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MORPHOMETRIC ANALYSIS OF ARTERIAL VASCULAR BRANCHES OF REPRODUCTIVE ORGANS IN RABBITS DURING THE INTENSIVE GROWTH PERIOD

The animal body presents a system, in which during the ontogenetic development many processes are regulated by the circulatory system. It ensures the blood circulation through vessels and the exchange of substances between tissues and organs, thus guaranteeing a structural and physiological development of organs, systems and the entire organism.

During the body development, the vascular system undergoes certain morphological changes that are in strict accordance with the organs changes at different stages of growth. Following the aforementioned, the examination of development laws of the vascular bed gives us the possibility to know the development trend of the organs, systems and the whole body, for establishing as precisely as possible the period of female rabbit physiological and sexual maturity.

Keywords: *arteries, female rabbits (does), vascularization, morphometry, physiological maturity, diameter, branches.*

Introduction. Blood circulation in domestic animals takes place through a completely closed system of blood vessels and plays an important role in the processes of structural and physiological development of the animal body [1–5].

Thus, in order to obtain the necessary clues, which can contribute to the understanding of development of the animal body and organ systems, it is necessary to study the vascularization particularities of these systems.

The need for a more in-depth anatomo-topographical study, with reference to the aspects variability of vascularization sources development, formation and distribution of the vascular bed in rabbit's genital apparatus compartments, is dictated by the technological needs of reproduction, maintaining the females' health, the problems solving of correcting and directing the functional process of reproduction [6–8].

Special attention deserves the analysis of individual and age variability of vascularization sources, the way of formation and distribution of the vascular bed in the reproductive organs. [9–11].

The goal of the work. Analysis and assessment of the morphometric changes of the arterial vascular bed of the genital organs in rabbits during the period of intensive growth, from the 2nd to the 4th month of postnatal development. The study

that will ensure and expand the possibility of knowing the laws of physiological development of this system.

Materials and methods. The experiment was carried out on animals from the zootechnical farm for intensive breeding of rabbits – hybrid HYPLUS. 28 healthy animals aged between 2 and 4 months were taken into the research study. The evaluation of the topography and morphometric changes of the rabbits' reproductive system blood network was carried out in the specialized laboratory of the Faculty of Veterinary Medicine of the Technical University of Moldova.

In the scientific examination process the following were used: anatomical tools (scalpel, dissecting needles, tweezers, etc.); caliper 31C628; AFMA anatomical magnifier; Samsung ES70 camera, RADWAGPS 210 R2 scale and polymer substances.

The animals used in the study were euthanized before slaughter in accordance with the legislation requirements. After the vascular bed injection and the polymer hardening, the blood network of the rabbits' reproductive system organs was subjected to morphometric analysis.

The morphometric method has a significant value for assessing the age changes of the rabbits' reproductive organs structural components. Based on some authors data, the vascular bed morphometric changes assessment can confirm the developmental legitimacy of this system in accordance with the organism growth [11, 13–15].

Thus, our research is based on the assessment of age-related morphometric changes of the rabbits' reproductive system arterial branches; observation the number of secondary and tertiary arterial branches; establishing the link between the age changes of the vascular bed compared to the period of intensive post-embryonic development of the species *Oryctolagus cuniculus* (HYplus hybrid).

Results of research and discussion. The examination of the morphological peculiarities of the rabbits' reproductive system vascular bed includes the assessment of the diameter and points of origin and termination of blood vessels.

Analyzing the scientific data and obtained in our research, we can find that the main sources of blood irrigation of the genital organs in rabbits are the ovarian artery (a.), uterine artery, vaginal artery and internal pudendal artery. These vessels undergo certain changes in their diameter, which are strictly related to the age changes of the target species.

The ovarian artery (*A. ovarica*) presents the main artery, which provides vascularization of the ovary, fallopian tube, cranial part of the uterine horns, sheets of the broad ligament of the uterus and the component parts of the ovarian bursa. The ovarian artery, having its point of origin at the level of the LV, goes laterally on the cranial edge of the uterus broad ligament, towards the ovarian bursa, where it emits the tubal branches, the proper ovarian artery and the fallopian tube valve artery. On

its path, in the middle third, it emits the cranial uterine artery (*A. uterina cranialis*), which ensures the vascularization of the uterine horns great curve and the uterus broad ligament.

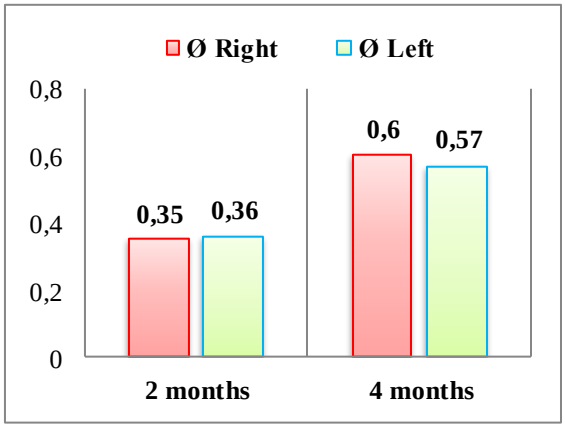

Fig. 1. Ovarian a. at the age of 2-4 months, mm

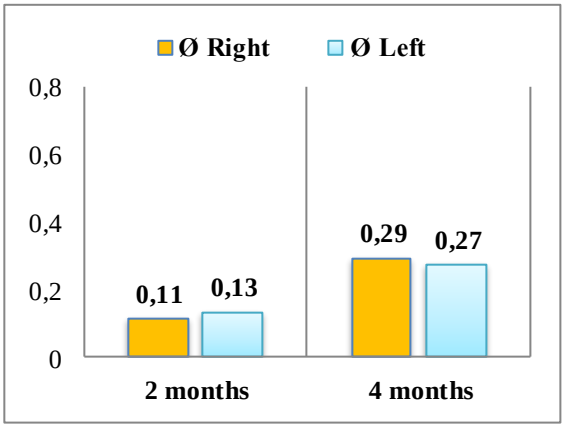

Fig. 2. Tubes branches at the age of 2-4 months, mm

From the data presented in figures 1, 2, 3, 4 we can see that right and left ovarian arteries, including their branches, undergo certain changes in diameter, which have a tendency to increase up to the 4th month of postnatal development of the reproductive system in rabbits.

According to the analysis of the data presented in figure 1, there are certain changes in the diameter of the right and left ovarian a. in the second month of growth, which is manifested by the insignificant increase of about 2.8% in diameter of the left ovarian a. compared to the right one and the increase till the fourth month of the right ovarian a. by about 5.0% compared to the left ovarian a. This proves that the changes in the diameter between the right and left ovarian main vessels, in the same age period, are not essential.

Analyzing the data obtained at different growth ages, we can see that the right ovarian a. shows an increase up to the 4th month by 0.25 mm, and the left one by 0.21 mm, demonstrating an absolute increase in the fourth month around 41.7% on the right and 36.8% on the left. These growth changes show us about 1.2 times greater development of the right a. ovarian compared to the left a. ovarian, confirming the absolute increase up to the 4th month by 16% of the right a. ovarian compared to the left one. Based on the above, we can see that the ovarian a. does not show essential changes between the right and left side at the 2nd month of growth, but shows a significant development till the fourth month of the animal's post-embryonic development.

After examining the changes in the diameter of the vascular branches of the ovarian a. shown in figure 2, it was observed that the tubes branches (*Ramus tubarius*) beginning from the 2nd month to the 4th month shows an increase of 0.18

mm on the right side and by 0.14 mm on the left. This proves an increase of about 17.9% of the right tubes branches compared to the left ones till the fourth month of the animal's development. Manifesting this growth, the tubes branches ended with its ramifications in the cranial portion of the uterine horns and in the fallopian tubes. The essential organ of the reproductive system is the ovary, which through its functioning ensures the sexual development and physiological maturation of the body. The vascularization of this organ is ensured by the proper ovarian artery, which, originating on its own or through the common trunk with the tubes artery, goes towards the posterior pole of the ovary, where it enters the organ providing its vascularization. During the body development, this vessel undergoes certain changes in diameter, which are shown in figure 3.

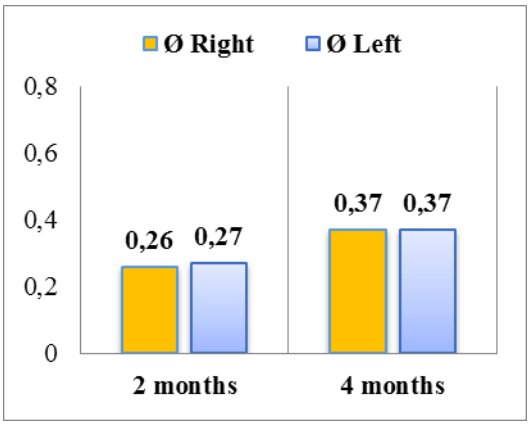

Fig. 3. Ovarian proper branches at the age of 2-4 months, mm.

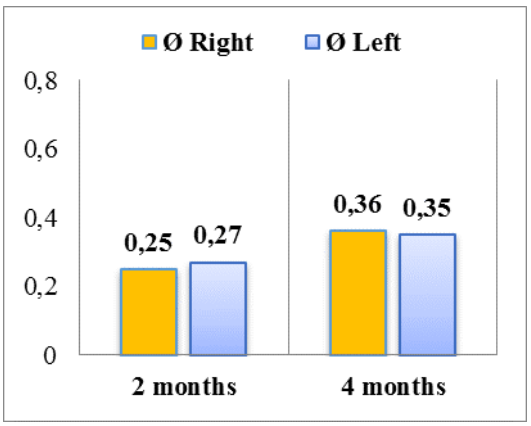

Fig. 4. Fallopian tube branches at the age of 2-4 months, mm.

Analyzing the data presented in figure 3, we can see that the actual ovarian branch (b.) (*Ramus ovarii*) demonstrates an average increase in diameter compared to the tubal branch by 54.7% at the age of 2 months and correspondingly by 24.3% at the age of 4 months.

The growth that proves that the ovarian branch is more developed in the 2nd month, but up to the 4th month of development the tubal branch shows an intensive growth reducing the growth ratio compared to the ovarian a. by about 0.9 times. At the same time, the actual ovarian b., also shows an increase of its own age, which constitutes 0.11 mm on the right side and 0.10 mm on the left side up to the 4th month, an aspect that confirms an increase of the diameter up to the 4th month by 29.7% on the right and 27.0% on the left compared to the 2nd month of animal development. The growth ratio of the actual ovarian b.**,** diameter on the right side shows an insignificant change and is higher by only 9.1% compared to the left side.

Another vascular branch that provides vascularization of the structures of the ovarian bursa, the fallopian tube and the fallopian tube pavilion is the fallopian tube artery. During its development, it acquires certain changes in diameter and creates

numerous bends along its path, thus providing the vascularization of all the previously mentioned segments of the reproductive system.

Taking into account the data presented in figure 4, which demonstrates the changes in the diameter of the fallopian tube pavilion b., we can note that the changes in the same period of growth between the right and the left side are not essential, but the changes between the ages demonstrate an increase till the fourth month by 0.11 mm on the right and 0.8 mm on the left. The given transformation indicates a change in diameter by 30.5% of the right branch and 22.8% of the left and confirms that through its changes, this branch provides vascularization to all segments of the ovarian bursa region throughout the course of the physiological development of the reproductive system.

The cranial uterine artery presents a branch of the ovarian artery, which, positioning itself between the sheets of the uterus broad ligament, emits many minor vessels that ensure-its vascularization and the cranial portion of the uterine horn. Like other branches of the ovarian artery, it undergoes certain changes in diameter during the reproductive system development. Thus, analyzing the obtained data, we can see that the changes in the growth of this vessel appear with increasing age of the animal and are 0.16 mm on the right side and 0.16 mm on the left side at the age of 4 months. That shows us an average increase of 43.2% compared to the 2nd month of development.

Analyzing the data obtained and demonstrated in figures 2, 3, 4, we can see that of all the branches of the ovarian a., the greatest average increase was demonstrated by the tubes b., constituting a change in diameter till the fourth month of physiological development of about by 57.1% compared to the 2nd month of development.

Following the mentioned, we can state that the ovarian artery, through its branches, creates the favorable conditions that ensure the growth and development of the rabbit's reproductive system organs.

Another main artery that provides vascularization of the genital system is the uterine artery. This artery, through its branches, participates in the irrigation of the uterine horns, the cervix and the vagina cranial end. This vessel during the reproductive organs development undergoes changes in diameter at the point of origin and at the level of its branches. Data of these changes are presented in figures 5, 6, 7.

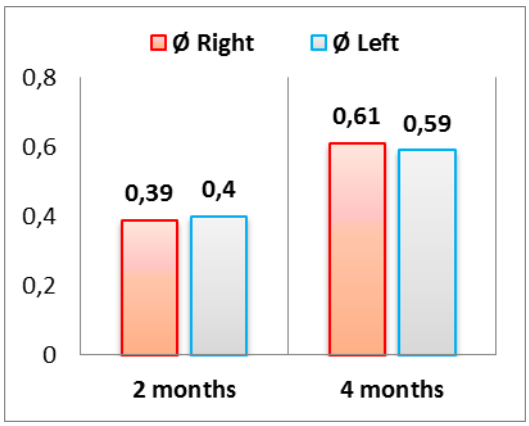

Figure 5. Uterine a. at the age of 2-4 months, mm.

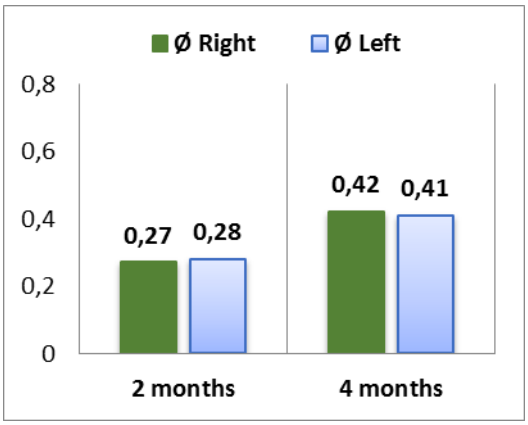

Figure 6. Anterior uterine a.b. at the age of 2-4 months, mm.

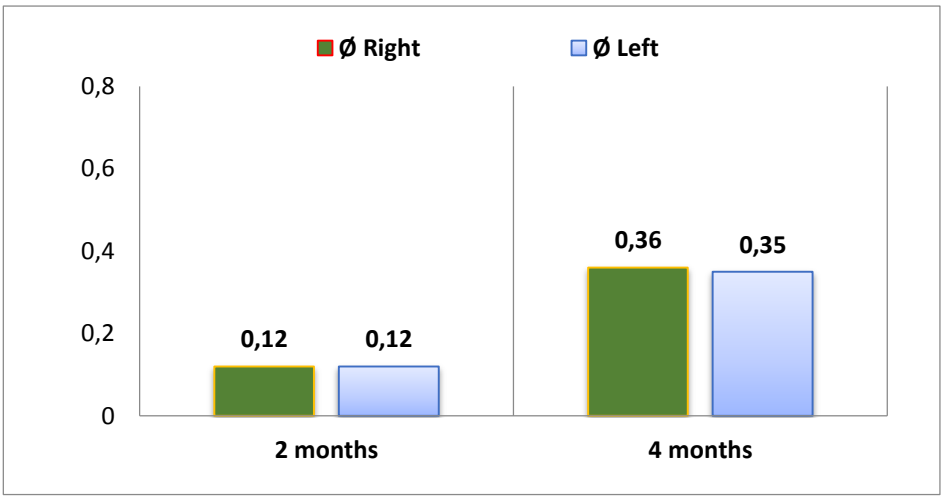

Figure 7. Posterior uterine b. at the age of 2-4 months, mm.

The volumetric dimensions of the uterine artery at its point of origin, from the analysis of the data presented in figure 5, show us that the left uterine artery at the 2nd month is 2.5% more developed than the right one, but up to the 4th month shows a decrease and is 3.3% smaller than the right one. It shows us an inconstant increase with age of the vascular branches in different parts of the animal body. Taking into account the age of the animal, in addition to the disproportionate growth of the vessel, we can see that the diameter of the vessels increases, from the 2nd month to the 4th month, by 0.22 mm on the right side and 0.19 mm on the left, which characterizes an average increase of about 1.5 times up to the fourth month of development. In the context of the obtained data, we can state that the uterine artery shows an insignificant increase at each age between the right and the left side, but it has a significant increase of 34.2% up to the 4th month of post-embryonic development.

To ensure the vascularization of all the uterus segments, the uterine artery emits the anterior and posterior branches, which through their terminations penetrate the organ walls, ensuring the formation of the blood microcirculation network.

Based on the data presented in figure 6, we can observe the anterior uterine b., providing the irrigation of the uterine horns, it shows age-related changes in diameter and constitutes by the 2nd month on the right side 0.27 mm and the left side 0.28 mm and consecutively at the 4th month the diameter of the vessel is 0.42 mm on the right and 0.41 mm on the left, showing an insignificant increase. But we can see an essential increase up to the 4th month with about 0.15mm or 35.7% on the right side and 0.13mm or 31.7% on the left.

Another change in the diameter of the vessels was shown in figure 7, where the changes in the diameter of the posterior uterine arteries can be seen. Like the previous one, it does not show any essential changes between the right and left sides at the ages of 2 and 4 months, but shows a major increase till the fourth month. Thus, the increase in the 4th month of post-embryonic development of the posterior uterine branch is on the right side by 0.24 mm and the left side by 0.23 mm, demonstrating an average increase by 66.2% compared to 2nd month of body development. Again from the mentioned we can see that the posterior uterine b., shows a higher average growth tendency, by 40.4%, compared to the anterior uterine branch.

Following the mentioned, the changes in the diameter of the uterine artery and its branches, till the fourth month, demonstrate the physiological metamorphism of the animal body, as a result of which, along with the increase in size of the uterus, the development of the vascular bed is also manifested, which spreads in all segments of this body.

Another segment of the reproductive system that requires an examination of the vascular bed development process is the vagina and vulva, which in turn are irrigated by the vaginal and internal pudendal arteries.

The vaginal artery is the last collateral of the internal iliac artery with its point of origin on the medial side of the corresponding artery. Through its secondary and tertiary branches, it ensures the vascularization of the caudal portion of the vagina and the vaginal vestibule up to the origin of the vulva, where it anastomoses with the branches of the vaginal vestibule of the internal pudendal artery. Like the other vessels of the reproductive system, vaginal a. undergoes diameter changes at the point of origin, which are included in figure 8.

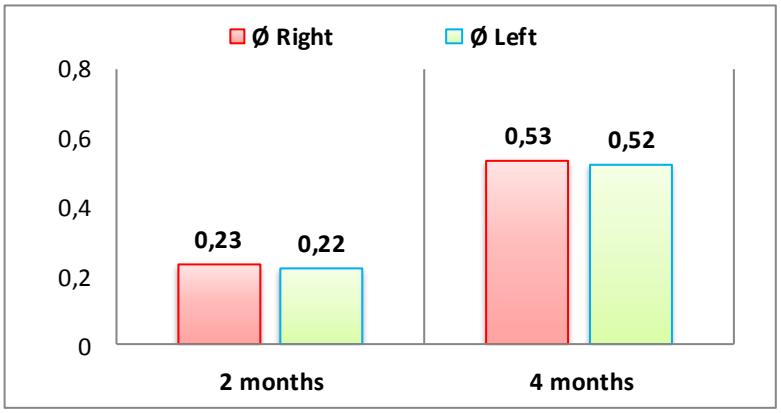

Figure 8. Vaginal a. at the age of 2-4 months, mm.

Analyzing the data in figure 8, we can see that the diameter of the vessel at the age of 4 months is 0.53 mm on the right side and 0.52 mm on the left side, which demonstrates an increase of 56.6% on the right side and 57.6% on the left compared to the second month. At the same time, from the obtained data we can see that the vaginal a. has a higher intensity of growth compared to other branches of the reproductive system and is 27.8% higher than the ovarian a. and by 40.8% compared to the uterine artery. These differences prove that during the period from the 2nd to the 4th month, an intensive growth of the external genital organs takes place.

Another aspect that demonstrates the growth intensification of the external genital organs are the changes in the diameter of the internal pudendal artery and its branches.

The internal pudendal artery is a terminal branch of the internal iliac artery, which provides the vascularization of the external genital organs and the posterior segment of the digestive tube. A. internal pudenda having the medial position of the pelvic bones goes towards the ischial arch where it emits two medial and lateral secondary branches that continue with its tertiary branches in the external genital organs – vulva. Following the aforementioned and analyzing the data presented in figure 9, we can state the following: the diameter of the internal pudendal undergoes certain changes with age and constitutes at its point of origin at the 2nd month of postembryonic development, makes 0.82 mm on the right side and 0.81 mm on the left, but at the age of 4 months the growth is similar in the two sides and is 1.41 mm. Thus, the increase up to the 4th month is about 44.8% on the right side and 42.5% on the left. Resulting from the mentioned the internal pudendal a. does not show the essential changes in diameter from different parts of the body at the same age, but demonstrates a major increase up to the 4th month of development. Taking into account other main branches that provide blood irrigation of the genital organs in rabbits, we can find that the internal pudendal artery shows a slightly higher growth intensity compared to the ovarian artery by 1.42%, compared to the uterine artery

18.9%, but compared to the vaginal a. a lower insignificant increase of 35.6%. The smaller growth compared to the ovarian and uterine arteries is due to the fact that the internal pudendal artery participates in the vascularization of the caudal segments of the reproductive system and the caudal portion of the digestive system.

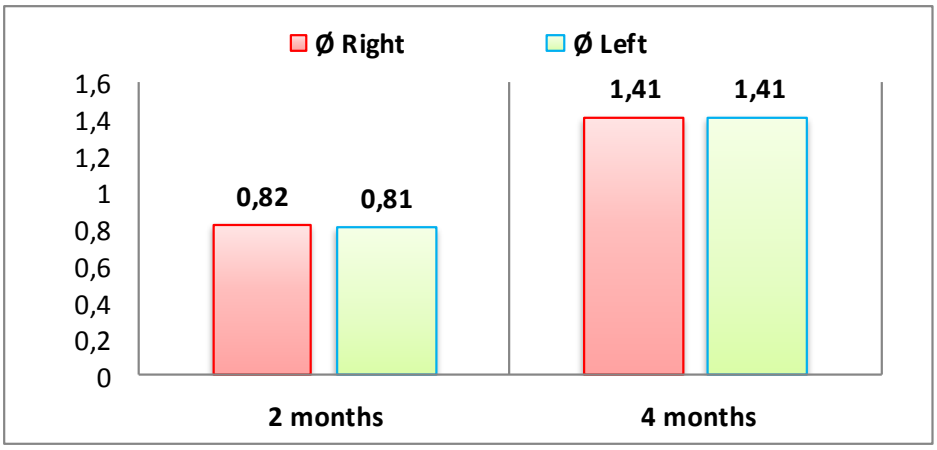

Figure 9. A. internal pudenda at the age of 2-4 months, mm.

Based on the obtained data, we can confirm that of the vascular branches that participate in providing the vascularization of the genital apparatus in rabbits, the greatest development towards the 4th month is supported by the vaginal and internal pudendal arteries. This fact denotes an intensive development of the vascular bed of the external genital organs. But these changes cannot deny an increase in the vascular bed of the internal segment of the reproductive system, considering that the growth of the uterine and ovarian arteries also demonstrates an intensification of the increase in diameter up to the 4th month of the body's development.

Conclusions and prospect for further researches. The main arteries through their secondary and tertiary branches show an intensive growth during the period from the 2nd to the 4th month of the postembryonic development of the reproductive system in rabbits.

The development of the blood network of the reproductive system in rabbits is ensured not only by changes in diameter but also by increasing the number of secondary and tertiary branches of these vessels.

The development trend of the vascular bed corresponds and is in strict accordance with the animal age changes.

МОРФОМЕТРИЧНИЙ АНАЛІЗ ГІЛОК АРТЕРІАЛЬНИХ СУДИН РЕПРОДУКТИВНИХ ОРГАНІВ У КРОЛИКІВ У ПЕРІОД ІНТЕНСИВНОГО РОСТУ / Дідорук С.

Вступ. *Необхідність детальнішого дослідження анатомо-топографічного розвитку джерел кровопостачання, формування та розподілу судинного русла у відділах статевого*

апарату кролиць продиктована технологічними потребами відтворення та збереження здоров'я самок.

Мета роботи. *Провести аналіз та оцінку морфометричних змін артеріального судинного русла статевих органів кролиць у період їх інтенсивного зростання з 2-го по 4-й місяці постнатального розвитку, що забезпечить та розширить можливість пізнання закономірностей фізіологічного розвитку цієї системи.*

Матеріал та методи. *Дослідження було проведено на тваринах, отриманих із зоотехнічної ферми з інтенсивного розведення кроликів – гібрид HYPlus. У дослідженні було використано 28 здорових тварин віком від 2 до 4 місяців.*

Результати досліджень та їх обговорення. *Аналізуючи результати, отримані в наших дослідженнях, ми бачимо, що основними джерелами кровопостачання статевих органів у кролиць є яєчникові артерії, що демонструють абсолютне збільшення до четвертого місяця на 41,7% з правого та на 36,8% з лівого боку.*

Маткові артерії показують середнє збільшення на 34,2% до 4 місяця постембріонального розвитку.

Вагінальна артерія демонструє приріст на 56,6% з правого та на 57,6% з лівого боку до 4-го місяця. Вона також виявляє більш високу інтенсивність зростання, ніж інші гілки репродуктивної системи, збільшуючись на 27,8% вище, ніж яєчникова арт. і на 40,8% ніж маточна арт.

Внутрішня статева артерія є термінальною гілкою і показує дещо більшу інтенсивність зростання порівняно з яєчниковою артерією на 1,42%, порівняно з матковою артерією на 18,9% та порівняно з вагінальною артерією менше зростання – на 35,6%.

Висновки та перспективи подальших досліджень.

Магістральні артерії спільно з вторинними та третинними гілками виявляють інтенсивне зростання в період з 2-го до 4-го місяця постембріонального розвитку репродуктивної системи кролиць.

Розвиток кровоносної мережі статевої системи кролиць забезпечується як зміною діаметра, так і збільшенням числа вторинних і третинних гілок цих судин.

Тенденція розвитку судинного русла знаходиться у суворій відповідності до вікових змін тварини.

Ключові слова: *артерії, кролиці, кровопостачання, морфометрія, фізіологічна зрілість, діаметр, гілки.*

REFERENCES

1. Aragon-Hernandez, J., Flores-Perez, F.I., Hallal-Calleros, C., & Perez-Martinez, M. (2013). Macroscopic morphometric analysis of genital organs of rabbit does with differing parturitions at 24 hours post-weaning. *Int. J. Morphol.*, 31(3), 991-996.

2. Barone, R. Artères. (2011). *Anatomie comparée des mammifères domestiques. Tome 5: angiologie*. 2nd ed. Paris: Editions Vigot Maloine.

3. Barone, R., Pavaux, C., Blin, P.C., Cuq, P. (1973). *Atlas d'anatomie du lapin.* Paris: Masson et Cie.

4. Coţofan V., Palicica R., Hriţcu V., & Enciu V. (2000). *Anatomia animalelor domestice. Aparatul circulator, Sistemul nervos.* (Vol. III). Timişoara: Orizonturi Universitare.

5. Spătaru, Constantin (2013). *Anatomia animalelor. Sistemul circulator. Sistemul nervos*. Iaşi: Alfa.

6. Balakyrev, N.A., Tynaeva, E.A. Tynaev, N.Y., & Shumylyna, N.N. (2007). Krolykovodstvo. Moskva: Kolos [in Russian].

7. Buryaile R., Negri R., Troncoso R., Papotto D., Lamelas Karina. (2015). *Guía de Recomendaciones de Buenas Prácticas en la Producción de Carne de Conejo*. Argentina: Ernestina Oliva.

8. Moreva S.A., (2017). Morfologiia reproduktivnoi sistemy krolchikh – Morphology of the reproductive system of rabbits. *Molodezh i nauka. Mezhdunarodnyi agrarnyi nauchnyi zhurnal – Youth and science. International agricultural scientific journal,* 4 [in Russian].

9. Bavaresco, A.Z., Culau, P.O.V., Campos, P.R. (2013). Ramos colaterais viscerais da aorta abdominal em coelhos da raça Nova Zelândia (Oryctolagus cuniculus). *Acta Scientiae Veterinariae*. Vol. 41(1), pp. 1-6.

10. Kigata, T., & Shibata, H. (2020). Ramification Pattern of the Arteries Supplying the Rabbit Female Genital Organs. *Anatomical Recrecord (Hoboken),* 303(5), 1478-1488.

11. König H.E., Liebich H-G. (2020) *Veterinary Anatomy of Domestic Animals: Textbook and Colour Atlas*. 7th edition. Germany: Georg Thieme Verlag KG.

12. Didoruc S., Enciu V. (2020). Schimbările periodice ale parametrilor morfometrici ai aparatului reproductiv la iepuroaice. *Ştiinţa agricolă*. nr. 2, pp. 112-118.

13. Didoruc, S.A. (2019). Modificari morfometrice ale sistemului reproductiv la iepuroaice in perioada maturizarii sexuale postnatale. *Medicina Veterinara – Veterinary Medicine*, Vol. 54, 213-218.

14. Dougnon, J.T., Ahossi, P.K., Soha Sas, A.S., & Ohouko, Okri F.H. (2016). Effect of Annona senegalensis leaves on morphometric parameters of reproductive organs in rabbits. *J Phytopharmacol*, Vol. 5(3), 122-125.

15. Tomitova, E.A. (2014). Morfofunktcionalnye izmeneniia v matke samok iakov v razlichnye periody polovogo tcikla – Morphological and functional changes in the uterus of female yaks at different periods of the sexual cycle. *Mongolian Journal of Agricultural Sciences*, 13, 153-158 [in Russian].