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Article

The Influence of Male Biostimulation on Cloacal Anatomy and Egg Laying Behaviour in Young Female Muscovy Ducks (*Cairina moschata forma domestica*)

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Simple Summary: This study analysed the effects of male biostimulation on female Muscovy ducks before egg laying. The results demonstrated that the biostimulated female ducks were influenced before egg-laying and laid eggs sooner than isolated ducks. Moreover, it has been demonstrated that changes in cloacal morphology can be utilized as a differentiating characteristic among ducks in either the pre- or post-laying phase. In summary, this study establishes a basis for improving the productivity of Muscovy duck farms.

Abstract: The importance of Muscovy ducks in industrial poultry production is growing; however, little is known about the physiology of their reproductive cycles. This study investigated the influence of male biostimulation on female ducks before the commencement of the laying phase. A total of 30 muscovy ducks, hatched in the same year at 289–341 days of age, were divided into two groups of 15 birds each and kept with and without contact with a male duck until the day of first egg laying 319 ± 14 and 335 ± 13 respectively. Before reaching egg-laying maturity, the cloacae of 29 adult ducks were subjected to daily clinical assessments. The evaluations yielded four unique categories of outcomes, determined by assessing factors such as the degree of redness and protrusion of the mucous membrane, moisture level, and swelling of the cloacal sphincter muscle. The results of the study on biostimulation revealed that, on average, female ducks that had contact with males laid their first egg 16 days earlier, weighing 78.7 ± 3.0 g, compared to isolated female ducks weighing 79.1 ± 7.0 g. Furthermore, there was no significant difference observed in the mean initial egg weight between groups ($p = 0.841$). The cloacal morphology indicated significant morphological changes 25–26 days before laying. Efforts to improve Muscovy production and develop biotechnological techniques to modify the reproductive cycle will benefit from these advancements.

Keywords: biostimulation; cloaca; ducks; egg laying; Muscovy; reproduction

1. Introduction

Biostimulation refers to the utilization of natural, advantageous, and cost-effective techniques involving the use of olfactory, visual, and auditory cues for interaction within the same species, which were reported first in ungulates in 1969 [1–4] and can impact neuroendocrine and behavioural responses, ultimately affecting reproductive efficiency and ovulation synchronisation in various animal species [5]. According to research, interactions among individuals in nature can have a significant effect on reproductive physiology [6], which is shown in domestic and farm animals, laboratory rodents, and primates to synchronise their reproductive activities with others of the same species [7].

Originally defined as the influence of a male on a female sexual status, biostimulation has become an intricate field. Recent findings indicate that biostimulatory effects extend beyond the impact of males on females [8–10]; females also elicit a reproductive response to female-male and female-female interactions, where female chemical signals play important roles in sexual attraction

[11–16]. According to the literature review, research on sheep, pigs, and goats demonstrates a noteworthy impact of biostimulation [17–20]. Although the male-female effect in cattle interaction has been demonstrated to affect female reproductive activity, it has received little attention [21]. Consequently, this practice has not yet become the standard for farms [10]. El-Azzazi et al. [22] noted a slight improvement in the reproductive performance due to the male effect.

In addition, numerous studies have been conducted on the female reproductive cycles of various poultry species, including domestic poultry, leading to a comprehensive understanding of the physiological and anatomical alterations in the female genital tract throughout the sexual maturation and reproductive process in these species [23–26]. In this context, the reproductive activity and effectiveness of chickens are significantly influenced by various environmental factors, including stress, housing conditions, availability of feed and water, and daily and seasonal changes [27–29]. Interestingly, studies investigating conspecific biostimulation in waterfowl are lacking. However, a previous study demonstrated that male turkeys play a role in the quantity of parthenogenetically fertilised eggs [30]. Additionally, in terms of king penguins, it has been reported that ambient noise coming from both their colony and to a lesser degree, a different colony can affect sexual behaviour and ovulation control, ultimately determining when eggs are laid. These environmental factors ultimately influence the reproductive success of king penguins with respect to egg-laying [31].

There is limited information available on the reproductive physiology of Muscovy ducks, and no studies have been conducted on modifying their reproductive cycle, despite the various significant roles played by other poultry species in global production [32]. The Muscovy duck (*Cairina moschata* forma domestica) is also playing an increasingly important role in industrial poultry production. This study, therefore, aimed to assess whether the reproductive performance of female Muscovy ducks can be improved by biostimulation through exposure to male conspecifics. Additionally, investigations were conducted to determine variations in cloacal conditions before the beginning of the laying period and to create a clinical examination method to forecast the points of laying.

2. Materials and Methods

All the data were collected on a breeding farm as part of routine procedures and, therefore, do not require animal welfare approval under German law. The research involved the use of 35 Muscovy ducks, consisting of five males and 30 females, which were chosen from a lineage with the goal of minimizing genetic variation among individuals. Each duck was artificially hatched in uniform breeding conditions and reared separately according to their sex. At the beginning of the study, the female ducks had not exhibited any egg-laying behavior. The male ducks were identified using unique footrings from the Federal Association of German Poultry Breeders (BDRG) and colour-coded plastic rings. Female ducks were also marked with BDRG foot rings, and individually numbered plastic wing tags were attached to their right-wing membranes. The ducks were housed in sex-segregated groups before observation.

2.1. Testing Mature Conspecific MALES for biostimulation

Prior to the start of the experiment, all animals were separated into groups based on their genders. The investigation commenced by involving two fully grown drakes, aged approximately 24 and 36 months, and three juvenile ducks that were hatched alongside the female ducks, in relation to the utilization of male ducks that had been previously used. 30 female ducks hatched within 60 days were randomly allocated to six outdoor aviaries, each measuring 6 x 1.5 meters. Each aviary was equipped with a one meter long feeding trough, a ten-liter inverted drinker and a nesting box of specific dimensions. Subsequently, 15 ducks were divided into three aviaries, each with five birds, arranged so that from the beginning of the study until the laying period, a sexually mature male duck could always be housed in a neighboring enclosure. During this time, the ducks had contact with the male ducks and constantly interacted tactilely, visually, auditorily and olfactorily, while another group of 15 ducks was divided into three further aviaries with five animals each. These aviaries were placed at a distance of about 100 meters, without any possibility of contact with male ducks. Consequently, all ducks were subjected to identical climatic and light conditions. In addition, the

length of days it took each duck to lay its first egg was accurately documented, along with the weight of the egg, to determine whether the inclusion of a male duck had a positive effect on the number of eggs produced and the weight of the first egg. Finally, the five male ducks were housed separately in 6 x 1.5-meter enclosures adjacent to three of the duck enclosures (Figure 1).



Figure 1. Demonstration of housed ducks (left) with contact to a drake (right) enabled by an olfactory, visual and acoustic connection through a wire mesh fence.

2.2. Determination of Cloacal Morphology

The cloacal morphology of the experimental ducks was determined by a systematic external examination of the cloaca on alternate days as soon as the first duck had indicated sexual maturity by laying the first egg. (Figure 2). A duck exhibited a persistent incident of cloacal mucosa, leading to its exclusion from the data collection. In this procedure, the animal being examined is secured upside down between the legs of the seated examiner. The tail is bent over the duck's back using the middle, ring, and little fingers of the left hand, while the cloaca is exposed from the plumage with the thumb and index finger of the same hand. The parameters to be evaluated included the level of redness and edema of the Musculus sphincter cloacae (MSC), the degree of MSC opening during the tail bending over the duck's back, the level of moisture and redness of the cloacal mucosa, and the extent to which the cloacal mucosa bulges out when the tail is bent through the cloacal opening. The data was systematically recorded, sorted, and appraised in readiness for the start of egg laying (Table 1). Subsequently, the findings were then categorized based on the subjective classification system, specific animal, and day of examination. After the initiation of the egg-laying activity, the collected data were converted into days before the commencement of laying to analyse the morphological changes preceding this activity.



Figure 2. Displaying of various diagnostic Cloacae classes, including Low-grade (1), Medium-grade (2), High-grade (3), and Musculus sphincter (4).

Table 1. Description of subjective diagnostic classes 1–4 as low-grade (lg), medium-grade (mg), high-grade (hg) and musculus sphincter cloacae (MSC), respectively.

	Class 1	Class 2	Class 3	Class 4
Redness of MSC	none	lg	mg	mg - hg
Edema of MSC	none	lg	mg	mg - hg
Opening of MSC	none	lg	mg	hg
Moisture in the cloacal opening	none	no	lg	mg - hg
Redness of Cloacal Mucosa	none	lg	mg	mg - hg
Protrusion of Cloacal Mucosa	none	no	lg	mg - hg

2.3. Detection of Laying Activity

To detect the act of laying eggs, the nesting boxes were examined during the time frame of 8 to 9 a.m. to determine if any eggs were present. If an egg was found, each animal within the associated aviary underwent digital screening to identify any egg-laying activity. The examiner then used their left hand to secure the wings of the animal at the level of the humeri and gently pressed them onto the ground. Subsequently, the examiner cautiously inserted the middle, ring, or little fingers from the right hand into the cloaca. When the duck laid an egg, a still shell-free and plump-elastic egg was felt through the cloacal wall on the right side of the belly.

2.4. Statistical Analysis

The data collected during the study were meticulously recorded in Excel® data sheets, while the statistical inquiries were computed utilizing the SPSS 15.0 statistical program (SPSS Software GmbH, Munich). In order to evaluate the influence of biostimulatory effects and hatching date, a T-test was performed to compare the disparities in the onset of laying and initial weight, aiming to identify any significant differences ($p < 0.05$) in the recorded parameters. Differences were considered significant if $p < 0.05$.

3. Results

3.1. Biostimulation by Male Counterparts

The research results demonstrated that all 30 sexually mature female Muscovy ducks began laying eggs, and each duck showed the presence of a second egg, without a shell, in the left dorsocaudal abdominal region of every duck. At 289–341 days of age, 15 ducks housed in visual, olfactory, and auditory contact with a male counterpart laid their first egg. The eggs were laid by the isolated ducks on days 312–358 of their lives. The average age of eggs laid by drake-stimulated ducks was 16 days earlier than solitary females (319 ± 14 vs 335 ± 13 days of age, respectively, $P=0.003$). The first-laid eggs in the drake contact group weighed an average of 78.7 ± 3.0 g. Nonetheless, the average weight of the eggs without drake contact was 79.1 ± 7.0 g, which did not differ significantly ($p=0.841$) from the eggs with drake contact (Table 2).

Table 2. Mean and standard deviation of the age of female Muscovy ducks at the onset of egg-laying activity in days with or without drake contact.

Nr.	Age at egg-laying(days)	Weight of first egg (grams)	Age at egg-laying (days)	Weight of first egg (grams)
1	289	81	312	70
2	299	78	321	79
3	309	81	323	76
4	310	82	325	79
5	313	73	328	80
6	315	75	329	79
7	316	79	333	73
8	322	78	333	98
9	322	82	333	79
10	325	83	338	78
11	325	78	342	78
12	327	77	347	87
13	333	75	350	82
14	337	82	350	81
15	341	77	358	68
319 ± 14		78.7 ± 3.0	335 ± 13	79.1 ± 7.0 g

There was a statistically significant difference between the two groups each 15 ducks ($p= 0.003$). However, the average egg weight was not significantly different between the two groups each 15 ducks ($p= 0.841$), ($n=30$).

3.1. Cloacal Anatomy before Laying

The results demonstrated in Table 3 indicate that significant alterations in the cloaca morphology were visible as early as the 25th or 26th day before the start of laying. Every female duck showed a class 1 morphology. After the 25th and 26th day before laying, 75% of the ducks were still classified as Class 1. The proportion of animals with Class 3 cloaca significantly increased prior to the first or second day before egg laying ($p = 0.003$). Up to the 9th or 10th day before the first egg, the Class 1 cloaca drastically decreased ($p < 0.001$). Most animals (97%) demonstrated signs of Class 3 cloaca two to three days before their first egg laying. Prior to egg laying, only 13% of the ducks showed a Class 4 cloaca, whereas following the laying process, 97% demonstrated a Class 4 cloaca. The increase in Class 4 cloaca on the 3rd day before egg laying was deemed statistically significant ($p < 0.001$).

Table 3. Cloacal findings in female Muscovy ducks within 58 days before the onset of egg laying (n=29).

Days before the onset of laying	Class 1	Class 2	Class 3	Class 4
	n / %	n / %	n / %	n / %
58-27	197 / 100	0 / 0	0 / 0	0 / 0
26-25	19 / 75	6 / 25	0 / 0	0 / 0
24-23	21 / 84	4 / 16	0 / 0	0 / 0
22-21	14 / 70	6 / 30	0 / 0	0 / 0
20-19	13 / 59	9 / 41	0 / 0	0 / 0
18-17	9 / 36	16 / 64	0 / 0	0 / 0
16-15	9 / 32	19 / 68	0 / 0	0 / 0
14-13	3 / 12	21 / 81	2 / 8	0 / 0
12-11	1 / 4	14 / 58	9 / 38	0 / 0
10-9	0 / 0	14 / 50	14 / 50	0 / 0
8-7	0 / 0	9 / 33	18 / 67	0 / 0
6-5	0 / 0	4 / 14	24 / 86	0 / 0
4-3	0 / 0	1 / 3	28 / 97	0 / 0
2-1	0 / 0	2 / 6	26 / 81	4 / 13
Laying	0 / 0	0 / 0	1 / 3	28 / 97

The classification of diagnostic classes 1 to 4 includes low-grade (lg), medium-grade (mg), high-grade (hg), and musculus sphincter cloacae (MSC), respectively.

4. Discussion

Physiological and structural alterations in the female genital tract during sexual development and the reproductive cycle in domestic poultry species are well-documented [25,26]. Previous studies have demonstrated the advantageous effects of conspecific biostimulation on puberty onset, oestrus stimulation, synchronisation, and ovulation rate in various species, such as sheep [18], goats [20], pigs [19,33,34], and cattle [35–37]. This biostimulation technique is a convenient and cost-effective means of enhancing the reproductive performance of domestic mammals. Interestingly, the effects of male conspecific biostimulation in domestic poultry have not yet been investigated. However, it has been found that acoustic signals can influence the egg-laying behaviour of penguins [31]. A popular and economical method for improving female reproductive performance in domestic mammals is the use of male counterparts for biostimulation [17]. In particular, a combination of auditory, visual, and olfactory stimuli elicited the strongest response in sheep [38] and pigs [34].

The primary objective of this study was to investigate the effect of male biostimulatory effects on the initiation of egg laying in young female Muscovy ducks. The study additionally assessed the cloacal conditions before egg laying to develop predictive clinical examination techniques. The current investigation demonstrated that female ducks exposed to male ducks through biostimulation experienced a mean advancement of 16 days in laying their initial egg compared to female ducks that were isolated. Moreover, isolated ducks without male interaction exhibited significant changes in cloacal morphology 25–26 days prior to egg laying. This suggests that Muscovy ducks are sensitive to environmental influences such as male effects through biostimulation. Conversely, research indicates that variables such as feed and water availability, housing conditions, stress, and seasonal and daily variations significantly influence reproductive activity and efficiency [39,40], supporting the results of the current investigation. Research has shown that the presence of males can speed up the egg-laying process in females. It is essential to note that the reproductive cycle of domestic poultry is controlled by hormones. In birds, unlike mammals, the selection of a follicle is not influenced by neighboring follicles’ inhibitory or stimulatory effects. The maturation and differentiation of follicles in the ovary are regulated by follicle-stimulating hormone (FSH) and vasoactive intestinal peptide (VIP) from the gastrointestinal tract. Moreover, FSH and VIP play a role in facilitating cellular processes within the follicles through paracrine and autocrine mechanisms [41]. Therefore, this

description suggests that hormonal changes due to the presence of males may act as a biostimulation factor in accelerating the reproductive cycle in Muscovy ducks.

Efficient diagnosis of approaching or occurring oestrus is of great importance for farm animals among domestic mammals, especially in terms of efficient insemination or controlled mating. The clinical examination of the external and internal female genitalia plays a significant role in this matter [42]. However, in poultry, an examination to predict or diagnose ovulation and the onset of the laying period has not yet been described. A crucial aspect of this study was, therefore, to determine whether it is possible to predict the onset of laying through clinical examination of the female genitalia of Muscovy ducks. The anatomical structures to be examined were defined and their relevant characteristics were divided into four diagnostic classes. This study provides evidence of the biostimulatory effect of male conspecifics on waterfowl. However, it remains unclear whether specific auditory, visual, or olfactory cues act independently or in conjunction to accelerate the onset of puberty. Previous studies in mammals have demonstrated that female reproductive performance is enhanced by olfactory, tactile, visual, and auditory cues from male conspecifics [17,35]. In addition, an ongoing investigation revealed that it is possible to predict the initiation of egg laying in Muscovy ducks by conducting a clinical assessment of the cloaca. Similar to previous studies conducted on cattle and pigs, in which the examination of external genitalia was used to determine the optimal timing for artificial insemination [43,44], it was feasible to select ducks with grade 4 cloaca for either artificial insemination or natural mating from a larger population of breeding animals. This approach eliminates the need to maintain small breeding groups comprising only one male and a maximum of ten females. A significant number of ducks can, therefore, be paired with a duck for line breeding without sacrificing one or two eggs for incubation, considering insemination is performed only after the first egg is laid. In contrast, ducks that prioritise fertilised eggs from the beginning no longer require multiple-blind inseminations; instead, they may be selectively inseminated shortly before the initiation of anticipated egg-laying. The cloacal examination additionally enabled the selection of a large number of mother ducks into smaller groups. Considering that animals at different reproductive stages have varying dietary energy, nutrient, and mineral requirements [45], ducks may be fed more accurately based on their specific needs. Furthermore, ducks with grade 1 cloacae, which are still at least 10 days away from egg-laying, may be selected and stimulated towards earlier maturity through biostimulatory effects such as light programs or exposure to male. Ultimately, in order to assess the impact of male Muscovy ducks on the reproductive success of females, visual, auditory, and olfactory stimuli were employed. Should the beneficial outcomes of biostimulation in Muscovy ducks be validated, it is imperative to explore selective stimulation methods in forthcoming research endeavors.

5. Conclusions

To sum up, advancements in Muscovy duck production and the application of biotechnological strategies to manipulate the reproductive cycle will prove advantageous. The findings indicate that young Muscovy ducks when exposed to a male drake commenced egg laying approximately 16 days earlier on average, whereas their initial egg weight remained unaffected. This early onset of egg laying has important implications for the cost-effectiveness of large breeding flocks. By starting egg production earlier, these ducks have the opportunity to increase their income and reduce production costs. In addition, the earlier start of egg laying allows for a faster turnover of eggs, resulting in more frequent sales and potentially higher profits. Furthermore, the shorter time to egg production helps to reduce the overall costs associated with rearing ducks until they reach laying age. Therefore, optimizing the time to start laying can have a positive impact on both the financial profitability and efficiency of duck farming. However, this study did not examine whether certain stimulus variables led to an early onset of puberty, and more research is needed to address this issue. Consequently, it is plausible that the collective influence of these stimuli contributes to some of the effects observed in ducks. Further research is, therefore, necessary to ascertain the extent to which tactile cues stimulate Muscovy ducks and the relative significance of each stimulus in females.

Author Contributions: M. Linde was responsible for sample collection and record evaluation. M. Linde, A. Wehrend, A. Farshad, and M. Linde collaborated extensively to critically assess the text and statistical findings, compose the manuscript, and evaluate the sources.

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Institutional Review Board Statement: The experimental procedures conducted are in accordance with the regulations established by the Justus-Liebig University of Giessen. This is done to ensure the welfare of experimental animals (Justus-Liebig University of Giessen, , Giessen; Germany).

Informed Consent Statement: I confirm that the above mentioned publication does not fall under the legislation for the protection of animals used for scientific purposes according to the German Animal Welfare Act (Tierschutzgesetz §7 and Tierschutz-Versuchstierverordnung) and to EU directive 2010/63. No special permission of the Local Ethical Committee is needed. We consider that this type of project has no impact on animal welfare. (Dr. Guido Haschke, veterinarian, specialist in experimental animals animal welfare officer, member of ethical board, Justus Liebig University Gießen, Germany).

Data Availability Statement: The data included in this study are the property of the authors and can be obtained by contacting the corresponding author at afarshad@uok.ac.ir or abbas.farshad@vetmed.uni-giessen.de upon a reasonable request.

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References

1. Murata, K.; Tamogami, S.; Itou, M.; Ohkubo, Y.; Wakabayashi, Y.; Watanabe, H.; Okamura, H.; Takeuchi, Y.; Mori, Y. Identification of an olfactory signal molecule that activates the central regulator of reproduction in goats. *Curr. Biol.* **2014**, *24*, 681–686. DOI:10.1016/j.cub.2014.01.073.
2. Chenoweth, P.J.; McPherson, F.J.; Landaeta-Hernandez, A.J. Reproductive and maternal behavior of livestock. *Genet. Behav. Domest. Anim. (3rd. ed.)* **2022**, 183–228. DOI:10.1016/B978-0-323-85752-9.00004.
3. Ungerfeld, R.; Orihuela, A.; Pérez-Clariget, R. Sexual behavior of subordinates, but not dominant, rams increases following observed sexual activity. *Theriogenology* **2019**, *129*, 99–102. DOI:10.1016/j.theriogenology.2019.02.033.
4. Fraser, A.F. *Reproductive Behavior in Ungulates*; Academic Press: New York, 1969.
5. Chen, P.; Hong, W. Neural circuit mechanisms of social behavior. *Neuron* **2018**, *98*, 16–30. DOI:10.1016/j.neuron.2018.02.026.
6. Choudhary, S.; Lal Kamboj, M. Effect of bull biostimulation on the oestrous behaviour of pubertal Sahiwal (*Bos indicus*) heifers. *Anim. Reprod. Sci.* **2019**, *209*, 106149. DOI:10.1016/j.anireprosci.2019.106149.
7. Martin, G.B.; Milton, J.T.B.; Davidson, R.H.; Banchemo Hunzicker, G.E.; Lindsay, D.R.; Blache, D. Natural methods for increasing reproductive efficiency in small ruminants. *Anim. Reprod. Sci.* **2004**, *82–83*, 231–245. DOI:10.1016/j.anireprosci.2004.05.014.
8. Gelez, H.; Fabre-Nys, C. The “male effect” in sheep and goats: a review of the respective roles of the two olfactory systems. *Horm. Behav.* **2004**, *46*, 257–271. DOI:10.1016/j.yhbeh.2004.05.002.
9. Chenoweth, P.J.; Landaeta-Hernandez, A.J.; Floercke, C. Reproductive and maternal behavior of livestock. In *Genetics and the Behavior of Domestic Animals*; Academic Press, Elsevier: London UK, Waltham and San Diego, USA, 2014.
10. Rajanarayanan, S.; Archunan, G. Identification of urinary sex pheromones in female buffaloes and their influence on bull reproductive behaviour. *Res. Vet. Sci.* **2011**, *91*, 301–305. DOI:10.1016/j.rvsc.2010.12.005.
11. Rodríguez-Martínez, R.; Angel-García, O.; Guillen-Munoz, J.M.; Robles-Trillo, P.A.; De Santiago-Miramontes, M.A.; Meza-Herrera, C.A.; Mellado, M.; Veliz, F.G. Estrus induction in anestrous mixed-breed goats using the “female-to-female effect”. *Trop. Anim. Health Prod.* **2013**, *45*, 911–915. DOI:10.1007/s11250-012-0305-z.
12. Orihuela, A.; Clemente, N.; Ungerfeld, R. Close contact with spontaneously cycling Saint Croix ewes triggers cyclic activity in seasonally anestrous Suffolk ewes. *Anim. Prod. Sci.* **2016**, *56*, 1816–1819. DOI:10.1071/AN141005.
13. Coombes, H.A.; Stockley, P.; Hurst, J.L. Female chemical signalling underlying reproduction in mammals. *J. Chem. Ecol.* **2018**, *44*, 851–873. DOI:10.1007/s10886-018-0981-x.

14. Abecia, J.A.; Carvajal-Serna, M.; Casao, A.; Palacios, C.; Pulinas, L.; Keller, M.; Chemineau, P.; Delgadillo, J.A. The continuous presence of ewes in estrus in spring influences testicular volume, testicular echogenicity, and testosterone concentration, but not LH pulsatility in rams. *Animal* **2020**, 1–8. DOI:10.1017/s1751731120001330.
15. Abecia, J.A.; Canto, F.; Keller, M.; Palacios, C.; Chemineau, P.; Delgadillo, J.A. Exposure of rams in sexual rest to sexually activated males in spring increases plasma LH and testosterone concentrations. *Theriogenology* **2022**, 192, 116–121. DOI:10.1016/j.theriogenology.2022.08.035.
16. Rekwot, P.I.; Ogwu, D.; Oyedipe, E.O.; Sekoni, V.O. The role of pheromones and biostimulation in animal reproduction. *Anim. Reprod. Sci.* **2001**, 65, 157–170. DOI:10.1016/s0378-4320(00)00223-2.
17. Ungerfeld, R.; Ramos, M.A.; González-Pensado, S.P. Ram effect: adults rams induce a greater reproductive response in anestrus ewes than yearling rams. *Anim. Reprod. Sci.* **2008**, 103, 271–277. DOI:10.1016/j.anireprosci.2006.12.013.
18. Kemp, B.; Soede, N.M.; Langendijk, P. Effects of boar contact and housing conditions on estrus expression in sows. *Theriogenology* **2005**, 63, 643–56. doi: 10.1016/j.theriogenology.2004.09.038. PMID: 15626422.
19. Kemp, B.; Soede, N.M.; Langendijk, P. Effects of boar contact and housing conditions on estrus expression in sows. *Theriogenology* **2005**, 63, 643–656. doi: 10.2527/2000.784871x.
20. Veliz, F.G.; Moreno, S.; Duarte, G.; Vielma, J.; Chemineau, P.; Poindron, P.; Malpoux, B.; Delgadillo, D.A. Male effect in seasonally anovulatory lactating goats depends on the presence of sexually active bucks, but not estrous females. *Anim. Reprod. Sci.* **2002**, 72, 197–207. 10.1016/S0378-4320(02)00093-3.
21. Zalesky, D.D.; Day, M.L.; Garcia-Winder, M.; Imakawa, K.; Kittok, R.J.; D'Occhio, M.J.; Kinder, J.E. Influence of exposure to bulls on resumption of estrous cycles following parturition in beef cows. *J. Anim. Sci.* **1984**, 59, 1135–1139. DOI:10.2527/jas1984.5951135x
22. EL-Azzazi, F.E.; Hegab, I.M.; Hanafy, A.M. UniversitBiostimulation and reproductive performance of artificially inseminated rabbit does (*Oryctolagus cuniculus*). *World Rabbit Sci.* **2017**, 25: 313–321. 10.4995/wrs.2017.7446.
23. Özen, A.; Erguen, E.; Kueruem, A. Light and electron microscopic studies on the oviduct epithelium of the Pekin duck (*Anas platyrhynchos*). *Ank. Ueniv Vet. Fak. Derg* **2009**, 56, 177–181.
24. Mohammadpour, A.A.; Keshtmandi, M. Histomorphometrical study of infundibulum and magnum in turkey and pigeon. *World J. Zool.* **2008**, 2, 47–50.
25. Sharma, R.K.; Duda, P.L. Histomorphological changes in the oviduct of the mallard (Aves: Anatidae). *Acta Morphol. Neerl. Scand.* **1989**, 27, 183–192. PMID: 2636811.
26. Chaudhuri, S.; Maiti, B.R. Oviductal function during the annual ovarian cycle of a Wild Avian species, the Tree Pie (*Dendrocitta vagabunda*). *Biol. Rhythm Res.* **1999**, 30, 290–296. DOI:10.1076/brhm.30.3.290.3050.
27. Raud, H.; Faure, J.M. Rhythmic occurrence of sexual behavior and egg laying activity of Muscovy ducks. *Br. Poult. Sci.* **1990**, 31, 23–32. DOI:10.1080/00071669008417227.
28. Siopes, T.D. Lighting for summer egg production by turkeys: day length and light intensity. *Poult Sci.* **2007**, 86, 2413–2419. doi: 10.3382/ps.2007-00245.
29. Barnett, J.L.; Tauson, R.; Downing, J.A.; Janardhana, V.; Lowenthal, J.W.; Butler, K.L.; Cronin, G.M. The effects of a perch, dust bath, and nest box, either alone or in combination as used in furnished cages, on the welfare of laying hens. *Poult Sci.* **2009**, 88, 456–470. doi: 10.3382/ps.2008-00168.
30. Olsen, M.W. Influence of turkey sires and dams on the level of parthenogenesis in eggs of their daughters. *Poult Sci.* **1972**, 52, 2035–2039. 10.3382/ps.0512035.
31. Waas, J.R.; Caulfield, M.; Colgan, P.W.; Boag, P.T. Colony sound facilitates sexual and agonistic activities in royal penguins. *Anim. Behav.* **2000**, 60, 77–84. DOI:10.1006/anbe.2000.1415
32. Yan, X. The changing face of the world of duck production. *Inte. Hatch. Pract.* **2004**, 18, 7–9.
33. Mota, D.; Alonso-Spilsbury, M.; Mayagoitia, L.; Trujillo M.E.; Valencia, J.; Ramírez-Necoechea, R. Lactational estrus induction in the Mexican hairless sow. *Anim. Reprod. Sci.* **2002**, 72, 115–124. 10.1016/S0378-4320(02)00073-8.
34. Knox, R.V.; Breen, S.M.; Willenburg, K.L.; Roth, S.; Miller, G.M.; Ruggiero, K.M.; Rodriguez-Zas, S.L. Effect of housing system and boar exposure on estrus expression in weaned sows. *J. Anim. Sci.* **2004**, 82, 3088–3093. DOI:10.2527/2004.82103088X.
35. Rekwot, P.I.; Ogwu, D.; Oyedipe, E.O. Influence of bull biostimulation, season and parity on resumption of ovarian activity of zebu (*Bos indicus*) cattle following parturition. *Anim. Reprod. Sci.* **2000**, 63, 1–11. doi: 10.1016/s0378-4320(00)00163-9.
36. Landaeta-Hernández, A.J.; Giangreco, M.; Melendez, P.; Bartolome, J.; Bennet, F.; Rae, D.O.; Hernández, J.; Archbald, L.F. Effect of biostimulation on uterine involution, early ovarian activity and first postpartum estrous cycle in beef cows. *Theriogenology* **2004**, 61, 1521–1532. 10.1016/j.theriogenology.2003.09.002.
37. Landaeta-Hernández, A.J.; Meléndez, P.; Bartolomé, J.; Rae, D.O.; Archbald, L.F. Effect of biostimulation on the expression of estrus in postpartum Angus cows. *Theriogenology* **2006**, 66, 710–716. DOI:10.1016/J.Theriogenology.2005.10.023.

38. Knight, T.W.; Lynch, P.R. Source of ram pheromones that stimulate ovulation in the ewe. *Anim. Reprod. Sci.* **1980**, *3*, 133–136. DOI:10.1016/0378-4320(80)90040-8.
39. Flowers, W.L.; Esbenshade, K.L. Optimizing management of natural and artificial matings in swine. *J. Reprod. Fertil. Suppl.* **1993**, *48*, 217–228. PMID: 8145206.
40. Siopes, T.D. Lighting for summer egg production by turkeys: day length and light intensity. *Poult Sci.* **2007**; *86*, 2413–2419. DOI: 10.3382/ps2007-00245.
41. Barnett, J.L.; Tauson, R.; Downing, J.A.; Janardhana, V.; Lowenthal, J.W.; Butler, K.L.; Cronin, G.M. The effects of a perch, dust bath, and nest box, either alone or in combination as used in furnished cages, on the welfare of laying hens. *Poult Sci.* **2009**; *88*, 456–470. DOI:10.3382/ps2008-00168. PMID:1921513.
42. Parkhurst, C.R.; Mountney, G.J. Physiology and Reproduction in Poultry. In: Poultry Meat and Egg Production. Springer, Boston, MA, 1988. DOI: org/10.1007/978-4757-0683-3_
43. Kowalski, A.; Sokół, R. Influence of *Dermanyssus gallinae* (poultry red mite) invasion on the plasma levels of corticosterone, catecholamines and proteins in layer hens. *Pol. J. Vet. Sci.* **2009**, *12*, 231–235. PMID: 19645354.
44. Schams, D.; Butz, H.D. Zeitliche Beziehungen zwischen Brunstsymptomen, elektrischen Widerstandsveränderungen des Vaginalsekrets, präovulatorischer Ausschüttung des Luteinisierungshormons und Ovulation beim Rind. *Reprod. Domest. Anim.* **1972**, *7*, 49–56. DOI:10.1111/j.1439-0531.1972.tb00221.x.
45. De Kruif, A. Factors influencing the fertility of a cattle population. *J. Reprod. Fertil.* **1978**, *54*, 507–518. DOI:10.1530/jrf.0.0540507.
46. Scott, M.L.; Dean, W.F. Nutrition, and management in ducks. **1991**, New York: Ithaca, ISBN 0317030477, 9780317030471

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