

The seasonal effect on the performance of pigs reared in a backyard pig farm in Thailand: retrospective study

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ABSTRACT

This study aimed to determine the seasonal effect on the performance of pigs reared in open-barn housing in Thailand. This retrospective study was performed using two years of recorded pig performance, including average birth weight, litter size, percentage of born alive and dead piglets, weaning weight, average daily gain (ADG), percentage of weaned alive and dead piglets and meteorological data. Data were grouped based on 3 different seasons: winter, summer and the rainy season, and the differences were compared. The highest temperature–humidity index (THI) was found during summer (85.3 ± 0.2) and the THI of the rainy season was higher than that in winter (between 82.3 ± 0.2 and 77.2 ± 0.4) ($p < 0.05$). The piglet growth performance was affected by season ($p < 0.05$). The weaning weight of piglets in the rainy season was higher than that in winter but not different from that in summer. The highest ADG was observed in the rainy season. In summary, growth performance of suckling pigs reared in open-barn housing in Thailand was affected by the season. The optimal climate promoting growth of nursery pigs was determined to be the rainy season.

Keywords: Growth, Nursery pig, Open barn, production, Seasonal effect

INTRODUCTION

One of the major environmental threats in the 21st century is global warming and climate change, which has a serious effect on the welfare, health, and performance of pigs. Regarding

the development of pig production in developing countries, which is mainly located in tropical and subtropical areas, the effect of high temperature (HTa) becomes more important (Campos *et al.*, 2017). In many tropical countries, heat stress is a major problem caused by the environment that

negatively affects livestock health, performance, and production. When animals are exposed to an excessive environmental temperature, nutrients are shifted to maintain eutheria. This preserves body temperature to the thermoneutral zone and reduces product synthesis (milk, meat, egg etc.) resulting in reduced productivity (Ross *et al.*, 2017; Sugiharto, 2020; Ouellet *et al.*, 2021). Studies on the effect of temperatures on animal production have been reported elsewhere. In pigs, heat stress affects food intake, body weight gain and carcass composition which accounts for large economic losses in pig production. Sows are more susceptible to heat stress during gestation and lactation periods (Ross *et al.*, 2017). Pigs are more sensitive to HTa compared to other animals according to their high metabolic heat production, greater fat deposition and lack of sweat glands (Gourdine *et al.*, 2021). The thermoregulation of pigs can maintain the body temperature at about 18–20 °C. Thus, high environmental temperatures above the thermoneutral zone can cause heat stress to pigs (Wegner *et al.*, 2014; Amavizca-Nazar *et al.*, 2019). When the temperature increased above 25 °C, negative effects on reproductive performance were observed, including decreased litter size and increased weaning-to-service (Almond and Bilkei, 2005; Suriyasomboon *et al.*, 2006). Although the effect of temperature on pig performance was intensively studied, most studies were conducted under experimental conditions. Additionally, the study of seasonal effects on pig performance in farm conditions, especially in open-barn housing, provided less information.

In Thailand, most pig production uses a conventional open-air housing system in which the air condition directly depends on the climate condition, including ambient temperature (Ta) and relative humidity (RH). In addition, the variation in temperature and humidity of this housing system is greater than that in the stable that contains evaporative cooling system (Suriyasomboon *et al.*, 2006). Thus, open-barn pigs are directly subjected to climate change among the different seasons throughout the year. According to HTa and high humidity, Thailand

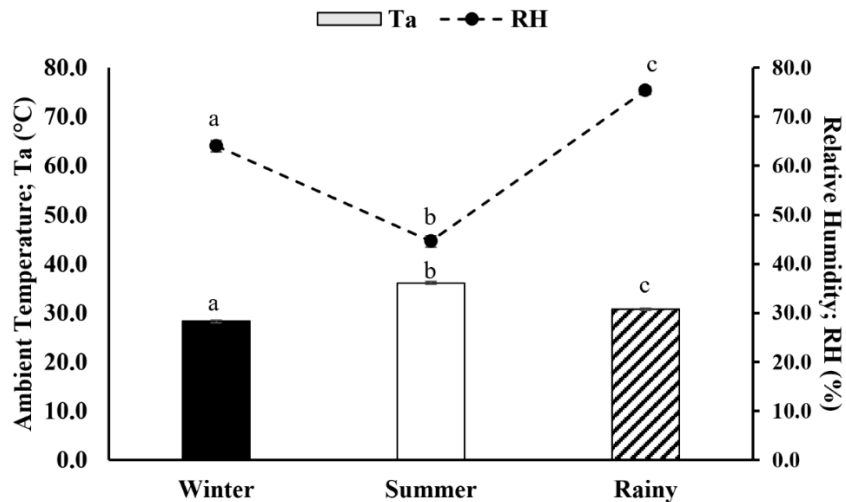
is characterized as a tropical country. During the year, Thailand has three main seasons including summer (mid-February to mid-May), the rainy season (mid-May to mid-October) and winter (mid-October to mid-February) (Thammacharoen *et al.*, 2020). Ta is the most important environmental parameter. However, RH also plays a role in physiological changes of animals, particularly in tropical climate. Therefore, the temperature–humidity index (THI) value is commonly used to measure heat stress in livestock based on the combined effects of Ta and RH, particularly in dairy cow (Brügemann *et al.*, 2012; Herbut *et al.*, 2018). In Thailand, a high range of THI was reported to be associated with decreased production (milk and milk yield) of dairy cows and goats (Thammacharoen *et al.*, 2014; Thammacharoen *et al.*, 2020). Less is known about the effect of THI on pig production. Besides, the seasonal effect on pig performance, particularly suckling piglets, and sows, is still lacking in data. Therefore, this retrospective study aimed to investigate the seasonal effect on the performance of suckling piglets and sows reared in open-barn housing in Thailand, comparing among the three seasons.

MATERIALS AND METHODS

Data Collection

This study was retrospective. The data were obtained from the routine one farm records of the Center of Learning Network for Region, Chulalongkorn University, Nan Province, which is in the northern region of Thailand (18°49'12" N, 100°46'15" E). The data were recorded from the beginning of farming since 2018. This farm contained crossbred pigs including 15 sows (8 Large white and 7 Landrace) and 309 piglets reared in a conventional barn, containing gestation stalls, farrowing pens, and nursing pens. The two years (from August 2018 to December 2020) of recorded sow and piglet performance was used for analysis. Since the study aimed to investigate the seasonal effect on pig performance, the data were differently grouped depending on each season, consisting of the winter season (November

1a



1b

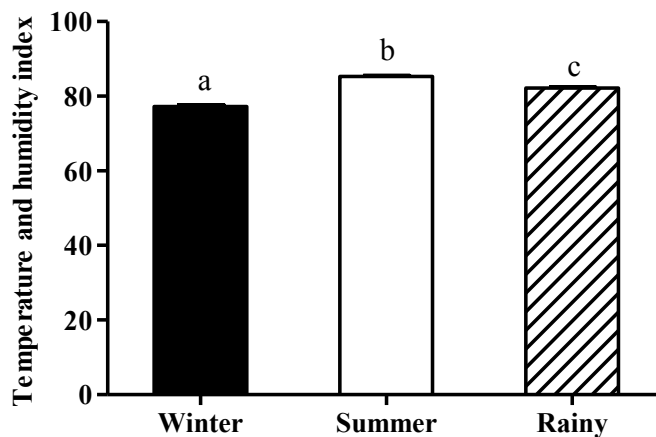


Figure 1. Ta, RH and THI were different among different seasons. The meteorological data were categorized into 3 groups of different seasons. a) The Ta and RH during different seasons. The Ta during summer was higher than others and the Ta during the rainy season was higher than during winter. The RH during the rainy season was higher than during the others and the RH of winter was higher than summer. b) The THI of different seasons. The highest THI was observed during summer and the THI during the rainy season was higher than during winter. The different non-capital alphabets indicated the statistically significance ($p < 0.05$).

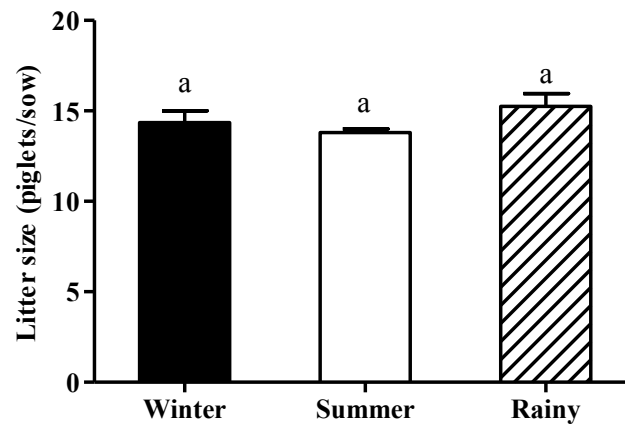
to February), the summer season (March to June), and the rainy season (July to October). The data were seasonally categorized according to the service date of sows to evaluate the seasonal effect for the period around farrowing, and included average birth weight, litter size, percentage of born alive and dead (stillborn and mummified)

piglets. Average birth weight was calculated by normalizing to the total number of born piglets of each litter to exclude the effect of litter size on birth weight of piglets. Stillborn, mummified and born alive piglets were calculated by comparing to the total number of piglets born and these were reported as a percentage. Likewise, the data were

Table 1. Farrowing Rate and % Return to Estrus in All Seasons Throughout the Studied Period

Season	Farrowing rate (%) (n of farrowing sows)	Return to estrus (%) (n of return-to-estrus sows)
Winter	62.5 (10)	37.5 (6)
Summer	76.5 (13)	23.5 (4)
Rainy	78.3 (18)	21.7 (5)

2a



2b

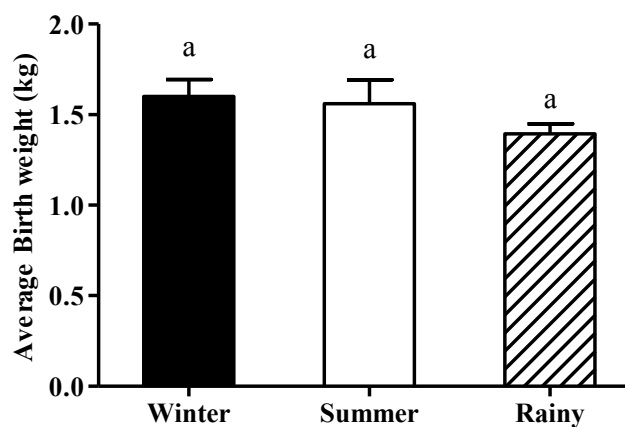


Figure 2. Litter size and birth weight were not affected by season. The data were determined according to the date that the sows received artificial insemination and were categorized into three groups depending on different seasons. a) The litter size and b) The average birth weight during winter, summer, and the rainy season. There was no seasonal variation of litter size and birth weight among the three seasons ($p > 0.05$).

categorized into three groups based on farrowing date among the different seasons, for investigating the seasonal effect after farrowing on the parameters weaning weight, average daily growth (ADG) at weaning, weaned alive piglets and pre-weaning mortality. Weaned alive piglets and pre-weaning mortality were calculated by comparing to the total number of born alive piglets and these were reported as a percentage. Farrowing rate and % return to estrus were differently grouped according to the seasons. Farrowing rate was calculated from the percentage of farrowing sows from the service group of each season. Likewise, % return to estrus was calculated from the percentage of non-farrowing sows of that service group of each season.

The meteorological data were routinely collected from August 2019 to December 2020 at the housing every day at noon using a wet and dry bulb thermometer. The thermometer was installed in the center of the housing and was hung freely from the ceiling at a height of 1.6 m from the floor. The meteorological data reported included Ta, RH, and the THI. Ta was equal to the dry bulb temperature. The calculation of RH was based on the temperature differences between dry and wet bulb and was compared using a psychrometric chart. The THI was calculated as in a previous study (Thammacharoen *et al.*, 2020).

Statistical Analysis

All data are presented as means \pm SEM. The statistical analyses were done using statistical software (GraphPad Prism, San Diego, CA, USA). One-way analysis of variances was used to analyze the meteorological data and pig performance. Multiple comparison was done using the Newman–Keuls test. To evaluate the seasonal association to farrowing forms (farrowing and return to estrus), the chi-square test was used. Significant differences were considered at *p* values less than 0.05.

RESULTS AND DISCUSSION

Climate Condition

The Ta and RH are shown in Figure 1a, and the THI are shown in Figure 1b. Seasonal variations of Ta, RH and THI were observed. The Ta during summer was higher than in winter and the rainy season and Ta of the rainy season was higher than in winter ($p < 0.05$). The RH in the rainy season was higher than in the other seasons ($p < 0.05$) and the RH in winter was higher than in summer ($p < 0.05$). The THI in summer was higher than in the other seasons and the THI in the rainy season was higher than in winter ($p < 0.05$). In this study, Ta and THI were used to evaluate the seasonal difference because the routine measurement of temperature at the pig housing was practical and did not require an expensive equipment or skilled operators. Besides, climate was the critical factor of livestock production in warm regions as it was mostly studied compared to that of other environmental factors. As Thailand is in a tropical zone, RH has a considerable influence on the climate. Thus, THI is the appropriate indicator to use for evaluating the seasonal climate variation in Thailand. In this study, the average THI of this study was above 75 and the average Ta was above 25 °C throughout the year. Regarding the classification of Köppen–Geiger, Thammacharoen *et al.* (2020) recently demonstrated that the climate of Thailand was a tropical savannah sub-climate. This climate can cause deleterious effects such as the death of livestock, as previously reported in North America and Italy (Hahn, 1999; Vitali *et al.*, 2009).

Seasonal effect on Sow Performance

The percentages of farrowing rate and the percentages of return to estrus are shown in Table 1. The average litter sizes and average birth weight in winter, summer and the rainy season were shown in Figure 2a and 2b. The season was not associated with the percentages of farrowing rate, the percentages return to estrus, the average litter size and the average birth weight ($p > 0.05$). During summer in Thailand, the THI was higher than 80 which was higher than the critical THI value of 72 that can cause death in livestock, previously mentioned (Hahn, 1999). Consistently,

the average Ta during summer was 36 °C which was above the reported HTa of 22 °C that could induce heat stress in sows (Bloemhof *et al.*, 2008). Increased Ta was associated with reduced farrowing rates, prolonged weaning-to-service, delay of onset of puberty and decreased litter size (Suriyasomboon *et al.*, 2006; Bloemhof *et al.*, 2008; Bertoldo *et al.*, 2009). However, the seasonal effect on sow performance was not obviously detected during the period of study. A small number of sows population and a short period of data collection could be one of possible explanations that why the seasonal difference of sow performance was not seen.

The percentage of born alive, stillborn, and mummified piglets are demonstrated in Figure 3a, 3b and 3c, respectively. A seasonal effect on the percentage of born alive, stillborn, and mummified piglets was not observed ($p > 0.05$). Stillborn and mummified piglets have been reported as multifactorial problems that are associated with infectious and non-infectious factors (Vanderhaeghe *et al.*, 2013; Raja *et al.*, 2017). Most relevant non-infectious factors, including genetic, maternal, piglet and environmental factors, have been discussed (Vanderhaeghe *et al.*, 2013; Raja *et al.*, 2017). HTa was reported to be a risk factor for stillborn piglets when the Ta was higher than 22 °C (Vanderhaeghe *et al.*, 2010) and the proportion of mummified fetuses increased when the temperature increased to 29 °C (Tummaruk *et al.*, 2010). As mentioned above, the HTa in summer in this study might induce heat stress to sows. However, the seasonal difference in sow performance were not detected as the sows adapted to the HTa of Thailand. The physiological adaptations to HTa include increased heat dissipation to the skin, increased respiration and adjusting voluntary food intake (Mayorga *et al.*, 2019). Regarding the retrospective data, the lack of these physical parameters was the limitation of this study. The association between physiological adaptations and HTa and sow performance should be further investigated.

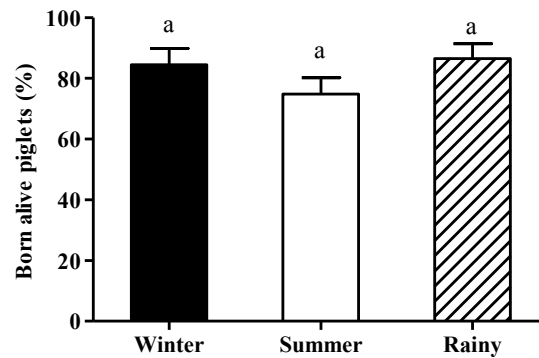
Seasonal Effect on Piglet Performance

The growth performance of piglets includ-

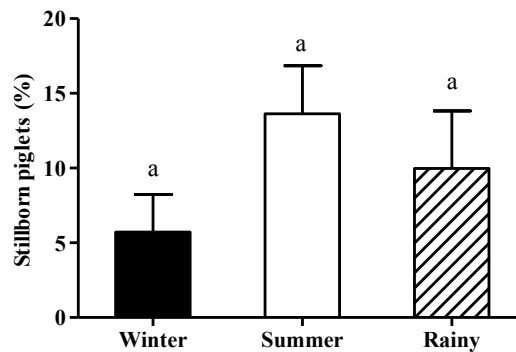
ing weaning weight and ADG are shown in Figure 4. There was a seasonal effect on weaning weight ($p < 0.05$). The weaning weight in winter was lower than in the rainy season but not different from in the summer. There was no difference between weaning weight in summer and the rainy season. Seasonal variation of ADG was observed ($p < 0.05$). The highest ADG was found in the rainy season and differed from winter and summer. The ADG in winter and in summer was not different. The range of Ta that allows pigs to prioritize nutrients for growth and reproduction rather than maintaining body temperature is defined as the thermoneutral zone (Bianca, 1976). When the Ta is above or below the thermoneutral zone, temperature stress is observed (Bianca, 1976). The thermoneutral zone of suckling piglets is notably narrow at 33–35 °C (Harmon and Xin, 1995). The piglets are at risk of experiencing cold stress when the temperature is below the thermoneutral zone at 33 °C (Bianca, 1976). Similarly, poor piglet performance, including low weaning weight and ADG, was indicated during winter when the lowest THI was observed in this study. Besides, the average Ta and the lowest Ta during winter were about 28 and 14 °C. The Ta in this study was recorded only in the daytime. Thus, the Ta at night could be much lower than that recorded. This could suggest that the Ta of winter was below the optimal zone of temperatures for piglets and negatively affected the growth performance of suckling pigs. The main resources for heat production in newborn piglets consist of fat, glycogen, and skeletal muscle mobilization. The body heat loss is more serious since the piglets are born with little adipose tissue and without brown fat, which is a special type of body fat preventing heat loss (Herpin *et al.*, 2002). Therefore, when the environment temperature is too cold, nutrient utilization is diverted to maintain body temperature rather than growth, which leads to decreased growth performance.

During summer, HTa negatively affected on growth performance of piglets by lowering ADG than that of the rainy season as the HTa of summer was above the thermoneutral zone of suck-

3a



3b



3c

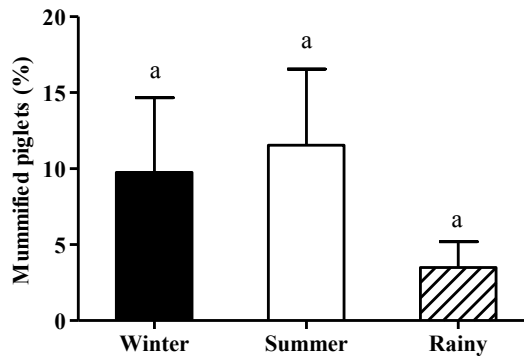
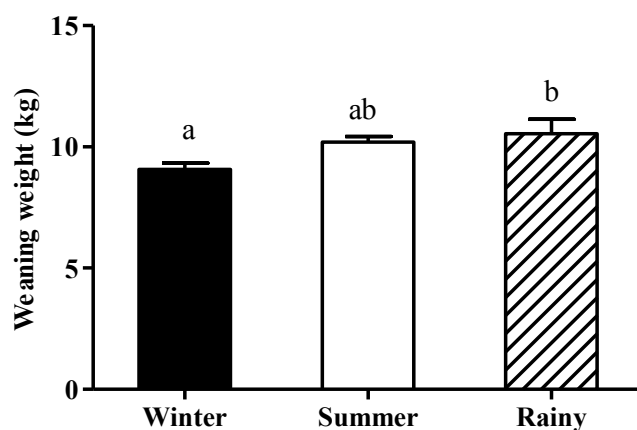


Figure 3. Percentage of born alive and dead piglets were not affected by season. The data were determined according to the date that sows received artificial insemination and were categorized into three groups depending on different seasons. The perinatal mortality, including stillborn piglets and mummified piglets, and born alive piglets among different seasons are shown. a) born alive piglets b) stillborn piglets and c) mummified piglets during different seasons. No seasonal variation of percentage of born alive piglets, stillborn piglets and mummified piglets was observed ($p > 0.05$).

4a



4b

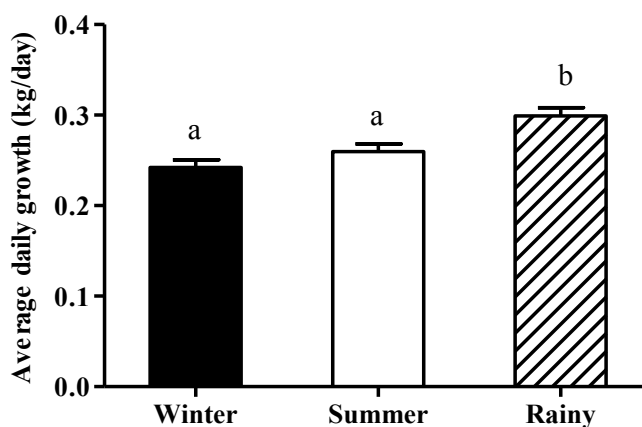
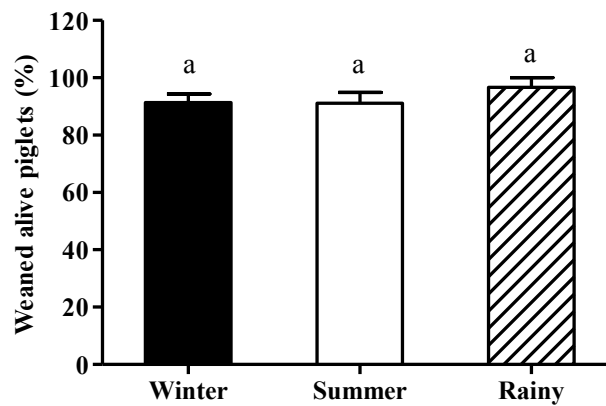


Figure 4. Growth performance of piglets was affected by season. The data were determined according to the farrowing date of sows and were categorized into three groups depending on different seasons. The growth performance of piglets including weaning weight and ADG are demonstrated. a) The weaning weight of piglets during different seasons. The weaning weight of piglets in the rainy season was higher than in winter but not different from summer. b) ADG of piglets during winter, summer, and the rainy season. The highest ADG of piglets was in the rainy season and was different from winter and summer. The different non-capital alphabets indicated statistically significant difference ($p < 0.05$).

ling pigs. The suppression of piglet weight gain under HTa was reported and was suggested to be associated with the reduction of sow milk yield under heat stress at 29 °C (Renaudeau and Noblet, 2001). HTa can affect growth and/or metabolism in pigs at any age. In growing to finishing pigs, effect of HTa on metabolism were char-

acterized by increased circulating basal insulin, decreased lipid mobilization, increased proteolysis, and impaired intestinal integrity (Pearce *et al.*, 2013). As a result, HTa negatively affected to growth performance and carcass quality (greater fat deposition but less protein accretion) when compared to their pair-fed counterparts kept at

5a



5b

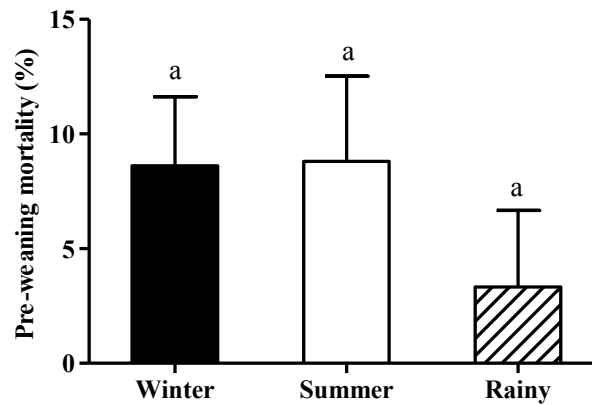


Figure 5. Pre-weaning loss was not affected by season. The data were determined according to the farrowing date of sows and were categorized into three groups depending on different seasons. a) weaned alive piglets and b) pre-weaning mortality during different seasons. There was no seasonal variation on the percentage of weaned alive and pre-weaning mortality ($p > 0.05$).

thermoneutral temperature (Bellego *et al.*, 2002). However, the underlying mechanism of HTa on growth reduction in suckling pigs needs to be further investigated.

In this study, the best growth performance of piglets was seen during the rainy season when moderate THI and Ta were observed. The Ta of the rainy season is not in the range of the thermoneutral zone of suckling piglets. Thus, the THI in rainy season, at 82.3, were accounted for the optimal THI promoting the growth of the suckling piglets. However, the range of optimal THI in pigs has not been clearly defined yet.

Growth performance during the suckling period is typically influenced by factors from sows (birth weight, milk yield and milk composition) and from piglets (milk intake) (White *et al.*, 1984; Hawe *et al.*, 2020; Hojgaard *et al.*, 2020). However, our results showed that average birth weight was not different all year round. Therefore, the high growth performance during the rainy season might be affected by milk and milk intake. The seasonal effect on milk production has been reported in dairy cows (Perera *et al.*, 1986; Singh *et al.*, 2015), dairy goats (Mioč *et al.*, 2008) and sheep (Tsartsianidou *et al.*, 2021).

The study of the seasonal effect on sow milk production provides little information. Recently, Amavizca-Nazar *et al.* (2019) reported that the milk yield of sows lactating in summer had a trend to lower than that of winter, but this was not significant. Nevertheless, the difference between only two seasons (summer and winter) was evaluated by their study. Thus, the effect of season on milk production and milk intake associated with growth performance in piglets should be further investigated.

As Figure 5 shown, there was no seasonal variation in the percentage of weaned alive and pre-weaning mortality ($p > 0.05$). As one of environmental factor, season has been reported to associate with pre-weaning mortality of piglets (Muns *et al.*, 2016). Cold exposure reduced absorption of immunoglobulins in colostrum and also induced hypothermia, which is one of the non-infectious causes of death in newborn piglets (Kelley *et al.*, 1982). Alternatively, heat stress reduced colostrum and milk yield production by sows and compromised growth of suckling pigs, leading to be the cause of preweaning death (Renaudeau and Noblet, 2001). However, the seasonal effect on pre-weaning mortality is controversial.

Although factors from management and human factors might associated with pig performances in this study, the results were obtained from only one farm that have only two expertise workers who have specific responsibilities. Therefore, the factors from management and human might less affect production data.

CONCLUSION

The present study demonstrated that the growth performance of suckling pigs in open-barn housing system was affected by climate variation among the different seasons. The climate of the rainy season with the moderate Ta and THI was the most appropriate for promoting the growth of suckling piglets in Thailand.

Conflict of interest

The authors declare no competing interests.

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