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SUCKLING DURATION, SOW BODY CONDITIONS AND EARLY POST-WEANING GROWTH PERFORMANCE IN *MOO LATH* PIGLETS

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Abstract

This study evaluated the suckling period's influence on the body conditions of primiparous sows and the growth performance of newly weaned Moo Lath piglets. 30 primiparous sows and 231 piglets (Moo Lath x Duroc) were used. They were grouped based on weaning duration: at 28 (group A), 35 (B), 42 (C), 49 (D), and 56 (E) days of age. There was no significant difference ($p = 0.179$) in weight loss between the sows' group at weaning time. In contrast, the lost backfat thickness at the weaning time was significant ($p < 0.034$). Sows in group D lost twice more backfat (12.38 mm = 27 %) at weaning compared to group A sows (5.96 mm = 12 %), while sows in group E lost nearly three times more (15.14 mm = 29 %). This loss did not adversely effects sows' first service or conception rate after weaning. On the other hand, the difference in the piglets' weight gain in the 1st week after weaning was also not significantly observed. However, it significantly affects the piglets' weight gain between groups in the 2nd week. In conclusion, proper nutrition management for lactating sows is vital in maintaining sows' body conditions. Long-term weaning might be possible only in case a lactation pen was designed with enough space for a sow to leave her piglets for some time. And, to achieve the increased economic outcome for Lao farmers, Moo Lath piglets should be weaned between 5 to 6 weeks.

Key words: weaning period, body condition, post-weaning performance, *Moo Lath*

INTRODUCTION

Moo Lath is a well-known native pig breed in Laos (Keonouchanh et al., 2011; Xayalath et al., 2021a). Most farmers rear and feed their pigs based on locally available feed resources, especially by-products from agriculture production and seasonal forest vegetation (Phengsavanh et al., 2010). Typically, in traditional extensive systems, weaning occurs between 12 and 15 weeks (Phengvilaysouk et al., 2017). Similarly, Xayalath et al., 2021b, described the mean suckling period of indigenous pigs rearing under small-scale farmers in Northern Laos ranging from 10.28 to 12.41 weeks. These figures varied from contemporary or commercial pig farms in Laos, where weaning occurs abruptly between 21 and 28 days.

It might be different in European countries, where it is no longer allowed to wean piglets earlier than 28 days (Council Directive, 2008). Especially in organic pig production, where weaning is not allowed earlier than 6 weeks. Because of animal welfare concerns, some countries approve 8

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weeks of age (Webster, 2011). As Van der Meulen et al., 2010, indicated that weaning earlier than 4 weeks of age created a stressor in post-weaning piglets due to impairing intestinal integrity and growth depression. Thus, improving feed intake post-weaning and piglets weaning at 7 weeks of age is an integral aspect of overcoming the earlier mentioned problems.

On the other hand, the weaning period also impaired the body condition of sows and their reproductive performance (Smith et al., 2008). Particularly in the intensive system where the sows were kept in a limited area. Currently, the data regarding growth performance for post-weaning and body conditions of *Moo Lath* sows in Laos are very limited. Therefore, this study aims to investigate the growth performance of piglets within the first two weeks after weaning. And, to assess sows' body condition and performance as a result of different weaning durations. Additionally, based on different lengths of weaning, this study should be the initial source of information on the physical conditions of *Moo Lath* primiparous sows. Moreover, the study follows the Lao governmental intention to increase the productivity of domestic and possibly the foreign market role of indigenous farm animals (Keonouchanh and Dengkhounxay, 2017).

MATERIAL AND METHOD

Animals, housing, and treatments

Animals used in the study were raised and cared for in accordance with the Law no. 08/NA, 2016, which covers the protection and welfare of all animals used in this study. Moreover, the experiment aimed to collect only primary farm data and did not involve any blood sampling or other activities impairing animal welfare. According to the Laos Livestock and Veterinary Law. Procedures or practices for this study were considered low risk of injury or blocking the welfare of the animals used. So, this study was deemed approval free by the research ethics committee.

Each gilt was reared in an individual pen with 1.5 x 2 m, or 3 m^2 dimensions, including gestation, farrowing, and lactation. All gilts were inseminated with Duroc semen. A total of 231 crossbred piglets (Duroc x *Moo Lath*) were used in this study. They were weaned at different durations: 28 days (group A), 35 days (B), 42 days (C), 49 days (D), and 56 days (group E). Each of the five groups contained six gilts (*Moo Lath*). All piglets were ear-notched on the first day of farrowing to ensure adequate data collection. On day 3, all piglets received 1 ml of iron injection, and male piglets were castrated on day 10 after farrowing. On the weaning day, piglets from each sow were separated from their mother and grouped with other litters within the group to rear in a nursing pen "3 x 4 m, or 12 m^2". They ranged from 10 to 20 piglets per pen based on their weaning weight to reduce aggression between piglets from different sows (Fig. 1).

Fig. 1. Piglets in nursing pens grouped based on bodyweight

In the nursery pen, the piglets were nursed and closely studied on their performance and behaviour for 2 weeks before they were sold out.

Feeding regime

The creep feed was offered to the piglets twice a day (at 8:00 AM and 4:00 PM), starting at 7 days of age. The leftover feeds in the trough were collected, weighed, and removed before serving a new feed. The feed that spilled on the ground was also assessed as the reference for feed intake calculation. This feeding regime was also applied to post-weaner piglets to ensure that new weaners did not find it challenging to adapt to the new feeding regime, particularly the feeding time. The nutritional compositions of the sow, creep, and post-weaning feeds were demonstrated in Table 1.

Table 1

The nutrient composition of the sow, creep, and post-weaning feeds

Nutrient Components	Sow feed (%)	Creep feed (%)	Post-weaning feed (%)
DM	88.5	89.13	89.05
CP	15.99	20.71	18.97
EE	1.94	5.52	2.78
CF	5.26	2.71	4.14
Ash	8.48	4.65	5.26
AIA	1.4	0.34	0.57

DM: Dry mater; CP: Crude protein; EE: Ether extract; CF: Crude fiber; AIA: Acid-insoluble.

All piglets were fed *ad libitum* and had full access to clean water during the suckling and post-weaning phases. All sows got 2 kgd^{-1} for the first week after farrowing, and the quantity was increased to 2.5 kgd^{-1} from week 2 until weaning. This quantity might be lower than in commercial practices (commercial type pig breeds) regarding the small body size of *Moo Lath* sows, which are rare to reach over 100 kg. Moreover, the mean litter size of

Moo Lath from this study was 7.7 per litter. It was very low compared to any commercial pig breeds, with a bigger litter size of 10 or more.

Assessment of sow's body conditions

The body conditions of the sows were assessed by manual palpation of sows' backs and visualizing using the scale 1 to 5 scoring principle (1 = thin, and 5 = fat). This assessment was performed weekly throughout the lactation. The bodyweight of sows was weighed using the 300 kg digital scale set up in the experimental farm. The backfat thickness (BF) of each sow was measured using FarmScan® L70 Eye muscles Veterinary Ultrasound. The operation point of the BF measurement is the P2 position (6-8 cm away-down from the back middle at the last rib, with the mean of the right and left side being the value of BF (Roongsitthichai and Tummaruk, 2014). The mineral coupling gel was applied to enhance an active transmission of the ultrasound wave.

Weaning and post-weaning measurement

Based on the group design, the piglets were weaned on day 28 or 35 or 42 or 49 or day 56 after farrowing. Piglets were separated from sow and grouped of 10 to 20 piglets per rearing (= nursery) pen. They were fed the same post-weaning feed at the nursery pen until 2nd week after weaning before they were sold out as growers. The post-weaning feed was mixed with the creep feed five days before weaning to ensure that the piglets adapted to the feed during the weaning phase. All piglets were moved to the rearing pen during the colder period of the day to reduce the abrupt weaning stress.

Piglet weight gain measurement and diarrhea assessment

The weight gain of piglets was individually recorded every 7 days, which started from day 1 after farrowing, continuing through the nursing phase or two weeks after weaning. Post-weaning piglets' diarrhea was assessed based on the daily observation of their feces. Alltech (N/A) the fecal score principle (scale of 1 to 4) was used, where 1−2 is considered solid and well-form, while a scale of 3−4 is considered diarrhea. The fecal evaluation was performed every morning and only focused on diarrhea two weeks after weaning or nursing phases. The number of diarrhea piglets was recorded based on the group weaning.

Data collection and data analyses

The bodyweight of each piglet was recorded at birth, every week after birth until weaning week, and two weeks after weaning. Bodyweight and backfat thickness of sows were recorded on day 110 before farrowing, then weekly until weaning. The estrous-weaning interval and conception rate,

including bodyweight and backfat thickness at their new insemination after weaning, were also recorded.

These data were analyzed using one-way ANOVA (LSD test) of the SPSS statistical software package version 26 (2019) to check for significant differences between groups. A significant level of 0.05 ($p < 0.05$) was used as the significant difference. The percentage of diarrhea was calculated based on the formula (% diarrhea = (total number of diarrhea piglets) x 100/total number of piglets in the group).

RESULTS AND DISCUSSION

Changing of body condition of sows during lactation

The mean bodyweight of gilts before farrowing was 76.22 ± 9.09 kg, and the heaviest was found in sows with weaning on day 56 (in group E). Meanwhile, the thinnest mean backfat thickness (BF) of gilts before farrowing was observed (41.52 mm) in the group with its' piglets weaned on day 42 (in group C), compared to others (Table 2).

Table 2

The body conditions of the sow from farrowing to weaning

Parameters	Weaning duration (day)					Mean ± SD	P-value
	A	B	C	D	E		
No. of sows	6	6	6	6	6		
BWF, kg	70.46^{a}	74.08^{a}	75.38^{a}	72.12^{a}	89.08^{b}	76.22 ± 9.09	0.000
BFF, mm	48.62^{abc}	45.95^{abc}	41.52^{b}	46.87^{abc}	52.05^{c}	47.00 ± 6.69	0.082
WLF, kg	11.99	13.38	13.08	12.36	11.17	12.39 ± 3.93	0.894
BFLF, mm	5.22	8.62	9.82	4.58	6.64	5.63 ± 3.34	0.511
BWW, kg	58.46^{a}	60.70^{a}	62.30^{a}	59.75^{a}	77.90^{b}	63.82 ±10.31	0.001
BFLW, mm	43.40^{ace}	37.33^{e}	31.70^{b}	42.28^{ace}	45.61^{dc}	40.06 ± 7.63	0.005
BWLW, kg	17.51	23.98	17.73	20.99	24.58	20.95 ± 6.54	0.179
BFLW, mm	5.96^{a}	8.66^{ab}	8.01^{ab}	12.38^{bc}	15.14^{c}	8.10 ± 7.01	0.034

A, B, C, D, E: sows weaned on days 28, 35, 42, 49, and 56, respectively. BWF: Bodyweight of sow before farrowing; BFF: backfat thickness before farrowing; WLF: weight lost 1 week after farrowing; BFLF: backfat thickness lost 1 week after farrowing; BWW: bodyweight at weaning; BFW: backfat thickness at weaning; BWLW: bodyweight lost at weaning; BFLW: backfat thickness lost at weaning.

There was no significant difference in the loss of bodyweight ($p = 0.894$) and BF ($p = 0.511$) after farrowing between groups. Similarly, there was no difference ($p = 0.179$) in weight loss at weaning time, while BF ($p < 0.003$) was. The largest bodyweight loss (24.58 kg) at weaning time was found in group E sows. In contrast, the smallest (17.51 kg) was observed in the sows with piglets weaned on day 28 (group A). Another interesting finding to note is that the largest backfat thickness loss ($p < 0.034$) was observed in the group E (15.14 mm) sows. This differs significantly ($p < 0.05$)

with group A (5.96 mm) sows. Conversely, it was not the case ($p > 0.05$) if compared to sows from groups B, C, and D (8.66, 8.01, and 12.38 mm, respectively).

Group B sows had the most significant weight loss of around 32 %, while 25 % in A, 24 % in C, 29 % in D, and 28 % in sows from group E. In contrast, backfat thickness loss was observed in over 29 % of sows from group E, 27 % in D, 19 % in B and C, over 12 % in sows from group A.

Group E sows with piglets were weaned on day 56 (group E), lost nearly 8 kg of their bodyweight compared to those whose piglets were weaned on day 28 (group A). Nearly 10 mm of BF was lost at weaning time in the group E sows compared to those in group A. From this point, it might be said that the weaning duration influenced the body conditions of *Moo Lath* primiparous sows.

However, there is currently a lack of data on the body conditions of *Moo Lath* primiparous sows related to their reproductive performance. According to the direct observation, *Moo Lath* sows seemed not to have milk left after 42 days of lactation (but this unclear data that needs more scientific study). This observation might correspond to Kyriazakis and Whittemore, 2006, and Neill et al., 2010, explained that modern sows reached their peak of milk production on day 21 after farrowing, when they can produce between 10 to 12 kgd^{-1}.

Additionally, the amount of milk production was controlled by the genetics of the individual's breed (Quesnel et al., 2015), and influenced by the energy level supplied (Noblet and Etienne, 1986). Bodyweight of sows gradually declined from week 4 (12 %) and became more severe after week 7 (26 %) of lactation. In this study, this loss did not find any adverse results on the first service-conception of sows after weaning, opposite to Thaker and Bilkei, 2005 and Cozannet et al., 2018. Who reported that sows with bodyweight loss between 19 to 25 kg or around 10 % during lactation risk losing conception for the first service after weaning. Another consideration concerns the lactation pen (3 m^2) used in this study, which seems too small for *Moo Lath* lactating sow with 7 or 8 piglets. Especially when they are older than 6 weeks, it was estimated that piglets created more stress on the sows. It might be one of the reasons why the body conditions of sows were found more severe in the 7 and 8 weeks of lactation in this study. The long-term suckling typically fits in traditional Lao farming methods.

The performance of sows after weaning

The estrous-weaning interval (EWI) of sows was between 3 and 9 days after weaning, average at about 5.80 ± 1.76 days. There was a significant difference ($p < 0.007$) in EWI of sows between the studied groups. The sows in group D had the longest mean EWI, while the shortest EWI was found in

group C (7.17 vs. 3.83 days). The present study did not observe any significant difference in EWI between sows from groups A, B, D, and E. In contrast, it was different in EWI of the sows from group C compared to those in groups A, B, and D (Fig. 2). However, in this study did not differ the first service-conception rates after weaning between the groups.

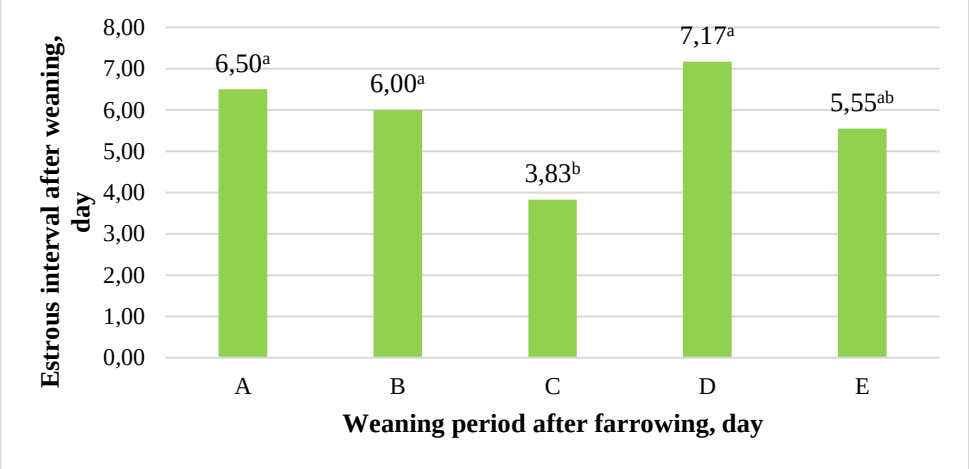

Fig. 2. Comparison of the estrous-weaning interval of sows due to weaning period. A, B, C, D, E: sows weaned on days 28, 35, 42, 49, and 56, respectively. [a,b:] Bar with different superscript differ significantly ($p < 0.05$)

Sows weaned on day 42 had the shortest mean EWI (3.83 days), while sows with piglets weaned on day 49 post-partum had the longest (7.17 days). It might be because most sows already well-established their uterine after 28 days post-partum, as described by Kyriazakis and Whittemore, 2006. In contrast, as found in this study, those sows with weaning on day 49 post-partum were at the point facing more serious body conditions. It would be reasonable to say that sows need more time to repair their body conditions. As Thaker and Bilkei, 2005, discovered that when sows lose around 16 - 20 % of their bodyweight during lactation, their estrous-weaning interval increased by 1 to 2 days compared to those lost < 5 %.

The growth performance of piglets

There was no significant difference in the birth weight of the piglets ($p = 0.106$), with an average of 0.65 ± 0.15 kg. In contrast, the growth performance of piglets from week 1 to week 4 of age was different ($p < 000$) between the studied groups. There was no significant difference in the mean weaning weight (WW) of piglets from groups A and B. Similarly, groups B and C found no difference in WW of piglets. The mean bodyweight of piglets for the 1st week and the 2nd week after weaning did not differ in groups C, D, and E, but it differed when compared to A and B (Fig. 3).

Piglets from group C gained the highest weight ($p < 0.040$) in the 1st week after weaning (1.28 kg), whereas piglets from groups A and E gained substantially less (0.33 vs. 0.50 kg). In contrast, in the 2nd week, piglets in groups C, D, and E gained weight (1.58, 1.30, and 1.27 kg, respectively), almost double the weight gain by piglets from groups A and B (Table 3). The average daily weight gain (ADG) of piglets in the present study, between the first two weeks after weaning, was about 139.75 gd^{-1} and 164.58 gd^{-1}.

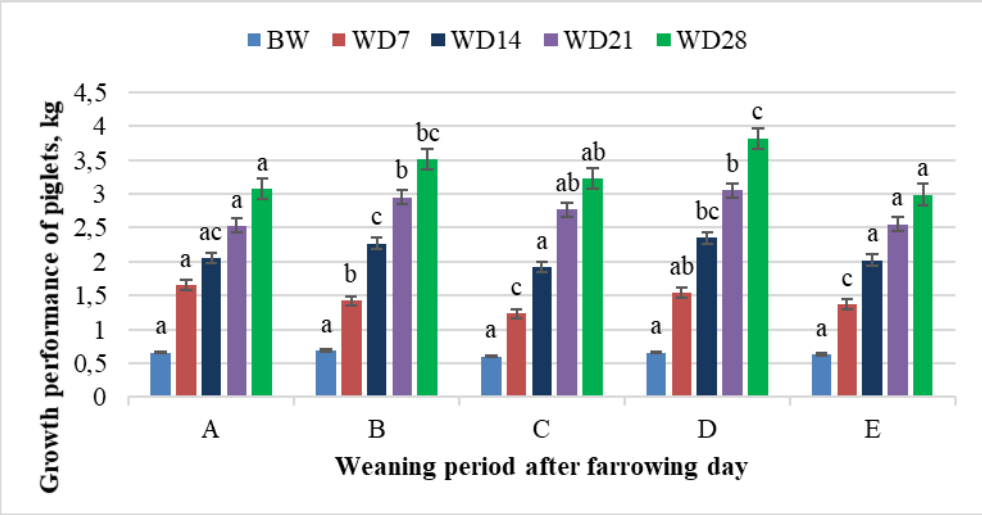

Fig. 3. Comparison of growth performance of piglets in four weeks after farrowing. A, B, C, D, E: sows weaned on days 28, 35, 42, 49, and 56, respectively. BW: birth weight; WD7, WD14, WD21 & WD28: weight of piglet at day 7, 14, 21 & 28. [a,b,c:] Mean in the bar with the same color with different superscripts differ significantly ($p < 0.05$)

Table 3

Comparison of post-weaning growth performance of piglets based on weaning periods

Parameters	Weaning duration (day)					Mean ± SD	P-value
	A	B	C	D	E		
No. of piglet	42	44	42	51	52		
WW, kg	3.48^{a}	4.19^{ab}	4.88^{bc}	5.92^{c}	5.92^{c}	4.94 ± 2.00	0.000
PWW1, kg	3.40^{a}	5.23^{b}	6.22^{c}	6.54^{c}	6.40^{c}	5.62 ± 2.28	0.000
PWW2, kg	4.03^{a}	6.13^{b}	7.85^{c}	7.85^{c}	7.67^{c}	6.77 ± 2.51	0.000
WGW1, kg	0.33^{a}	0.88^{b}	1.28^{bc}	0.62^{bd}	0.50^{ad}	0.70 ± 0.77	0.000
WGW2. kg	0.63^{a}	0.98^{acd}	1.58^{b}	1.30^{bc}	1.27^{bd}	1.16 ± 0.98	0.000

A, B, C, D, E: piglets were weaned at day 28, 35, 42, 49, and 56, respectively. WW: weaning weight; PWW1: post-weaning weight for week 1; PWW2: post-weaning weight for week 2; WGW1: weight gain for week 1; WGW2: weight gain for week 2. [a,b,c,d:] Means in the same row with different superscripts differ significantly ($p < 0.05$).

The difference in the growth performance of piglets for the first four weeks of suckling was significant in all study groups. A good explanation for this issue might be related to the ability of feed intake and resistance to

diarrhea infection of each piglet. This was more serious between the 2nd to 3rd week of age when they started eating the solid creep feed. The mean weight gain of piglets in the 1st-week post-weaning did not differ between groups weaned at 28 and 56 days of age.

It is assumed that weaning duration does not influence post-weaning growth performance much, but management does. It relates much to weaning procedures and early weaning management (Blavi et al., 2021). Usually, weaning creates more stress for new weaners and reduces their feed consumption (Campbell et al., 2013). In contrast, the weight gain of piglets in groups C, D, and E for the 2nd of post-weaning week increased almost 3 times compared to groups A and B. This supports the finding of (Van der Meulen et al., 2010; Leibbrandt et al., 1975), which reported increasing weaning age could improve feed intake and weight gain for post-weaned piglets.

Feed intake of piglets

The present study found that feed intake was influenced by diarrhea infection, which was faced in both suckling and post-weaning periods. The average feed intake of piglets a week before weaning was approximately 157 gd^{-1}, ranging between 110 to 268 gd^{-1}. However, the average feed intake in the 1st and the 2nd week of post-weaning slightly increased (189 and 297 gd^{-1}). Most new weaners consume less feed within the first 3 days after weaning, resulting from severe chronic diarrhea and stress from weaning. In the second week, new weaner piglets had nearly 4 times the feed intake compared to the 1st week (109 vs. 32 gd^{-1}).

Diarrhea infection after weaning

Early post-weaning diarrhea infection was a severe issue to block the growth performance of piglets in the present study. Particularly day 2 and day 3 after weaning. However, in general, there was no difference ($p = 0.401$) in the percent of diarrhea piglets in the group's study. But there was a significant difference ($p < 0.053$) if specific check within the first post-weaning week, especially on days 2 and 3 after weaning. Approximately 83.33 % on day 2 and 64.29 % on day 3 of the total piglets in group A got diarrhea. Meanwhile, groups D (19.6 and 31.37 %) and E (28.85 and 40.39 %) were lower infections (Fig. 4). However, the percentage of diarrhea exported in the piglets between groups A and C did not differ and was very close to each other on days 2 and 3. But, the piglets in group C appeared to recover faster. Almost all piglets from each studied group had no diarrhea after day 10 of weaning.

The present study discovered that a longer duration of weaning was a high risk of diarrhea infection in piglets due to the pig house environment. So, it can be explained that the appreciated lactation management related to

diarrhea prevention was critically addressed. The regular changing and the use of rice straw for floor bedding was the primary consideration for causing diarrhea infection in piglets in the present study. Especially after 2 weeks of age, when piglets started eating solid creep feed and chewing straw on the floor. Therefore, stockmen need to pay more attention to all the measures preventing the occurrence of piglet diarrhea because of its significant adverse economic consequences.

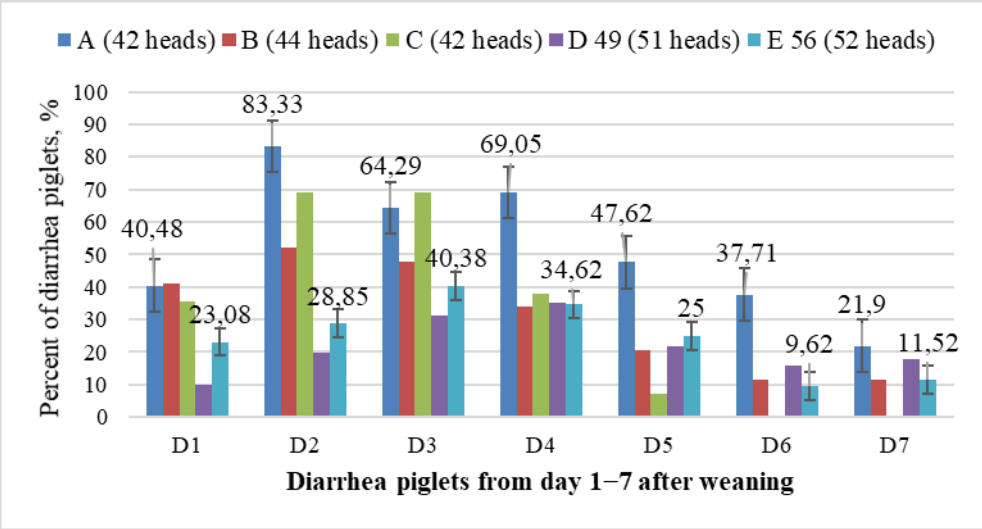

Fig. 4. Comparison of the diarrhea piglets' percentage. A, B, C, D, E: weaning group of piglets weaned on day 28, 35, 42, 49, and 56, respectively. D1, D2, D3, D4, D5, D6, D7: day 1, 2, 3, 4, 5, 6, and day 7 after weaning

CONCLUSIONS

Weaning duration influenced negative impacts on the body conditions of *Moo Lath* primiparous sows, which started from week 4 and became more severe by week 7 of lactation.

The management of weaning procedures and diarrhea infections after weaning are two critical factors that impact the growth performance of post-weaning. Especially, in the first week after weaning. For the 2nd-week post-weaning, piglets with longer weaning periods had nearly 3 times weight gain compared to those with shorter suckling periods.

Based on the findings of this study, we recommend the provision of proper feed amounts for lactating sows in order to reduce the severe body conditions of *Moo Lath* sows during lactation.

Appropriate management during and early post-weaning to address diarrhea infection must be considered.

To achieve the increased economic outcome of Lao farmers, *Moo Lath* piglets should be weaned between 5 to 6 weeks. That would be rather important to increase the future market impact of Lao pig production.

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REFERENCES

1. Alltech (N/A), 2022, Guide to diarrhea in pigs. How to monitor and find solutions (poster). Available at: https://www.alltech.com/sites/default/files/2021-02/Guide%20to%20Pig%20Diarrhea%20Poster.pdf; Accesed on: August 26;
2. Blavi L., Solà-Oriol D., Llonch P., López-Vergé S., Martín-Orúe S.M., Pérez J.F., 2021, Management and Feeding Strategies in Early Life to Increase piglet performance and welfare around weaning. Animals, vol. 11, issue 2, pp. 1−43, https://doi.org/10.3390/ani11020302;
3. Campbell J.M., Crenshaw J.D., Polo J., 2013, The biological stress of early weaned piglets. Journal of Animal Science and Biotechnology, vol. 4, issue 19, pp. 1−4; https://doi.org/10.1186/2049-1891-4-19;
4. Council Directive 2008/120/EC, 2008, Official Journal of the European Union. Available at: http://data.europa.eu/eli/dir/2008/120/oj;
5. Cozannet P., Lawlor P.G., Leterme P., Devillard E., Geraert P.A., Rouffineau F., Preynat A., 2018, Reducing BW loss during lactation in sows: a meta-analysis on the use of a nonstarch polysaccharide-hydrolyzing enzyme supplement. Journal of Animal Science, vol. 96, issue 7, pp. 2777−2788, https://doi.org/10.1093/jas/sky045;
6. Keonouchanh S., Egerszegi I., Ratky J., Bounthong B., Manabe N., Brüssow K-P., 2011, Native pig (Moo Lat) breeds in Lao PDR. (Short Communication), Archive Animal Breeding, vol. 54, pp. 600–606, https://doi.org/10.5194/aab-54-600-2011;
7. Keonouchanh S., Dengkhounxay T.H., 2017, Pig production and pork quality improvement in Lao PDR. NAFRI. Available at https://www.angrin.tlri.gov.tw/meeting/2017TwVn/2017TwVn_p37-42.pdf;
8. Kyriazakis I., Whittemore C.T., 2006, Whittemore's science and practice of pig production. 3rd Edith. Blackwell Publishing, pp. 127−138;
9. Law no. 08/NA, 2016, Laos Livestock and Veterinary Law, Laos;
10. Leibbrandt V.D., Ewan R.C., Speer V.C., Zimmerman Dean R., 1975, Effect of weaning and age at weaning on baby pig performance. Journal of Animal Science, vol. 40, issue 6, pp. 1077–1080, https://doi.org/10.2527/jas1975.4061077x;
11. Neill C., Williams N., America P.N., 2010, Milk production and nutritional requirements of modern sows. London swine conference-focus on the future March 31−April 1, pp. 23–32;
12. Noblet J., Etienne M., 1986, Effect of energy level in lactating sows on yield and composition of milk and nutrient balance of piglets. Journal Animal Science, vol. 63, issue 6, pp. 1888–1896, https://doi.org/10.2527/jas1986.6361888x;
13. Phengsavanh P., Ogle B., Stür W., Frankow-Lindberg B.E., Lindberg J.E., 2010, Feeding and performance of pigs in smallholder production systems in Northern

Lao PDR. Tropical Animal Health and Production, vol. 42, issue 8, pp. 1627–33, https://doi.org/10.1007/s11250-010-9612-4;
14. Phengvilaysouk A., Jansson A., Phengsavanh P., Tiemann T., Phengvichith V., Lindberg J.E., 2017, Sow and piglet management in small-holder and larger-scale pig farms in Northern part of Laos. Livestock Research for Rural Development, vol. 29, issue 10, http://www.lrrd.org/lrrd29/10/jan29201.html;
15. Quesnel H., Farmer C., Theil P.K., 2015, Colostrum and milk production. The gestating and lactating sow. Wageningen Academic Publishers, pp. 173–192;
16. Roongsitthichai A., Tummaruk P., 2014, Importance of backfat thickness to reproductive performance in female pigs. Thai Journal of Veterinary and Medicine, vol. 44; issue 2, pp. 171–178;
17. Smith A.L., Stalder K.J., Serenius T.V., Baas T.J., Mabry J.W., 2008, Effect of weaning age on nursery pig and sow reproductive performance. Journal of Swine Health and Production, vol. 16, issue 3, pp. 131–137;
18. Thaker M.Y.C., Bilkei G., 2005, Lactation weight loss influences subsequent reproductive performance of sows. Animal Reproduction Science, vol. 88, issue 3–4, pp. 309–318, https://doi.org/10.1016/j.anireprosci.2004.10.001;
19. Van der Meulen J., Koopmans S.J., Dekker R.A., Hoogendoorn A., 2010, Increasing weaning age of piglets from 4 to 7 weeks reduces stress, increases post-weaning feed intake but does not improve intestinal functionality. Animals, vol. 4, issue 10, pp. 1653−1661, https://doi.org/10.1017/S1751731110001011;
20. Webster J., 2011, Management and welfare of farm animals. The UPAW farm handbook. 5th edition. Edith by Webster J. Wiley-Blackwell. pp. 253–291;
21. Xayalath S., Mujitaba M.A., Ortega A.D.S.V., Rátky J., 2021a, Review on the trend of livestock breeds in Laos. Acta Agraria Debreceniensis, no. 1, pp. 227–237, https://doi.org/10.34101/actaagrar/1/9047;
22. Xayalath S., Novotni-Dankó G., Balogh P., Brüssow K.P., Rátky J., 2021b, Reproductive performance of indigenous Lao pigs reared by small-scale farmers in northern provinces of Laos. Archives animal breeding, vol. 64, issue 2, pp. 365–373, https://doi.org/10.5194/aab-64-365-2021.

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