs (Pham Van Son, 2015; Dang Hoang Bien, 2016a; Hoang Phi Phuong, 2020). However, these studies only focused on their origins, appearance characteristics, and performance traits. Recently, in Vietnam, several authors have been studying gene polymorphisms as associated with some performance traits in pigs (Do Vo Anh Khoa, 2012; Do Vo Anh Khoa and Nguyen Thi Dieu Thuy, 2012; Dang Hoang Bien, 2016). However, few reports were published on the influences of *OVGP1*, *LIF*, *GH*, and *IGF1* gene polymorphisms on the reproduction and growth performance of Hung and Meo pigs. Therefore, this dissertation: *"Biological characteristics and gene polymorphisms associated with some growth and reproduction traits of Hung and Meo pigs"* was carried out.

2. OBJECTIVES OF RESEARCH

2.1. Overall objective

To determine some appearance characteristics, performance traits, carcass composition, and gene polymorphisms associated with reproductive and growth performance to fulfill for conservation and exploitation, and effectively develop the genetic resources of Hung and Meo pigs in Vietnam.

2.2. Specific objectives

To determine the appearance characteristics, performance, and carcass composition of Hung and Meo pigs.

To determine polymorphisms of *OVGP1*, *LIF*, *GH*, *and IGF1* genes.

To determine the association between genotypes of *OVGP1* and *LIF* genes with reproductive traits.

To determine the association between genotypes of *GH* and *IGF1* genes with growth traits.

3. SCIENTIFIC AND PRACTICAL MERIT OF DISSERTATION

3.1. Scientific merit

The dissertation is a systematically scientific work from the evaluation of apprearance characteristics to performance, and the carcass component traits of Hung and Meo pigs. It is the first work to determine *OVGP1* and *LIF* gene polymorphisms associated with reproductive performance traits; *GH* and *IGF1* gene polymorphisms associated with the growth performance traits of Hung and Meo pigs to assist in selection of highly yielding and quality pigs more quickly, precise and efficiency.

The dissertation's results utilized as a valuable reference in research, education and training, and national management of indigenous pig genetic resources in Vietnam.

3.2. Practical merit

The researched findings are the scientific bases to conserve and select more quickly and accurately in enhancement of performance and cacass component traits of Hung and Meo pigs to produce and commercialize high-quality meaty products of Hung and Meo pigs in holds in middle and alpine moutainous regions, especially in the tendency of biologic safety and organic systems.

The researched findings are the practical bases to select and develop purebred breeding pigs of Hung and Meo pigs with highly breeding merit for livestock development, exploitation, and use for breeding systems and production of bio-safely organic products with highly economic efficiency. Besides, it also sets up a pure breeding stock for crossbreeding, exploiting and using the addtive genetic value and heterosis from the component breeds with the contribution of domestic pig genetic resources such as Hung and Meo pigs.

4. NEW CONTRIBUTIONS OF THESIS

The dissertation is a systematic work from a fairly detailed and complete description of appearance characteristics, coat-skin color, reproductivity, growth performance, and carcass component traits in Hung and Meo pigs.

The dissertation detemined the *OVGP1* and *LIF* gene polymorphisms, especially their associations among genotypes with

reproductive performance; and the associations between *GH* and *IGF1* gene polymorphisms with growth traits; as well as total genetic values, genetic components: Additive value and dominant values of these genotypes in Hung and Meo pigs. From those associations, they assist for more quick and accurate selection, so that two breeds of Hung and Meo pigs achieved continuously high quality, bring about economic efficiency for farmers and assured the targets of national rare and precious genetic resource conservations.

CHAPTER 1. LITERATURE REVIEW

1.1. SCIENTIFIC BASIS OF RESEARCH

1.1.1. Appearance characteristics, perfromance, carcass component traits, and influencing factors

Appearance characteristics are the external traits of the animal. It may reflect definite aspects of an animal's health and productive capacity.

The reproductive performance of pigs was evaluated by the following main traits: age at insemination, age at first farrowing, number of newborns, number born alive, weaned number, birth weight of piglets, and weaned weight of pigs, farrowing interval and number of weaned per sow per year.

Growth is the more increase in body weight, size, volume of each part or of the whole body of an animal; or growth is the growth and division of cells in the animal's body.

The swine carcass component were evaluated through traits: weight of carcass (kg), percentage of the carcass (%), dressing carcass weight (kg), percentage of the dressing carcass (%), length of body carcass (cm), backfat thickness (mm), lean meat percentage (%), fat percentage (%), percentage of bones, skin, ...

1.1.2. Characterization of candidate gene polymorphisms

The *OVGP1* gene is glycoprotein with large molecular weight presented in the oviduct (Agarwal *et al.*, 2002). *OVGP1* is located on exon 5 and exon 6 of chromosome 4 from position q22→q23. *OVGP1* is synthesized from epithelial cells and is secreted into oviduct, participate into fertilization and early embryonic development.

The *LIF* gene is a leucocyte inhibitory factor (*LIF*). In pig, *LIF* gene is located on chromosome number l4 at position q2.1→q2.2 and plays a role in preparing for process of embryonic implantation in the uterus.

The *GH* gene is produced by the pituitary anterior gland, plays an important role in growth control, and participates into regulating metabolic processes and growth stimulation. *GH* gene is located on chromosome 12 at position p1.2→p1.5. In mammary animals, *GH* gene lengthens 2-3 kb including 5 exons and 4 introns.

The *IGF1* gene (Somatomedin-C) is a protein comprise of 70 amino acids with a molecular weight of 7649U. *IGF1* gene promotes cell absorbed amino acids and glucose, increases synthesized protein, fatty material, and glycogen, stimulates DNA transcription, cytologic proliferation, and differentiation; stimulates sexual gland to secrete hormones, promotes milk secretion and develop small intestine of animals.

CHAPTER 2. MATERIALS, CONTENTS AND METHODOLOGY

2.1. MATERIALS, LOCATIONS AND RESEARCH PERIOD

2.1.1. Materials

Hung pig, Meo pig and ear skin samples of Hung and Meo pig.

2.1.2. Locations

Hung pig was performed in Hoang Su Phi district, Ha Giang province.

Meo pig was performed in Ky-Son and Nghia-Dan districts, Nghe An province.

Analysis of *OVGP1, LIF, GH* and *IGF1* gene polymorphisms at Key Laboratory of Animal Cell Technology, National Institute of Animal Science.

2.1.3. Research Period

From 2015 to 2021.

2.2. CONTENTS

2.2.1. Appearnce characteristics, performance and carcass component of Hung and Meo pigs

2.2.1.1. Appearance characteristics of Hung and Meo pigs

2.2.1.2. Evaluation of the productivity and carcass component of Hung and Meo pigs

2.2.2. Gene polymorphisms and the associations between gene polymorphisms with reproductive and growth performance of Hung and Meo pigs

2.2.1.1. OVGP1, LIF, GH and IGF1 gene polymorphisms in Hung and Meo pigs.

2.2.1.2. Associations between OVGP1 and LIF genotypes with reproductive performance of Hung and Meo pigs.

2.2.1.3. Association between GH and IGF1 genotypes with growth performance of Hung and Meo pigs.

2.3. METHODS

2.3.1. Appearance characteristics, productivity, carcass component of Hung and Meo pigs.

2.3.1.1. Determine appearance characteristics of Hung and Meo pigs

Appearance characteristics were determined by common observation and measurement methods.

2.3.1.2.Evaluate reproductivity of Hung and Meo pigs

Monitoring sexual physiologics: 110 Hung and 95 Meo breeding gilts. Monitoring indicators: Age at first estrus, weight at first estrus, age at first service, weight at first service, age at first farrowing, weight at first farrowing.

Monitored reproductive performance of 80 Hung sows (430 litters) and 86 Meo sows (380 litters) from 1st to 6th litter. Monitoring indicators: Number of piglets/litter, number of alive piglets/litter, number of weaner/litter, birth weight of piglets, birth weight of litter, weaned weight of piglets, weaned weight of the litter and farrowing interval.

2.3.1.3. Evaluation of growth performance and carcass component of Hung and Meo pigs

a. For growth performance

- Select experimental pigs:

+ Piglets were born from the research breeding stock (Hung sows and Meo sows), were numbered for individual observation.

- Design experiments:

+ Piglets after birth were individually weighed.

+ Litters were selected and monitored weight until pigs reached 8 months of age.

- Methods and traits:

+ Observed characteristics: birth weight, 2, 4, 6, and 8 months age weight.

b. For carcass component

Observed characteristics: live weight (kg), carcass weight, carcass percentage (%), dressing carcass percentage (%), lean meat percentage (%), fat percentage (%), bone percentage (%) and skin percentage (%), back fat thickness (mm).

2.3.2. Determine gene polymorphisms and the associations between gene polymorphisms with reproductive and growth performance of Hung and Meo pigs

2.3.2.1. Methods for Sample collection and preservation

Sample collection: 78 ear skin samples of sows and 86 ear skin samples of pork for Hung pig. In addition, 76 ear skin samples of sows and 85 ear skin samples of pork for Meo pigs. Samples were placed in an Eppendorf tube containing 1,5 ml alcohol (99%).

2.3.2.2. Method for DNA extraction

DNA extraction procedure of Bioneer K-3032 kit (Korea).

2.3.2.3. Methods to determine OVGP1, LIF, GH and IGF1 gene polymorphisms

Sows were observed and collected data for reproductive performance at parities, and collected the ear skin samples to analyze determined gene polymorphisms. The pork was observed and collected growth data, and collected ear skin samples, after 8 months of age to analyze and determine gene polymorphisms.

2.4. DATA ANALYSES

The collected dataset was processed by the Excel program, SAS9.1, with the General Linear Model (GLM).

CHAPTER 3. RESULTS AND DISCUSSIONS

3.1. Appearacne characteristics, performance and carcass component of Hung and Meo pigs

3.1.1. Appearacne characteristics

3.1.1.1. Coat skin color characteristics

Hung and Meo pigs had white spots on their foreheads accounted for 24.43% and 60.06%, white spots on legs accounted for 37.87% and 91.19%. White spots on the abdomen, chest, back, flanks and tails were accounted for 15.18; 1.40; 2.62; 1.57; 22.86% and 67.30; 8.18; 15.72; 18.24; 59.43%.

3.1.1.2. Body morphism

a. Hair morphism

Hung pigs had straight-haired mophism account for 96.03%. Medium hair density was 70.76%, thick hair style was 16.60%, sparse hair style was 12.64%, mane hair accounted for 6.14%. Meo pigs had straight-haired mophism account for 90.07%. Medium hair density was 72.34%, thick hair style was 24.82%, sparse hair tyle was 2.84%, mane hair style was 2.13%.

b. Skin and tusk morphism

The rough skin of Hung pig was accounted for 77.62%, Meo pigs with rough and wrinkled skin (41.13 and 41.13%). Hung pigs' tusk accounted for 0.72%, Meo pigs did not see tusk.

c. Morphism of the face, snout, and ears

The straight-faced Hung pig accounted for 98.92%, higher than the Meo pig 88.65%, Hung pig and Meo pig with long snout accounted for 97.83% and 44.68%, respectively. Vertical-eared pig was accounted for 85.56%, that was lower than in Meo pigs only 3.55%.

d. Belly, back mophism and walking style

Hung and Meo pigs with slim bellies accounted for 84.12% and 78.72%, straight-backed mophism accounted for 71.48% and 52.48%, percentage of Hung pigs with toed walking was 88.09%, while Meo pigs with toed walking was 100%.

3.1.1.3.Teat number

Hung pigs had 83.80% of the individuals with 10 teats, in the mean while, the Meo pig was 65.22%, the percentage of Meo pigs with 12 teats was 26.63%, and the Hung pig was 6.70%.

3.1.1.4. Sizes of some main dimensions

Table 3.1. Sizes of some main dimensions of Hung pig and Meo pig (cm)

Indexes	Gender	Hung pigs		Meo pigs	
		n	Mean±SE	n	Mean±SE
Body length	Male	118	56.86±0.88	104	60.40^{a}±0.95
	Female	74	59.61 ±1.47	10	52.40^{b}±3.15
	Both sexes	192	57.92±0.79	114	59.70±0.93
wither height	Male	118	46.52^{a}±0.63	106	48.16±0.74
	Female	72	49.51^{b}±1.08	10	40.70±3.97
	Both sexes	190	47.65±0.58	116	47.52±0.77
Back height	Male	115	45.26^{a}±0.60	106	46.43±0.69
	Female	62	49.39^{b}±1.04	10	39.70±3.88
	Both sexes	177	46.71±0.55	116	45.85±0.73

The average body length of Hung pig was 57.92 cm, the body length of the male was higher than the body length of female pig (P>0.05), the average body length of Meo pig was 59.70 cm, the body length of the female was higher than male pigs (P<0.05). The wither height and back height of Hung and Meo pigs were (47.65 and 47.52 cm) and (46.71 and 45.85 cm), respectively.

3.1.2. Performance and carcass component of Hung and Meo pigs

3.1.2.1. Sexually physiological characteristics of Hung and Meo breeding gilts.

Ages at first estrus of Hung and Meo pigs were 225.17 and 199.24 days, when pigs reached the weight of 14.58 and 17.29 kg, the ages of first service was 296.35 and 287.54 days.

When the pigs reached the weight of 19.33 kg and 23.61 kg. Ages at first farrowing were 410.54 and 401.49 days, the weights of first farrowing were 28.34 and 35.14 kg.

3.1.2.2. Reproductive performance of Hung and Meo sows.

a. Number of newborns per litter and influencing factors

The number of newborns per litter of Meo sows raised in Ky-Son district (6.66 piglets) was lower than in Nghia-Dan district (7.01 piglets) (P>0.05), the number of newborns per litter of Hung pigs in the period of 2015-2018 (6.09 piglets) lower than the period of 2019-2021 (6.11 piglets) (P>0.05). In Meo pig, the number of newborn pigs per litter in the period of 2015-2018 (7.05 piglets)) was higher than in the period from 2019 to 2021 (6.62 piglets) (P<0.05), the

number of newborns per litter of Hung and Meo pigs in the winter-spring season (6.04 and 6.77 piglets) lower than the summer-autumn season (6.16 and 6.90 piglets) (P>0.05). The number of newborns per litter Hung and Meo sow in litter 1 (5.40 and 5.66 piglets), litter 2 (6.05 and 6.60 piglets), litter 3 (6.33 and 6.96 piglets), litter 4 (6.44 and 7.48 piglets), litter 5 (6.37 and 7.47 piglets) and litter ≥6 (6.01 and 6.84 piglets), Hung pigs in litter 1 were different from litter 2, 3, 4, 5 (P<0.05). For Meo pigs in litter 1, the difference between litters 2, 3, 4, 5, and ≥6 was not statistical significance (P<0.05).

b. Number born alive per litter and influencing factors

Table 3.2. Number born alives per litter of Hung and Meo pigs (piglets)

Factors	Classify	Hung pigs		Meo pigs	
		n (litters)	LSM±SE	n (litters)	LSM±SE
Regions	Ky-Son District	-	-	326	6.39±0.11
	Nghia-Dan District	-	-	54	6.69±0.24
Periods	2015-2018	144	5.56±0.13	201	6.83^{a}±0.17
	2019-2021	286	5.81±0.10	179	6.25^{b}±0.15
Seasons	Winter - Spring	214	5.64±0.11	188	6.47±0.16
	Summer-Autumn	216	5.72±0.11	192	6.61±0.16
Litters	1	110	5.09^{b}±0.15	95	5.34^{b}±0.21
	2	108	5.68^{a}±0.15	92	6.31^{a}±0.21
	3	107	5.92^{a}±0.14	88	6.72^{a}±0.21
	4	40	5.88^{a}±0.24	36	7.11^{a}±0.29
	5	27	6.01^{a}±0.28	29	7.24^{a}±0.33
	≥6	38	5.50^{ab}±0.2	40	6.51^{a}±0.29

The number born alive per litter of Meo pigs in Nghia-Dan district (6.60 piglets) was higher in Ky-Son district (6.39 piglets) (P>0.05). The number born alive per litter of Hung pigs in the period of 2015-2018 (5.56 piglets) was lower than the period from 2019 to 2021 (5.81 piglets) (P>0.05), Meo pigs in the period of 2015-2018 (P>0.05) (6.83 piglets) were higher than the period of 2019-2021 (6.25 piglets) (P<0.05). The number born alives per litter of Hung and Meo pigs was not affected by seasonal factors (P>0.05), the

number of born alives per litter of Hung pigs from litter 1 to litter ≥6 were: 5.90; 5.68; 5.92; 5.88; 6.01 and 5.50 piglets, the differences between litter 1 and litter 2, 3, 4 and 5 (P<0.05). Meo pigs: 5.34; 6.31; 6.72; 7.11; 7.24 and 6.51 piglets, respectively. Litter 1 was different from litter 2, 3, 4, 5 and litter ≥6 (P<0.05).

c. Number of weaners per litter and influencing factors

Table 3.3. Number of weaners per litter of Hung and Meo pigs (piglets)

Factors	Classes	Hung pigs		Meo pigs	
		n (litters)	LSM±SE	n (litters)	LSM±SE
Regions	Ky-Son District	-	-	326	5.97±0.10
	Nghia-Dan District	-	-	54	6.32±0.21
Periods	2015-2018	144	5.22±0.12	201	6.40^{a}±0.15
	2019-2021	283	5.40±0.09	179	5.90^{b}±0.13
Seasons	Winter - Spring	213	5.26±0.10	188	6.06±0.14
	Summer-Autumn	214	5.35±0.10	192	6.23±0.14
Litters	1	110	4.88^{b}±0.13	95	5.08^{b}±0.18
	2	108	5.34^{ab}±0.13	92	6.00^{a}±0.18
	3	107	5.55^{a}±0.13	88	6.37^{a}±0.19
	4	40	5.50^{ab}±0.21	36	6.75^{a}±0.26
	5	24	5.49^{ab}±0.27	29	6.72^{a}±0.29
	≥6	38	5.08^{ab}±0.21	40	5.97^{a}±0.25

The number of weaner per litter of Meo pigs in Nghia-Dan district was 6.32, which was higher than in Ky-Son district (5.97 pigs) (P>0.05). The number of weaned pigs per litter of Hung pigs in the period 2015-2018 (5.22 piglets) was lower than in the period 2019-2021 (5.40 piglets) (P>0.05). In contrast, in Meo pigs, the period of 2015-2018, the number of weaned pigs per litter (6.40 piglest) was higher than the period of 2019-2021 (5.90 heads) (P<0.05). Hung pigs and Meo pigs had a lower number of weaned pigs per litter in the winter-spring season (5.26 and 6.06 piglets) than in the summer-autumn season (5.35 and 6.23 piglets) (P>0.05), the numbers of weaned pigs per litter of Hung sows from parity 1 to parity ≥6 were: 4.88; 5.34; 5.55; 5.50; 5.49 and 5.08 piglets; the

difference of 1st, and 3rd litter was statistically significant (P<0.05); number of weaned pigs per litter of Meo sows from parity 1 to parity ≥6: 5.08; 6.00; 6.37; 6.75; 6.72 and; 5.97 piglets, litter 1 differed significantly from litter 2, 3, 4, 5 and litter ≥6 (P<0.05).

d. Farrowing interval of Hung and Meo sows

The farrowing interval of Meo sows in Ky-Son district (208.12 days) was higher than that of sows raised in Nghia-Dan district (190.36 days) (P<0.05). The farrowing interval of Hung sows in the period from 2015 to 2018 (211.63 days) was higher than the period between 2019 and 2021 (202.63 days) (P<0.05), the farrowing interval of Meo sows in the period of 2015-2018 (201.25 days) was higher than the period of 2019-2021 (197.23 days) (P>0.05). The farrowing intervals of Hung and Meo pigs in the winter-spring season were 207.56 and 198.82 days, respectively; in the summer-autumn season were 206.70 and 199.67 days, respectively (P>0.05), The farrowing intervals Hung and Meo sows among litters 1-2; 2-3; 3-4; 4-5; 5-6 and 6-≥6 were: 212.65 and 197.65 days; 209.70 and 202.40 days; 207.81 and 199.73 days; 201.62 and 198.11 days; 198.94 and 201.32 days; 212.06 and 196.25 days, respectively (P>0.05).

e. Body weight of sows through parities of Hung and Meo sows

The average body weight of Meo sows raised in Ky-Son district was 50.11 kg/sow, in Nghia-Dan district was 46.98 kg/sow (P<0.05). The body weight of Hung sows in the period from 2015 to 2018 was 43.22 kg higher than the period between 2019 and 2021 with 40.40 kg (P<0.05). The body weight of Meo pig in the period from 2015-2018 was 47.37 kg lower than the period of 2019-2021 with 49.73 kg (P<0.05). Winter-spring season, the body weights of Hung sows and Meo sows were 42.11 and 48.41 kg, summer-autumn season were 41.51 and 48.68 kg (P>0.05). The body weights of Hung sows at parity 1, 2, 3, 4, 5 and ≥6 were: 29.29; 36.12; 41.32; 45.55; 46.98 and 51.62 kg, the weights of 1st, 2nd, 3rd parities were different from the 4th, 5th and 6th parities (P<0.05). The body weights of Meo sows were 34.42; 41.34; 46.15; 53.56; 55.97 and 59.84 kg, respectively, the weights of 1st, 2nd and 3rd parities were different from the weights of 4th, 5th and 6th parities (P<0.05).

3.1.2.3. Growth perfromance of Hung and Meo pigs

a. Body weight of Hung and Meo pigs through months of age

The body weight of Hung and Meo pigs at 2 months old were 5.61 and 6.13 kg, respectively. At 8 months old, the average body weights were 24.83 and 28.18 kg.

Table 3.4. Body weight and weight gain over months old of Hung and Meo pigs

Trait groups	Months old	Hung pigs		Meo pigs	
		n	Mean±SE	n	Mean±SE
Body weight (kg)	2	390	5.61±0.11	352	6.13±0.11
	8	127	24.83±0.83	174	28.18±0.75
Weight gain (g/day)	2-8	127	105.93±3.79	174	122.25±3.66

b. Weight gain of Hung and Meo pigs through the ages

Weight gain of Hung pigs in the period from 2-8 months old was 105.93 g/day; that of Meo pigs was 122.25 g/day.

c. Body weight according to the litter of Hung and Meo pigs

* Newborn weight/litter and influencing factors

The newborn weight per litter of Nghia-Dan district was 3.04 kg higher than that of Ky-Son district (2.79 kg) (P>0.05). The period from 2015 to 2018, the newborn weight per litter of Hung pigs (2.82 kg) was higher than that from 2019 to 2021 (2.49 kg) (P>0.05), the newborn weight per litter of Meo pig in the period of 2015-2018 was 2.86 kg, that of the period between 2019 and 2021 was 2.98 kg (P>0.05); those of Hung and Meo pigs in winter-spring season were 2.72 and 2.99 kg were higher than in summer-autumn (2.59 and 2.85 kg) (P>0.05). The newborn weights per litter of Hung pigs from parity 1 to parity ≥6 were 2.34; 2.36; 2.55; 2.76; 3.24 and 2.68 kg; The newborn weights per litter of the 1^{st} and 2^{nd} parity were different from the 5^{th} (P<0.05). Meo pig were 2.43; 2.48; 2.82; 3.06; 3.24 and 3.49 kg, respectively; The newborn weights per litter of the 1^{st}, and 2^{nd} parity were different from the ≥ 6 parities (P<0.05).

Table 3.5. Newborn weight per litter of Hung and Meo pigs (kg)

Factors	Classes	Hung pigs		Meo pigs	
		n (litters)	LSM±SE	n (litters)	LSM±SE
Regions	Ky-Son District	-	-	56	2.79±0.16
	Nghia-DanDistrict	-	-	10	3.04±0.31
Periods	2015-2018	64	2.82±0.13	27	2.86±0.22
	2019-2021	11	2.49±0.27	39	2.98±0.21
Seasons	Winter - Spring	24	2.72±0.20	50	2.99±0.22
	Summer-Autumn	51	2.59±0.17	16	2.85±0.27
Litters	1	13	2.34^{b}±0.24	15	2.43^{b}±0.30
	2	22	2.36^{b}±0.21	12	2.48^{b}±0.34
	3	20	2.55^{ab}±0.21	12	2.82^{ab}±0.30
	4	9	2.76^{ab}±0.31	10	3.06^{ab}±0.33
	5	6	3.24^{a}±0.37	8	3.24^{ab}±0.37
	≥6	5	2.68^{ab}±0.39	9	3.49^{a}±0.37

* Weaned weight per litter and influencing factors

Table 3.6. Weaned weight per litter of Hung and Meo pigs (kg)

Factors	Classes	Hung pigs		Meo pigs	
		n (litters)	LSM±SE	n (litters)	LSM±SE
Regions	Ky-Son District	-	-	54	32.72^{b}±2.73
	Nghia-Dan District	-	-	7	55.93^{a}±6.11
Periods	2015-2018	63	29.57±1.82	26	41.29±4.04
	2019-2021	11	31.35±3.84	35	47.36±3.99
Seasons	Winter - Spring	23	30.44±2.95	48	44.63±3.94
	Summer-Autumn	51	30.48±2.45	13	44.02±5.17
Litters	1	13	24.78±3.48	13	38.94±5.53
	2	22	29.42±3.00	12	40.93±5.79
	3	20	32.77±2.92	11	44.88±5.31
	4	8	34.74±4.69	9	43.70±5.98
	5	6	27.18±5.26	7	47.71±6.82
	≥6	5	33.88±5.51	9	49.78±6.38

The weaned weight per litter of Meo pigs in Nghia-Dan district was 55.93 kg/litter higher than in Ky-Son district of 32.72 kg/litter (P<0.05). The weaned weight per litter Hung and Meo pigs in the period of 2015-2018 were 29.57 and 41.29 kg, lower than the period from 2019 to 2021 (31.35 and 47.36 kg) (P>0.05), weaned weight per litter of Hung and Meo pigs in winter-spring season were 30.44 and 44.63 kg, in the summer-autumn season were 30.48 and 44.02 kg (P>0.05). The weaned weight per litter in Hung pigs was lowest in litter 1, increased gradually in litter 2, 3, reached to the peak at litter 4, and then decreased from litter 5 (P>0.05), Meo pigs had the lowest weaned weight in litter 1 (38.94 kg), the highest in litter ≥6 (49.78 kg) (P>0,05).

d. Body weight of Hung and Meo pigs over months old by influencing factors.

* Body weight of Hung pigs over months old and influencing factors

Body weights from birth to 8 months old in the period of 2015-2018 were 0.46; 5.47; 11.34; 18.34 and 25.51 kg, the weights in the period of 2019-2021 were 0.45; 6.29; 13.73; 21.47 and 29.98 kg. The differences between the 2 stages at 2, 4, 6, and 8 months old were statistically significant (P<0.05). But in the age of 4, 6 and 8 months old, the weights at winter-spring season were higher than in the summer-autumn season (P<0.05). The weights of females from birth to 6 months old were lower than those of males, to 8 months old, the weights of females were higher than those of males, and there was a significant difference in newborn weight and weight at 6 months old. (P<0.05), Hung pig's weight from birth to 8 months, the lowest was in pigs born in litter 1, then gradually increased in litter 2, reached highly in litter 3, 4 and ≥6.

* Body weight of Meo pigs over months old and influencing factors

The body weight of Meo pigs from birth to 8 months old raised in Nghia-Dan district was higher than in Ky-Son district, the period from 2015 to 2018, the body weight of Meo pigs from 2 to 8 months old was lower than the period from 2019 to 2021, the differences in 2 months old, 4 and 6 months old between the two periods were statistically significant (P<0.05). The body weights of Meo pig over the months old were not influenced by seasonal factors, however they were influenced by sexes (P<0.05), the body weights of Meo pigs

over months old were influenced by the litter factor (with exception at 2 months old).

3.1.2.4. Weight gain of Hung and Meo pigs and influencing factors

a. Weight gain (g/day) of Hung and Meo pigs from birth to 8 months old and influencing factors

The weight gain from birth to 8 months old of Meo pigs raised in Nghia-Dan district (149.37g/day) was higher than in Ky-Son district (109.90 g/day) (P<0.05), Hung pigs and Meo pigs in the period from 2015 to 2018 (104.41 and 124.21 g/day), lower than the period between 2019 and 2021 (123.03 and 135.06 g/day) (P<0.05). The weight gain of Hung pigs in the winter-spring season was higher than that in the summer-autumn season (P<0.05). However, the weight gain of Meo pigs in the winter-spring season was lower than in the summer-autumn season (P<0.05), the body weight gain of Hung females was higher weight than males (P>0.05), in contrary, Meo males showed higher weight gain Meo females (P<0.05). Weight gains of Hung pigs in litter 1 were different from litters 3, 4 and litter ≥6 (P<0,05), the weight gains of Meo pigs in the 1st litter were different from the 3rd and 6th parities; the weight gains of 3rd differed from litter 5 (P<0.05).

b. Weight gain (g/day) of Hung and Meo pigs from 2 to 8 months old and influencing factors

The weight gain from 2 to 8 months old of Meo pigs raised in Nghia-Dan district (159.15 g/day) was higher than in Ky-Son district (119.74 g/day) (P<0.05), the weight gain of Hung pigs and Meo pigs in the period of 2015-2018 was lower than that of period 2019-2021. In the winter-spring season, the weight gain of Hung pigs (130.76 g/day) was higher than in the summer-autumn season (109.50 g/day) (P<0.05), the weight gain of Meo pigs in the winter-spring season (130.50 g/day) was lower in the summer-autumn season (148.38 g/day) (P>0.05). The weight gain Hung female pigs was 120.94 (g/day) weight, higher than males (119.32 g/day) (P>0.05). On the contrary, the weight gain in Meo females was 132.10 (g/day) lower than that of Meo males with 146.79 (g/day) (P<0.05), the weight gain of Hung pigs born in 1st litter differed from litter ≥6th (P<0.05), the weight gain of Pigs born in litter 3 were different from litter 1 and litter 5 (P<0.05).

Table 3.7. Weight gain (g/day) of Hung and Meo pigs from 2 to 8 months old and influencing factors.

Factors	Classes	Hung pigs		Meo pigs	
		n	LSM±SE	n	LSM±SE
Regions	Ky-Son District	-	-	150	119.74^{b}±5.05
	Nghia-Dan District	-	-	24	159.15^{a}±10.72
Periods	2015-2018	95	106.62^{b}±4.98	62	136.41±8.42
	2019-2021	32	133.64^{a}±7.82	112	142.48±5.91
Seasons	Winter - Spring	34	130.76^{a}±7.01	136	130.50±6.57
	Summer-Autumn	93	109.50^{b}±5.79	38	148.38±8.96
Sexes	Female	60	120.94±6.14	87	132.10^{b}±6.99
	Male	67	119.32±5.98	87	146.79^{a}±6.83
Litters	1	29	107.37^{b}±7.56	20	122.86^{b}±10.86
	2	38	109.65^{ab}±7.00	30	136.17^{ab}±10.78
	3	29	127.26^{ab}±7.49	27	159.01^{a}±10.16
	4	15	131.96^{ab}±10.98	33	140.26^{ab}±9.38
	5	7	107.30^{ab}±15.43	25	131.51^{b}±11.23
	≥6	9	137.24^{a}±13.15	39	146.85^{ab}±10.06

3.1.2.5. Carcass component of Hung and Meo pigs

a. Carcass component of Hung pigs

Body weight of Hung pigs slaughtered at 8 months old was 26.45 kg, carcass percenatage was 71.22%; dressing carcass percentage was 58.91%; the lean meat percentage was 44.97%; fat and bone percentage were 26.61% and 14.15%, skin percentage and back fat thickness were 13.90% and 14.64 mm, respectively.

b. Carcass component of Meo pigs

Body weight of Hung pigs slaughtered at 8 months old was 35.05 kg; carcass percenatage was 71.78%; dressing carcass percentage was 58.80%; the lean meat percentage was 51.39%; fat, bone and skin percentage were: 18.58%; 15.64% and 12.70%, respectively, and back fat thisckness was 14.09 mm.

3.2. Gene polymorphisms and the association between gene polymorphisms with reproductive and growth performance of Hung and Meo pigs

3.2.1. Polymorphisms of *OVGP1* and *LIF*, *GH* and *IGF1* genes, in Hung and Meo pigs

3.2.1.1. OVGP1 and LIF gene polymorphisms in Hung sows and Meo sows

a. OVGP1 and LIF gene polymorphisms in Hung sows

Gene polymorphism of *OVGP1* had the lowest frequency BB genotype (3.6%), AA genotype (47.60%), and the highest was of AB genotype (48.80%). The frequencies of the A and B alleles were 0.720 and 0.280, respectively. For *LIF* gene polymorphism, TT genotype was dominant with frequency of 0.787, CT genotype was 0.187 and the lowest was CC genotype 0.026. The frequencies of the C and T alleles were 0.120 and 0.880, respectively.

b. OVGP1 and LIF gene polymorphisms in Meo sows

Gene polymorphism of *OVGP1* had the lowest frequency of BB genotype (6.60%), AB genotype (30.30%), AA genotype (63.10%), frequency of A and B alleles was 0.783 and 0.217. For *LIF* gene polymorphism, TT genotype accounted for the highest percentage (84.90%), CC genotype (2.30%), CT genotype (12.80%). The frequencies of the C and T alleles were 0.087 and 0.913, respectively.

3.2.1.2. Polymorphisms of GH and IGF1 genes in Hung and Meo pigs

a. GH and IGF1 gene polymorphisms in Hung pigs

GH gene polymorphism had genotype frequency of AB (54.30%), AA and AB genotype accounted for (25.90% and 19.80%). A and B allele frequencies were 0.53 and 0.47, respectively. For *IGF1* gene polymorphism, AA genotype accounted for (65.10%), was higher than AB genotype (34.90%), the frequency of A allele was 0.826 and B allele was 0.174.

b. GH and IGF1 gene polymorphisms in Meo pigs

Genotype and allele frequencies of *GH* gene in Meo pigs with BB genotype accounted for the lowest percentage (8%), the highest was genotype AA (48%), genotype AB (44%). Allele frequencies A and B were 0.700 and 0.300, respectively. For *IGF1* gene polymorphism, AB genotype was dominated with the percentage of 89.40%, AA genotype accounted for 10.60%. However, the frequency of A allele was 0.553 and the frequency of B allele was 0.447.

3.2.2. The association between genotypes of genes with growth and reproductive performance of Hung and Meo pigs

3.2.2.1. The association between OVGP1 and LIF gene polymorphisms on reproductive performance of Hung sows and Meo sows

a. For Hung sows

* The association between *OVGP1* gene polymorphism with sexually physiological indicators

Individual groups with AB genotype had the highest age at first service and at first farrowing (296.63 and 410.50 days); and then, the individual groups with AA genotype were 295.29 and 409.31 days, respectively; and the individual groups with BB genotype were lowest (253.67 and 368.00 days) (P>0.05). The body weight at first service and at first farrowing were highest in the individual groups with BB genotype (23.67 and 33.00 kg); the individual groups with AB genotype were 20.27, and 29.15 kg, respectively; and the groups with AA genotype were lowest (17.88 and 26.43 kg) (P<0.05).

* The association between *OVGP1* gene polymorphism with reproductive performance of the three first parities.

Table 3.8. The association between *OVGP1* gene polymorphism with reproductive performance of the three first parities

Traits	Genotypes	n	Mean±SE	G	u	d-value
Total number of newbonn (piglets)	AA	35	16.80^{b}±0.54	-1.065	-1.108	0.043
	AB	40	18.63^{ab}±0.70	0.760	0.871	-0.111
	BB	3	21.00^{a}±0.58	3.135	2.850	0.285
Total number born alive (piglets)	AA	35	15.77^{b}±0.57	-1.256	-1.264	0.008
	AB	40	18.00^{ab}±0.72	0.972	0.993	-0.021
	BB	3	20.33^{a}±0.88	3.306	3.251	0.054
Total number of weaners (piglets)	AA	35	15.06^{b}±0.50	-1.113	-1.109	-0.003
	AB	40	17.05^{ab}±0.61	0.880	0.872	0.009
	BB	3	19.00^{a}±0.58	2.830	2.852	-0.022

The total number of newborns of three first parities in sow groups with BB genotype was highest (21.00 piglets), sow groups with AB genotype (18.63 piglets), and sow groups with AA genotype was lowest (16.80 piglets). The total number born alives over three first parities of the sow group carried AA, AB and BB genotypes were 15.77; 18.00 and 20.33 piglets. The sow groups carried BB genotype had the highest total number of weaners from three first parities (19.00 piglets), carried AB genotype was 17.05, and the lowest was sow groups carried AA genotype (15.06 piglets). The differences in the total number of newborns, number born alives, and weaners of three first parities between the sow groups carried BB genotype and the sow groups carried AA genotype were statistically significant ($P<0.05$).

* The association between *LIF* gene polymorphisms with some sexually physiological parameters of breeding gilts

The age at first service and first farrowing of Hung individual groups carried CC genotype were highest (375.00 and 489.00 days), individual groups carried CT genotype (294.71 and 408.79 days), and the was lowest found in individual groups carried TT genotype (293.63 and 407.54 days) ($P>0.05$). The body weight at first service and first farrowing of the sow groups carried TT genotype (19.23 and 28.02 kg) was the highest, followed by individual groups carried CT genotype (19.14 and 27.86 kg), and the lowest was found in groups carried CC genotype (17.00 and 24.00 kg) ($P>0.05$).

* The association between *LIF* gene polymorphism with reproductive performance of three first parities.

At three first parities, Hung sows carried TT genotype had total number of newbonns more than +0.55 piglets, total number born alives more than +0.08 piglets, and total number of weaners was more than +0.01 piglets compared with Hung sows carried CT genotype, and more than sows carried CC genotype +3.98; +4.08 and +3.72 piglets, respectively ($P>0.05$).

b. For Meo sows

* The association between *OVGP1* gene polymorphisms with some sexually physiological traits of breeding gilts

Age at first service, age at first farrowing, weight at first service and weight at first farrowing of individuals carried AB

genotype had the highest values, and then individuals carried AA, and the lowest value was founf in individuals carried BB genotype (P>0.05).

* The association between *OVGP1* gene polymorphism with reproductive performance of three first parities.

Table 3.9. The association between *OVGP1* gene polymorphism with reproductive performance of Meo sows in three first parities.

Traits	Genotypes	n	Mean±SE	G	u	d- value
Total number of newborns (piglets)	AA	48	18.17^{a}±0.59	-0.354	-0.534	0.181
	AB	23	18.57^{a}±0.80	0.045	0.697	-0.652
	BB	5	22.80^{b}±0.86	4.280	1.928	2.352
Total number born alives (piglets)	AA	48	17.58^{a}±0.59	-0.256	-0.462	0.207
	AB	23	17.70^{a}±0.73	-0.143	0.603	-0.746
	BB	5	22.20^{b}±0.97	4.361	1.668	2.693
Total number of weaners (pigs)	AA	48	16.52^{a}±0.54	-0.317	-0.427	0.109
	AB	23	17.00^{ab}±0.61	0.162	0.556	-0.394
	BB	5	19.80^{b}±1.39	2.962	1.539	1.423

The total number of newborns and the total number born alives through three first parities in the individual groups carried BB genotype (22.80 and 22.20 piglets), carried AA genotype (18.17 and 17.58 piglets) and carried AB genotype (18.57 and 17.70 piglets). The differences between the individual groups with BB genotype and the groups with AA and AB genotypes were significant (P<0.05). The total number of weaners of three first parities in the groups carried BB genotype (19.80 piglets) was the highest and the groups carried AA genotype (16.52 piglets) was the lowest (P<0.05).

* The association between *LIF* gene polymorphisms with some sexually physiological traits of breeding gilts.

Sow groups carried CC, CT, and TT genotypes did not affected some sexually physiological and reproductive traits and body weight of Meo breeding gilts (P>0.05).

* The association between *LIF* gene polymorphism with reproductive performance of three first parities

Genotypes did not influence on traits such as the total number of newborns, number born alive and number of weaner of three first parities (P>0.05).

3.2.2.2. The association between GH and IGF1 gene polymorphisms with the growth performance of Hung and Meo pigs

a. For Hung pigs

* *GH* gene

Pigs carried BB had birth weight from birth to 8 months old (0.45-25.46 kg), pigs carried AB genotype had the weights of 0.44-22.92 kg, and pigs carried AA genotype AA had the weights of 0.42-22.17 kg, there was the only difference in pigs carried AB genotype and BB genotype at 2 months old (P<0.05).

* *IGF1* gene

The birth weight pigs carried AA genotype (0.44 kg) was higher than the ones carried AB genotype (0.43 kg) (P>0.05). The weights of pigs at 2, 4, 6 and 8 months old, pigs carried AB genotype had the weights: 6.06; 11.90; 17.74 and 23.34 kg were higher than pigs carried AA genotype (5.80; 11.44; 17.18 and 23.13 kg) (P>0.05).

b. For Meo pigs

* *GH* gene

The body weights at 2 months old of pigs carried AA, AB and BB genotypes were 6.10; 6.08 and 4.63 kg/pig, respectively (P>0.05). Body weight at 4 months old, pigs carried AA genotype was highest (13.10 kg), followed by AB genotype (11.24 kg), and the lowest was BB genotype (8.63 kg). The differences between pigs with AA and BB genotypes were significant (P<0.05), pigs carried AA genotype had the highest weights at 6 and 8 months old (21.47 and 29.68 kg), and the lowest was pigs carried genotype BB (14.47 and 20.13 kg), the differences in weights at 6 and 8 months old of pigs carried genotype AA and BB were significant (P<0.05).

Table 3.10. The association between *GH* polymorphisms with the growth performance of Meo pigs over months old (kg)

Traits	Genotypes	n	LSM±SE	G	a	d-value
Weight at 2 months old	AA	35	6.10±0.33	0.142	0.270	-0.128
	AB	32	6.08±0.35	0.118	-0.180	0.298
	BB	6	4.63±0.81	-1.325	-0.630	-0.695
Weight at 4 months old	AA	35	13.10^{a}±0.65	1.183	1.250	-0.067
	AB	32	11.24^{ab}±0.68	-0.677	-0.834	0.157
	BB	6	8.63^{b}±1.57	-3.283	-2.917	-0.366
Weight at 6 months old	AA	35	21.47^{a}±1.13	2.581	2.376	0.205
	AB	32	16.83^{b}±1.18	-2.062	-1.584	-0.478
	BB	6	14.47^{b}±2.71	-4.427	-5.543	1.116
Weight at 8 months old	AA	35	29.68^{a}±1.65	4.083	3.560	0.523
	AB	32	22.00^{b}±1.72	-3.594	-2.373	-1.221
	BB	6	20.13^{b}±3.98	-5.458	-8.306	2.848

* *IGF1* gene

Meo pigs at 2, 4, 6 and 8 months old, pigs carried AA genotype had the body weight (6.43-31.22 kg), were higher than pigs carried AB genotype (5.91-24.72 kg). However, we only found the statistically significant impact between the *IGF1* gene polymorphism on the body weight of Meo pigs at of 6^{th} and 8^{th} months old ($P<0.05$).

Table 3.11. The association between *IGF1* polymorphisms with the growth performance of Meo pigs over months old (kg)

Traits	Genotypes	n	LSM±SE
Weight at 2 months old	AA	9	6.43±0.67
	AB	64	5.91±0.25
Weight at 4 months old	AA	9	13.98±1.32
	AB	64	11.62±0.50
Weight at 6 months old	AA	9	23.45^{a}±2.30
	AB	64	18.21^{b}±0.86
Weight at 8 months old	AA	9	31.22^{a}±3.42
	AB	64	24.72^{b}±1.28

CONCLUSIONS AND RECOMMENDATIONS

1. Conclusions

a. Appearance characteristics and performance of Hung and Meo pigs

Hung and Meo pigs have variously distinctive characteristics of appearance traits: Hung pigs have tawny-reddish colored hair and skin, they may have white spots on the forehead, legs, tails ..., straight hair, medium hair density, few pigs have mane hair, Hung pigs have rough skin, straight face, long snout, some pigs exposed tusks, erectile ears, slim belly, straight back, mainly toe-walking. Sows have 8-14 teats, but most sows have 10 teats (83.80%). Meo pigs have black hair, skin; white spots on forehead, belly, chest, flanks, and tails, ..., straight hair, medium hair density, few pigs have mane hair, the pig has wrinkled and rough skin, not expose tusk, horizontal ears, straight face, slim belly, maily toe-walking. Especially, sows have from 8-15 teats, but however, major females have 10 teats (65.22%) and 12 teats (26.63%); at matured age, Meo pigs are bigger than Hung pigs.

Age at first estrus, age at first mating and age at first farrowing of Hung pigs (225.17; 296.35 and 410.54 days) were higher than those of Meo pigs (199.24; 287.54 and 401.49 days), respectively. Hung pigs have newborns per litter of 5.40-6.44 piglets, number born alives per litter of 5.09-6.01 piglets, number of weaners per litter of 4.88-5.55 piglets; birth weight per litter was 2.34-3.24 kg, weaned weights per litter were 24.78-34.74 kg, these were lower than those of Meo pigs (5.66-7.48 piglets; 5.34-7.24 piglets; 5.08-6.75 piglets; 2.43-3.49 kg; 38.94-49.78 kg).

The body weights of Hung pigs and Meo pigs at 8 months old were 24.83 and 28.18 kg, and the average daily gain from 2-8 months old were 105.93 and 122.25 g/day, respectively.

The average slaughtered weights of Hung and Meo pigs were 26.45 and 35.05 kg; the carcass percentages were 71.22 and 71.78%; lean meat percentage were 44.97 and 51.39%; fat percentages were 26.61 and 18.58%; back fat thicknesses were 14.64 and 14.09 mm.

b. Gene polymorphisms associated with reproductive and groth performance

The results determined the genotype frequencies and allele frequencies of the *OVGP1*, *LIF* candidate genes associated to

reproductive traits, and *GH*, *IGF1* genes associated with growth traits in Hung and Meo pigs: *OVGP1* gene had 3 AA, AB, BB genotypes with A and B allele frequencies of Meo pigs were 0.783 and 0.217 in Hung pigs was 0.720 and 0.280. *LIF* gene had 3 genotypes: CC, CT and TT; allele frequencies of T and C in Meo pig were 0.913 and 0.087 in Hung pig were 0.880 and 0.120. The *GH* gene had 3 genotypes: AA, AB, and BB; A and B allele frequencies were 0.700 and 0.300 in Meo pigs; 0.531 and 0.469 in Hung pigs. The *IGF1* gene had 2 genotypes: AA and AB with A and B allele frequencies in Meo pigs of 0.553 and 0.447; in Hung pigs of 0.826 and 0.174. The Hardy-Weinberg genetic equilibrium test on the studied genes showed that the Hung pig reached equilibrium in all 4 genes, in the mean while, the Meo pig was balanced at only 3 genes (unbalanced at the *IGF1*_SacII locus).

Polymorphisms of *OVGP1* and *LIF* genes were associated with the reproductive performance of Hung and Meo pigs. In which, pigs carried BB genotype of the *OVGP1* gene had a total number of newborns, total number born alive, and the total number of weaners of three first parities were higher than groups carried AB and AA genotypes. The *LIF* gene polymorphism also influenced on the farrowing interval in Hung pigs, whereby, pigs carried TT genotype had the shortest farrowing interval. Therefore, for these two pig breeds, the B allele (*OVGP1* gene) and the T allele (*LIF* gene) need to be maintained and developed to improve reproductive performance in two these swine breeds. Meanwhile, *GH* and *IGF1* gene polymorphisms were associated with the growth performance of Meo pigs. Pigs carried AA genotype of *GH* and *IGF1* gene polymorphisms in Meo pigs had higher weights at birth, 2, 4, $6^{th,}$ and 8^{th} months old than groups carried AB-*GH*, BB-*GH*, and AB-*IGF1* genotypes.

2. Recommendations

Using the individuals carried BB genotype of the *OVGP1* gene for selection and pure breeding aim at increasing the total number of newborns, total number born alive, and total number of weaners of Hung and Meo pigs.

Select individuals carrying AA genotypes of the *IGF1* gene and the *GH* gene into the nuclear herd to select enhanced the body weight of Meo pigs.

PUBLISHED SCIENTIFIC WORKS RELATED TO THE THESIS

1. Nguyen Van Trung, Nguyen Trong Ngu and Pham Van Gioi. Genetic polymorphisms of some genes associated with reproductive and growth performance in Hung and Meo pigs. Journal of Livestock Science and Technology No. 121, March 2021, pp. 80-88.
2. Nguyen Van Trung, Nguyen Trong Ngu and Pham Van Gioi. Appearance characteristics of two Hung and Meo swine breeds. Journal of Livestock Science and Technology No. 264, April 2021, pp. 35-39.
3. Nguyen Van Trung, Nguyen Trong Ngu and Pham Van Gioi. Association between *OVGP1* and *LIF* gene polymorphisms with reproductive performance of Hung and Meo pigs. Journal of Livestock Science and Technology, No. 271, pp. 6-11.