



## Research Article

# Reproductive Performance of a New GF24 Female Gilt Line Reared under Different Conditions in Vietnam

<sup>1</sup>Nguyen Tien Thanh, <sup>2</sup>Randolph Reinecker Zoerb and <sup>3,4,5</sup>Do Vo Anh Khoa

<sup>1</sup>Nong Lam University, Thu Duc, Ho Chi Minh City, Vietnam

<sup>2</sup>GreenFeed Vietnam Corporation, Vietnam

<sup>3</sup>Department of Animal Sciences, College of Agriculture and Applied Biology, Can Tho University, Xuan Khanh Ward Ninh Kieu District, Can Tho, Vietnam

<sup>4</sup>Animal Husbandry Association of Vietnam, Vietnam

<sup>5</sup>Southwest University of Science and Technology, China

## Abstract

**Background and Objectives:** Most of farms in Vietnam are raising pigs originating/importing from temperate countries. Normally, their adaptation must be recorded, analyzed and evaluated before developing population. Objective of this study was to retrospectively characterize the reproductive performance of a new crossed pig line called GF24 line, which was crossed among pure Landrace, large white and Piétrain breeds imported from America under different management and climate conditions in Vietnam. **Materials and Methods:** The GF24 sows were arranged to mate with boars of GF399, GF337 or GF280 lines originating from American pure lines. Reproductive parameters were collected in 165 commercial pig farms and 1981 litters of GF24 reared in good management farms in Vietnamese provinces/cities during 4 years (2014-2017). Collected data was analyzed by using the R-Statistical Program with descriptive statistical method and GML model. **Results:** The prolificacy of GF24 sows was obtained among different mentioned conditions. Mean of total number of born/litter (TNB), number of born alive/litter (NBA), number born selected/litter (NBS) and number of weaning/litter (NW), were 13.06, 12.11, 11.17 and 10.49 piglets/litter, respectively. During the 24.39 day-lactation period, ADG (average daily gain) of piglets was 207.24 g/day. Although the differences for some observed traits among geographical regions such as subtropical and tropical zones along Vietnam and different managements for housings as well as farms and litters size were found, GF24 line always maintains their highly prolific characteristics under such conditions and definitely outperforms the other sow breeds/lines raised in Vietnam in terms of reproductive performance and total economic efficiency, especially under good management conditions of the farm, the performance of GF24 is very high and stable. **Conclusion:** The GF24 commercial sow line should be added to the industrialized pig production system to enhance the performance and benefits, which help pig production in Vietnam and other countries such as Cambodia, Laos and Myanmar have a faster move forward to prepare for the new economic integration.

**Key words:** American pure lines, total economic efficiency, reproductive performance, Vietnam

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**Corresponding Author:** Do Vo Anh Khoa, Department of Animal Sciences, College of Agriculture and Applied Biology, Can Tho University, Xuan Khanh Ward, Ninh Kieu District, Can Tho, Vietnam Tel: +84 918 026653

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**Competing Interest:** The authors have declared that no competing interest exists.

**Data Availability:** All relevant data are within the paper and its supporting information files.

## INTRODUCTION

With marvelous applications for plenty of advances in genetic selection, nutrition, housing and disease control since the 1950s, modern pork production significantly has increased the efficiency of reproduction in the breeding herd<sup>1</sup>. Using information technology advances for commercial herd data collections and analysis could help geneticists improve herd productivity and stable output in breeding herds<sup>2</sup>.

Recently, industrial pig production has developed quite rapidly in Vietnam. Many pure bred pigs in temperate regions (cold and dry climates) such as Demark, America, France, Belgium, etc. are imported directly to Vietnam, one of the tropical East Asian countries (hot and humid climate), where the climate is different among regions (North with four seasons: Spring, summer, fall and winter; the South with two seasons: Rainy and sunny seasons and Central with complicated seasons). In developed countries, pigs are usually kept in a closed housing system. However, many of them are kept in a closed or opened housing one in Vietnam because the farmers often have not enough money to investigate the closed housing.

In the past 6 years, the Pig Improvement Company (PIC, USA) has co-operated with GreenFeed Vietnam Joint Stock Company (GreenFeed) to successfully transfer and produce high-yielding pig lines in Vietnam. Initially,

GreenFeed has produced new lines, namely GF399, GF337 and GF280 boars, as well as GF24 sows (Fig. 1), which is the owner of specific genotypes for F18 strain resistance of *E. coli*. In recent reports, only some data regardings to reproductive performance of the parental GF24 such as TNB, NBA, NW and WW have been recorded in the two GreenFeed's farms with good management condition from 2013 to 2014<sup>3</sup> and in a 30-gilts farm with conventional conditions in Quang Binh province located in the Central of Vietnam from January to July in 2015<sup>4</sup>. However, due to limitation of observed data, the previous published results were not good enough to reflect all of the adaptability and genetic potential of GF24 in various fostering conditions (kinds of climate, sizes of farm, types of housing, etc.) along Vietnam. Therefore, based on big data collected during 4 years from many farms, factors influencing on the reproductive performance of the GF24 were analyzed by using multivariate analysis of data sets in this study. Additionally, although there are many reports on reproductive performance of pig breeds raised in Vietnam in the past decades, including native, hybrid and imported pigs, most of them were surveyed and researched at the local level or a few farms. So far, there has not been any research on the reproductive performance of pig breeds in whole Vietnam yet. All they were reasons why this study was conducted. Hence, the present study was carried out to characterize the reproductive performance of a new crossed pig line called GF24 sow.

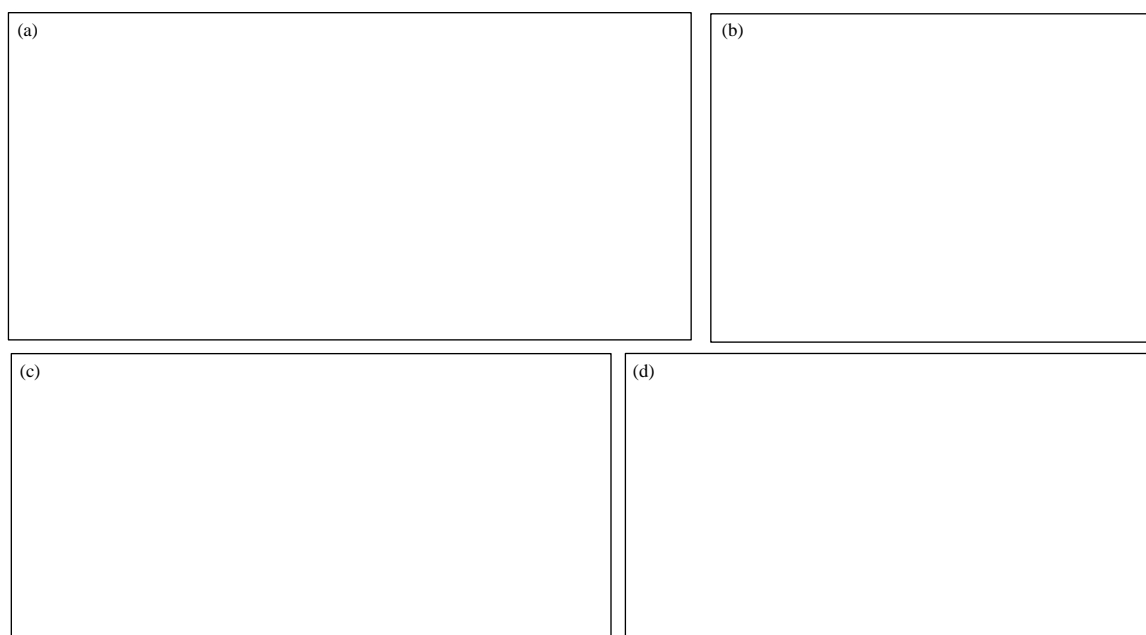


Fig. 1(a-d): Appearance of GF24 sow line and boar lines of GF337, GF399 and GF280 raised in Vietnam

## MATERIALS AND METHODS

An observation on 20,295 litters of the GF24 sows from 165 commercial farms containing 145 opened-housings and 20 closed-housings and 1,981 litters of GF24 reared in good management farm were conducted in Vietnam from January, 2014 to July, 2017. To obtain the study objective, the GF24 sows (a crossed product among Piétrain, Landrace and Large White) with different litters were used to mate with GF399, GF337 or GF280 males and then reproductive parameters of the GF24 such as total number of born/litter (TNB), number of born alive/litter (NBA), total number born dead/litter (TBD), number born selected/litter (NBS), number weaning/litter (NW), litter weight selected/piglet (LWS, kg), weaning weight/piglet (WW, kg), total weaning weight/litter (TWW, kg), weaning mortality from born to weaning/litter (DBW,%), weaning mortality from selected to weaning/litter (DSW,%), weight gain from born to weaning/piglet (WG, kg) and average daily gain/piglet (ADG, g) were recorded for further analysis.

Data sets were estimated by Mean  $\pm$  standard deviation MS Excel 2013 for coding data and R program (version 3.4.2) for statistical analysis. To exactly evaluate different factors affecting reproductive performance of the GF24, (1) The farrowing results were divided into 3 sizes (small size  $A \leq 10$  piglets/litter, 10 piglets/litter < medium size  $B \leq 13$  piglets/litter and large size  $C > 13$  piglets/litter), (2) The farms were distributed to 3 scales (small scale  $S < 100$  sows, 100 sows  $\leq$  medium size  $M < 300$  sows and large scale  $L \geq 300$  sows), (3) The housings were classified into 2 types (opened housings with outdoor climate conditions and closed housings with control of temperature, humidity and ventilation) and (4) Geography of Vietnam was divided into 4 regions (North, Center, Southeast and Southwest).

## RESULTS AND DISCUSSION

**Descriptive statistics of reproductive performance:** The obtained results showed that TNB (13.06 heads/litter) and NBA (12.11 heads/litter) traits of GF24 line were higher than those of Duroc (DR), Large White (YS) and Landrace (LR) in Korea<sup>5</sup>, LR-DU-YS composite population in US<sup>6</sup>, YS and Landrace (LR) pigs in US<sup>7</sup>, YS in China<sup>8</sup>. In addition, DBW (19.05%) and TWW (51.58 kg) of YS in Henan Province of China<sup>8</sup> was lower than GF24 line in this study. These may be due to the difference in genetic background among breeds as well as environment and management conditions. It was cleared that the GF24 sows raised in a good condition<sup>3</sup> showed some reproductive

Table 1: Descriptive statistics for reproductive traits

Observed traits	N	Mean	SD
TNB	165	13.06	1.77
NBA	165	12.11	1.26
TBD	165	0.95	0.67
NBS	165	11.17	1.00
WD	143	24.39	2.93
NW	157	10.49	0.97
LWS	119	1.39	0.09
WW	131	6.47	0.64
TWW	131	67.71	7.44
DBW	157	13.15	6.50
DSW	157	5.98	4.45
WG	109	4.93	0.55
ADG	109	207.24	22.66

TNB: Total number of born/litter (piglets/litter), NBA: Number of born alive/litter (piglets/litter), TBD: Total number born dead/litter (piglets/litter), NBS: Number born selected/litter (piglets/litter), WD: Number of weaning days (days), NW: Number weaning/litter (heads/litter), LWS: Litter weight selected/piglet (kg/litter), WW: Weaning weight/piglet (kg/head), TWW: Total weaning weight/litter (kg/litter), DBW: Weaning mortality from born to weaning/litter (%), DSW: Weaning mortality from selected to weaning/litter (%), WG: Weight gain from born to weaning/piglet (kg/head), ADG: Average daily gain/piglet (gram/head/day), N: Number of observations, SD: Standard deviation

performance traits such as TNB (12.43-14.07 vs. 13.06), NBA (12.73 vs. 12.11), LWS (1.93 vs. 1.39), NW (12.6 vs. 10.49) and WW (6.91 vs. 6.47) higher than the sows raised in conventional condition of this study. This indicated that due to improvement of techniques for housing, mating, raising, nursing, feeding, etc., from 2015-2017 in GreenFeed's pig production system, GF24 performance has been gradually increasing. Actually, sow's NBA was determined by genetic potential and also environmental or management factors<sup>9</sup> (Table 1). Especially, in good management conditions, top 10, 30, 50 or 70% of GF24 sows mated with GF399, GF337 or GF280 showed some traits of reproductive performance such as TNB and NBA very high (Table 2).

Some studies in Vietnam showed that the GP of Large White  $\times$  (Landrace  $\times$  Large White) in Ha Tinh province had TNB of 11.4-11.6 heads/litter, LWS of 1.27 kg/head and NW of 9.2 heads/litter<sup>10</sup> while TNB, NBA, NW, LWS and WW in the GP of VCN21 and VCN22 originated from the British Pigsty the Thuy Phuong Pangasius Research Center were 11.33-12.19, 11.16-11.91 and 10.51-10.98 heads/litter and 1.31-1.34 and 6.65-6.69 kg/head, respectively<sup>11</sup>.

### Effects of types of housing, sizes of farm and sizes of litter on reproductive traits:

In this study, the results of GF24 reproductive performance were analyzed regarding types of housing, sizes of farm as well as sizes of litter. Although sows in the closed-enclosure showed higher for TNB (14.04 heads/litter) and NBA (12.77 heads/litter), they were lower results for TBD (0.903 heads/litter), WW (6.05 kg/head)

Table 2: High performance of GF24 reared in good management farms

Sows group	GF24×GF399			GF24×GF337			GF24×GF280		
	N	TNB	NBA	N	TNB	NBA	N	TNB	NBA
GF24's top 10%	158	18.15	17.55	11	19.18	18.63	30	18.53	17.60
GF24's top 30%	473	16.85	16.21	32	17.43	16.65	89	16.97	16.19
GF24's top 50%	788	16.14	15.40	54	16.59	15.75	149	16.20	15.41
GF24's top 70%	1,103	15.41	14.61	76	15.68	14.86	208	15.50	14.62
Average		13.87	12.87	108	14.19	12.93	297	14.11	12.79

TNB: Total number of born/litter (piglets/litter), NBA: Number of born alive/litter (piglets/litter), N: Number of observations, SD: Standard deviation

Table 3: Difference of some reproductive traits due to types of housing, sizes of farm and sizes of litter

Observed Traits	Types of housing		Sizes of farm			Sizes of litter			p-value
	Closed	Opened	S	M	L	A	B	C	
TNB	14.040±1.09 <sup>a</sup>	12.93±1.81 <sup>b</sup>	12.91±1.99	13.17±1.41	13.74±1.19	9.78±0.50 <sup>c</sup>	12.80±1.03 <sup>b</sup>	15.280±1.69 <sup>a</sup>	<0.01
NBA	12.770±0.86 <sup>a</sup>	12.02±1.28 <sup>b</sup>	12.00±1.41	12.21±0.99	12.56±1.00	9.56±0.44 <sup>c</sup>	11.93±0.71 <sup>b</sup>	13.730±0.98 <sup>a</sup>	<0.01
TBD	0.903±0.71 <sup>b</sup>	1.27±0.55 <sup>a</sup>	0.91±0.75	0.96±0.64	1.18±0.50	0.21±0.25 <sup>c</sup>	0.86±0.54 <sup>b</sup>	1.540±0.90 <sup>a</sup>	<0.01
NBS	11.120±1.00	11.50±0.95	11.09±1.06	11.25±0.88	11.38±1.04	9.35±0.51 <sup>c</sup>	11.07±0.73 <sup>b</sup>	12.190±0.84 <sup>a</sup>	<0.01
WD	23.280±2.59	24.55±2.94	24.65±2.93	24.09±2.97	23.75±2.63	25.10±1.13	24.49±3.22	23.740±2.15	>0.01
NW	10.460±0.97	10.75±0.96	10.76±1.02	10.54±0.97	10.42±0.96	8.68±0.59 <sup>c</sup>	10.46±0.79 <sup>b</sup>	11.230±0.86 <sup>a</sup>	<0.01
LWS	1.370±0.09	1.40±0.10	1.39±0.11	1.39±0.10	1.38±0.06	1.43±0.09	1.40±0.10	1.380±0.09	>0.01
WW	6.050±0.38 <sup>b</sup>	6.53±0.65 <sup>a</sup>	6.57±0.68 <sup>a</sup>	6.41±0.54 <sup>a</sup>	5.94±0.43 <sup>b</sup>	7.24±0.49 <sup>a</sup>	6.46±0.58 <sup>b</sup>	6.270±0.69 <sup>b</sup>	<0.01
TWW	65.950±4.07	67.98±7.80	68.25±8.31	67.31±6.32	65.23±3.47	62.58±6.30 <sup>b</sup>	67.43±6.85 <sup>ab</sup>	70.310±8.79 <sup>a</sup>	<0.05
DBW	15.400±5.28	12.84±6.61	12.72±6.91	13.64±6.07	14.24±5.30	8.33±6.01 <sup>b</sup>	12.40±5.67 <sup>b</sup>	17.680±7.51 <sup>a</sup>	<0.01
DSW	6.030±4.25	5.94±4.48	5.82±4.55	6.40±4.38	5.34±4.18	5.90±5.25 <sup>b</sup>	5.53±4.14 <sup>b</sup>	7.780±5.00 <sup>a</sup>	<0.01
WG	4.670±0.38 <sup>b</sup>	4.97±0.57 <sup>a</sup>	4.97±0.58 <sup>a</sup>	4.95±0.51 <sup>a</sup>	4.55±0.40	4.95±0.32	4.89±0.49	5.070±0.81	<0.01
ADG	207.670±23.67	204.90±16.46	207.52±25.57	208.21±18.77	201.85±17.73	209.15±14.83	207.38±21.63	205.720±29.80	>0.01

TNB: Total number of born/litter (piglets/litter), NBA: Number of born alive/litter (piglets/litter), TBD: Total number born dead/litter (piglets/litter), NBS: Number born selected/litter (piglets/litter), WD: Number of weaning days (days), NW: Number weaning/litter (heads/litter), LWS: Litter weight selected/piglet (kg/litter), WW: Weaning weight/piglet (kg/head), TWW: Total weaning weight/litter (kg/litter), DBW: Weaning mortality from born to weaning/litter (%), DSW: Weaning mortality from selected to weaning/litter (%), WG: Weight gain from born to weaning/piglet (kg/head), ADG: Average daily gain/piglet (gram/head/day), N: Number of observations, SD: standard deviation

and WG (4.67 kg/head) compared with the ones in the opened housing (Table 3). Obtained results in closing house of this study were higher than others which were shown in the INRA experimental herd of Galle (France) for French Large White (NBA = 9.58 heads/litter, DBW = 5.9%, NW = 8.2 heads/litter, LWS 1.34 kg/head, WW = 7.63 kg/head)<sup>12</sup> or in a Commercial Test Herd in CTH-Albion (USA) for 3 cross ways among Large White, Landrace and Duroc (TNB = 13.43 heads/litter, NBA = 12.59 heads/litter, LWS = 1.61 kg/head and TWW at 19.94 days old is 65.65 kg/litter<sup>13</sup>. In addition, relating to sizes of farm, WW and WG tended to gradually reduce from small scale to large scale leading to the highest TWW in small scale ( $p < 0.01$ ). Moreover, significant differences were found among there different sizes of farm for DBW, DSW, WW ( $p < 0.01$ ) and TWW ( $p < 0.05$ ). Sows with large farrow had DBW higher than the others. However, TWW of these sows (70.31 kg/litter) were highest. This was very good for a farm with objective of selling the weaners in Vietnam.

**Effects of regions on reproductive traits:** The results showed in Table 4 that there was a statistically significant difference in the reproductive performance of GF24 among different

regions. The highest of TNB (14.64 heads/litter), NBA (13.04 heads/litter) and NBS (11.44 heads/litter) in the North region was presented ( $p < 0.01$ ). However, the North also showed the highest values of TBD (1.6 heads/litter), DBW (19.98%) and DSW (8.86%) ( $p > 0.01$ ) which reduced the efficiency of GF24 reproductive performance. It could be because that the GF24 fertility of the North was quite good be cause of the effects of subtropical factors and types of housing (closed-housing).

Although the values of TNB and NBA in some provinces/cities such as Khanh Hoa, Gia Lai, Kon Tum and Quang Binh were higher than those in the other provinces, the values of WW and WG ( $p < 0.01$ ) in the provinces/cities in the Southeast (BARIA-VUNGTAU, DONGNAI and LAMDONG) as pioneers of pig breeding industry in Vietnam were dominant. In current study, as shown in Table 5, the highest value of TNB ( $14.53 \pm 1.28$ ) and NBA ( $13.34 \pm 0.58$ ) was observed in HANOI. While lowest value of TNB ( $12.07 \pm 1.25$ ) and NBA ( $11.33 \pm 0.9$ ) was noticed in BRVT. Those differences may be rooted in the various number of WD among regions. Particularly, WD of the northern was earlier than that in other regions. In fact, the differences in

Table 4: Difference of some reproductive traits due to geography

Observed traits	North	Center	Southeast	Southwest	p-value
TNB	14.64±0.78 <sup>a</sup>	13.97±0.89 <sup>a</sup>	12.59±2.02 <sup>b</sup>	12.66±1.52 <sup>b</sup>	<0.01
NBA	13.04±0.46 <sup>a</sup>	12.80±0.66 <sup>a</sup>	11.75±1.44 <sup>b</sup>	11.89±1.10 <sup>b</sup>	<0.01
TBD	1.60±0.59 <sup>a</sup>	1.17±0.55 <sup>a</sup>	0.84±0.75 <sup>b</sup>	0.77±0.62 <sup>b</sup>	<0.01
NBS	11.44±0.70 <sup>ab</sup>	11.63±0.83 <sup>a</sup>	10.91±1.08 <sup>b</sup>	11.12±0.91 <sup>b</sup>	<0.01
WD	22.15±1.35 <sup>b</sup>	23.93±2.48 <sup>b</sup>	24.94±3.19 <sup>a</sup>	24.46±2.86 <sup>a</sup>	<0.05
NW	10.34±0.33 <sup>ab</sup>	10.99±0.84 <sup>a</sup>	10.24±1.00 <sup>b</sup>	10.52±0.95 <sup>ab</sup>	<0.01
LWS	1.36±0.08 <sup>b</sup>	1.37±0.07 <sup>b</sup>	1.40±0.10 <sup>a</sup>	1.42±0.13 <sup>a</sup>	<0.01
WW	6.35±0.25 <sup>bcd</sup>	5.97±0.35 <sup>d</sup>	6.95±0.57 <sup>a</sup>	6.21±0.42 <sup>cd</sup>	<0.01
TWW	65.75±3.16 <sup>ab</sup>	65.41±4.91 <sup>b</sup>	70.54±8.57 <sup>a</sup>	65.63±7.08 <sup>b</sup>	<0.05
DBW	19.98±2.30	14.13±4.79	12.68±6.78	11.30±7.15	<0.01
DSW	8.86±3.65	5.45±3.26	6.19±5.04	5.41±4.28	>0.01
WG	4.98±0.22 <sup>a</sup>	4.60±0.38 <sup>b</sup>	5.39±0.61 <sup>a</sup>	4.77±0.38 <sup>b</sup>	<0.01
ADG	206.96±15.79 <sup>ab</sup>	207.56±18.17 <sup>a</sup>	217.71±28.78 <sup>a</sup>	193.30±12.38	<0.01

TNB: Total number of born/litter (piglets/litter), NBA: Number of born alive/litter (piglets/litter), TBD: Total number born dead/litter (piglets/litter), NBS: Number born selected/litter (piglets/litter), WD: Number of weaning days (days), NW: Number weaning/litter (heads/litter), LWS: Litter weight selected/piglet (kg/litter), WW: Weaning weight/piglet (kg/head), TWW: Total weaning weight/litter (kg/litter), DBW: Weaning mortality from born to weaning/litter (%), DSW: Weaning mortality from selected to weaning/litter (%), WG: Weight gain from born to weaning/piglet (kg/head), ADG: Average daily gain/piglet (gram/head/day), N: Number of observations, SD: standard deviation

Table 5: Effect of provinces/cities on reproductive traits

Provinces/cities	TNB	NBA	TBD	NBS	WD	NW	LWS	WW
BENTRE	12.41±1.37	11.87±0.98	0.55±0.65	11.32±0.94	24.35±2.64	10.76±1.02	1.38±0.18	6.26±0.29 <sup>bc</sup>
BINH DINH	12.57±1.09	12.65±0.93	0.92±0.27	11.72±0.82	22.42±1.78	11.04±0.91	1.36±0.06	5.80±0.43 <sup>b</sup>
BARIA-VUNGTAU	12.07±1.25	11.33±0.90	0.74±0.41	10.60±0.63	24.61±2.46	10.20±0.74	1.31±0.10	7.25±0.30 <sup>a</sup>
DONGNAI	12.67±2.34	11.80±1.66	0.86±0.82	10.94±1.18	24.64±2.60	10.14±1.05	1.41±0.10	7.04±0.56 <sup>a</sup>
GIALAI	13.98±0.82	12.64±0.63	1.34±0.51	11.29±0.81	24.68±2.45	10.69±0.74	1.37±0.07	6.10±0.21 <sup>bc</sup>
HANOI	14.53±1.28	13.34±0.58	1.19±0.70	12.15±0.15	22.23±0.86	10.80±0.31	1.28±0.05	6.30±0.33 <sup>ab</sup>
KHANH HOA	14.43±1.04	12.85±0.41	1.57±0.93	11.28±1.00	23.33±3.00	10.69±1.01	1.38±0.07	5.99±0.27 <sup>bc</sup>
KONTUM	13.62±1.10	12.08±0.94	0.81±0.43	11.99±0.96	24.23±3.31	11.53±0.99	1.31±0.05	5.74±0.43 <sup>bc</sup>
LAMDONG	12.42±1.17	11.72±0.85	0.70±0.62	11.01±0.92	26.24±5.53	10.59±0.91	1.38±0.04	6.60±0.60 <sup>bc</sup>
LONGAN	12.24±1.35	11.54±0.99	1.04±0.44	10.83±0.72	24.68±3.27	10.38±0.69	1.49±0.12	6.19±0.38 <sup>bc</sup>
QUANGBINH	13.50±0.29	12.47±0.46	1.03±0.47	11.43±0.89	25.99±3.66	10.36±0.84	1.38±0.06	6.01±0.33 <sup>bc</sup>
TIENGIANG	12.80±2.38	11.77±1.71	1.03±0.77	10.74±1.18	24.81±2.46	10.10±0.90	1.44±0.06	5.93±0.61 <sup>bc</sup>
TPHCM	12.32±1.08	11.47±0.72	0.85±0.46	10.62±0.52	24.21±4.05	9.86±0.35	1.43±0.12	6.18±0.26 <sup>bc</sup>
p-value	>0.01	>0.01	>0.01	>0.01	>0.01	>0.01	>0.01	<0.01
Provinces/cities	TWW	DBW	DSW	WG	ADG			
BENTRE	68.21±6.19	9.01±8.08	4.90±4.64	4.85±0.14 <sup>bcd</sup>	198.96±6.65 <sup>b</sup>			
BINH DINH	63.78±2.39	12.67±4.68	5.82±4.53	4.45±0.41 <sup>d</sup>	206.47±21.64 <sup>ab</sup>			
BARIA-VUNGTAU	70.19±2.17	10.26±1.89	3.70±2.96	6.11±0.21 <sup>a</sup>	221.61±12.38 <sup>ab</sup>			
DONGNAI	70.71±9.53	13.55±7.29	7.23±5.46	5.40±0.60 <sup>ab</sup>	210.50±31.16 <sup>ab</sup>			
GIALAI	65.19±3.51	15.35±4.43	5.24±3.00	4.73±0.25 <sup>cd</sup>	207.43±21.41 <sup>ab</sup>			
HANOI	68.02±1.55	16.93±1.62	11.61±1.79	5.00±0.23 <sup>cd</sup>	231.29±15.34 <sup>ab</sup>			
KHANH HOA	64.10±7.74	16.89±6.71	5.24±2.85	4.06±0.30 <sup>cd</sup>	198.80±16.56 <sup>ab</sup>			
KONTUM	65.97±4.34	9.97±4.34	3.87±1.52	4.43±0.38 <sup>cd</sup>	214.99±21.82 <sup>ab</sup>			
LAMDONG	69.82±7.67	10.59±6.62	4.57±3.46	5.22±0.60 <sup>bc</sup>	230.54±24.61 <sup>a</sup>			
LONGAN	64.35±7.36	9.79±5.67	4.12±2.66	4.69±0.34 <sup>bcd</sup>	195.02±11.36 <sup>ab</sup>			
QUANGBINH	62.44±8.28	17.01±3.77	9.37±3.32	4.64±0.31 <sup>bcd</sup>	204.85±14.17 <sup>ab</sup>			
TIENGIANG	59.88±7.92	16.95±5.54	7.69±2.71	4.50±0.56 <sup>cd</sup>	178.85±12.06 <sup>b</sup>			
TPHCM	61.36±1.16	14.81±5.95	7.22±5.12	4.76±0.30 <sup>bcd</sup>	200.16±6.83 <sup>ab</sup>			
p-value	>0.01	>0.01	>0.01	<0.01	<0.01			

TNB: Total number of born/litter (piglets/litter), NBA: Number of born alive/litter (piglets/litter), TBD: Total number born dead/litter (piglets/litter), NBS: Number born selected/litter (piglets/litter), WD: Number of weaning days (days), NW: Number weaning/litter (heads/litter), LWS: Litter weight selected/piglet (kg/litter), WW: Weaning weight/piglet (kg/head), TWW: Total weaning weight/litter (kg/litter), DBW: Weaning mortality from born to weaning/litter (%), DSW: Weaning mortality from selected to weaning/litter (%), WG: Weight gain from born to weaning/piglet (kg/head), ADG: Average daily gain/piglet (gram/head/day), N: Number of observations, SD: standard deviation

TWW in of Large White sows were recorded on 20,373 piglets in 2,032 litters of XinDa Livestock Limited Company<sup>8</sup> at 21 days whose TWW values were lower than in this GF24

values at 24.39 days. Besides, increasing TNB resulted in reducing birth weight<sup>14</sup> and WW<sup>15</sup> as well as LWS in this study.

Based on obtained evidences, it can be suggested that GF24 performed better in many economically important traits than other sow lines/breeds for different management systems in Vietnam.

In this study, it was indicated that (1) Types of housing affected TNB, NBA, TBD, WW and WG ( $p < 0.01$ ). Actually, the enclosure is easy to regulate temperature, humidity and ventilation for the whole day. This leads to reduction of stress on piglets and increment of milk production in sows. It was also in strong agreement with previous studies that larger litters generally mean smaller piglets<sup>16</sup> and prolificacy decrease during summer months<sup>17</sup>. The ambient temperature should, therefore, keep consistently to improve the piglets' performance<sup>18</sup>, (2) sizes of farm greatly influenced WW and WG where the large farms performed the lowest values ( $p < 0.01$ ). It was possible that large scale farms dominate the neonatal groups for TNB (13.74 heads/litter) and NBA (12.56 heads/litter), but the traits of WW (5.94 kg/head) and WG (4.55 kg/head) are lower ( $p < 0.01$ ). Small and medium-scale farms can be managed more remarkably than large scale farms. Therefore, there should be support for overall management solutions forth health care of pigs on large farms, where the daily workload is rather high for the direct labors and (3) Sizes of litter also contribute to reproductive performance. The sows with the small litter size had the lowest TBD (9.78 heads/litter), DBW (8.33%) and DSW (5.90%), but WW (7.24 kg/head) was the opposite ( $p < 0.01$ ) in Table 3. It was cleared that the health, body weight and weight gain of piglets in lactation stage are due to great contribution of sow's milk source. Sows with small sizes usually have good opportunities to provide more milk for their babies. In addition, the nutrient of sow milk significantly determined the growth performance of the neonatal pig<sup>19</sup> and the higher birth weight associated with the higher weaning weight<sup>20</sup>. The problems related to birth weight and no uniform litters were increased contributing to the higher variability of weight between piglets<sup>21,22</sup>.

In fact, some studies showed that (1) Seasons affected sow productivity<sup>23</sup>, (2) The decrease in reproductive performance was observed in the late summer and early autumn<sup>17,24</sup> due to decreased oocyte quality and progesterone<sup>17</sup>, increased the number of reproductive failure in sows (25-35 days after insemination) by melatonin<sup>24</sup> and decreased LH by restricted feeding after service<sup>25</sup>. Thus, *ad libitum* feeding of sows during the first few weeks of gestation may reduce melatonin secretion<sup>24</sup> and increase LH secretion to improve pregnancy rate. Some studies in

Finland and Australia also showed different reproductive performances due to the seasonal influence<sup>26,27</sup>. Thus, to upraise the reproductive potential of sows, producers should improve herd management. In this study, differences of climate crossing regions in Vietnam partly affected to reproductive performance of GF24 sows.

## CONCLUSION

Based on the obtained results, it is easy to resume that though the differences in reproductive indicators under the effects of management system (type of housing, size of farm and size of litter) and environmental conditions (regions, areas and provinces/cities) were found, the reproductive performance of GF24 sows was generally higher compared with other referent breeds/lines in Vietnam or in some other countries in the world, especially under good management conditions the performance of GF24 is very high and stable when mated with different boar lines such as GF337, GF399 and GF280. It is indicated that GF24 is well-adapted in Vietnam as well as some countries such as Myanmar, Laos and Cambodia where the natural and production conditions are similar to Vietnam; therefore, GF24 should be added to the commercial pig production system to enhance the performance and benefits.

## SIGNIFICANCE STATEMENT

This study discovered the pure American pig breeds that can be beneficial for pig production system in Vietnam. It will help the researcher to uncover the critical areas of adaptation of GF24 gilts (a crossbred of pure Landrace, Large White and Piétrain breed) and of American pure boars like GF399, GF337 or GF280 to different raising conditions of climate, housing, scales, in whole country of Vietnam that many researchers were not able to explore. Thus a new theory on importing and raising high-yield pig breeds from temperate countries to tropical/subtropical ones may be arrived at.

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