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**ADDITIONAL FEEDING OF SUCKLING RABBITS**

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## 1. TABLE OF CONTENTS

|  |    |
|--|----|
| 1. BACKGROUND OF RESEARCH, OBJECTIVES -----  | 3  |
| 1.1. OBJECTIVES OF THE RESEARCH -----  | 4  |
| 2. MATERIAL AND METHODS -----  | 5  |
| 2.1. Additional feeding of suckling rabbits based on milk powder -----   | 5  |
| 2.2. Soybean based additional feeding of suckling rabbits with thyme<br>supplementation-----   | 6  |
| 2.3. Additional feeding of suckling rabbits with piglet feed based pellets and<br>glycerine supplementation-----                                   | 7  |
| 2.4. Additional feeding of suckling rabbits by providing powder or liquid based<br>drench solutions-----   | 8  |
| 2.5. Examination of nursing behaviour and production of does depending on the<br>method of nursing used at the time of their suckling period ----- | 9  |
| 3. RESULTS -----   | 11 |
| 3.1. Consumption and hardness of supplementary feed -----  | 11 |
| 3.2. Additional feeding of suckling rabbits based on milk powder -----   | 11 |
| 3.3. Soybean based additional feeding of suckling rabbits with thyme<br>supplementation-----   | 12 |
| 3.4. Additional feeding of suckling rabbits with piglet feed based pellets and<br>glycerine supplementation-----                                   | 12 |
| 3.5. Additional feeding of suckling rabbits by providing powder or liquid based<br>drench solutions-----   | 13 |
| 3.6. Examination of nursing behaviour and production of does depending on the<br>method of nursing used at the time of their suckling period ----- | 14 |
| 4. CONCLUSIONS AND SUGGESTIONS -----   | 15 |
| 5. NEW SCIENTIFIC RESULTS -----  | 16 |
| 6. REFERENCES -----  | 17 |
| 7. PUBLICATIONS ON THE SUBJECT OF THE DISSERTATION-----  | 18 |

## **1. BACKGROUND OF RESEARCH, OBJECTIVES**

While several researchers have investigated ways to increase the weight and weight gain of rabbits during the fattening period, there are limited literature on the possibilities to take advantage of the high growth potential of suckling kits during the lactation period, especially during the first two weeks of life.

The growth and development of suckling rabbits are influenced by genetic background, maternal effect and environmental factors. The kits consume milk produced by the doe until the age of 3 weeks, which, due to its favorable composition, provides intensive growth. However, they are able to take on additional nutritious material through their high growth potential, which has been demonstrated by the “nursing by two does” methods. By nursing twice a day, kits are able to consume more milk, thereby increasing their weight gain and achieving slaughter weight sooner. However, due to increased costs, increased labour, working time expenditure and animal health risk, this technology has not spread in the practice.

In the doctoral work, we examined various possibilities for supplementary feeding of suckling rabbits (milk powder-, soybean-, piglet feed based pellets, as well as powder-, liquid-based drench solutions and the effect of nursing frequency on certain production indicators). Only a limited number of studies can be found in the literature in this field, in particular this finding is true for the early lifestage (days 1-16). Most research teams started to work on this field after our results have been published (Paës *et al.*, 2019; 2020).

It is important in an economic point of view to take advantage of all possibilities, since the direct practical benefit of utilizing the growth capacity of suckling rabbits is that rabbits reach slaughter weight sooner.

At present, there is no technology that can be used in production and high growth potential can be exploited. It is necessary to develop a method that approaches the results achieved by the two-mother nursing system without the disadvantages of the technique.

## **1.1. OBJECTIVES OF THE RESEARCH**

### **I. Additional feeding of suckling rabbits based on milk powder**

Suckling rabbits are able and willing to consume solid faecal pellets excreted into the nest by the doe and to take on additional feed in addition to maternal milk (two-mother nursing). Our goal was to examine if suckling kits are willing to eat solid feed based on milk powder.

### **II. Soybean based additional feeding of suckling rabbits with thyme supplementation**

In the case of pregnant and lactating does consuming aromatic plants, a preference can be observed for kits towards the plant. Our aim was to examine whether thyme supplementation can increase the consumption of solid supplementary feed of suckling rabbits.

### **III. Additional feeding of suckling rabbits with piglet feed based pellets and glycerine supplementation**

Our aim was to examine the effect of a commercially available supplementary feed (for piglets), on the production of suckling kits. The nutritious content of the product is similar to the does' milk. We also examined the effect of energy content increased by glycerin supplementation.

### **IV. Additional feeding of suckling rabbits by providing powder or liquid based drench solutions**

Our aim was to examine the effect of various drench solutions (powder, liquid) on the production of pregnant and lactating does and suckling kits, with voluntary fluid consumption.

### **V. Examination of nursing behaviour and production of does depending on the method of nursing applied at the time of their suckling period**

In the study, we examined the nursing behavior and performance of does which were nursed once or twice a day at the age of their suckling period. Our goal was to examine how the daily rhythm of the kits (single or double nursed) affects later on their nursing patterns as lactating does.

## **2. MATERIAL AND METHODS**

### **2.1. Additional feeding of suckling rabbits based on milk powder**

The study was carried out in the Rabbit Farm of Kaposvár University, with the animals of the Pannon rabbit breeding programme. The does were individually placed in single-storey wiremesh cages (870 × 381 mm floor area and 320 mm height). The nest area was 28.5 x 38 cm in size. The room temperature was 18-25°C and the daily lighting was 16 hours (6:00 - 22:00). A 49-day reproductive rhythm was applied during the study. After parturition, the kits born with a weight of less than 45 g were removed and cross-fostering was carried out (9 kits/litter). The does were allowed to nurse once a day (8 a.m.) until the 16<sup>th</sup> day of lactation, after that the entrance to the nest was opened. Feed from self-feeders and drinking water from nipple drinkers were provided to the rabbits *ad libitum*. Litters were randomly divided into two groups (10 does and 90 kits per group): kits did not receive supplementary feed (C) or received supplementary, milk powder-based pellets (T). For homogeneous feed production, we used a 8 mm rib diameter boiliesroller (Carp Expert Mega Bojliroller 8mm<sup>®</sup> with a diameter of 8 mm, using a mixture of milk powder and water of 90 : 10 percent ratio.

The hardness of pellets and hard faeces balls have been measured for each test by Zwick Roell/Z005 (ProLine table meter) device, the value of which is the maximum force measured on the compression curve (N). The speed of the test head was 500 mm/min and the thickness of the blade used for cutting was 1 mm. The results of the measurements were recorded by the testXpert V11.0 software.

During the study, we measured the individual weight of the kits at 2, 5, 9, 12, 16, 19 and 21 days of age (before nursing) and calculated the daily weight gain. From the sum of individual weights measured before nursing, we calculated the litter weight, which, by subtracting from the litter weight after

nursing, gave as a result of the milk production of the does (2-16 days). At 19 and 21 days of age (free nursing), the weight of the kits was measured at 9 a.m.. Nests were visited daily, dead kits were not replaced. Consumption of pellets in the nests was checked daily.

Daily milk production, individual weight and weight gain of kits were evaluated using linear mixed model (LMM) (additional feed as a fixed factor; does effect as random factor), hardness of pellets by T-test, mortality of kits by Chi-square test. Statistical evaluations were performed using SPSS 10.0 software (SPSS Inc., Chicago, USA).

## **2.2. Soybean based additional feeding of suckling rabbits with thyme supplementation**

Housing and feeding of animals as described in *Chapter 2.1*. The study was carried out with the does (77) and kits (734) of the Pannon rabbit breeding programme. Eleven days after insemination, does deemed pregnant were divided into two groups. One group consumed control (C) diet, the other group consumed feed supplemented with thyme (200 g/t) (K) *ad libitum* until weaning. Within the two maternal groups (C, K), 3 subgroups were formed based on additional feeding of the kits: N = without additional feeding; S = soybean based pellets (soybean : coconut oil : sheet gelatin 82,5 : 16,5 : 1 percentage ratio); S+K = 1% thyme-supplemented soyben based (S) pellets. The pellets were cylinder shaped, 8 mm in diameter and 20 mm long, which were placed on top of the nest material.

Litter weight was measured at 2, 5, 9, 12 and 16 days immediately before and after nursing. From the difference between the two weights, we calculated the amount of produced milk. Individual weight of the kits was measured at 3, 10 and 16 days of age an hour after nursing. The pellets left in the nest were examined every day (missing pellets, bite marks).

Litter and individual weight and milk production were evaluated using two-factor variance analysis (rabbit does' feed and supplementary feed for kits as

fixed factors), kits' mortality was evaluated with Chi-square test using SPSS 10.0 software (SPSS Inc., Chicago, USA). In the individual weight and weight gain of the kits the does were treated as random factor. The hardness of the pellets was evaluated with a T-test.

### **2.3. Additional feeding of suckling rabbits with piglet feed based pellets and glycerine supplementation**

Housing and feeding of animals as described in *Chapter 2.1*. The study was carried out with Pannon White rabbits ( $n = 3 \times 10$  does,  $n = 3 \times 90$  suckling rabbits). The kits of the control group (C) were not given additional feed. Kits in group M received piglet feed (Bonni-M Forte<sup>®</sup> by SANO: dry matter: 6.0%; crude protein: 20,0 %; crude fat 13.5%; crude fibre: 1,5 %; ash: 7.0%) based pellets (piglet feed : pellet adhesive : water - 79.5 : 0.6 : 19.9 percent ratio). To test the effect of an additional feeding with increased energy, glycerine (Retore *et al.* 2012) was mixed with piglet feed (piglet feed: powdered glycerine : water - 71.2 : 11.9 : 16.9 percent ratio) as a pellet adhesive in the third group (G).

The suckling rabbits were weighed individually at 2, 5, 9, 12 and 16 days of age before nursing. The amount of produced milk was calculated on the same days. Litter weight and litter weight gain were calculated from individual weights before nursing. At 19 and 21 days of age (free nursing), the kits were weighed at 9 a.m..

Daily milk production, individual weights and weight gain were evaluated using a linear mixed model (LMM) (additional feed as a fixed factor; does' effect as random factor), hardness of pellets by T-test, kits mortality by Chi-square test, using SPSS 10.0 software (SPSS Inc., Chicago, USA).

## **2.4. Additional feeding of suckling rabbits by providing powder or liquid based drench solutions**

The does were housed individually in wiremesh pens (50 × 100 cm, with a 100 cm high sidewall and without a roof). Each pen was equipped with a 30 cm wide self-feeder and two spoon drinkers with bottles. The room temperature varied between 21-27 °C, the daily lighting was 16 hours (6:00 - 22:00). During the study, a 49-day reproduction rhythm and controlled nursing was applied (till the 16<sup>th</sup> day of lactation). Feed and drinking water were available *ad libitum*. The tests lasted from the 11<sup>th</sup> day before parturition till weaning (35<sup>th</sup> day of lactation).

### *First test: Continuous drench access*

On the 11<sup>th</sup> day before parturition, pregnant does were divided into three groups (n = 8/group): Control (C): drinking water in both drinkers; Liquid-based drench solution (F): drinking water in one drinker, 5% volume proportional drench solution (water 50%, glycerine 20%, dextred 20%, Celmanax<sup>®</sup> 5%, MHA<sup>®</sup> 5%) in the other drinker; Powder-based drench solution (P): drinking water in one drinker, 5% proportional powder-based drench solution (maltodextrin 30%, dextrans 35%, whey powder 25%, WPC-80<sup>®</sup> 9.8%, Coleis<sup>®</sup> 0.2%) in another drinker.

The consumption of liquids was measured at 8.00 a.m. each morning and, if necessary, during the day. Feed consumption was measured on a weekly basis. The weight of the does was measured immediately after parturition and then on the 7<sup>th</sup>, 10<sup>th</sup>, 14<sup>th</sup>, 17<sup>th</sup> and 35<sup>th</sup> days of lactation. Milk production was calculated on the same days. The litter weight was measured at 2, 9, 16, 21 and 35 days of age.

### *Second test: Periodical drench access*

Its methodology was similar to the previous study. In the control group (C) *ad libitum* drinking water was provided from both drinkers. Drench solutions



(P, F) were provided in one drinker. Drinkers were refilled twice a week (Monday and Thursday at 9.00 a.m.), for 24-hour periods.

The consumption of liquids was measured twice a week (Tuesdays and Fridays at 9.00 a.m.) and if necessary, during the day. Feed consumption was measured on a weekly basis. The weight of the does was measured immediately after parturition and then on the 7<sup>th</sup>, 10<sup>th</sup>, 14<sup>th</sup>, 17<sup>th</sup> and 35<sup>th</sup> days of lactation. Milk production was calculated on the same days. The litter weight was measured at 2, 9, 16, 21 and 35 days of age. Dead kits were checked daily.

The data were evaluated using one-factor variance analysis (One-Way ANOVA) and Chi-square test using SPSS 10.0 software (SPSS Inc., Chicago, USA).

## **2.5. Examination of nursing behaviour and production of does depending on the method of nursing used at the time of their suckling period**

The study was carried out in the Rabbit Farm of Kaposvár University, with the animals of the Pannon rabbit breeding programme. Housing and feeding of animals as described in *Chapter 2.1*. During the first phase of the study, we selected 90 newborn female kits and formed 10 litters from them. The litters were divided into two groups (n = 5 litters/groups). In the control group (E), controlled nursing was applied once a day. The does were allowed to nurse their kits at 8 a.m. every day until the kits were 21 days old, after that free nursing was applied. For the second group (D), the kits were nursed twice a day (8 a.m. and 4 p.m.; two mothers/litters) until the age of 21 days, after which free nursing method was applied (keeping one of the does). Rabbits weaned at 5 weeks of age were raised under the same conditions. Artificial insemination was applied at 16.5 weeks of age. In the second stage of the study, free nursing was used.

The lactation behaviour of rabbits was studied during the first (EI and DI) and second (EII and DII) lactations. We have installed infrared cameras over the cages. Between the 2<sup>nd</sup> and 14<sup>th</sup> days of lactation, we made continuous 24-hour video recordings. During the evaluation, we recorded the number and time of the successful nursing events. Dead kits were checked daily. During the study, litter weights were measured at 2, 6, 13 and 21 days of age (8.00 a.m.) and the average individual weight and weight gain were calculated.

The daily frequency of nursing events was evaluated by Chi-square test, the average individual weight and weight gain of the kits by two-sample T-test, and mortality by Chi-square test. Statistical evaluations were performed using SPSS 10.0 software (SPSS Inc., Chicago, USA).

### **3. RESULTS**

#### **3.1. Consumption and hardness of supplementary feed**

The observations showed that suckling rabbits consumed the provided solid supplementary feed, as evidenced by bite marks and video recordings. Later Paës *et al.* (2019) published similar results, the possibility of supplementary feeding at early age was identified. In their study, suckling rabbits took an average of  $1.63 \pm 0.76$  g (dry matter) supplementary feed in addition to does' milk between the ages of 3 and 17 days. In our studies, we were unable to measure the amount of consumed feed due to the loss of pellet residues in the littermaterial, the moisture binding and dissincreasing properties of the pellet. Despite the fact that in all the three studies we sought to make pellets resistant to humid, warm environments in the nest which is still chewable for suckling rabbits, the hardness (N) of pellets and faeces pellets (fresh, BF; dry, BS) of different compositions differed (T: 8,4<sup>b</sup>; S: 18,4<sup>f</sup>; S+K: 16,8<sup>e</sup>; M: 5,9<sup>a</sup>; M+G: 12,2<sup>d</sup>; BF: 9,9<sup>c</sup>; BS:65,7<sup>g</sup>;  $P < 0.001$ ). According to the results of the test, it can be concluded that the hardness of the fresh faecal ball excreted in the nest is close to that of the pellets produced. Soybean-based pellets proved to be the toughest, regardless of whether we mixed thyme or not. The least hard supplementary food was made of piglet feed, while glycerine supplementation significantly increased the hardness of piglet feed based pellets.

#### **3.2. Additional feeding of suckling rabbits based on milk powder**

Additional feeding did not have a significant effect on milk production of groups at any measurement time and during the entire lactation period (mean milk production: Control: 375 g/day, Milk powder supplement feeding: 357 g/day). The lactation curve of the control group is similar as in the literature (Volek *et al.* 2018). Solid supplementary feeding based on milk powder had no effect on the weight, weight gain and mortality of suckling rabbits.

### **3.3. Soybean based additional feeding of suckling rabbits with thyme supplementation**

The addition of thyme mixed into the lactating does' feed had no significant effect on milk production. Group of pellets supplemented with thyme had moderately higher body weight and weight gain compared to the control group (average +5.3 g; +0.2 g/day) and soybean (average +4.7 g; + 0.2 g/day), but this difference cannot be statistically proven. No significant differences in weight and weight gain were found between the groups at any time of the study. Although, Altbäcker *et al.* (1995) found that thyme consumed by the does positively influences the preference of the offspring, this is not confirmed by our experimental results. The growth of rabbits did not show a positive effect of thyme supplementation. Neither the feed of the does nor the supplementary feeding of the kits affected the mortality of the kits.

### **3.4. Additional feeding of suckling rabbits with piglet feed based pellets and glycerine supplementation**

Supplementary feeding had no significant effect on milk production (mean values: C: 232 g/day; M: 232 g/day; M+G: 237 g/day). Milk production in the control group continuously increased during the first 16 days of lactation, while in the group of piglet feed based pellets and in the group of pellets supplemented with glycerine, lactation slightly decreased after day 9. We could assume that this decrease coincides with an increase in pellet consumption.

There was no significant difference in the weight of the rabbits at 2, 5 and 9 days of age, although the resulting value was higher in the piglet feed based group at 9 days of age (+4.8% and +6.2%;  $P=0.051$ ) than in the other two groups. From the 12<sup>th</sup> day of age, the difference in favour of the group that consumed the piglet feed supplement was statistically proven. This weight difference of 6-9% on average remained throughout the study.

Despite differences in body weight, the slightly more favourable weight gain in M rabbits was not statistically proven. Further trials should be carried out to determine why there are no differences in the feeding of piglet feed based pellets when supplementing with glycerine. Feeding the additional pellets did not affect the mortality of the kits.

### **3.5. Additional feeding of suckling rabbits by providing powder or liquid based drench solutions**

In both studies, rabbits were found to have largely covered their daily fluid needs from drench solutions. Throughout the first study (continuous drench access), there were significant differences ( $P < 0.05$ ) between groups. Rabbits in groups F and P preferred water in the first phase of the study ( $P < 0.05$ ), but the trend reversed after the parturition. This change was observed primarily in group P. This difference was maintained until the end of the trial and became more pronounced. In Group P, the drench consumption was 56.2%, 67.8%, 75.7%, 76.0% and 83.9% of total liquid consumption in the 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup> and 5<sup>th</sup> lactation weeks, respectively.

In both studies, it was observed that as soon as the kits left the nest (from about 16 days of age), they began to consume drench solutions. Increasing consumption was observed primarily in the powder-based drench solution. One of the reasons may be a sweet smell and aroma reminiscent of milk (whey content). Paës *et al.* (2020) published a similar finding. In their study, kits consumed more from the gel containing vanilla aroma than from the control, banana or forest fruit flavour jelly.

In our second study (periodical drench solution access), similar trends were observed, but to a less pronounced extent. In the first study, groups consuming liquid-based drench (-48 g/day; -71 g/day) and powder-based drench solution (-22 g/day; -74 g/day) between the ages of 8-14 and 22-28 days consumed less feed than the control group ( $P < 0.05$ ). In the second study the trends were similar, but no significant differences were found.

The amount of produced milk was not affected by the consumption of drench solutions. In case of the body weight increase of the does (from 1<sup>st</sup> to 35<sup>th</sup> day of lactation) the differences in the first trial are the following: C: +6.3%; F: +8.7%; P: +10.1%. In the second trial the results are similar: C: +3.0%; F: +10.7%; P: +6.4%. In both study, no statistically verifiable differences were found between groups in the case of the individual weight of suckling rabbits and their daily weight gain.

### **3.6. Examination of nursing behaviour and production of does depending on the method of nursing used at the time of their suckling period**

The results showed that in 48.4% of all observed days, does nursed the kits at least twice. Rabbits raised by two does (first DI and second DII lactation) nursed more than once a day, in more than 2/3 of the observed days. In the case of does nursed once a day (first EI and second EII lactation), this figure is 26.6%, which is in accordance with the relevant literature.

In general, almost half (49.6%) of the nursing events were observed in the second half of the dark period (2-6 hours). It is also clear that E does did not nurse later than eight hours after the start of the light period during both lactations. On the other hand D does visited the nest and nursed for the rest of the day as well. In group D, a second peak of lactation was observed at around 4 p.m., which is consistent with the time of the second nursing event of the does' second nursing event as a kit.

There is a trend in live weight of kits ( $P < 0.1$ ) in favour of kits in group D, but the difference can only be demonstrated statistically on the 13<sup>th</sup> day of age ( $P < 0.05$ ). It is assumed that due to the high variance in the weight of the kits in E group, no significant differences were found at additional times. Nursing once and twice during the early ages of the does' had no effect on the weight gain and mortality of the kits during the first two lactations (E: 8.8%; D: 8.8%).

#### **4. CONCLUSIONS AND SUGGESTIONS**

Our observations show that suckling rabbits consumed milk powder-based and soybean-based solid supplementary feed (pellets), but nevertheless did not consume less milk, it did not improve the weight and weight gain of the suckling rabbits, and did not reduce the mortality of the kits.

Unlike in the literature, the beneficial effect of the thyme supplement on the feed preference could not be demonstrated.

It can be concluded that the kits were able and willing to eat solid supplementary feed made of piglet feed formula. Kits in the piglet feed based pellet group had higher body weight (+6-9%) from the 12<sup>th</sup> days of age throughout the study, compared to both other groups. The added energy source (glycerine) had no effect on the weight, growth and mortality of kits.

Does and suckling rabbits voluntarily consumed the drench solutions. Overall, it can be concluded that powder-based drench solutions were preferred by rabbits over liquid-based drench solution. The consumption of drench solutions did not affect most of the production parameters (does, kits). A drenching method for rabbits requires testing solutions with a composition and concentration that is more adapted to the needs of rabbits.

It can be concluded that the method of nursing at an early age (nursing once or twice a day) had an effect on the lactation behaviour of the does. Does raised by two mothers nursed more than once a day compared to once-a-day nursed does. However, the weight gain and the survival of suckling rabbits was not affected by the way does were raised.

Based on our results, our further goal is to increase the consumption of supplementary feed in order to make greater use of the growth potential of kits, and to objectively measure the consumed amount of feed. Studies shall be carried out on the use of various nutritious substances and ingredients as supplementary feedstuffs. Further studies are needed to develop a method that gives more pronounced results and can be applied in practice.

## 5. NEW SCIENTIFIC RESULTS

1. Suckling rabbits consumed milkpowder-based (90% milk powder), soybean-based (82.5% soybean) and piglet feed based (79.5% piglet formula) solid pellets at 2-19 days of age, but supplementary nutrition did not affect milk consumption. Feeding milkpowder-based and soybean-based pellets had no effect on the weight, weight gain and mortality of suckling rabbits. Supplementary feed made from piglet formula had a positive effect on the growth of suckling rabbits.
2. Contrary to the literature, thyme supplementation in the feed of the rabbit does (200 mg/kg) and in the solid feed of suckling rabbits (1%) had no beneficial effect. Glycerine (11.9%) as an energy source in the additional feed for suckling rabbits has also proved ineffective.
3. Rabbit does and suckling rabbits voluntarily consumed the drench solutions offered from drinkers. The powder-based drench solution was consumed at a higher rate than the liquid-based drench solution. However, the consumption of the drench solutions did not affect the production (does, suckling kits).
4. It can be stated that the way the does are raised has an effect on their nursing behavior. Does who were nursed twice-a-day during the early age were more likely to nurse several times a day (70.5%) compared to the once-a-day nursed group (26.6%). The weight gain and the survival of suckling rabbits were not affected by the way the does were raised.



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## **7. PUBLICATIONS ON THE SUBJECT OF THE DISSERTATION**

### ***Peer-reviewed papers published in foreign scientific journals***

Kacsala, L., Szendrő, Zs., Gerencsér, Zs., Radnai, I., Kovács, M., Kasza, R., Nagy, I., Odermatt, M., Atkári, T., Matics, Zs. 2018. Early solid additional feeding of suckling rabbits from 3 to 15 days of age. *Animal: The International Journal of Animal Biosciences* 12:1 pp. 28-33.

Kacsala, L., Tóth, T., Gerencsér, Zs., Matics, Zs. 2018. Effect of providing different drench solutions on lactating does and suckling kits. *Journal of Central European Agriculture*. 19:4 pp. 943-947.

### ***Peer-reviewed abstracts published in foreign scientific journals***

Kacsala, L., Szendrő, Zs., Radnai, I., Gerencsér, Zs., Ács, V., Terhes, K., Andrásyné, Baka G., Kasza, R., Odermatt, M., Matics, Zs. 2018. Milk powder based solid additional feeding of suckling rabbit kits in early age. *World Rabbit Science*. 26:2 pp. 195.

Kacsala, L., Radnai, I., Gerencsér, Zs., Ács, V., Terhes, K., Matics, Zs. 2018. Nursing behaviour of rabbit does which were nursed once or twice a day (preliminary results). *World Rabbit Science*. 26:2 pp. 195.

### ***Peer-reviewed full conference papers, proceedings in foreign language***

Kacsala, L., Tóth, T., Gerencsér, Zs., Matics, Zs. 2018. Examination of different provided drench solutions on lactating does and suckling kits. VI. American Rabbit Congress, Goiania, Brazilia. Paper: 0601. 5p.

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