DOI: http://doi.org/10.4038/agrieast.v16i1.110

Effect of weaning age on behaviour and production performances of New Zealand White rabbit does in tropical climatic condition

R.M.A.S. Bandara[1]*, T.S. Samarakone[2], M. P.S. Magamage[1] and M.P.B. Wijayagunawardane[2]

[1]*Department of Livestock Production, Faculty of Agricultural Sciences, Sabaragamuwa University of Sri Lanka, Belihuloya, 70140, Sri Lanka.*

[2]*Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Peradeniya, 20400, Sri Lanka.*

ABSTRACT

Artificial weaning induces stress in animals which is a welfare concern. Rearing temperate rabbit breeds in the tropics in addition may cause stress to them. This study assessed the effect of weaning on stress (based on behaviour), subsequent body development and production performances (litter weight at birth, litter size and gestation period) of New Zealand White rabbit does under tropical climatic condition. Fifteen nulliparous rabbit does were divided into three treatment groups (n = 5) corresponding to three different weaning ages of litters (T1= weaning at 21 days. T2 = weaning at 35 days and T3 = weaning at 49 days). The experiment was conducted up to the third parity in each doe while providing one week of resting period between the parities. Data were analysed by General Linear Model procedure of SAS. Decreased lying and increased grooming itself were observed following weaning in all 3 treatments (P<0.05). Some other behaviours were affected with different weaning ages. Does weaned at 21 days and 35 days were able to start to recover their negative energy balance during the resting period. However, multiparous does weaned at 49 days exhibited negative growth rate even after weaning. There were no significant differences (P>0.05) in the production parameters of the does (litter weight at birth, litter size in consecutive weeks up to a ninth week and average gestation length) among the treatments. Results revealed that weaning induced changes in behaviour of the rabbit does. Weaning age affected on recovering of the negative energy balance of the rabbit does in lactation.

Keywords: *Behaviour, growth rate, parity, rabbit doe, stress, weaning*

INTRODUCTION

Under natural conditions, weaning of the young occurs gradually at different ages based on the food supply and arrival of the mother's next offspring. However, in commercial production, livestock species are typically weaned abruptly at a relatively young age prior to the natural weaning in order to activate the mother's reproductive cycle and enhance the yield of offspring in breeding stocks. The social bonding between mother and her offspring is gradually developed due to milk feeding and maternal care. Artificial weaning suddenly breakdowns the bond between the mother and her offspring that develop at birth. Therefore, abrupt weaning is a stressful process that induces emotional anxiety and physiological changes in many domestic species (Apter and Householder 1996; Day and Webster 1999) that are a welfare concern. Reactions in animals including behavioural and physiological modifications aims at coping with the stressors (Moberg and Mench, 2000). Behaviour changes are

*Corresponding author: rmamilabandara@gmail.com https://orcid.org/0000-0001-7933-5185
Received: 22.02.2022 Accepted: 08.08.2022

considered the most consistent and reliable indicator of stress (Hicks *et al*., 1998). Previous studies suggested that artificial weaning cause behavioural changes in mother animal (cows - Keyserlingk and Weary, 2007; ewes - Cockram *et al*., 1993; mares - Houpt, 2002) based on a comparison of pre-weaning and post-weaning behaviours. However, the effect of weaning on the behaviour of rabbit doe is scarce in scientific literature. Therefore, it is worth examining whether weaning causes any behaviour changes of weaned rabbit does which could be used to assess the degree of distress.

The thermoneutral zone for rabbits is between 15-250C (Cevera and Caramona, 1998). Therefore, the major problem of rearing European rabbit breeds in a tropical climate is the susceptibility of animals to heat stress. Several studies reported that there was a negative effect of heat stress on rabbit milk production (Maertens and De Groote, 1990; Fernández-Carmona et al., 1995 and 2003). In addition, a longer lactation period may stress the rabbit does additionally under high environmental temperature. In previous studies, it was concluded that early weaning of rabbits resulted in reduced doe body energy output due to a shorter lactation period (Xiccato *et al*., 2000; Nicodemus *et al*., 2002). However, a negative effect of early weaning on rabbit reproductive performance was reported in terms of the lower number of kits born alive per litter in multiparous does whose litters were weaned at 21 days of age (Xiccato *et al*., 2004).

Welfare scientists assume that mammals experience negative feelings associated with social loss based on studies on behavioural responses, neuroanatomy and neuropharmacology (Panksepp, 2003; Dawkins, 2006). In this study, we hypothesized that abrupt weaning causes stress and affects negatively on growth and reproduction parameters of the breeding does. The general principle of animal caring is to avoid unnecessary suffering in any circumstance. Thus, we must assess to what extent that the mothers are distressed by separation from their litters in order to identify any management practices to mitigate negative effects. Therefore, the present study aimed to determine the effect of weaning on stress (based on behaviour), subsequent growth performances and reproductive performances of New Zealand White rabbit does under tropical climate.

MATERIALS AND METHODS

Animals and experimental design

Fifteen nulliparous rabbit does of breed New Zealand White were randomly selected at the standard breeding age (approximately five months old) for the study. Three different weaning ages were studied to get a better insight into the effect of weaning on breeding rabbit does.

Breeding does were divided into the three treatment groups (n = 5) corresponding to different weaning ages of their litters and designated as Treatment 1 = weaning at 21 days (T1); Treatment 2 = weaning at 35 days (T2), and Treatment 3 = weaning at 49 days (T3). In commercial rabbit rearing, weaning of litter usually occurs from 30 to 35 days of age. Weaning at 21 days postpartum was studied in temperate climate (Xiccato et al., 2004). However, literature is not available for 21 days weaning in the tropical climate. Thus, 21 days postpartum weaning was selected as early weaning to assess the possibility in tropical climate. Weaning at 49 days postpartum was selected as late weaning to assess the effect on breeding does in the tropics.

The average starting body weights (mean±SD) of the does were 3.24 ± 0.63kg,

3.20 ± 0.35kg and 2.84 ± 0.68kg for T1, T2 and T3, respectively, and the experiment was conducted up to the third parity in each doe. A total of five breeding bucks at the age of six months old were used for mating all the does. Re-mating of the does for their consecutive parities was performed one week of resting period following weaning according to a predetermined mating protocol. This one week of resting period was given to reduce negative consequences of weaning (psychological stress due to artificial breakdown of the bond in between the mother doe and the kits) and to increase welfare of the breeding does before the next mating by providing time to replenish the body energy. The same five breeding bucks that were used in the first mating were mated randomly with the breeding does in a rotational programme in consecutive parities to minimise the buck effect on litter parameters.

Housing and feeding

The experimental animals were managed in a semi-enclosed building (900cm length x 360 cm width x 240 cm height) under 12 h light and 12 h dark period schedule and under natural ventilation. On average, the day and night temperatures were 27^0C and 21^0C, and the relative humidity was 64% at the experimental location. Each doe was provided with an individual cage (75cm length x 75cm width and 50cm height) made of wood and poultry wire mesh (31mm hexagonal hole). On the 28th day of gestation, pregnant does were provided with a front-loading wooden nest box (30cm length x 25cm width x 30cm height) containing sanitised straw which was kept inside the cage. Commercially available Broiler Finisher pellet diet (Metabolisable energy 2980 kcal/kg, Crude protein 19.5%, Crude fibre 4.5%, Crude Fat 3.2%, Calcium 0.85%, Phosphorous 0.7%, Methionine 0.48% and Ash 7%), water and wilted Napier grass *(Pennisetum purpureum)* were provided *ad libitum* for all the breeding does.

Data collection

Behaviour of the does was observed based on an ethogram (Table 1) three days prior to weaning and three days following weaning. Behaviour observations were recorded for three hours in the morning (from 9.00 a.m. to 12.00 noon) and three hours in the afternoon (1.00 p.m. to 4.00 p.m.) by live observations where the observer was blind to the treatments. For consistency, the observer was constant throughout all observations and data were collected with no disturbance to the breeding does. Instantaneous scan sampling method at every five-minute interval was practiced to observe the behaviour of does in pre-weaning and post-weaning stages (Lehner, 1996). Pre-weaning and post-weaning behaviours were compared to assess weaning stress in animals in previous studies (cows - Keyserlingk and Weary, 2007; ewes - Cockram et al., 1993; mares - Houpt, 2002). From those observations, an estimate of the percentage of time that the rabbit does were engaged in each behaviour during each observation session was calculated for the statistical analysis.

Body weights of does were recorded on the day of kindling and thereafter on a weekly basis during the three consecutive lactations and at the end of each resting period following weaning to detect the growth rate of the does. Litter weight at birth, litter size in consecutive weeks up to a ninth week and average gestation length were recorded for each doe on an individual basis during three parities.

Table 1. Ethogram used to observe before and after weaning behaviours in rabbit does

Behaviour	Description of behaviour
Lying	Resting with trunk on ground, hind limbs tucked under the fore limbs lying under or forward stretched from body or all four limbs outstretched
Coprophagy	Chews and swallowed of soft faecal pellets directly from the anus
Moving	Move from one location to another
Self Grooming	Fore limbs are licked and pass over the face and ears, licking the rest of the body
Drinking	Lapping up water with tongue
Feeding	Take food material in to mouth and chew and swallow
Rearing	Sitting up on hind limbs with both forepaws off the ground, ears partially or fully down
Sitting	Sitting in upright stationary position with rare end and forepaws on ground and ears down or erect.
Crouching	A submissive behaviour, animal freezes and presses head and shoulders against ground with ears flattened.
Sleeping	Lying or sitting with both eyes closed, ears usually flat against the back.

Statistical analyses

All analyses were performed by the basic ANOVA model of the General Linear Model (GLM) procedure using SAS 9.4 version (SAS Inst., Inc. Cary, NC, USA). Differences among the means were evaluated with the least significant difference (LSD) means separation test using the PDIFF and STDERR options of SAS. With respect to doe behaviour data, percentages of the proportion of time spent on behaviours of the does were analysed following checked for normal distribution. Before and after weaning behaviours of the does were compared within a treatment group in each parity. Before and after weaning behaviours were also analysed, excluding the parity effect. Additionally, the effect of day on after weaning behaviours of the does within a treatment was analysed to assess any difference in the degree of stress of the does in three consecutive days. Even though theinteraction between treatment and parity for litter weight at birth, litter size in consecutive weeks, and gestation length evaluated were not significant, the parameters among three treatments within each parity and among three parities within each treatment were also statistically analysed to see any patterns.

RESULTS AND DISCUSSION

Behaviour of rabbit does

The present study showed that there was a significant influence on some of the studied behaviours of the rabbit does immediately the following weaning in the three weaning age groups (Table 2, Table 3, Table 4). Lying and grooming itself were ($P < 0.05$) affected by weaning in all three treatments groups. The most common behaviour observed in all the does before weaning was solely lying. This observation is in accordance with Debbie and Morton (1995) who reported that rabbit does spent nearly 50% of the time on lying in

sternal recumbency inside laboratory cages during day light. However, lying was severely affected by weaning in all three treatments, and the time spent on lying was ($P < 0.05$) decreased following weaning in all the does. Rabbit does weaned at 21 days postpartum exhibited reduced frequency of lying after weaning in all three parities (Table 2). In contrast, in the other two groups, reduced lying was observed at least in two parities. Self-grooming of rodents can be increased in stress or in all novelty situations (Kalueff 2000; Jolles et al., 1979). Similar to those observations, increased self-grooming ($P < 0.05$) after weaning was observed in all three parities of all treatment groups. Thus, it can be suggested that lying behaviour and self-grooming are good behavioural indicators to assess weaning stress in rabbit does in all ages.

Current results revealed that certain behaviours were affected by weaning in some treatment groups. The highest number of observed behaviours were affected in T1 does whereas the lowest number of behaviours were affected in T2 does by weaning. Moving was increased ($P < 0.05$) in T1 and T3 groups following weaning in all three parities. Similarly, significant increase in moving behavior following weaning has been reported in some other species (cows: Keyserlingk and Weary 2007; mares: Houpt 2002) based on studies of comparison of pre and post-weaning behaviours. In addition, feeding behaviour was also decreased ($P < 0.05$) both in T1 and T3 does following weaning in all three parities. Coprophagy was increased ($P < 0.01$) by weaning in T3 does (Table 4). However, there was a decreasing trend ($P = 0.05$) in coprophagy in T1 does following weaning. Sitting and crouching behaviours were significantly ($P < 0.05$) increased when the does were weaned at 21 days (Table 2). However, we did not notice differences in moving, feeding, coprophagy, and crouching behaviours in T2 does following weaning. Thus, it can be suggested that there could be an effect of weaning age on affected behaviours of the rabbit does.

Nest building behaviour of rabbit does have been studied previously (Ross et al., 1956; Denenberg et al., 1963; Manal et al., 2010). However, for the authors knowledge behaviour of rabbit does during lactation has not yet studied. In this study, we tried to budget the behaviour of rabbit does during lactation and how those behaviours affected following weaning. Therefore, additionally this study provides information of quantification of behaviour of lactating rabbit does in different stages of their lactations.

A higher frequency of feeding was observed before weaning in T1 does than T2 and T3 does. T1 does were weaned at 21 days, and behaviours were recorded on the 19th, 20th and 21st days of kindling. The peak of milk production of rabbits occurs at the end of the third week of lactation (McNitt and Lukefahr, 1990; Kustos et al., 1996). Therefore, the observed result revealed that rabbit does exhibited a higher frequency of eating during their peak lactation (19th, 20th and 21st days of kindling). However, weaning significantly reduced the frequency of eating following weaning in T1 does. Xiccato et al. (2004) also reported a marked reduction in the daily energy intake of rabbit does after weaning at 21 days of kindling. Rearing and sleeping behaviours were not affected by weaning in all three treatment groups.

Table 2: Behaviour (% of proportion of time) of rabbit does before and after weaning at 21 days of postpartum

	First parity				Second parity				Third parity			
Behaviour	Before	After	SE	P Value	Before	After	SE	P Value	Before	After	SE	P Value
Lying	65.6	57.6	1.6	**0.002**	65.5	58.3	1.4	**0.001**	57.2	48.5	1.1	**<0.001**
Coprophagy	0.9	0.8	0.3	0.83	0.9	0.4	0.2	0.02	1.0	0.5	0.2	0.07
Moving	0.4	2.4	0.3	**<0.001**	0.4	3.4	0.5	**<0.001**	0.2	5.5	0.4	**<0.001**
Grooming itself	6.4	11.4	1.1	**0.002**	6.1	12.7	0.9	**<0.001**	6.7	14.2	0.7	**<0.001**
Drinking	4.5	4.1	0.7	0.67	5.0	3.8	0.6	0.17	4.4	5.1	0.5	0.34
Feeding	20.6	13.7	1.2	**<0.001**	20.5	15.4	1.1	**0.003**	29.0	18.4	0.7	**<0.001**
Rearing	0.0	0.0	0.0	-	0.0	0.1	0.1	0.33	0.0	0.0	0.0	-
Sitting	0.8	1.6	0.4	0.15	0.6	1.8	0.4	0.05	0.5	2.9	0.4	0.001
Crouching	0.6	7.5	0.8	**<0.001**	0.6	4.1	0.6	**<0.001**	0.8	4.9	0.7	**<0.001**
Sleeping	0.2	0.8	0.2	0.06	0.3	0.0	0.1	0.07	0.2	0.1	0.1	0.66

Table 3: Behaviour (% of proportion of time) of rabbit does before and after weaning at 35 days of postpartum

	First parity				Second parity				Third parity			
Behaviour	Before	After	SE	P Value	Before	After	SE	P Value	Before	After	SE	P Value
Lying	70.4	66.1	1.6	**0.07**	69.6	66.6	1.2	0.10	70.3	65.0	0.9	**0.001**
Coprophagy	0.5	0.8	0.2	0.43	0.9	0.7	0.2	0.60	0.9	0.8	0.2	0.72
Moving	3.0	2.2	0.5	0.32	1.1	1.4	0.2	0.46	0.3	0.6	0.2	0.28
Grooming itself	6.3	9.4	0.8	**0.02**	4.4	6.8	0.7	**0.03**	6.8	10.1	1.0	**0.02**
Drinking	2.8	3.0	0.5	0.77	4.2	3.8	0.5	0.53	3.8	4.0	0.3	0.71
Feeding	9.6	11.8	1.0	0.14	18.2	18.1	0.8	0.94	17.8	18.4	1.1	0.69
Rearing	0.2	0.3	0.1	0.51	0.0	0.1	0.1	0.33	0.0	0.0	0.0	.
Sitting	1.6	0.9	0.3	0.12	0.8	1.1	0.4	0.61	0.2	0.4	0.2	0.29
Crouching	3.2	3.5	1.0	0.79	0.3	1.1	0.4	0.19	0.0	0.5	0.2	0.04
Sleeping	2.5	1.9	0.8	0.58	0.5	0.4	0.2	0.80	0.1	0.2	0.1	0.56

Table 4: Behaviour (% of proportion of time) of rabbit does before and after weaning at 49 days of postpartum

	First parity				Second parity				Third parity			
Behaviour	Before	After	SE	P Value	Before	After	SE	P Value	Before	After	SE	P Value
Lying	61.3	58.6	1.9	0.34	72.8	68.8	1.2	**0.02**	71.1	65.7	1.0	**0.002**
Coprophagy	0.4	1.8	0.4	0.01	1.0	1.2	0.3	0.53	0.2	0.4	0.2	0.38
Moving	1.3	3.7	0.7	**0.02**	0.9	2.4	0.5	**0.04**	0.0	1.2	0.3	**0.005**
Grooming itself	9.5	13.6	1.3	**0.03**	5.5	12.8	0.6	**<0.001**	9.6	16.9	0.9	**<0.001**
Drinking	2.8	1.7	0.4	0.06	3.1	2.6	0.4	0.39	3.4	2.5	0.2	0.008
Feeding	18.0	12.6	1.2	**0.004**	15.4	11.6	0.6	**<0.001**	15.8	11.7	0.5	**<0.001**
Rearing	0.0	0.4	0.2	0.10	0.0	0.0	0.0	-	0.0	0.0	0.0	-
Sitting	1.6	3.0	0.5	0.07	0.8	0.4	0.3	0.46	0.0	0.4	0.2	0.09
Crouching	0.9	1.4	0.5	0.38	0.3	0.0	0.2	0.16	0.0	0.2	0.1	0.13
Sleeping	4.3	3.0	1.0	0.37	0.2	0.2	0.1	1.00	0.0	0.9	0.3	0.03

Table 5: Behaviour (% of proportion of time ± SE) of rabbit does before and after weaning irrespective of parity in three different Weaning ages

	Treatment								
	T1			T2			T3		
Behaviour	Before	After	P Value	Before	After	P Value	Before	After	P Value
Lying	62.8±1	54.8±1	<0.001	70.1±0.7	66±0.7	<0.001	68.2±1.1	64.2±1.1	0.01
Coprophagy	0.9±0.1	0.6±0.1	0.05	0.8±0.1	0.8±0.1	0.1	0.6±0.2	1.2±0.2	0.01
Moving	0.3±0.3	3.8±0.3	<0.001	1.4±0.2	1.4±0.2	0.98	0.8±0.3	2.5±0.3	<0.001
Grooming itself	6.4±0.5	12.8±0.5	<0.001	5.8±0.5	8.8±0.5	<0.001	8.1±0.6	14.3±0.6	<0.001
Drinking	4.6±0.3	4.3±0.3	0.52	3.6±0.3	3.6±0.3	0.95	3.1±0.2	2.3±0.2	0.01
Feeding	23.4±0.7	15.8±0.7	<0.001	15.2±0.8	16.1±0.8	0.42	16.4±0.5	12±0.5	<0.001
Rearing	0±0.02	0.03±0.02	0.32	0.1±0.1	0.1±0.1	0.4	0±0.1	0.1±0.1	0.09
Sitting	0.7±0.2	2.1±0.2	<0.001	0.9±0.2	0.8±0.2	0.86	0.9±0.3	1.4±0.3	0.18

Crouching	0.7±0.4	5.5±0.4	<0.001	1.1±0.4	1.6±0.4	0.43	0.4±0.2	0.6±0.2	0.57
Sleeping	0.2±0.1	0.3±0.1	0.54	1±0.3	0.8±0.3	0.62	1.6±0.4	1.4±0.4	0.73

T1- weaning at 21 days, T2- weaning at 35 days, T3- weaning at 49 days

There was no significant difference (P > 0.05) observed in behaviours of does among three consecutive days following weaning in all treatment groups. Therefore, it can be suggested that behaviour changes due to weaning of the does were persisted in three consecutive days following weaning, indicating continuous stress due to weaning for at least three consecutive days.

Previous studies reported that weaning induced abnormal behaviours such as bar biting (Morton et al., 1993; Gharib et al., 2018) and scraping the bottom of the cage (Morton et al., 1993) in young rabbits, and stated that these behaviours indicate frustration in rabbits (Morton et al., 1993). However, these abnormal behaviours were not observed following weaning in rabbit does in this study.

Consequence body development of rabbit does

Average growth rates of T1, T2, and T3 does in the consecutive lactations are presented in Figure 1. The growth rate decreased during the first week following kindling in all three treatments with regards to all three parities and decreased again in the second week to negative values and persisted negative during the whole lactation in most of the parities of the treatments.

If the rabbit does in lactations are mated and conceived, their lactation is overlapped with their gestation. Thus, energy requirements will be increased due to the high demand of energy for both milk production and growth of the fetuses (Parigi-Bini *et al*., 1996). Therefore, in the present study does were re-mated following one week of resting period of weaning in order to provide a resting period for body replenishment. The growth rate of T2 does were increased to positive during the resting period in all three parities while T1 does exhibited negative growth rate (-0.01kg/day) only in the first parity and positive values for the second (0.11kg/day) and third (0.066kg/day) parities were observed. About 80% of the energy for reproduction comes from feed intake and about 20% from body mobilization (Parigi-Bini *et al*., 1990). Further, they suggested that feed intake of a doe (Maximum ingestion of digestible energy is 3.70MJ/day) in lactation is insufficient to meet the requirement due to maintenance (1.27MJ/day) and milk production (2.90MJ/day), and this results in a substantial negative energy balance during the first lactation (-12.93MJ) and considerable mobilization of body fat (-52%). The milk production of the doe is dependent on the day of lactation and increases until the end of the third week of lactation (Kustos *et al*., 1996; McNitt and Lukefahr, 1990). The highest negative value of growth rate was observed in the third week of lactation in T1 does in all three parities. T1 does were not able to reach a positive growth rate even in the resting period in their first parity. A similar result was observed by Xiccato *et al*. (2004), and they suggested that the reason for the persistence of the body energy deficit when weaning age was reduced from 32 to 21 was a result of the marked reduction in daily energy intake of rabbit does after weaning. The present study is also supported this statement as there was a significant reduction in feed intake in T1 does after weaning, according to the results of the behaviour study of present experiment. However, in the second and third parities, T1 does were able to reach positive weight gain at the end of the resting period. This result can be explained as during the second and third parities multiparous does are able to bear a high energy cost because their higher feed intake capacity and due to completion of body growth (Pascual *et al*. 1999; Xiccato *et al*., 2004).

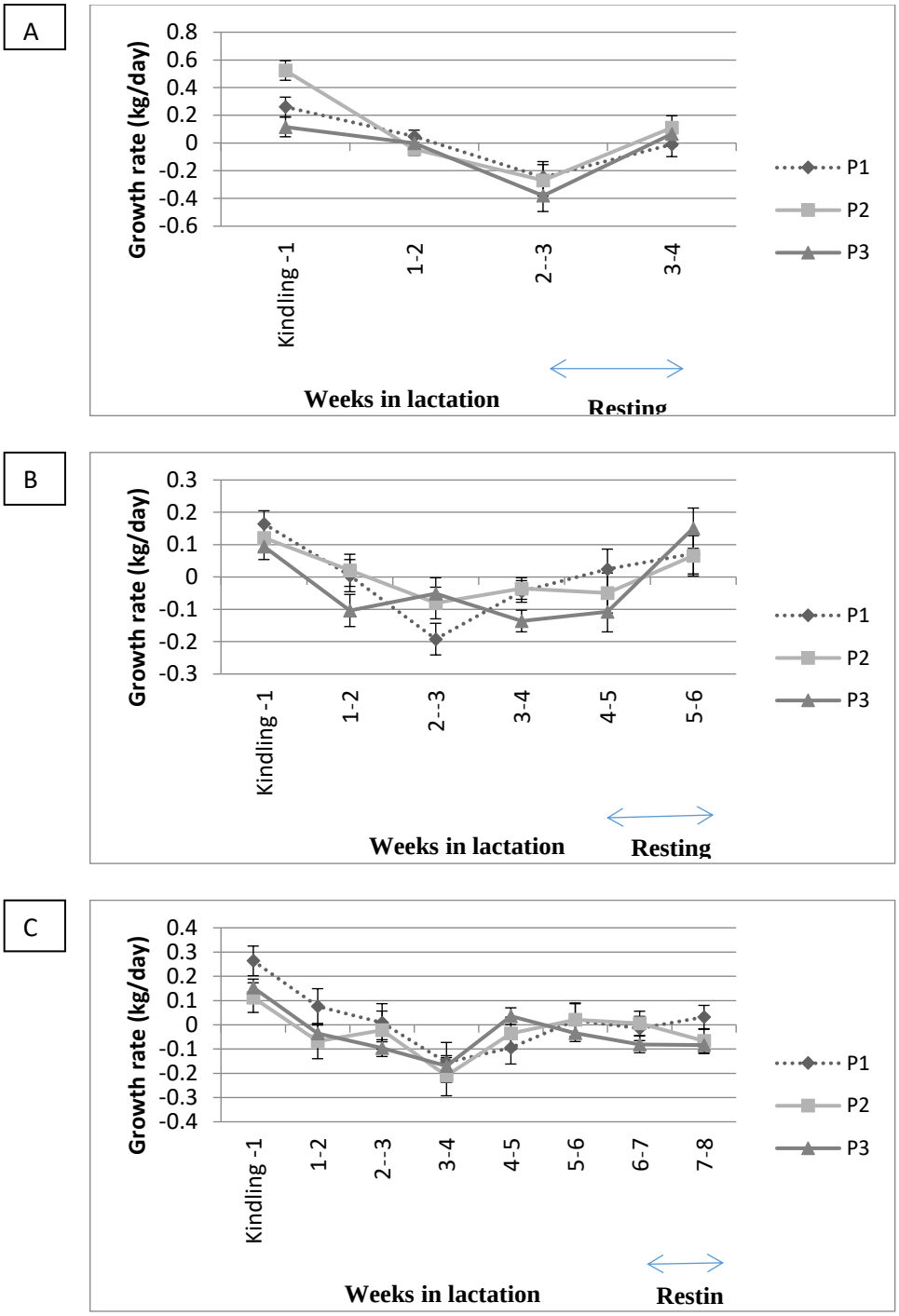

Figure 1: Growth rate (kg/day) of rabbit does in consecutive lactations
A - Treatment 1 (weaning at 21 days), B - Treatment 2 (weaning at 35 days), C - Treatment 3 (weaning at 49 days). P1-First parity, P2-Second parity, P3 - Third parity.

Positive growth rates were achieved during the resting period in all three parities (0.072±0.062kg/day, 0.065±0.062kg/day and 0.15± 0.062kg/day, respectively) in 35 days weaned does. Though the growth rate reached positive during the week following weaning in the first parity (0.032kg/day) of T3 does, it was persisted as negative even after weaning in the second (-0.066kg/day) and third (-0.084kg/day) parities. Early weaning decreases the mobilization of body stores in lactating does by limiting the duration of lactation. Xiccato *et al*. (2004) reported that the energy deficit of does decrease due to the short lactation (8%, 14 % and 19% from the initial energy content of the does for weaning at 21st, 26th and 32nd day of lactation, respectively). Therefore, prolong lactation may be the reason to observe negative growth rates in the resting period in the second and third parities of T3 does under tropical environment.

This study was conducted by using five rabbit does in each weaning age group. This number may not be sufficient enough to make a strong conclusion on the weaning effect on studied growth parameters. The observed growth rate patterns are very important to get a basic knowledge of how the body energy utilize by rabbit does in their consecutive lactations and how did the age at weaning affected on growth performances of the rabbit does in tropical environment. However, this should be subjected to further investigations which will certainly enable us to perform a more complete and detailed statistical analysis with fairly larger sample size.

Production parameters

Litter size in consecutive weeks

The average litter size at the birth was 8.2 in treatment 1, 7.6 in treatment 2 and 8.2 in treatment 3. It was found that the average litter size to be similar during the first five weeks of all treatments and gradually decreased from the 7th week onwards. The average litter size on the ninth week was persisted as 5.2, 5.5 and 4.9 in T1, T2, and T3 does respectively. Many authors observed smaller size and weight of litters in primiparous does compare with multiparous ones (Pascual *et al*., 1998; Fortun-Lamothe, 1998). In contrary, there was no ($P > 0.05$) significant interaction between treatment and parity for average litter size evaluated from birth to the ninth week. There was no significant difference among the treatments in average litter size in consecutive weeks ($P > 0.05$). Furthermore, parity was not also significantly affected on the average litter size ($P > 0.05$). Cevera *et al*. (1993) reported that a continuous intensive rhythm decreases litter size and fertility rate of the does. In contrary, litter size was not significantly affected by parity in T1 does. This observed result may be due to the one week of resting period following weaning for the does, which enables them to replenish their body energy deficit to some extent. In most of the previous studies, does were intensively re-mated just after kindling or while they were in lactation. A similar re-mating protocol used in this study has not been recorded in previous studies.

Average litter weight at birth

Marykutty and Nandakumar (2000) reported that the average litter weight at birth was 0.220±0.014kg (average litter size was recorded as 4.24) in the Indian humid tropics. However, the present study showed higher values of litter weight at birth (T1- 0.363kg, T2-0.426kg and T3- 0.432kg) than previous reports in the tropics. The average litter weight was not significantly affected ($P > 0.05$) by the treatments or the parities within a treatment. However, average birth weight of a kit was lower in comparison to New

Zealand White rabbit kits in temperate climate. The average birth weight of a kit was between 50 - 57g in all treatments (T1-51g, T2- 56g and T3- 57g) of the study, and this weight is lower than the weights reported by Xiccato *et al.* (2005) in 25 days weaned does (59.8g) and in 21 days weaned does (62.6g) in temperate climate.

Average gestation length

The average gestation length of the does in T1, T2 and T3 were 32.1, 31.8 and 32.3 days, respectively (P = 0.61). The Gestation length of rabbits in the tropics was recorded as 29-33days (Rajadevan et al., 1987; Odubote and Somade, 1992). Results obtained in the present study are in accordance with those observations in the tropics, and the average gestation length was always recorded as more than 29 days. However, there was no significant interaction for treatments and parity for gestation length in the present study, and parity did not also significantly affected on the length of gestation.

CONCLUSION

Some behaviours were affected by weaning in rabbit does. Change in lying behaviour and self-grooming are possible behavioural indicators to assess weaning stress in rabbit does. We suggest that the current study as a preliminary study to assess the possibility of using behaviour as one of the stress indicators of weaned rabbit does.

The energy balance of the rabbit does persisted negative from the second week of lactation until weaning in all three weaning ages in all three parities evaluated. Late weaning resulted in prolonged negative energy balance and could not achieve positive even in the one week of resting period, indicating that 49 days of weaning is not suitable for the welfare of rabbit does in tropical climatic conditions.

Acknowledgement

The authors gratefully acknowledge funding for this research provided by Sabaragamuwa University of Sri Lanka (Research Grant-SUSL/RG/2011/03). We wish to thank Prof. A.W. Wijeratne, Department of Agribusiness Management, Sabaragamuwa University of Sri Lanka for assistance with statistical analyses.

REFERENCES

Apter, R.C. and Householder, D.D. (1996) Weaning and weaning management of foals: a review and some recommendations. *Journal of Equine Veterinary Science,* 16: 428–435. https://doi.org/10.1016/S0737-0806(96)80208-5

Cevera, C.J. and Caramona, F. (1998) Climatic Environment. In. C. de Blas and J. Wisman (ed). *The Nutrition of the Rabbit*. Cab. International, 273-295.

Cevera, C.J., Fernandez-Carmona, J., Viudes, P. and Blas, E. (1993) Effect of re-mating interval and diet on the performance of female rabbits and their litters. *Animal Science*, 56 (3): 399-405.

Cockram, M.S., Imlah, P., Goddard, P.J., Harkiss, G.D. and Waran, N.K. (1993) The behavioural, endocrine and leucocyte response of ewes to repeated removal of lambs before the age of natural weaning. *Applied Animal Behaviour Science*, 38: 127-142.

Dawkins, M.S. (2006) Through animal eyes: what behaviour tells us. *Applied Animal Behaviour Science,* 100: 4–10.

Day, J.E.L. and Webster, S.D. (1999)The effects of early weaning. *Biologist,* 46:177–180.

Debbi, G. and Morton, D.B. (1995) Inventry of the behaviour of New Zealand White Rabbits in laboratory cages.*Applied Animal Behaviour Science*, 45 (No. 3-4): 277-292.

Denenberg, V.H., Huff, R.L., Ross, S., Sawin, P.B. and Zarrow, M.X. (1963) Maternal behaviour in the rabbit: The quantification of nest building. Animal Behaviour, 11(4), 495-499. https://doi.org/10.1016/0003-3472(63)90268-9

Fernández-Carmona, J., Alqedra, I., Cervera, C., Moya, J. and Pascual, J.J. (2003) Effect of lucerne-based diets on performance of reproductive rabbit does at two temperatures. *Animal Science*, 76: 283-295.

Fernández-Carmona, J., Cervera, C., Sabater, C. and Blas, E., (1995) Effect of diet composition on the production of rabbit breeding does housed in traditional building and at 30°C. *Animal Feed Science Technology*, 52: 289- 297.

Fortun-Lamothe, L. (1998) Effects of pre-mating energy intake on reproductive performance of rabbit does. *Journal of Animal Science*, 66: 263-269.

Gharib, H.S.A., Azhar, F., Abdel-Fattah, A.F., Haiam, A., Mohammed, H.A. and Abdel-Fattah, D.M. (2018) Weaning induces changes in behavior and stress indicators in young New Zealand rabbits. *Journal of Advanced Veterinary and Animal Research*, 5 (2):166 (Electronic).http://doi.org/10.5455/javar.2018.e262

Hicks, T.A., McGlone, J.J., Whisnant, C.S., Kattesh, H.G. and Norman, R.L. (1998) Behavioural, endocrine, immune and performance measures for pigs exposed to acute stress. *Journal of Animal Science*, 76: 474-483.

Houpt, K.A. (2002) Formation and dissolution of the mare-foal bond. *Applied Animal Behaviour Science*, 78: 319-328. https://doi.org/10.1016/S0163-1047(79)90362-5

Joless, J., Rompa-Barendregt, J. and Gispen, W. H. (1979) Novelty and grooming behavior in the rat. *Behaviour and neural biology* 25, 563-572.

Kalueff, A.V. (2000) Measuring grooming in stress and comfort. Proc. Meas. *Behaviour* 3,148-149.

Keyserlingk, V.M.A.G. and Weary, D.M., (2007) Maternal behaviour in cattle. *Journal of Hormones and Behaviour* 52, 106-113. https://doi.org/10.1016/j.yhbeh.2007.03.015

Kustos, K. and Balint, A., (1996) Effect of lactation stage and pregnancy status on milk production. In: Proc. 6th World Rabbit Congress, Toulouse, 2,187-190.

Lehner, P.N. (1996) Handbook of Ethological Methods. Cambridge University press, U.K. 672

Maertens, L. and De Groote, G. (1990) Comparison of feed intake and milk yield of does under normal and high ambient temperature. *J. Appl. Rabbit Res.* 13, 159–162.

Manal, A.F., Tonyb, M.A. and Ezzoc, O.H. (2010) Feed restriction of pregnant nulliparous rabbit does: consequences on reproductive performance and maternal behaviour. *Animal reproduction Science* 120,179–186

Marykutty, T. and Nandakumar, P. (2000) Factors influencing litter traits and body

weight up to 12 weeks among temperate rabbit breeds in humid tropics. *World Rabbit Science*, Vol.8 (8), 67-70.

Mcnitt, J.I. and Lukefahr, S.D. (1990) Effects of breed, parity, day of lactation and number of kits on milk production of rabbits. *Journal of Animal Sci*. 68 (2), 1505-1512.

Moberg, G.P. and Mench, J. A. (2000) The Biology of Animal Stress: Basic principles and implications for Animal Welfare. CABI Publishing, CAB International, Wallingford, UK.

Morton, D.B., Jennings, M. and Batchelor, G.R. (1993) Refinements in rabbits husbandry: Second report of the BVAAWF/FRAME/RSPCA/UFAW Joint Working Group on Refinement. *Laboratory Animals* 27, 301-29.

Nicodemus, N., Gutierrez, I. J., Garcia, R., Carabano, C. and De Blas, I. (2002) The effect of re-mating interval and weaning age on the reproductive performance of rabbit does. *Animal Research* 51: 517-523 DOI: 10.101/animres: 2002037.

Odubote, I. K. and Somade, B. (1992) Genetic analyse of rabbit litter traits at birth and weaning. *Nigerian Journal of Animal Science Production* 19, 64-69.

Panksepp, J. (2003) Feeling the pain of social loss. *Science*, 302 (5643) : 237–239. DOI: 10.1126/science.1091062

Parigi-Bini, R., Xiccato, G. and Cinetto, M. (1990) Energy and protein retention and partition in rabbit does during the first pregnancy. *Cuni-Sciences*, 6 (1) : 19-29.

Parigi-Bini, R., Xiccato, G., Dalle Zotte, A., Castellini, C. and Stradaioli, G. (1996) Effect of remating interval and diet on the performance and energy balance of rabbit does. In: Lebas, F. (Ed.), Proc. 6th World Rabbit Congress., vol. 1. 253-258. AFC publ., Toulouse, France.

2.1.1 Pascual, J.J., Cervera, C., Blas, E. and Fernandez-Carmona, J. (1998) Effect of high fat diets on the performance and food intake of primiparous and multiparous rabbit does. *British Journal of Animal Science,* 66 (2): 491-499.

Pascual, J.J., Tolosa, C., Cervera, C., Blas, E. and Fernandez-Carmona, J. (1999) Effect of diets with different digestible energy content on the performance of rabbit does. *Animal Feed Science Technology,* 81:105-117.

Rajadevan, P., Goonewardene, L., Ravindren, V. and Rajaguru, S.R. (1987) An investigation on the productive traits of crossbred rabbits in Sri Lanka. *World review Animal Production,* 13(2): 59-61.

Ross, S., Denenberg, V.H., Paul, B., Sawin, P.B. and Meyer, P. (1956) Changes in nest building behaviour in multiparous rabbits. *The British Journal of Animal Behaviour*,4(2):69-70. https://doi.org/ 10.1016/S0950-5601(56)80024-5

SAS Institute Inc. SAS / STAT User's Guide, Version 9.4. Statistical Analysis System Ins., Cary, NC.

Xiccato, G., Trocino, A. ł., Boiti, C. and Brecchia, G. (2005) Reproductive rhythm and litter weaning age as they affected rabbit doe performance and body energy balance. *British Society of Animal Science,* 81: 289-296.

Xiccato, G., Trocino, A., Queaque, P.I. and Sartori, A. (2004) Effect of parity order and litter weaning age on the performance and body energy balance of rabbit does. *Journal of Livestock Production Science,* 85: 239-251.

Xiccato, G., Trocino, A., Sartory, A. and Queaque, P.I. (2000) Early weaning of rabbits; effect of age and diet on weaning and post weaning performances. In. Proc. 7th World Rabbit Congress, Valencia, Vol. C: 483-490.