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ANATOMICAL STUDIES OF CORPUS PARACLOACALIS VASCULARIS IN COCKS*

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In the corpus paracloacalis vascularis of cocks the authors distinguished 5 different tissues: the capsule, the trabecula, the capillary cord, the peripheral lymphatic space, and the internal lymphatic space. In the peripheral and internal lymphatic spaces almost no argyrophilic fibers were found. This research work was performed with the following observation in mind, "the lymphatic spaces of the corpus paracloacalis vascularis were not the ordinary lymphatic sinuses, but a plexus of lymphatic capillaries".

INTRODUCTION

It has been believed that the reproductive organs of the male domestic fowl consist of testis, epididymis, deferent duct, and phallus, and that there are no glands corresponding to the seminal vesicle, prostate, and bulbo-urethral gland as found in mammals.

The accessory reproductive organs of the male domestic fowl consist of two parts, the lymph fold, and the corpus paracloacalis vascularis.

ECKHARD (1876) was the first to describe accurately the erection mechanism in the duck. He consistently observed that the "cavernous tissue" in the phallus did not fill with the injection material after intraarterial injection. He, therefore, conducted several experiments. He first stimulated the nerve lying close to the rectum and observed the cavity surrounding the "corpora cavernosa" filling with a clear yellowish fluid and simultaneously observed the phallus becoming erect and evert through the vent. This was the first evidence that lymph or a lymph-like fluid was involved in erection.

The corpus paracloacalis vascularis in the duck is an accessory organ of the penis and its function was demonstrated by LIEBE (1914). He reported that lymph originated from the "arterial vascular coil" in the "gefäßreicher Körper" and flowed to the phallus causing the phallus to swell.

In the cock only the existence of the corpus paracloacalis vascularis had

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been determined, but the relationship between the phallus and the corpus paracloacalis vascularis had remained unknown. NISHIYAMA (1950) was the first to report that "lymph" was involved in the erection of the phallus in the cock. NISHIYAMA (1950) and NISHIYAMA & OGAWA (1961) were primarily interested in the production of the diluting fluid. They conducted several experiments to demonstrate the origin and release of this fluid.

The mechanism of erection and semen dilution in the cock differs from that in mammals. In the mammal turgidity of the penis during sexual stimulation is due to engorgement of cavernous tissue with blood. In contrast, the phallus of the domestic cock during sexual stimulation becomes engorged with a blood filtrate, but not blood itself.

In this paper it is the authors' aim to clarify the anatomical structure and physiological meaning of the corpus paracloacalis vascularis of cocks by describing some macroscopical and histological observations made on the organ.

MATERIALS AND METHODS

As shown in table 1, 35 specimens of White Cornish (Vantress) males were used in this study. The White Cornish were selected because their large size

TABLE 1 *Investigated materials*

EXP. NO.	MATERIAL NO.	AGE	BODY WEIGHT	EXP. NO.	MATERIAL NO.	AGE	BODY WEIGHT
1	5407	6 ^m	2800 ^g	19	5425	16 ^m	4800 ^g
2	5401	"	3000	20	5431	"	4800
3	5409	"	3100	21	5428	"	4950
4	5404	"	3150	22	5426	"	5000
5	5405	"	3200	23	5429	"	5100
6	5402	"	3400	24	5433	"	5100
7	5408	"	3650	25	5424	"	5250
8	5406	"	4400	26	5454- 8		3600
9	5413	14	3950	27	5454- 3		4450
10	5415	"	4100	28	5454- 2		4500
11	5419	"	4400	29	5454- 4		4500
12	5416	"	4900	30	5454- 5		4500
13	5418	"	5000	31	5454- 7		4650
14	5420	"	5100	32	5454- 1		4800
15	5417	"	6000	33	5454- 6		4900
16	5427	16	4200	34	5454-10		5000
17	5432	"	4450	35	5454- 9		5150
18	5430	"	4500				

made a detailed study of parts easier than in breeds of smaller size.

Cocks were killed by cervical bleeding and the corpus paracloacalis vascularis was removed immediately after death. In some specimens, the arteries supplying to the corpus paracloacalis vascularis, the phallus, and the lymph fold were injected with India ink. In others, the ink was injected into the lymphatic vessels in the phallus.

The organs were fixed with 10% formalin, stained by using haematoxylin and eosin, Heidenhain's "Azan" variant, Weigert's resorcin fuchsin stain, and Gomori's silver impregnation method, and examined microscopically.

RESULTS

1 Macroscopical observations

The corpus paracloacalis vascularis of cocks is a small, red, oblong-shaped structure which lies medial to the M. retractor ani (after FUJIOKA et al.; M. retractor penis posterior, after LIEBE) and the M. dilatator ani (after FUJIOKA et al.; M. retractor penis anterior, after LIEBE). In addition, the location of the corpus paracloacalis vascularis corresponds to the outer side of the ampulla ductus deferentis.

TABLE 2 *Size of corpus paracloacalis vascularis in each animal*

EXP. NO.	AGE	SIZE	
		left side	right side
10	14 ^m	8.8× 5.2×4.8 ^{mm}	10.2×7.0×5.7 ^{mm}
11	"	7.9× 4.2×3.4	6.5×5.0×4.0
12	"	13.4× 6.6×5.5	
13	"	10.4× 8.5×6.4	10.3×4.0×4.5
14	"	11.6× 8.0×6.4	10.9×7.8×5.4
15	"	13.4× 6.5×5.5	14.6×7.7×5.3
16	16	11.6× 6.8×5.0	9.5×6.2×4.8
17	"	9.2× 7.4×6.0	11.0×5.0×4.0
18	"	10.6× 8.0×7.0	10.8×4.8×4.8
19	"	7.5× 5.5×4.5	8.6×5.4×4.2
20	"	12.8×10.2×5.2	13.2×5.6×4.2
21	"	9.8× 7.5×6.2	10.0×6.8×5.0
22	"	6.0× 5.3×4.6	9.2×6.5×4.9
23	"	11.2× 7.8×5.8	12.6×7.0×5.8
24	"	12.4× 8.0×4.4	11.6×4.5×3.8
25	"	14.2× 7.6×5.7	10.8×4.9×4.4
AVERAGE		10.7× 7.1×5.4	10.7×5.9×4.7

As shown in table 2, this organ is about 11 mm in length, 6~7 mm in breadth, and 5 mm in thickness, on the average, in 16 cases, and is covered with a connective tissue capsule.

The A. pudenda interna pours into the organ.

In order to confirm the lymphatic relation of the corpus paracloacalis vascularis, India ink was injected into the phallus and the lymph folds.

The lymphatic vessels filled with an injection mass easily originate from the phallus, run into the corpus paracloacalis vascularis, and also along the A. pudenda interna.

Excision of the corpus paracloacalis vascularis reveals that the lateral surface is convex and covered with a delicate connective tissue capsule. The medial surface of this organ is more even than the lateral surface. The major vessels lie on the medial surface beneath the capsule. The term "hilus" is recommended to refer to the above-mentioned medial region of this organ as with many other organs.

2 Microscopical observations

The corpus paracloacalis vascularis consists of capsule, parenchyma, and lymphatic space. Numerous capillaries distribute in the parenchyma, and much blood is found in the capillaries. The present authors designate this tuft-like capillary as the capillary cord.

The authors divided the tissue of the corpus paracloacalis vascularis into 5 components: the capsule, the trabecula, the capillary cord, the peripheral lymphatic space, and the internal lymphatic space.

The parenchyma of the corpus paracloacalis vascularis can be divided into cortical and hilus areas by microscopic observations. The cortical area is densely packed with capillary cords. The hilus corresponds to the area in which the many rami of the arteries lie. The hilar area contains, in addition to the major vessels and nerves, some supporting connective tissue trabeculae, which are primarily associated with larger vessels and nerves.

A section injected into lymphatic vessels with India ink reveals the drainage pattern in the lymphatic space. The injection mass does not pass into the capillary cord within the structure. As the channels course to the phallus and the lymph fold, they initially surround the vascular tissue of the corpus paracloacalis vascularis. Reaching the level of the lymph fold the blood vascular tissue terminates but the channels continue into the phallus and the lymph folds. This experiment clearly showed that the channels connect between the corpus paracloacalis vascularis and the phallus and lymph folds. From this it was confirmed that these organs belonged to the same system.

In adult cocks the lymphatic spaces always appear as a proper element of

TABLE 3 *Breadth of the lymphatic space in each animal*

EXP. NO.	AGE	BREADTH	EXP. NO.	AGE	BREADTH
2	6 ^m	±	22	16 ^m	+
9	14	+	23	"	+
10	"	+	24	"	+
11	"	±	25	"	+
13	"	+	26		+
14	"	±	27		+
16	16	±	29		+
17	"	±	30		+
18	"	+	33		+
19	"	+	34		+
20	"	+	35		±
21	"	+			

Remarks: Lymphatic spaces were graded on a (±) to (+) scale according to their comparative breadth

(±); scarcely observed, (+); narrowly observed, (±); broadly observed

the corpus paracloacalis vascularis, however, they vary in breadth in different sections. In most specimens the peripheral lymphatic space of the corpus paracloacalis vascularis, lying immediately beneath the capsule, was comparatively broader than the internal lymphatic space. In some specimens, moreover, the breadth of this space is more or less constant throughout the organ, but in other specimens there is a considerable variation in different parts, a variation that may be demonstrated even in a single section. The comparative breadth of lymphatic spaces in the microscopic sections of the corpora paracloacales vasculares is indicated in table 3.

On studying the above results it will be noticed that the breadth of the lymphatic spaces varied among different cocks as well as in different parts of the organ. Besides the form and size of the organ there seem to be unknown factors related to it which affect the degree of variation in the breadth of the lymphatic spaces.

The Gomori's silver impregnation method for argyrophilic fibers demonstrated numerous fine fibers in the capillary cord of these organs. However, only a few fine fibers were observed in the peripheral or internal lymphatic spaces. There was a distinguishable difference between the lymphatic space of the corpus paracloacalis vascularis and the lymph node.

In some cases a small number of lymph infiltrations or lymphatic nodules

were found under the endothelium of the lymphatic spaces.

In the trabecula of this organ, many fairly small blood vessels were found, and the authors also found some arterial buds in the small arteries.

In some sections the authors discovered the Herbst's corpuscles of the nerve endings in the connective tissue of the corpus paracloacalis vascularis.

DISCUSSION

Many terms were used for the accessory reproductive structures containing many capillaries of male fowls (corpus cavernosum, after TANNENBERG, 1810; spongy body of the urethra, after LEREBoullet, 1851; Tannenbergscher Körper, after ECKHARD, 1876; gefäßreicher Körper, after LIEBE, 1914; vascular body, after NISHIYAMA, 1955; glomus paracloacalis, after LUCAS & STETTENHEIM, 1965; corpus paracloacalis vascularis, after KNIGHT, 1970). The term corpus paracloacalis vascularis is recommended for this structure.

The size of the corpus paracloacalis vascularis varied considerably in this experiment. The individual deviation was so great that the authors could not discern a definite relation between the size of the corpus paracloacalis vascularis and the age, etc. It is possible that larger or smaller corpus paracloacalis vascularis would have an influence on fertility. This could have considerable economic value.

A transverse section through the corpus paracloacalis vascularis reveals that the reddish tissue dominates most of the internal parts of the organ. In the corpus paracloacalis vascularis of the cock 3 different elements of the structure were observed: the connective tissue area; the parenchyma consisting of mainly the capillary cord; and the lymphatic space. The present authors also divided the tissue of the corpus paracloacalis vascularis into the capsule, the trabecula, the capillary cord, the peripheral lymphatic space, and the internal lymphatic space.

Many previous authors reported that the peripheral lymphatic spaces of the corpus paracloacalis vascularis were the tissues between the organ and the connective tissue capsule, and they said that the peripheral lymphatic spaces belong to the external tissues of the corpus paracloacalis vascularis. In contrast, the present authors suspected that the peripheral lymphatic spaces of the corpus paracloacalis vascularis were a part of this organ. The peripheral lymphatic spaces and the internal lymphatic spaces were found in this organ as in the lymphatic sinus of the lymph node, and the peripheral lymphatic spaces, which were located in the space between the connective tissue capsule and the parenchyma, correspond to the Lymphbildungsraum after LIEBE. The breadth of the lymphatic spaces varied among different cocks as well as in different parts of the organ.

Many argyrophilic fibers were found in the capillary cord at the parenchyma of the corpus paraclacalis vascularis as in ordinary lymph nodes. On the other hand, almost no fibers were found within the lymphatic space. From this evidence, the authors believe that the peripheral and the internal lymphatic spaces of the corpus paraclacalis vascularis were analogous to the lymphatic vessel, from the anatomical point of view. The lymphatic spaces of the corpus paraclacalis vascularis should not be regarded as modifications of the ordinary lymphatic sinuses, but as structures sui generis. In this respect the lymphatic spaces of this organ and these of the lymph node seem to indicate a functional difference from each other, which has been overlooked in the past.

MÜLLER (1908) and LIEBE (1914) reported that in the drake the erection of the penis was caused by the inflow of lymph which was generated in the corpus paraclacalis vascularis (these organs were called Tannenbergscher Körper by Müller and gefässreicher Körper by LIEBE).

According to NISHIYAMA (1955), the corpus paraclacalis vascularis, the lymph fold, and the phallus are connected to one another by lymph sinuses, these organs belonging to one and the same system. When a cock responds to sexual impulse, lymph, or a fluid similar to lymph, is separated from the blood in the tissue of the corpus paraclacalis vascularis and runs off in copious amounts from the opening of the organ into the phallus and the lymph fold through the lymph sinuses connecting the organ with the lymph fold and phallus. Lymph pressure in the phallus increases greatly, thus, causing the erection of the phallus. The lymph in the phallus and lymph fold runs off within a short time through the same passage, flowing in the opposite direction from the phallus and the lymph fold to the corpus paraclacalis vascularis and, finally, into the lymphatic vessels lying along the *A. pudenda interna*; then, the phallus reverts to its original quiescent condition and the ejection of the transparent fluid ceases.

KNIGHT's (1970) findings related to the anatomical structure of the corpus paraclacalis vascularis strongly suggest that the fluid originates from the densely packed capillary tufts.

In this experiment, it was found that the lymphatic spaces of the corpus paraclacalis vascularis were connected to the sinuses in the phallus and the lymph fold. The present authors agree with previous authors with regards to the mechanism of erection and semen dilution in the fowl. It seems that the corpus paraclacalis vascularis is under hormonal control and further hormone studies would be of interest.

The authors found some arterial buds in the tissue of this organ. These features indicate that the small arteries have many windings and may help

to control the blood flow in this organ.

HASIMOTO & MOTOOKA (1933) reported that the nerve endings and the Herbst's corpuscle were found in the rudimentary phallus of the adult fowl; many Golgi-Mazzoni's corpuscles were also found in the rete mucosum of the two large, round folds. In some sections the authors found the Herbst's corpuscles of the nerve endings in the connective tissues of the corpus paracloacalis vascularis. Further study on the symphathetic and parasymphathetic system and its effect on the erection-dilution mechanism in the fowl is needed.

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EXPLANATION OF PLATE

- Fig. 1 Numerous capillary cords can be observed in the parenchyma.
A section injected into artery with India ink
Haematoxylin and eosin stain $\times 148$ Exp. No. 9, 14 months
- Fig. 2 The lymphatic space of the corpus paraclacalis vascularis scarcely shows.
Haematoxylin and eosin stain $\times 148$ Exp. No. 14, 14 months
- Fig. 3 The lymphatic space of the corpus paraclacalis vascularis shows clearly.
Haematoxylin and eosin stain $\times 148$ Exp. No. 25, 16 months
- Fig. 4 Almost no fine argyrophilic fibers are observed in the lymphatic space of the corpus paraclacalis vascularis.
Gomori's silver impregnation method $\times 148$ Exp. No. 10, 14 months
- Fig. 5 The lymphatic space of the corpus paraclacalis vascularis filled with India ink
A section injected into the phallus with India ink
Haematoxylin and eosin stain $\times 148$ Exp. No. 35
- Fig. 6 Herbst's corpuscle and the arterial bud are observed in the corpus paraclacalis vascularis.
Haematoxylin and eosin stain $\times 148$ Exp. No. 27

