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Effect of Sexual Rest in Buck and Changes in Maternal Behavior on Litter Performance

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DECLARATION

I declare that this thesis entitled "Effect of sexual rest in buck and changes in maternal behavior on litter performance" is the results of my own research except as cited in the references.

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Effect of Sexual Rest in Rabbit Buck and Changes in Maternal Behavior on Litter Performance

ABSTRACT

The potential of rabbit industry is emerging, and number of breeders elevated recently. Optimization on rabbit production rely on proper breeding management. Bucks with best performance are preferred and mated frequently promises best quality and highest litter seize. However, repetitive services of buck may lead to sexual exhaustion and low conception rate in doe. To our knowledge, information on the effect of sexual rest buck on does and litter performance are lacking. The study aimed a) to determine the effect of different days of sexual rest in the buck on doe's conception rate. b) to investigate the maternal effect and post-maternal behaviors on litter performance. A total of eight does with 4 bucks (New Zealand White) performed natural mating. Rabbits were divided into two groups (G1 and G2) where males were given one day and three days of sexual rest before natural mating. Effect in different days of sexual rest for buck on doe's conception rate and the influence of maternal effect and post-maternal behaviors on litter performance were observed. Result showed that there is no significant difference in different days of sexual rest given in buck on doe's conception rate (p value= 0.356). For post maternal analysis, there is significant difference in doe's body weight changes due to pregnancy (p value= 0.04). Moreover, positive correlation (r= 0.67) was confirmed between gestation period with litter size at birth was reported. Plus, positive correlation (r= 0.1615) was observed between nest-building behaviors and kits born alive after 1 week. In conclusion, there is no significant differences on conception date and post maternal for different days of sexual rest on buck. Future work on semen quality would improve the current finding.

Keywords: sexual rest, conception rate, post maternal, litter size, nest building

Kesan Rehat Seksual Arnab Pejantan dan Perubahan Tingkah Laku Ibu Terhadap Prestasi Anak

ABSTRAK

Potensi industri arnab semakin meningkat, dan bilangan penternak meningkat baru-baru ini. Pengeluaran arnab yang optimal bergantung pada pengurusan pembiakan yang betul. Arnab pejantan dengan prestasi terbaik lebih diutamakan dan sering dibiakkan untuk menghasilkan anak arnab yang bekualiti terbaik. Walaubagaimanapun, penggunaan pejantan yang berulang boleh menyebabkan keletihan seksual dan kadar konsepsi mengawan yang rendah. Dalam pengetahuan kami, maklumat tentang kesan rehat seksual terhadap prestasi mengawan dan prestasi anak yang dilahirkan adalah kurang. Kajian ini bertujuan a) untuk menentukan kesan hari rehat seksual yang berbeza terhadap kadar konsepsi mengawan. b) untuk menyiasat perubahan dan tingkah laku ibu semasa bunting terhadap prestasi anak. Sebanyak 4 ekor jantan dan 8 ekor betina telah mengawan secara semulajadi. Arnab dibahagikan kepada dua kumpulan (G1 dan G2) di mana jantan diberi rehat seksual sehari dan tiga hari sebelum mengawan. Kesan hari rehat seksual terhadap kadar kejayaan mengawan dan kesan perubahan dan tingkahlaku ibu apabila bunting terhadap prestasi anak diperhatikan. Keputusan menunjukkan bahawa tiada perbezaan yang ketara pada perbezaan hari rehat seksual yang diberikan kepada jantan terhadap kadar konsepsi mengawan (nilai p= 0.356). Untuk analisis perubahan ibu semasa mengandung, terdapat perbezaan yang signifikan dalam perubahan berat badan ibu akibat kehamilan (nilai p= 0.04). Selain itu, korelasi positif (r= 0.67) telah disahkan antara tempoh kehamilan dengan saiz anak semasa dilahirkan telah dilaporkan. Selain itu, korelasi positif (r= 0.1615) diperhatikan antara tingkah laku membina sarang dan bilangan anak yang hidup selepas 1 minggu. Kesimpulannya, tiada perbezaan yang ketara pada kadar konsepsi mengawan dan perubahan ibu semasa mengandung dipengaruhi oleh hari rehat seksual yang diberikan kepada jantan sebelum persenyawaan. Kajian masa depan mengenai kualiti air mani akan dapat menambahbaik penemuan semasa.

Kata kunci: rehat seksual, kadar kejayaan persenyawaan, perubahan ibu, saiz anak, pembuatan sarang

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LIST OF ABBREVIATIONS

EGR	Extra-Gonadal Sperm Reserves
EAA	Essential Amino Acid
CLA	Conjugated Linoleic Acid
HCG	Human Chorionic Gonadotrophin
LH	Luteinizing Hormone
GnRH	Gonadotropin-Releasing
FSH	Follicle-Stimulating Hormone
kg	Kilogram
g	Gram

LIST OF SYMBOLS

℃	Celsius
%	Percent

CHAPTER 1

INTRODUCTION

1.1 Research background

Rabbits were first bred as pets in the 1980s and by the early 1990s, they were being raised as a meat substitute for livestock (Dahlan et al., 1993). According to the most recent industry statistics, there are 24,987 does and 600 farmers registered with the DVS District Office (Department of Veterinary Service, 2016). The rabbit industry is relatively new in Malaysia, but it has grown in popularity due to numerous government programs and incentives aimed towards its development. The government wants to explore if rabbit meat can be used to replace up to 20% of poultry meat consumption (Gunalan et al., 2019).

Rabbit meat is high in nutrients and has a low-fat content. Its protein content (about 22% when considering the loin) is evident in its proximate composition. Rabbit flesh is also high in important amino acids (EAA). The water and protein composition of the lean meat region of the carcass is relatively stable (73.02.3 g water and 21.51.4 g protein/100 g meat), Rabbit flesh contains a considerable amount of energy. The presence of CLA in rabbit meat provides the healthy meat for human nutrition (Dalle Zotte & Szendro, 2011).

At copulation, a mixture of sperm cells and secretions from accessory glands (prostates, coagulating glands and seminal vesicles) is ejaculated into the female's vagina. The male accessory gland’s role is to transfer sperm to the female reproductive tract during mating while creating seminal fluid protein substances that mix with sperm to preserve it (Noda & Ikawa, 2019). Davies & Mann (1947) state that the vesicular and prostate glands of the rabbit produce fructose. There was a significant difference after 'exhaustion' in the recovery time for sperm output including the volume of sperm and the quantity of fructose showing fundamental testicular variance and function of the accessory glands. Desjardins et al. (1968) previously discussed the rate of replenishment of accessory gland secretions in rabbits exposed to multiple and less rigorous collecting regimens. They found that accessory gland secretions were generally fully restored between ejaculations in males who ejaculated at 24-hour intervals, but not when ejaculation was performed within 15 minutes. However, the current findings were significantly more intensive use is consistent with good fertility at least for short periods of time. But excessive use of males is not recommended for semen production (Adams & Singh, 1981).

The gestation period in rabbits will last between 28 and 32 days. Pregnancy can be discovered using a variety of techniques, including abdominal palpation which massage the belly with the hand to feel the embryos. Other than that, buck is not allowed to mate when the buck was placed near to pregnant does. For mating, the buck is placed near the doe. Next, changes in body weight after mating also indicate the pregnancy does. From mating to 30 days afterward, there is a significant change in body weight due to pregnancy. During the pregnancy, adequate feeding and management measures should be implemented. 5-6 days before parturition, the nest must be prepared in the cage. Does may pull out their fur to make their own nest as bedding for the newborn.

Kindling is the process of a rabbit giving birth to new young. The process normally takes between 7-30 minutes. Some kits are born after a few hours or even a day. The does used to lick the newborns and swallow the placenta after they were born. The mother will attempt to nurse her newborn kits. Kits who are unable to suckle could become weak and vulnerable to infections. Rabbit used to only nurse her young once, generally early in the morning or at night.

1.2 Problem statement

Farmers are currently aware of the opportunity in rabbit industry, but they are hesitant to participate because there is no guarantee that the products would find a market. For the beginner, the breeders only raised rabbits in small group. The male and female sex ratio used is 1: 3 to save the cost of production. The problem for breeders is the buck that has the best performance will be used in mating frequently to produce the best quality of rabbit offspring. However, ejaculation frequency and repetitive service of rabbit buck may lead to sexual exhaustion. In research from Lloyd-Jones & Hays (1918) the rabbit conception rate dropped gradually from 72 % at the first service to 35% at the 20th service. The ejaculation frequency influences sperm output, sperm characteristics, and fertility. Repetitive ejaculation causes a decrease in semen volume, which is associated by decreases in protein, fructose, and citric acid (Kirton, 1966). While the amount of sperm in the epididymis was completely restored between ejaculation to the level required at sexual rest days. But there is still lacking the information on the effect of sexual rest buck on does and litter performance. This study to determine the effect of number of days for sexual rest given to male rabbit on fertility and conception rate. The rest day given to the male rabbit to make sure the accessory gland secretions were generally fully restored between ejaculations.

1.3 Hypothesis

1. H_0: There is no significant difference in different days of sexual rest in buck on doe's conception rate

   H_1: There is a significant difference in different days of sexual rest in buck on doe's conception rate

2. H_0: There is no significant difference in the maternal effect and post-maternal behaviour on litter performance

   H_1: There is a significant difference in the maternal effect and post-maternal behavior on litter performance

1.4 Objectives:

1. To determine the effect in different days of sexual rest in buck on doe's conception rate
2. To investigate the maternal process and post-maternal behavior on litter performance.

1.5 Scope of study

The study will be started by selection of 4 bucks and 8 does for natural mating. The does mating was performed at the same time of day from 0800 to 1000 but in different days followed by group. First group was served by males given one days of sexual rest before mating with the does. The second group was mated by males given three days of sexual rest before mating with the does. Each group consisted of 2 bucks and 4 does. Before mating, the colour of vulva approach was used to measure the receptiveness of does.

Then, frequency of occurrence of some courtship features such as ear sniffing, genital sniffing, chin rubbing, leg striking, backward falling, or sideways falling during mating were observed during mating. After that, pregnancy of does was confirmed on 14 days after mating by checking manual abdominal palpation. At about 26 days of pregnancy, building nest is one of the maternal behaviors before parturition was observed. Maternal effect such as body weight change and gestation length. Fertility parameters of does were estimated as conception rate, parturition rate, litter size at birth and the number of kits born alive.

1.6 Significant of study

This study's significance is to determine the effect of male sexual rest on conception rate and does performance. Short-term frequent ejaculation caused a steady decrease in sperm density, semen volume, and fructose content. In breeding practice, male rabbits are used selectively. Usually twice a day and no more than two or three times each week. So, it is recommended that the bucks be given a rest period of 1-2 days between days of intensive sperm collection to enable for a more complete sperm replenishment to collect spermatozoa for reproductive purposes (Salamon, 1964).

CHAPTER 2

LITERATURE REVIEW

2.1 Rabbit mating

At the age of eight months, a buck start develops breeding abilities. A healthy buck should be able to reproduce for at least beyond two to three years. A young buck may be permitted to mate with one doe every three to four days. However, from the age of 12 months, it may mate 4-6 times in 7 days. Because the quality of a buck's sperm decreases as he gets older, a buck above the age of six should be culled. Breed, nutritional state, and seasons are influence a doe's reproductivity. The smaller breeds develop sexuality faster than the larger breeds. A small breed may accept breeding at the age of 3-4 months, while a larger breed may allow breeding at the age of 8-9 months. A doe can be used for reproduction up to three years of age. After that, the doe should be culled.

The first mating takes place around the age of 5-6 months. To avoid fighting or territory behavior, a doe should always be taken to a buck's cage rather than the other way around. Receptive doe will raise her tail to allow for mating. It’s difficult to know whether a doe is in heat or not from the outside. However, it may exhibit behaviors such as nervousness, restlessness, and rubbing of the chin against the cage or other things. The vulva swollen and turned purple in colour. However, the attractiveness of does to bucks or the response of does to bucks should be used as a parameter for heat. So, before allowing copulation, detection of heat using buck is needed**.**

To optimize and maximize the productivity and performance of rabbits, the ideal or suitable time for natural mating of New Zealand White rabbit does could be in the morning about 0800. This could be caused by higher E2 levels and its direct influence on body metabolism. High activity in the early morning could also lead to increased blood glucose levels, which are mostly controlled by body hormones particularly thyroxin and adrenal cortical hormones as prepare females for reproductive efficiency (Kishk, 2006).

2.2 Sexual behavior

Sexual behavior of buck at peak of puberty is honking, chinning, circling mounting, and humping. Negative sexual behaviors such as territoriality and aggression are at their peak of puberty. Males and females who were early puberty may urinate and defecate outside of the box to mark their territory (Bays 2012). Courtship features at mating such as ear sniffing, genital sniffing, chin rubbing, leg striking, and backward falling, or sideways falling after mating. Honking or oinking: Sounds that sound like "honk" or "oink" are frequently created attention. Even with neutered rabbits, honking is commonly related with desire mating (Harriman 1995).

2.3 Female receptivity

The following parameters were recorded in Ola et al. (2012) to determine her sexual receptivity when the doe was introduced to the buck. Firstly, the color of vulva either white, pink, red or purple. The pink or purple colour of vulva in rabbit does has been correlated to mating readiness or estrus but maybe influenced by nutrition, particularly forages, on this parameter. Purple vulva was the most common vulva colour in all the does fed various forages, including those on solely concentrate diet, whereas reddish vulva was the least common (Rodriguez et al., 1989). Secondly, mating period which is for mating behavior observation until the ejaculation occur. Less than 5 minutes was considered as quick mating while more than 5 minutes was defined as slow mating. Thirdly, copulation rate is the number of ejaculations permitted by the female within 10 minutes of mating with the buck.(Ola et al., 2012)

Males who repeatedly followed around, tried copulation, and regularly scented and nibbled at their hindquarters exhibited the did' sexual attractiveness. Females become sexually desirable for short periods of time, usually seven days or multiples of seven days. At these behavioral peaks, their appeal to the males in their group appeared to differ substantially. Because their excitement usually began after smelling the ground where the females sat, and also because a female's attractiveness to the males in her group was considerably decreased on rainy nights, the initial stimulus to the males was most likely an aroma (Myers & Poole, 1958).

2.4 Reproduction

2.4.1 Spermatogenesis

Testicle, seminiferous ducts, and accessory glands are contributed to the formation of seminal plasma, which contains a wide range of substances. The ejaculated contains secreation, cell debris, sperm, and immature germ cells, from the accessory glands. Inside the testicle, the seminal fluid is produced in the tubule recti, rete testis, and the epididymis. Some seminal plasma proteins produced by different types of tissues are used as indicators.

The rise or fall in these markers' levels could indicate a pathological process in a particular tissue. Fructose is the most common sugar associated to metabolism and sperm motility, and it's a major indicator of seminal vesicle performance (Ricardo, 2018). Individuals with diabetes, oligozoospermia, and azoospermia have been found to have abnormally high fructose levels (Gonzales, 1994). Decreased fructose concentration are detected in ejaculates with high sperm density and motile spermatozoa. it is shows that spermatic fructolysis reduces fructose concentration (Mauss et al., 1974).

2.4.2 Semen quality

Macroscopic parameters included examination of semen smell, colour and PH analysis. The appearance of a normal sperm sample is uniform white opalescent. Semen samples that were dark, yellow, or abnormal were rejected. Microscopic parameters are including semen concentration, motility, and the live/death ratio of sperm. A haemacytometer was used to determine sperm concentration (Neubauer chamber) (Obasi et al., 2016).

In rabbits, ejaculated semen consists of spermatozoa contained in seminal plasma. The epididymis and accessory glands release a variety of substances which are found in seminal plasma. This liquid contains high levels of fructose, citric acid, inositol, glycerol, ergothioneine, glutamic acid, some enzymes, proteins, electrolytes, and small lipid drops. Depending on the secretion of accessory glands, the volume of semen ranges between 0.3 and 6.0 ml (gel fraction). Sperm concentrations range from 50-500 x 10^6 /ml. The pH of the sperm measured immediately after collection ranges from 6.8 to 8.4 and is a reliable indicator of semen quality (Bell et al., 2000).

2.4.3 EGR and sexual rest

Kozbluha (1940) found that the passage of sperm from the corpus into the proximal cauda epididymidis did not occur until 3 hours after depletion (1940). They concluded that the cauda epididymidis was refilled 48 hours after depletion based on the apparent density of the sperm mass in histological sections. The recent study from Amann and Lambiase (1968) quantitative evidence refutes this hypothesis and clearly shows that after a 10-ejaculate depletion, it takes 8 days to restore the EGR.

Within the excurrent duct system, sperm are resorbed at a variable rate, according to Amann and Almquist (1962). The rate of sperm retention or loss by other ways in rabbits ejaculated 2 times per 48 hours is mild, equaling about one-half of the daily sperm output. However, once the EGR is depleted, the rate of sperm dispersion rapidly declines to almost 0 % of daily sperm production and maintains for about 1 day. If the rabbit is sexually rested after exhaustion, sperm retention increases between the 2nd and 4th days following exhaustion and nearly reaches daily sperm production after eight days.

The storage capacity of this part of the reproductive system is modest and inadequate to produce all the sperm for an ejaculation response to sexual rest. The amount of sperm in the epididymis was completely restored to the level required at sexual rest days following depletion. The sperm released by the testis should have collected in the cauda epididymidis because ejaculation had no effect on the sperm quantity of the caput-corpus. To replace each ductus deferens, approximately 50 $x10^6$ sperm were required.

Only a limited replenishment of spermatozoa in the epididymidis occurred between the last collection of one day and the first collection of the next day. So, it is recommended that the bucks be given a rest period of 1-2 days between days of intensive sperm collection to enable for a more complete sperm replenishment to collect spermatozoa for reproductive purposes (Salamon, 1964).

The higher concentration of spermatozoa in the productive tract of Angora bucks could be due to breed differences as well as the fact that they were nearing the peak of seasonal sperm production at the time of slaughter (for testis examination) and following a period of sexual rest. This greatly enhances sperm stores (Almquist & Amann, 1961).

2.4.4 Ovulation

The rabbit is part of a group of mammals that do not ovulate on their own. Ovulation is induced in nature because it requires a mating trigger. Ovulation occurs after sexual stimulation such as copulation or in reaction to exogenous gonadotropins. Females can sometimes help stimulate each other. This kind of ovulation is associated with the possibility of becoming pregnant or sterile for a few days. Ovulation usually happens between 9 and 13 hours. However, it often occurs 10 hours after mating. Does are supposed to be in a continual state of heat throughout the year or during breeding season. Follicles are known to develop and decline in 15–16day cycles. There is a length of time when the doe loses interest in the buck.

In the rabbit, ovulation is triggered by a neurohormonal response that is stimulated during coitus. In the absence of a buck, ovulation can be artificially induced, with the most common ovulation inductor being a synthetic analogue or intramuscular injection of GnRH. Human chorionic gonadotrophin (HCG) and luteinizing hormone (LH) are two hormones that can be used to induce ovulation in females. However, frequent injections of these hormonal chemicals may cause antibody development, resulting in failure to induce ovulation (Quintela et al., 2004)

2.4.5 Pregnancy

The gestation period in rabbit is from 28-32 days. During pregnancy, sexual response of females to males declines, but sporadic sexual drives for mating remain and rise soon before parturition. The rabbit's receptivity is maintained at a low level during pseudopregnancy. Receptivity increases in rabbits at the end of pseudopregnancy, and progesterone levels fall. The tummy of a pregnant female rabbit will get larger as her offspring grow inside her during the pregnancy, making this the most evident symptom of a pregnant rabbit. Some rabbits may have a false pregnancy when their bodies believe that they are pregnant, but they are not. A rabbit with a false pregnancy will express nesting behaviour and become restless. False pregnancy symptoms typically last 2-3 weeks.

Pregnant rabbits will begin to eat more frequently, and most will become irritable or grumpy. Because they are feeding both themselves and their growing young. pregnant and nursing rabbits will consume more food. So, the quantity of fresh vegetables provided should be maximized, and alfalfa hay should always be available. About a week before giving birth, a pregnant rabbit will start nesting. If a rabbit is digging and piling up bedding into a corner of the cage, this is the clearest indicator that she is starting to nest. It is to construct a pleasant environment to give birth.

2.5 Pregnancy diagnosis

Necropsy is a technique that defines the growth of embryos, fetuses, and extraembryonic membranes at such a specific time. However, since the animals are slaughtered, this practice does not mean the size of the litter at birth. On day 15 of pregnancy, CT scanning cannot count the number of corpora lutea (ovulation rate) and unused vesicular, nor can it distinguish between viable and non-viable fetuses (early fetal mortality). The animals have data on these litter size elements that can be obtained by necropsy and endoscopy only (Abdelnour, 2018). Endoscopy can be used to assess ovulation and fertilization rate without harming embryo development or sacrificing the rabbits (Theau-Clément and Bolet, 1987 as cited in Abdelnour, 2018).

2.5.1 Manual abdominal palpation

Manual abdominal palpation was conducted 5 days after mating until the pregnancy was confirmed. The result of the pregnancy diagnosed positively pregnant should be at least two days ("Pregnancy Detection in Rabbits By Ultrasonography As Compared To Manual Palpation," 2014). Abdominal palpation presented an accurate diagnosis by day. Manual palpation requires the least amount of effort and no supplies. However, objective findings are only warranted after day 12 of pregnancy. However, Morell (1995) states that if used excessively, it can put a lot of pressure on the doe and cause fetal loss. After palpation, the mating should be done again if the female non-pregnant. Maximum is 3 times of re-breeding was performed until they were diagnosed as pregnant. The female was culled after the third negative mating (Riproduttive et al., 2002).

2.5.2 Real-time ultrasound

Real-time ultrasonography revealed an excess of uterine fluid in rabbits. Signaling that no fetus pulse may indicate either the fetus is too early for the heartbeat to be detected or a pregnancy failure has happened. Between 5-9 days of conception, real-time ultrasonography provided the first observation of uterine fluid. Real-time ultrasonography will provide high accuracy 8 days after mating, assuming the materials needed, and assistance are sufficient. ("Pregnancy Detection in Rabbits By Ultrasonography As Compared To Manual Palpation," 2014).

Since the early 1980s, real-time ultrasonography has been used to diagnose pregnancy in multiple animals and it has been widely used in rabbits does after day seven of pregnancy (Inaba et al., 1986). The use of ultrasound scanning of the abdomen has shown to be a reliable and practical method of detecting pregnancy at an early stage. The length of time needed, including constraint, clipping, and inspection was never more than seven minutes. In rabbits, ultrasound screening of the belly is also useful in diagnosing extrauterine conception, ovarian tumors, abscesses, cysts, pyometra, and hydrometra (Varga, 2014 as cited in pregnancy detected).

2.6 Post maternal behaviour

2.6.1 Nest building behavior

Rabbits begin constructing nests from straw and other suitable materials accessible to them around day 26 of pregnancy. They begin pulling fur from their body two days before parturition and further construct the nest for the incoming kits. To ensure the well-being and survival of the hairless kits, it is important that the does create high-quality nests at the appropriate period. (peripartum). Nest-building behavior was described by Gonzalez-Mariscal et al. (1996) as consisting of three stages: digging, straw dragging, and hair pulling.

The onset of nest-building behaviour and the order in which the steps occur are very reliable. The procedure begins on day 25–26 of pregnancy and ends one day before delivery. The timing of nest building in some rabbits may be unusual. Does may give birth without building the maternal nest in certain scenarios. Those rabbits who do not build the nest before parturition commonly give birth outside the nesting box and have a difficult time raising their young.

Some does pulls fur to build a nest several days before parturition and a day after parturition to cares her young. Many rabbit kits survive indicated the success of the rabbitry associated by the quality and hygiene of the nest. In addition, Borka and Adam (1988) found that sufficient and good quantity of materials used in the nest (straw and fur) are necessary at first day of parturition. It is important to ensure the rabbit born keep warmly because they were born naked (no fur), blind, helpless, and unable to move much. Some young rabbits will become chilled and die within days due to coldness. Poor condition of hair nest construction with every litter can be related to rising ambient temperatures more than the number of litters. However, low nesting quality was not correlated to increasing mortality according to Partridge et al. (1981).

Nest quality is critical to provide warmly nest for the newborn. Nest quality can be measured followed by rate of 1-6 which is number 6 had the highest quality of nest building. (1) No resource nest, no fur pulled, (2) no content nest, plumes of fur pulled, (3) considerable bit of fur pulled but not blended with nest stuff, (4) lots of fur taken but not blended with nest stuff, (5) considerable bit of fur mixed with nest stuff, and (6) amazing nest; loads of fur well blended with nest stuff (Negatu & McNitt, 2002).

2.6.2 Nuture behaviour

During the first 20 days of lactation, rabbit kits are completely dependent on does milk for feeding. The failure of does to nursing her young is likely due to her nipple tenderness, and inability to provide milk will result in the death of the young rabbit (Yamani, 1991). Insufficient milk supply and the capability of young animals to successfully discover teat during one a day for 2-3 minutes influence mortality rate, according to Schlolaut (1980). Khalil (1993) reported mortality rate increase when low postnatal maternal ability which is limited milking and suckling abilities

2.7 Maternal effect

2.7.1 body weight change

Agaviezor & Ologbose (2020) who state that the physiological changes that occur in the doe's body due to pregnancy could explain the positive changes between body weight before mating and during pregnancy.

2.7.2 Gestation Length

Curnow & Finn (1963) state that gestation period is regulated by the number of conceptuses. Since in a normal pregnancy there are approximately the same number of corpora lutea in the ovaries as there are fetus in the uterus, it is possible that the control of gestation resides in the ovaries rather than the uterus. However, Hammond (1925) state that there is no inverse relation between gestation length and litter size in the rabbit, the data he gives show a highly significant negative regression of gestation length on litter size.

2.8 Does performance

2.8.1 Conception rate

Conception rate may be influenced by seasons, time of mating, mating frequency receptive doe and age of rabbits at mating (Hygiene & Medicine, 2013). Furthermore, rabbit does that mated when in standing heat (receptive) which had red and swollen vulva had a higher conception rate. Kishk (2006) stated that does mating in the morning had high percentage of pink and a dark red vulva colour, the highest sexual responsiveness is obtained.

Hygiene & Medicine (2013) suggested it is better to perform double mating for each susceptible doe either in the morning or night for a high conception rate and litter size Moreover, Obasi (2016) reported in their findings of conception rate of 100% was observed in natural mating compared to 80% conception rate in artificial insemination with HCG injection.

2.9 Litter performance

2.9.1 Litter size at birth

Genetics and farm management including housing, feeding, and breeding have an impact on litter size. Female rabbits on a regulated diet had good reproductive efficiency, high number of litter size, and great milk production (Eiben et al. 2001). Furthermore, rabbit does that mated when in standing heat (receptive) which had red and swollen vulva had a higher number of litter size and conception rate. (Szendro et al, 2006).

Fayeye and Ayorinde (2010) reported that the number of litter size in the rainy season was lower than the number of litter size in the summer season for Nigerian rabbits. According to Mousa (2004), the litter size (number of kits) was influenced by the age of the buck. They found that the highest litter size (7 kits) obtained from does mate with a buck of an average age of 8 months while the does mated with bucks of an average age of 6 months had 6.2 kits and does mated with 4 months of bucks age had 3.4 kits.

In addition, Poigner J. et al. (2010) found that the number of rabbits in the uterus determines the foetal and birth weight. The maternal influence had a considerable impact on birth weight and litter size. Agaviezor & Ologbose (2020) state that the litter size had a significant impact on rabbit litter weight. The weight of the doe before and after mating also had a significant effect on the weight of the rabbit litter. This meant that increasing a doe's body weight before and after kindling could also result in an increase in litter weight. Poigner J. et al. (2010) reported that kits from larger litter sizes had lower weight at weaning than kits from smaller litter sizes in their study about the effect of birth weight and litter size on rabbit growth and mortality.

2.9.2 Number of kits born alive

Pre-weaning mortality can be influenced by genotype, pathological reason, doe features such as litter size, birth weight, frequency of parturition, order, season of birth, management, and nest quality, and weather conditions. Young rabbit mortality may be influenced by genetics, weaning weight, kit age, and external environmental conditions after weaning. The rate of pre-weaning mortality varies by breed and between purebred and crossbred rabbits. In another study, the genetic variability of rabbit pre-weaning mortality was reported to be 12%, having enteritis and pneumonia being the leading causes.

The maternal component of heritability's advantage over the paternal component shows the mother's significant influence on the young's viability (rolling and casady,1976). Although undesirable characteristics can be fixed, genetic improvement can minimise pre-weaning mortality. Elqen,1899 found that crossbred animals were more efficient in producing young per litter or nurturing them more efficiently than purebred animals. Habeeb (1997) discovered that New Zealand White rabbits had a greater survival rate from 5 to 14 weeks of age than Californian rabbits (88 vs 81%). Pre-weaning mortality increased insignificantly in line with the increase in doe weight at conception and kindling.

The percentage of newborns that died during the suckling phase increased significantly as the litter size at birth (caro et al 1984). In both small and large litters, mortality increases. Pre-weaning mortality in New Zealand White rabbits was reduced in litters of 5 or 7 young, according to Asker (1989). According to certain studies, there is no relationship between litter size and mortality (Rollin and Casady, 1967). The decrease in average individual weight per litter at birth appears to be the reason for the increase in preweaning mortality with increased litter size at birth. Furthermore, when litter sizes increase, competition for teats increases, resulting in smaller rabbits receiving less milk (Afifi, 1973).

CHAPTER 3

METHODOLOGY

3.1 Experimental animals

This research was conducted on four bucks and 8 does of New Zealand White rabbits (*Oryctolagus cuniculus*) which housed at FELDA Ayer Hitam, Johor. The age of buck is around 7 to 12 months, with an average weight of 3.0 kg to 3.8 kg. The age of does is around 7 to 12 months, with an average weight of 2.9 kg to 3.8 kg. Animals were put in separate cage (while the bucks and does were in the same house) at normal room temperature and maintained 12 hours light/12 hours dark cycle. They were fed 50 g twice per day of grower commercial feed brand FFM which containing crude protein 16%, crude fiber 25%, crude fat 2%, crude moisture 13% and calcium 0.75%. A safe drinking water supply was given, and a sanitary environment was maintained.

The animals were grouped into two: first group was served by males given one days of sexual rest before mating with the does. The second group was mated by males given three days of sexual rest before mating with the does. Each group consisted of 2 bucks and 4 does.

3.2 Rabbit mating

To avoid the influence of the time factor, does were mated at the same time of day from 0800 to 1000. Before mating, the colour of vulva approach was used to measure the receptiveness of does. Vulva was examined to see if any red or pink colour was present immediately before mating, which indicates a receptive rabbit. A non-receptive rabbit would have a purple or white coloration. Weight of male and female rabbit was recorded before mating.

At mating, the doe was introduced to the buck in the cage. For about 30 seconds, the doe was followed around by buck while sniffing. The receptive female was either hop in circles or lay flat on the ground. Lordosis was developed by doe when the pressure applied to her back. While the non-receptive doe was escaped from the buck and made sounds or bite the buck (Bays 2006). Active mating began when the buck grabbed the female's nape with his teeth. The female rabbit was mounted by the buck and pushed her forcefully until the ejaculation occurred immediately. After that, the buck scream before collapsing onto his back or side. Frequency of occurrence of some courtship features such as ear sniffing, genital sniffing, chin rubbing, leg striking, backward falling, or sideways falling during mating were observed and recorded.

3.3 Pregnancy diagnosis

The day of mating was considered day 1 of pregnancy. Pregnancy was confirmed on 14 days after mating by checking manual abdominal palpation. After weight of does were taken, the does were kept calm, relax and not aggressive. When the doe was ready, our right hand was put under the lower abdomen area near to back legs of doe. The groin area was searched until feel any lump like a soft egg. The presence of lumps was indicated the doe is positively pregnant. Each female's gestation status (pregnant or non-pregnant) was recorded.

3.4 Maternal behavior

Building nest was one of the maternal behaviors before parturition. At about 26 days of pregnancy, building nest behavior of does was observed. Does began building nests from straw or other suitable materials that available to them. They literally pulled the fur from their body two days before parturition and further build the nest for the incoming kits. Building nest behaviour of does were recorded.

3.5 Fertility parameters of does

Fertility parameters of does were estimated as:

3.5.1 Conception rate

$$\text{Conception rate} = \frac{\text{No. of pregnant does}}{\text{Total No. of mating does}} \times 100\%$$

3.5.2 Litter size at birth

Number of kits at birth

3.5.3 Number of kits born alive

Number of kits born alive after 1 weeks

3.6 Statistical analysis

Compare the effect of number of days for sexual rest given to male rabbit on does performance. Data were analyzed by independent t-test. Determination of the effect of does maternal behavior on litter performance by pearson correlation.

3.7 FLOW CHART

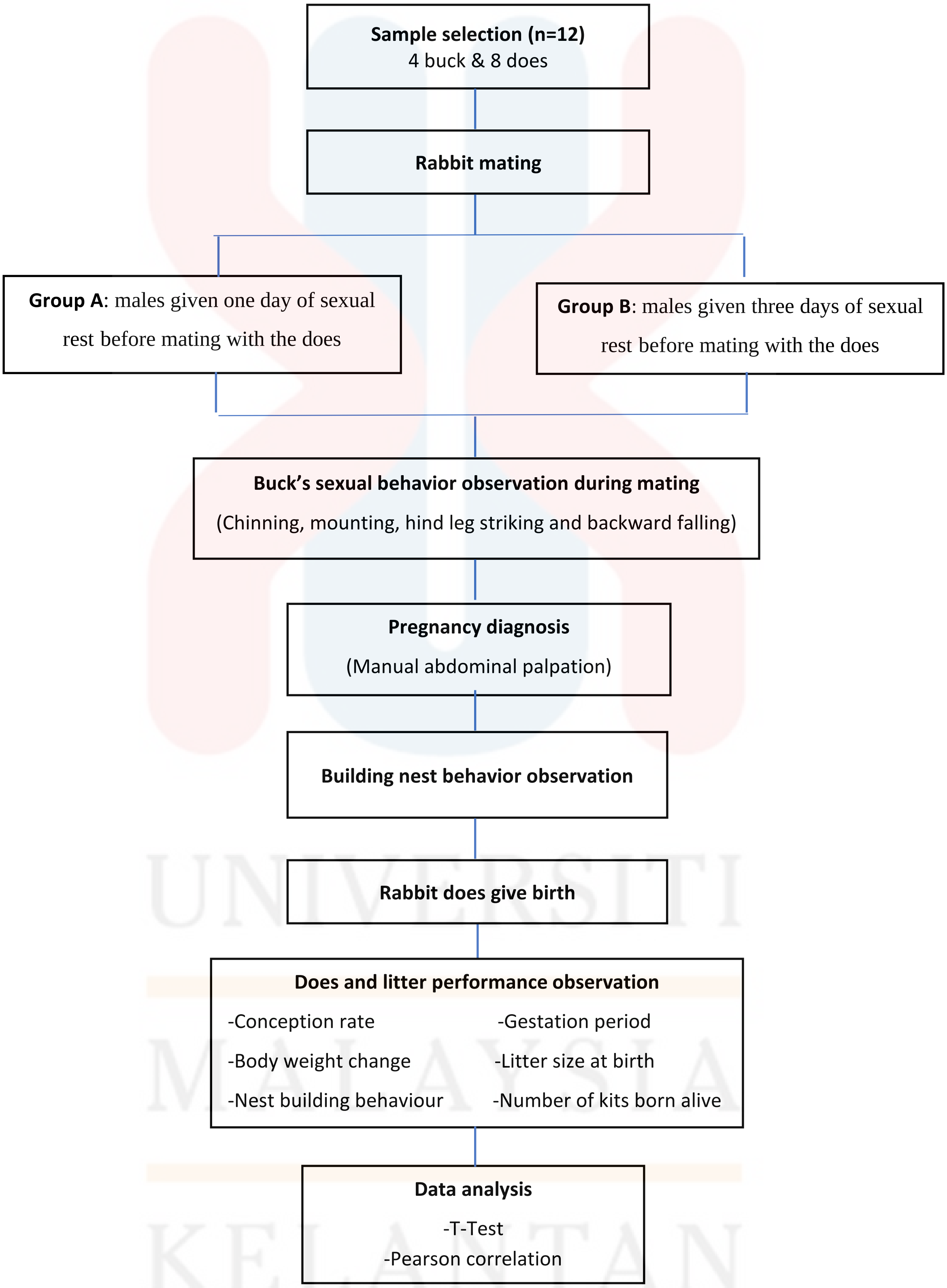


Figure 3.7.1: Flow chart of research activities throughout the experiment

CHAPTER 4

RESULT AND DISCUSSION

4.1 Effect of sexual rest days in bucks on the conception rate

Figure 4.1.1: Number of sexual rest days of bucks effect the conception rate

Number of sexual rest days	**1 Day**	**3 Days**	**P value**
Conception rate	75%	100%	0.3559

The reproductive performance for Group A (rest on day 1, mated on day 2) and Group B (mated on day 1, rest for three days and remated on day 5) in Table 4.1.1. The result revealed that a conception rate (CR) of 100% was observed in does mated with buck given 3 days of sexual rest compared to 75% conception rate in does that mated with buck given only 1 day of sexual rest. Even though Group B is higher than Group A, there is no significant differences between the groups. Conception rate may be influenced by seasons, time of mating, mating frequency receptive doe and age of rabbits at mating (Hygiene & Medicine, 2013).

In this study, natural mating was carried out around 0800 to 1000 (Chapter 3.1). This is similar to Hygiene & Medicine (2013) and Kishk (2006) which reported mating between the intervals of 0800 to 1000 gives the highest conception rate. Good environmental temperature and quiet during these times may explain the highest conception rate observed by mating rabbits in the morning. In contrast, Ndors (2015) suggested that natural mating of rabbit at morning and night gave highest conception rate (77.78%) than mating only in the morning. To note, Ndors (2015) investigated the effect of time and mating frequency on conception rate of New Zealand White rabbit does in the humid tropics. Thus, this may influence the finding.

Moreover, Obasi (2016) reported in their findings of conception rate of 100% was observed in natural mating compared to 80% conception rate in artificial insemination with HCG injection. This could be caused by the doe's inability to respond to the ovulatory hormonal therapy (HCG) injection or the sperm's inability to fertilise with eggs. This was in line with the findings of Tawfeek and ElGaafary (1991) who found that natural mating resulted in higher conception rate and litter size at birth compared to artificial insemination (AI) with HCG therapy. In contrast, Morrell (1995) found that the rabbit performed natural mating had lower conception rate than artificial insemination with injection of gonadotrophin releasing hormone to induce the rabbit does ovulation.

Hygiene & Medicine (2013) recommended that rabbits not be bred during the summer due to the lower conception rate and litter size during this season. In contrast, Fayeye & Ayorinde (1982) found that dry season mating resulted in higher conception rate than rainy season. Moreover, Bakare (1984) also reported that rabbits raised and bred in Nigeria's south-west had a greater conception rate during the dry season. The climate in Malaysia is considered hot and humid throughout the year. So, the season did not affect the conception rate in rabbit mating.

Hygiene & Medicine (2013) suggested it is better to perform double mating for each susceptible doe either in the morning or night for a high conception rate and litter size. In other research in Amann and Lambiase (1968) reported that the does which applied two services from two different bucks resulted in a greater conception rate (100%) than using one or two services from one buck (75%). In contrast, the number of mating did not significantly influence the most productive traits (conception rate, litter weight and litter size) in domestic rabbit in Nigeria (Fayeye and Ayorinde, 2010).

Table 4.0.1.2: First reaction of rabbit bucks when rabbit does were introduced

First reaction	Group A Percentage (n=4)	Group B Percentage (n=4)	P value
Spontaneous mating	75% (3/4)	100% (4/4)	0.3559
Refuse to mate (need external force)	25% (1/4)	0% (0/4)	0.3559

Table 4.1.2 showed that no significant differences were observed from buck's first reaction when introduced to receptive females. Group A and B gave 75% and 100% for spontaneous mating, respectively.

In our experiment, all females that were introduced to bucks were receptive (red and swollen vulva) (chapter 3.1). Kishk (2006) revealed a higher conception rate was obtained in the group of rabbits that had the highest percentage of dark red vulva color than white vulva color at mating. The red vulva is a sign of receptivity in nulliparous does according to Lefevre and Moret (1978). Findings in Marai and Rashwan (2003) show that genital features such as color and turgidity are closely linked to sexual behaviour and are influenced by hormones estradiol-17β concentration.

The study suggested 25% and 0% for Group A and B on refuse to mate, respectively. Marai (2003) suggested that white vaginal vulva colour is related to the high rate of male rejection. Due to a lack of Luteinizing hormone, all pre-ovulatory follicles do not ovulate especially in non-oestrous rabbits (Lopez et al., 1993). So, recommended for injection of HCG may induce the rabbit does ovulation at mating and increase conception rate. Other than that, refusal of mating may be cause the rabbit does is pregnant.

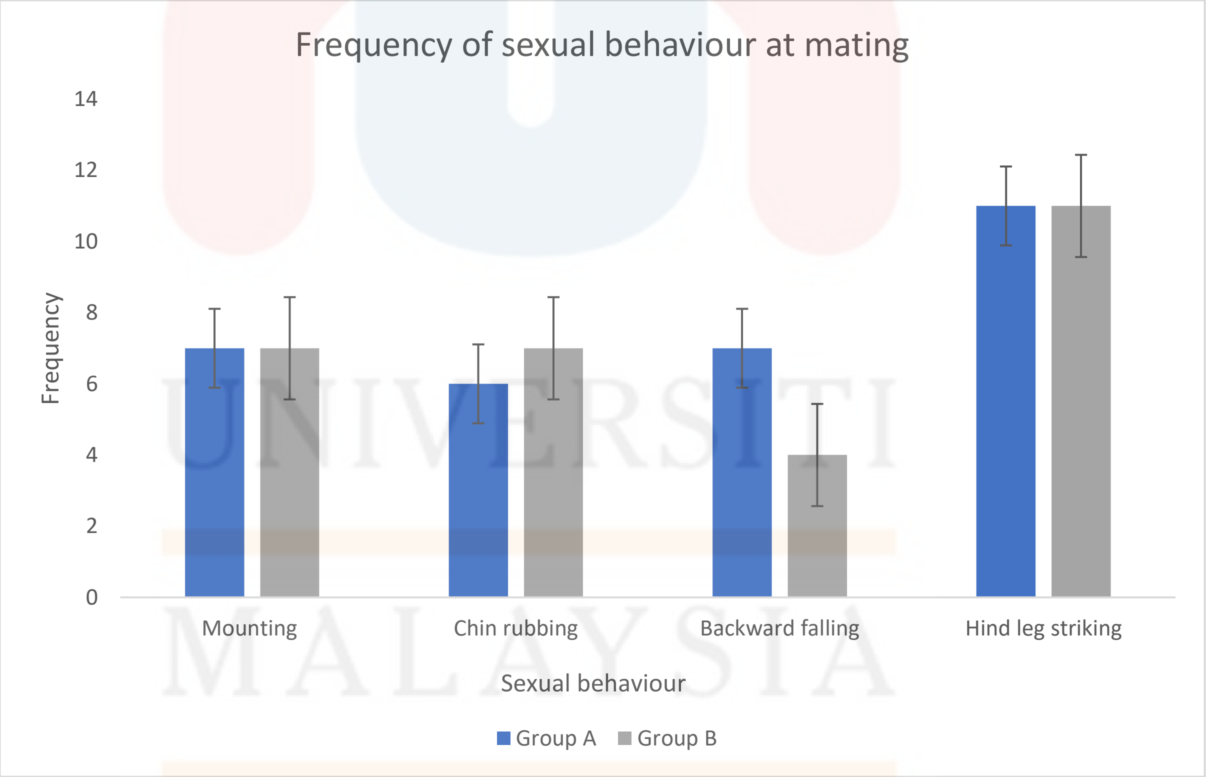


Figure 4.1.3: Frequency of occurrence of courtship features at mating

The result in figure 4.1.3 showed no significant differences between Group A and Group B for the number of mountings on buck. Mounting is considered as sexual behaviours in other studies even though Larsson (1979) reported that the number of mounts that did not end in copulation and there is no significant different between a series of tests that lead to sexual satisfaction in rabbit. While there was a notable decline in the number of mounts that ended in ejaculation between the first day and day 55 of testing. In contrast, Jiménez (2012) found in rat that the post-ejaculatory latency increased with each copulatory series. In the rat, the number of mounts without intromission is highest during the first ejaculation series, declines in the second and third series, and rises in the fourth series.

The result showed no significant differences between Group A and Group B for the chinning frequency on buck. González-Mariscal et al., (1992) confirmed that despite the high heterogeneity across experimental animals, baseline chinning frequency remained impressively consistent in all individuals over subsequent tests that lead to sexual satisfaction in rabbit. In addition, chinning has been shown to be related to a rabbit readiness for mating. However, González-Mariscal (1997) found that the frequency of chinning was significantly decreased by ad libitum copulation. As a result, chinning frequency is lowered by approximately 70% in all the buck at 2 hours following the last ejaculation. This effect was visible in all tests from first ejaculation until last ejaculation regardless of their length or number of sexual experiences.

Hind leg striking and backfalls are the courtship feature that usually observed during rabbit mating. At the completion of the mating act, the buck will usually fall over backwards or on his side (Michigan State University Extension, 2017). In our research, hind leg striking, and backfalls also show no significant differences between Group A and Group B. Information on the factors that may affect the number of frequencies for both observations are still scarce.

4.2 Maternal Effect During Pregnancy

Figure 4.2.1: Doe's body weight changes due to pregnancy

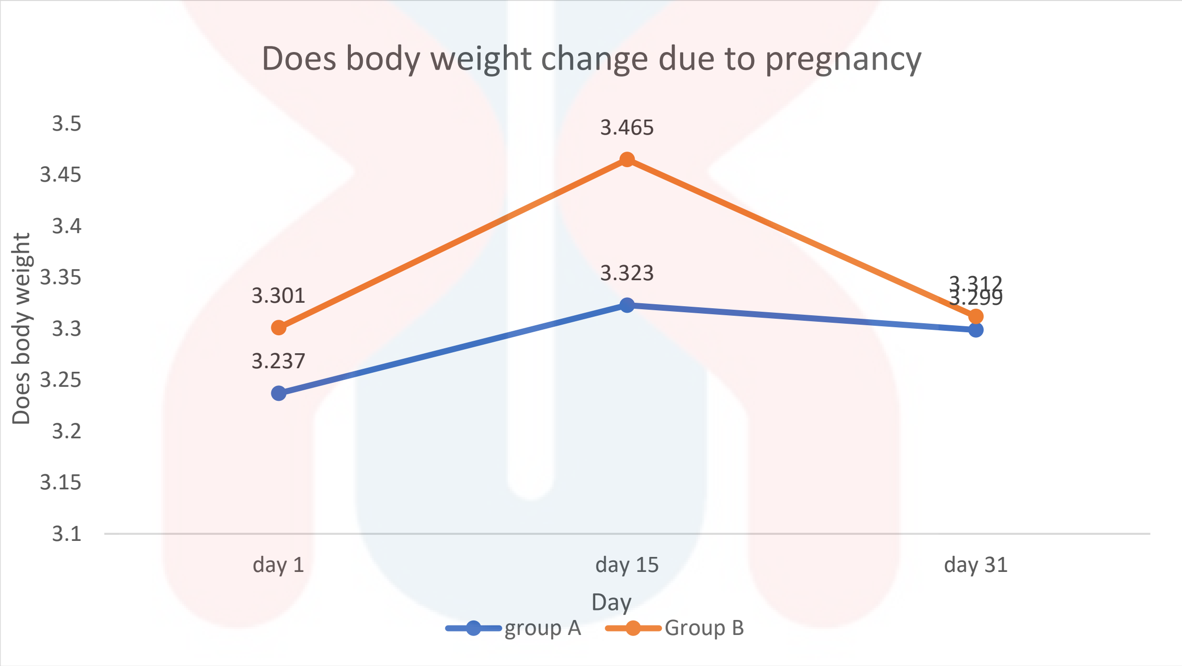
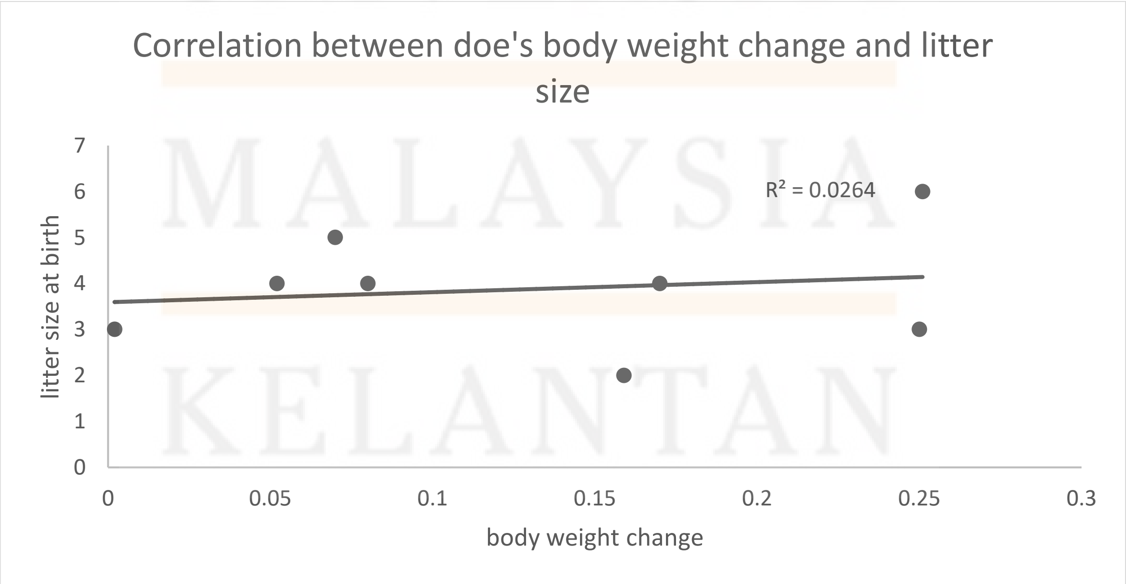


Figure 4.2.2: Correlation between doe's body weight change and litter size at birth.



Results in figure 4.2.1 showed there is significant difference ($P \leq 0.05$) in body weight change of does in group A and group B. As expected, pregnant does increased in body weight and these correlated with Agaviezor & Ologbose (2020) who state that the physiological changes that occur in the doe's body due to pregnancy could explain the positive changes between body weight before mating and during pregnancy.

The findings were slightly in contrast with those of Oguike et al. (2008), who found no significant difference in the body weight of pregnant doe rabbits at mating and at parturition. Rodriguez et al. (1985), who discovered that the body weight of pregnant doe rabbits increased by 277 g after parturition. The findings from (Afifi et al., 1980) demonstrated that the body weight of does before and after mating and kindling was influenced by breed and age. This is primarily due to variances in body size between breeds at different phases of development. In contrast, there is no significant difference in body change during pregnancy due to the age of does at mating (Agaviezor & Ologbose, 2020).

The study also investigated the correlation between body weight and litter size between groups. Figure 4.2.2 shows that there is positive correlation ($r=0.1625$) between change in does' body weight and litter size. However, the litter size or the range of the doe body weight are not considered in the literature when determining the doe body weight change during pregnancy (Hygiene & Medicine, 2013).

Table 4.0.2.1: Average of litter size at birth between Group A and Group B

	Average ± SEM		P Value
	Group A	**Group B**	
Litter size at birth	3.25±0.48	4.5±0.65	0.1708

(n=8); SEM, Standard error of mean

The result showed no significant differences ($p>0.05$) between Group A and Group B for the litter size at birth. Our study was similar to Kadry and Afifi (1983) that reported that buck performance and number of services had no effect on litter size at birth. Litter size at birth may be influenced by number of mating, seasons, parity and age of buck (Fayeye & Ayorinde, 1982).

Hygiene & Medicine (2013) found that double mating of rabbit obtained the highest litter size compared to single and triple mating. This may cause by increased mechanical stimulation in double matings that increases ovulation rate and thus litter size increased.

Nelson et al. (1979) and Toson et al. (1995) also reported that there was a significant difference in litter size between does mate with different numbers of services. Does that mated by two services from separate two bucks had higher litter size than does mated by two services from the same buck or one service.

Moreover, Das and Yadav (2007) revealed that the size of the litter at birth increased as parity increased, peaked at the third parity, and then steadily decreased. Parity affects litter size at birth and service per conception. Moreover, Afifi (1987) reported that increasing parity until the fifth parity influence average birth weight increased. In other hand, Singh (2004) found that parity had no effect on litter size at birth and weaning traits in German Angora rabbits. In this study, the rabbit does was selected randomly without considering their parity order.

Next, it was reported that litter size was also affected by season (Fayeye & Ayorinde, 2010) and (Hygiene & Medicine, 2013). Hygiene & Medicine (2013) reported that the highest litter size was obtained during winter in White New Zealand Rabbit under Egyptian condition. In contrast, Fayeye and Ayorinde (2010) reported that the number of litter size in the rainy season was lower than the number of litter size in the summer season for Nigerian rabbits. The climate in Malaysia is considered hot and humid throughout the year. So, the season did not affect the litter size at birth in New Zealand White rabbit.

In addition, according to Mousa (2004), the litter size (number of kits) was influenced by the age of the buck. They found that the highest litter size (7 kits) obtained from does mate with a buck of an average age of 8 months while the does mated with bucks of an average age of 6 months had 6.2 kits and does mated with 4 months of bucks age had 3.4 kits.

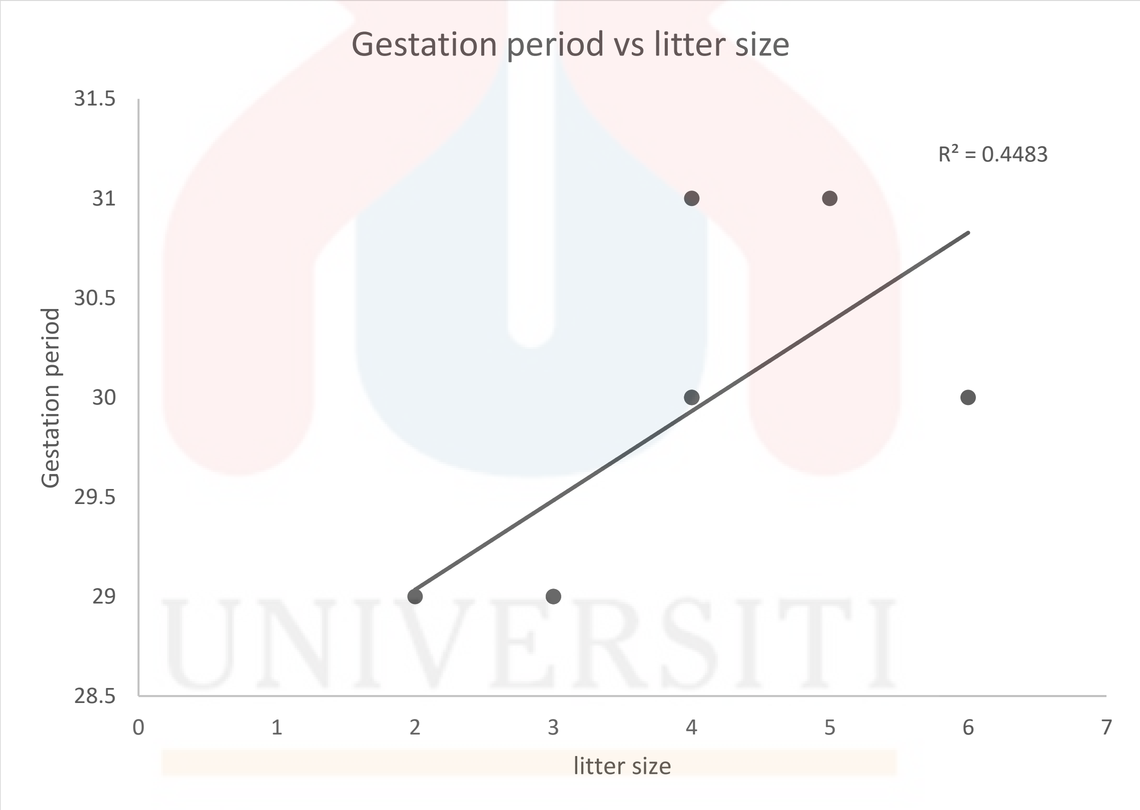


Figure 4.2.3: Correlation between gestation period and litter size

Figure 4.2.3 show clearly positive correlation (r=0.067) between gestation period and litter size. This may be explained that duration of gestation depends on the total number of fetuses in a female. This result correlated with Curnow & Finn (1963) state that the gestation period is regulated by the number of conceptuses. Since in a normal pregnancy there are approximately the same number of corpora lutea in the ovaries as there are fetus in the uterus, it is possible that the control of gestation resides in the ovaries rather than the uterus (Cunnow &Finn, 1963).

In contrast, Zucchi and Desalvo (1987) reported there are no significant correlation between litter size and gestation length while Mcnitt and Moody (1991) and Farghaly (1996) found that increasing litter size reduced the gestation length. Manresa (1933) has shown a significant negative correlation between gestation length and litter size in the rabbit.

Moreover, Hammond (1925) state that there is adversely relation between gestation length and litter size in the rabbit. The data he gives show a highly significant negative regression of gestation length on litter size. Gestation length may be influenced by parity (Farghaly, 1996).

Previous studies have reported parity had significant effect gestation length. The length of the pregnancy tended to increase with parity increased in rabbit (Farghaly, 1996).

However, Afifi and Emara (1985) revealed the different between parity had no significant affect the gestation period. To note, Afifi and Emara (1985) investigated the Crossbreeding between different breeds of rabbits which is local rabbit (Giza White & Baladi Red and White) with foreign breeds (New Zealand White, Californian, Bousca) under the Egyptian conditions. Thus, this may influence the finding.

Table 4.2.2: Nest building behavior of does in Group A and Group B

	Group A	Group B	P Value
Nest building behavior	50 %	75%	0.5367

As shown in Table 4.2.2, there were no significant differences ($P>0.05$) between Group A and Group B on nest building behavior. Only 50% of Group A and 75% of Group B express nest building behavior before parturition. This result related to endocrine control responsible for nest building behavior by secretion of prolactin hormone.

In the study of maternal behavior in the rabbit Zarrow et al., (1961) provided evidence for the endocrine system's potential influence in one component of maternal behavior (nest building). Nest building behavior is particularly useful because it has been demonstrated in other animal that have an endocrine component particularly birds but seems to be distinct to a few species of lagomorphs (Cahalane, 1947).

This nest building behavior commonly occur in the rabbit. In the case of the rabbit, the nest building behavior appears start with straw nest followed by lined with fur. In research of Zarrow et al. (1961) the rate of maternal nest building was reported to be 98% among normal pregnant does. 86.7% constructed the nest on the day of parturition, 82% created nests a day or more before parturition, and 5.1% built nests just after gave birth of the kits.

Normally, the hair or fur used for nest building when straw nest or other material becomes inadequate for heat resistance. This scenario may increase mortality due to chilling (scholaut, 1980). The increase in ambient temperatures to the litter has resulted in a decline in hair nest construction. Minor changes in the external environment are not really have a significant impact on the climate, but they may influence the nest's building. The temperature seems to be more essential since it affects the amount of fur used for the nest layer (Szendro' et al., 1988).

Various factors role in the creation of the hair nest are related to exact stimuli such as hormone changes and environment temperature rather than doe's experience (Zarrow et al., 1961). Gonzalez-Mariscal et al. (1996) observed that prolactin is needed for straw carrying and fur pulling behaviors during nest building.

However, this is in contrast with study from Negatu & McNitt (2002) reported that the timing of the prolactin surge does not coincide with the timing of nest building. Furthermore, treatment of rabbits with bromocryptine failed to consistently inhibit nest-building behavior in that experiment. To note, bromocryptine is a dopamine stimulant that prevents prolactin secretion. Zarrow et al. (1961) also reported that treatment of rabbits with prolactin twice daily from day 20 of gestation failed to induce early nest building.

Table 4.2.3: Comparison of number kits born alive and mortality rate between Group A and Group B

	Average ± SEM	Mortality rate	P Value
Group A	2.5±0.65	23 %	0.1067
Group B	4.0±0.41	12.5 %	

(n=8); SEM, Standard error of mean

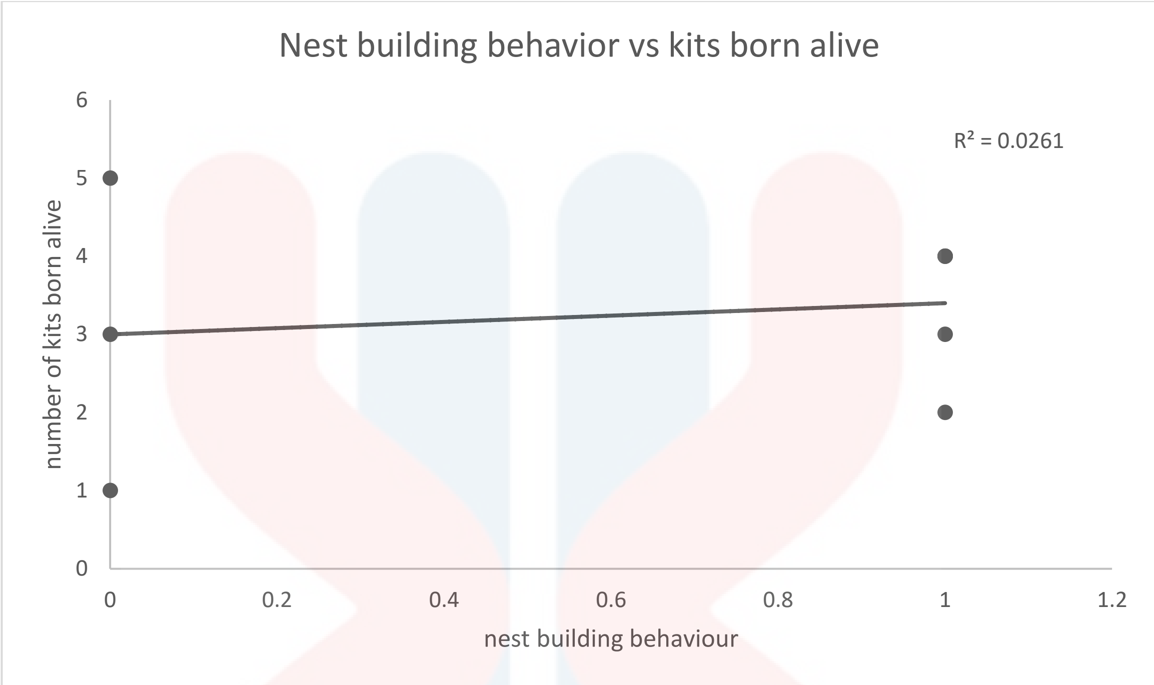


Figure 4.2.4: Effect of nest building behavior on number of kits born alive

Statistical analyses on the number of kits born alive in Figures 4.2.3 showed group B had lower mortality rate (12.5%) than Group A (23%) but there is no significant difference ($p>0.05$) for these groups. Pre-weaning mortality can be influenced by maternal behaviour (nest building), breed, seasons, litter size at birth and remating interval according to Harris et al., (1982). The maternal component of heritability's advantage over the paternal component shows the mother's significant influence on the young's viability (rolling and casady, 1976).

The results of this research in figure 4.2.4 showed clearly positive correlation ($r=0.162$) between nest building behavior and number of kits born alive. The present findings seem to be consistent with Rashwan (2000) which found there are positive relationship between the mortality (or survival) of the young rabbits and the nest. A possible explanation for this might be that the available nest helps the survival of the hairless kits and keep them warmly.

Furthermore, Canali et al, (1991) were investigated about the relationship between rabbit does nest building and litter development reported that this characteristic is a maternal behavior that has a significant influence on the growth of the young. They discovered that a decent straw nest resulted in more kits born alive and lower death rates in the first five days of life. Conversely, Castellini et al., (2003) reported the nest's quality and the number of kits born alive are associated and both inversely correlated with mortality. The amount of fur in the nest is inversely proportional to the ambient temperature.

Pre-weaning mortality may be cause by maternal behaviour which is nest building and lactation ability (*Rashwan, 2000*). Yamani (1991) reported that during the first 20 days of lactation, rabbit kits are completely dependent on does milk for feeding. The failure of does to nursing her young is likely due to her nipple tenderness and inability to provide milk will result in the death of the young rabbit. According to Schlolaut (1980), insufficient milk supply and the capability of young animals to successfully discover teat during one a day for 2-3 minutes influence mortality rate. The mortality rate increase when low postnatal maternal ability due to limited milking and suckling abilities.

Other than that, mortality rate was also reported to be affected by breed according to El-Maghawary (1988), Elqen (1988), Lebas (1986). El-Maghawry et al, (1988) revealed the rate of pre-weaning mortality significantly different by breed and between purebred and crossbred rabbits. Lebas et al. (1986) found higher pre-weaning mortality rate in purebred crossbred animals, while Elqen (1988) revealed that crossbred animals were more competent at producing larger litter size and rearing them effectively than purebred animals. Rollins and Casaday (1967). Reported although fixing unwanted and fatal features may occur simultaneously with fixing desirable traits without selection, genetic improvement can minimise pre-weaning mortality.

In contrast, Rashwan (1995) and Dorra (1997) reported no significant genetic variations in mortality rates. Lebas et al (1986) reported that breed variations in General Combining Ability (GCA) were restricted and non-significant for pre-weaning mortality rate.

Moreover, Casady and Rollins (1967) discovered kindling season had a significant impact on pre-weaning mortality rates. Ayyat and Marai (1998) found that mortality rate in pre-weaning rabbit was higher in the summer than in the winter. This may associate with heat stress on the vulnerable young offspring and decline the rabbit's milk production. However, Rafai and Papp (1984) found that increasing of ambient temperature influenced the increasing of pre-weaning mortality. The number of kits that died in the experiment at temperatures of 20℃, 25℃, 30℃, and 35℃ was significantly lower at temperatures of 20℃ and 25℃ than at higher temperatures.

Other than that, according to Partridge et al. (1981), mortality increased in both large and small size of litters at birth. Tawfeek (1995) discovered mortality rate was significantly increase with increasing of litter size at birth. Asker (1989) mentioned pre-weaning mortality in New Zealand White rabbits was also lower in litters of 5 or 7 kits. Pre-weaning mortality increased with increased litter size at birth may be attributed to a reduction in average of body weight per litter at birth (Afifi et al., 1973). Moreover, litter size increased resulted in competition for teats increased and consequently lesser rabbits receive less milk. However, several studies from Rollints and Casaday (1967), and Afifi and Khalil (1986) found that the correlation between litter size at birth and mortality was not significant.

In research on New Zealand White rabbits, Perry (1983) discovered that does mated at 3 and 4 weeks after kindling had significantly decreased on pre-weaning mortality rates. In addition, Mendez et al. (1986) discovered that the group remated on day 4 had significantly lower mortality during lactation than those remated on days 1 and 24 post-kindling. After that, Toson et al. (1995) found that the mortality rate in young borne by does remated one day after parturition was significantly larger than in those does remated 14- or 28-days following parturition due to the pregnant does' reduced milk production throughout the suckling phase. However, Szendro et al. (1983) showed there is no significant influence of remating interval on pre-weaning mortality rate.

CHAPTER 5

5.1 CONCLUSION

In this study, we concluded that there is no significant differences in different days of sexual rest given in buck on doe's conception rate. Moreover, sexual rest days given to the bucks before mating either one day rest or 3 days did not significantly affect sexual behaviors (spontaneous response, chin rubbing, mounting, leg hind striking and backfall) during mating. Sexual rest of bucks before mating did not directly affect post maternal behaviour.

In addition, this research confirmed correlation between maternal effect and post maternal on litter performance. For post maternal effect, there is a positive correlation between gestation period with litter size at birth. Plus, we also found correlation between nest-building behaviour and kits born alive after 1 week. This study may assist farmers and researchers by providing new data and information on mating behaviour, sexual rest in bucks, post maternal behaviour and litter performance in New Zealand white rabbits in Malaysia. However, further studies are necessary for more comprehensive analysis.

5.2 RECOMMENDATION

Further study on the effect of sperm preservation during sexual rest in rabbit buck is vital. Daily observation on rabbit sexual and maternal behaviours are important for farmers. Analysed data would assist farmers in breeding management to produce the best quality efficiently.

Future research specifically in semen quality affected by sexual rest for 2 and 5 days is recommended. Semen qualities such as viability, mobility, membrane integrity should be analysed. Other than that volume, pH and color of semen collected would be an added data for future studies. In addition, large sample size could provide a better analysis regarding the effect of sexual rest in rabbit bucks towards does and litter performance.

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APPENDIX A

Figure A.1.0: New Zealand White Rabbit

Figure A.2.0: Natural mating of New Zealand White rabbit

Figure A.3.0: Nest building behaviour

Figure A.4.0: No nest building behaviour

APPENDIX B

Table B.1.0: t-Test: Two-Sample Assuming Unequal Variances for conception rate

t-Test: Two-Sample Assuming Unequal Variances for conception rate

	Group A	*Group B*
Mean	0.75	1
Variance	0.25	0
Observations	4	4
Hypothesized Mean Difference	0	
df	3	
t Stat	-1	
P(T<=t) one-tail	0.195501	
t Critical one-tail	2.353363	
P(T<=t) two-tail	0.391002	

Table B 2.0: t-Test: Two-Sample Assuming Unequal Variances for mounting frequency

t-Test: Two-Sample Assuming Unequal Variances

	Group A	*Group B*
Mean	1.75	1.75
Variance	0.25	0.25
Observations	4	4
Hypothesized Mean Difference	0	
df	6	
t Stat	0	
P(T<=t) one-tail	0.5	
t Critical one-tail	1.94318	
P(T<=t) two-tail	1	
t Critical two-tail	2.446912	

Table B.3.0: t-Test: Two-Sample Assuming Unequal Variances for chinning frequency

t-Test: Two-Sample Assuming Unequal Variances

	Group A	*Group B*
Mean	1.5	1.75
Variance	1.666667	0.25
Observations	4	4
Hypothesized Mean Difference	0	
df	4	
t Stat	-0.36116	
P(T<=t) one-tail	0.368124	
t Critical one-tail	2.131847	
P(T<=t) two-tail	0.736249	
t Critical two-tail	2.776445	

Table B.4.0: t-Test: Two-Sample Assuming Unequal Variances for backward falling

t-Test: Two-Sample Assuming Unequal Variances

	Variable 1	*Variable 2*
Mean	1.75	1
Variance	0.25	0
Observations	4	4
Hypothesized Mean Difference	0	
df	3	
t Stat	3	
P(T<=t) one-tail	0.028834	
t Critical one-tail	2.353363	
P(T<=t) two-tail	0.057669	
t Critical two-tail	3.182446	

Table B.5.0: t-Test: Two-Sample Assuming Unequal Variances for hind leg striking

t-Test: Two-Sample Assuming Unequal Variances

	Group A	*Group B*
Mean	2.75	2.75
Variance	0.25	0.25
Observations	4	4
Hypothesized Mean Difference	0	
df	6	
t Stat	0	
P(T<=t) one-tail	0.5	
t Critical one-tail	1.94318	
P(T<=t) two-tail	1	
t Critical two-tail	2.446912	

Table B.6.0: t-Test: Two-Sample Assuming Unequal Variances for body weight change of does during pregnancy

t-Test: Paired Two Sample for Means

	Day 1	*Day 15*
Mean	3.30125	3.4645
Variance	0.073888	0.03606
Observations	4	4
Pearson Correlation	0.966597	
Hypothesized Mean Difference	0	
df	3	
t Stat	-3.23904	
P(T<=t) one-tail	0.023943	
t Critical one-tail	2.353363	
P(T<=t) two-tail	0.047886	
t Critical two-tail	3.182446	

Table B.7.0: t-Test: Two-Sample Assuming Unequal Variances for litter size at birth

t-Test: Two-Sample Assuming Unequal Variances

	Group A	*Group B*
Mean	3.25	4.5
Variance	0.916667	1.666667
Observations	4	4
Hypothesized Mean Difference	0	
df	6	
t Stat	-1.55543	
P(T<=t) one-tail	0.085422	
t Critical one-tail	1.94318	
P(T<=t) two-tail	0.170844	
t Critical two-tail	2.446912	

Table B.8.0: t-Test: Two-Sample Assuming Unequal Variances for nest building behaviour

t-Test: Two-Sample Assuming Unequal Variances

	Group A	*Group B*
Mean	50	75
Variance	3333.333	2500
Observations	4	4
Hypothesized Mean Difference	0	
df	6	
t Stat	-0.65465	
P(T<=t) one-tail	0.268482	
t Critical one-tail	1.94318	
P(T<=t) two-tail	0.536963	
t Critical two-tail	2.446912	

Table B.9.0: t-Test: Two-Sample Assuming Unequal Variances for number of kits born alive

t-Test: Two-Sample Assuming Unequal Variances

	Group A	*Group B*
Mean	2.5	4
Variance	1.666667	0.666667
Observations	4	4
Hypothesized Mean Difference	0	
df	5	
t Stat	-1.96396	
P(T<=t) one-tail	0.053373	
t Critical one-tail	2.015048	
P(T<=t) two-tail	0.106746	
t Critical two-tail	2.570582	

Table B.10.0: Correlation between litter size at birth and gestation period

	Litter size	*gestation period*
Litter size	1	0.669534063
gestation period	0.669534063	1

r=0.67

Table B.11.0: Correlation between nest building behaviour and number of kits born alive

	nest building	*kit born alive*
nest building behaviour	1	0.161515
kit born alive	0.161515	1

r= 0.1615