Ultrasonography of the normal reproductive tract of the female domestic cat

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ABSTRACT

The objective of this study was (1) to describe the US appearance and obtain reference values for the uterus and ovaries in nongravid and gravid queens with histologically confirmed reproductive tracts without disorders, (2) to provide US measurements of the reproductive tract compared to gross macroscopic and water-bath post-OVH US measurements in nongravid queens, and (3) to describe the sonographic appearance of the female reproductive tract during the different histopathologic phases of the reproductive cycle in nongravid and gravid queens. Ninety-three queens from a “trap, neuter, return” program were included in this study. Sonographic evaluation of the reproductive tract was performed in all queens, and measurements of the corpus uteri, uterine horns, and ovaries were recorded. Following OVH, macroscopic measurements were obtained, and a water-bath US evaluation of these tissues and measurements was recorded. Samples from the corpus uteri and both the uterine horns and ovaries were collected for histopathologic examination after all measurements had been recorded. Seventy-two reproductive tracts met the inclusion criteria by having a histopathologically confirmed normal reproductive tract. Sixty-three queens were nonpregnant and 9 were pregnant. The ovaries and uterus were sonographically visible in all queens regardless of reproductive status. The ovaries were ovoid in shape, and the uterus appeared as a tubular structure with distinct wall layers (serosa and indistinct myometrium and myometrium, or serosa, myometrium, and endometrium), with variable echogenicity of the inner layers. The layering of the uterine wall, observed during the second half of pregnancy, was described. Ovarian follicles were visible in 66/72 (92%) cats. However, the CL was only visible in 40/72 (55%) cats. The reference values of the left ovarian length, right ovarian length, uterine horn diameter, and uterine body are 7.1⁎±13.9, 7.3⁎±13.6, 1⁎±5.8, and 1.5⁎±5.3 mm, respectively, in a nongravid uterus. The uterine wall thickness during pregnancy varied from 2.4 to 6.8 mm. There was a significant positive correlation between US measurements obtained in vivo and those obtained macroscopically and in a water bath post-OVH. The body weight, follicular size, sonographic visibility of the uterine wall layering, the histopathologic luteal phase, and the active/inactive status on histopathology had a significant effect on the uterine measurements (p < 0.05). It was not possible to describe the exact US features of the reproductive tract during the different histopathologic phases.

In conclusion, ultrasonographic reference values for the normal female reproductive tract in cats were determined. The results of this study indicated that the ovaries and uterus were visible in cats regardless of reproductive status.

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reproductive tract are well studied and described in domestic cats [1,2]. Ultrasound (US) is widely used in the screening of pregnant companion animals. It can be used to assess the viability of embryos or feti, determine the embryonic or fetal age, predict parturition time, and evaluate for any signs of resorption or abortion [3]. However, in queens, detailed US description of the normal reproductive tract and reference measurement values are lacking and incomplete [4–7].

Hysterography, followed by histopathology, has been used to document variations in the uterus size, shape, and lumen diameter during the normal estrus cycle in queens [8]. To date, US features during the different reproductive cycle phases have yet to be described in queens. Additionally, the US appearance of the placenta and uterine wall during pregnancy has only been described prior to the fetal stage [9]. Recently, high frequency probes were used to study the ovaries and uterine horns of healthy pregnant queens [10]. Despite their relatively small size, both organs could be measured with low intra- and interobserver variability; however, the accuracy of such measurements has not been evaluated.

The current description of US findings of ovaries in cats is limited to follicular growth and ovulation during proestrus and estrus and to prepubertal development of the ovary [5,7]. To the authors’ knowledge, no literature is available describing US findings of the ovaries during the anestrous or diestrous phase. Furthermore, the normal US appearance of the corpora lutea (CL) remains unknown.

The purpose of this study was (1) to describe the US appearance and obtain reference values for the uterus and ovaries in nongravid and gravid queens with histologically confirmed reproductive tracts without disorders, (2) to provide US measurements of the reproductive tract compared to gross macroscopic and water-bath post-OVH US measurements in nongravid queens, and (3) to describe the sonographic appearance of the female reproductive tract during the different histopathologic phases of the reproductive cycle in nongravid and gravid queens.

2. Material and methods

2.1. Study design

Within a timeframe of one year, 93 intact queens captured in a “trap, neuter, and return” program were prospectively enrolled in this study. Stray cats were humanely captured, using a box trap per cat, and treated at the Faculty of Veterinary Medicine of Ghent University as part of a “trap, neuter, return” program conducted by the Belgium Government and the Faculty of Veterinary Medicine of Ghent University in the city of Ghent, Belgium. This program serves to stabilize and gradually reduce the feral cat colony population, as offspring are no longer produced, enlarging nongravid and gravid queens. Additionally, the program provides final-year veterinary students surgical experience performing ovariohysterectomy (OVH) procedures. The students could practice the procedure in a safe environment, with the supervision of residents in surgery and reproduction, and/or board certified surgeons. Feline immunodeficiency virus and feline leukemia virus (FIV/FelV) testing was performed on all queens, and body weights were recorded. The feral queens were not amendable to human handling; therefore, a thorough clinical exam could not be performed, and no additional data was collected regarding the patients’ health, body condition, or age. No specific breed was recognized, and the cats were considered domestic short- and longhair. The queens’ living habitats were unknown, with the exception of the trap location. The queens were intramuscularly anesthetized with combined ketamine (8 mg/kg) and medetomidine (10 μg/kg) as a standard protocol of the neutering program. The body temperature of the cats was controlled and maintained during the ultrasound and the entire surgery (above 36.5 °C and below 38.5 °C). No anesthetic complications were recorded, and all cats were returned to the trap location the day after surgery. Queens with an identifiable scar at the umbilicus level were excluded from the study and presumed to have been previously spayed. Sonographic evaluation of the reproductive tract was performed before surgery. US was considered a noninvasive act and did not cause any additional stress to the cats, as they were anesthetized as part of the neutering program. All queens subsequently underwent an OVH performed by a final-year veterinary student, as taught in the surgery department of the Faculty of Veterinary Medicine of Ghent University, under the supervision of a board-certified surgeon or surgery resident, and the reproductive tracts (ovary, uterine horns and body) were collected, measured, placed in a water bath for a second ultrasonographic assessment, and placed in formalin. Tissue samples were then collected for histopathology.

2.2. Ultrasonography

Transabdominal ultrasonographic examinations of the reproductive tract were performed with the queens in dorsal recumbency, and sedation was used. Hair from the ventral abdomen was clipped, and coupling gel was applied. An ECVDI resident-in-training (LG) with sonographic experience in evaluating the female feline reproductive tract performed all the US examinations with a high frequency 17 MHz linear-array transducer (Philips IU22 US machine). The US examination duration was approximately 10 min per cat, with a maximum limit of 15 min.

The cervix, uterine body, uterine horns, and both ovaries were assessed, and their shape, contour, and echogenicity was recorded. Uterine wall layering (myometrium and endometrium) was identified, and the relative subjective echogenicity of the endometrium compared to that of the myometrium was evaluated. In this study, the uterine horns were categorized as being active when a clear demarcation between the endometrium and the myometrium was present and inactive when no layering was observed. The presence of ovarian follicles (round intraovarian anechoic structures with distal acoustic enhancement) and/or CL (slightly hyperechoic to the surrounding ovarian tissue with no acoustic enhancement) was recorded. The US appearance of the reproductive tract (shape, size, echogenicity, and layering) and the histopathologic findings were compared.

The maximal ventrodorsal diameter measurements of the uterine horns and body were measured in the sagittal and transverse planes. Measurements of the uterine horns were made approximately in the mid-portion of the horn (between the ovary and uterine bifurcation). In the pregnant queens, the total thickness of the uterine wall and placenta was measured. Only the maximal length of the ovaries was recorded; thickness was not measured. The diameter of the largest follicle and/or largest corpus luteum was also measured.

2.3. Post-ovariohysterectomy evaluation

Immediately following the surgery, the resected ovaries and uteri were measured using an electronic caliper, and the length of the ovaries and diameter of the uterine horns and body were recorded. Gross measurements of the ovaries and uterus were obtained atop a horizontal surface. Only the maximal length of the ovaries was recorded, with the bursa excluded. The transverse diameter of the uterine horn was obtained approximatively in the mid–portion of the horn as before. The macroscopic appearance of the organ was not recorded. Following gross measurements, the
organisms were placed in a water bath (10 cm diameter plastic pot filled with tap water), and a second US was performed as previously described in 2.2. The surface of the probe was superficially immersed in the pot to scan the organs. There was always water between the organ and the probe to avoid any compression of the organ. The maximal length of the ovaries was recorded. The diameters of the uterine horns in their mid-portion were measured in the sagittal and transverse planes.

2.4. Histopathologic evaluation

Transverse samples of the uterine horns (in the middle of the horn) and body as well as longitudinal samples of both ovaries (through the median plane) were collected and fixed in a 4% buffered formaldehyde solution. The samples of the uterine horns were collected approximatively in the middle of the horn (region of sonographic assessment). Tissue sections of 5 μm were prepared and stained with hematoxylin-eosin (HE) according to standard techniques and examined by two observers (LG and KC [ECVP diplomates]). All the samples were renamed and evaluated independently from the US. The uterine samples were classified as inactive phase, follicular phase, or luteal phase based on the description by Chatdarong et al. (2005) [8]. Uterine samples with a few layers of inactive endometrial glands were classified as inactive. Uterine samples with slight proliferation of the endometrial gland in the upper part of the endometrium were classified as inactive. Uterine samples with the presence of tertiary follicles and the CL (excluding atretic CL) was recorded.

2.5. Statistical analysis

The statistical analysis was performed by two authors (LG and KCM) with R software [11]. The data were collected over a year period, as no calculated sample size was possible (the percentage of expected normal reproductive tracts in the stray cat population of Ghent being unknown). Graphic evaluation of the data and logarithmic transformation of some uterine measurements allowed the usage of a parametric statistical analysis. The comparison between the right and left side measurements as well as the comparison between the transverse and longitudinal measurements from the same part of the uterus were assessed using a paired t-test. Pearson correlation coefficients (r) were calculated to assess the correlation between pre-OVH US measurements and post-OVH macroscopic and US measurements. The coefficient variation (standard deviation [SD] divided by the measurement mean) was calculated to compare the measurements pre- and post-OVH, using a linear mixed-effect model. Descriptive statistics (i.e., mean, SD, and reference values) were calculated from the tabulated measurements. The relation between the organs’ size and several qualitative criterions, including the season, the US activity of the uterus, and the histopathologic stage (follicular, luteal, or inactive), were graphically visually inspected. A Welch’s two-sample t-test was performed to compare two groups of measurements in relation to one qualitative parameter. When three groups or more were compared, a Kruskal–Wallis test was utilized. The correlation between several quantitative data points was investigated; some did not follow a normal distribution. A nonparametric correlation test was used, and a Spearman’s rank correlation coefficient (rho) was calculated. The correlations between the organs’ size and the weight of the queen, the maximal diameter of the follicle, and the maximal diameter of the corpus luteum were evaluated. Values of p < 0.05 were considered significant.

3. Results

Based on the histopathologic evaluation, 72 queens had a normal reproductive tract and therefore met the inclusion criteria; 21 had an abnormal reproductive tract. Sixty-three queens were nonpregnant and 9 were gravid. Seven queens with cystic endometrial hyperplasia, six with suppurative endometritis, three with para-ovarian cysts, one with a follicular cyst, one with resorption, one with focal cystic adenomyosis of the uterus, one with a serosal para-uterine cyst, and one with an abnormally wide uterine lumen without parietal or luminal abnormalities were excluded from the study.

The weight of the queens ranged from 0.5 kg to 5.0 kg, with a mean of 2.8 kg (SD = 0.76 kg). Of the queens, 17 were evaluated in the spring, 9 in summer, and 46 in the fall. There were no anesthetic or immediate postsurgical complications.

3.1. Normal sonographic features

The examination started with a transverse image of the caudal abdomen. The uterus was always identified on the transverse images as a round to ovoid structure located between the urinary bladder and the colon. Depending on the amount of pressure applied on the probe and the degree of urinary bladder or colonic distention, the uterine body was either located between both structures or adjacent to the colon. The cervix was not easily identified in the transverse or longitudinal plane. The uterine body was clearly identified. A transitional zone between the body and the horns was also detected, where the horns merged together. In this particular portion, there were two lumens observed within in a single tubular structure, observed in transverse plane (Fig. 1). The uterine horns were always visible in their entire length. Although the positions of the uterine horns varied by the degree of intestinal distention, the patient’s body condition, and the amount of pressure applied on the US probe, they were always located near the abdominal wall.

A thin hyperechoic rim was always identified surrounding the uterine horns and body that corresponded to the serosa and the interface between the surrounding tissue and the serosa (Fig. 2). The lumen of a nongravid uterus was observed as a thin hyperechoic line in the center of the uterus.

There were different US features of the uterus in nonpregnant queens compared to pregnant ones. In the majority of the cases (60/63; 95% [87%; 99%]), the uterus was diffusely hypoechoic to the surrounding tissues and, in three cases (3/63; 5% [1%; 13%]), it was hyperechoic to the surrounding tissues. In 44% [32%;58%] of the cases (28/63), no clear demarcation between the endometrium and myometrium was seen, and the uterus appeared as a homogeneous, hyperechoic tubular structure surrounded by a thin hyperechoic line. In the remaining 35 cases (35/63; 56% [42%; 68%]), a clear demarcation between the endometrium and myometrium was seen, characterized by a thin hypoechoic line between the two layers (Fig. 3). When a demarcation between the endometrium and myometrium was observed, the echogenicity of the endometrium remained hypoechoic to the myometrium in 32 cases (32/35; 91% [77%; 98%]) or isoechoic to hyperechoic to the myometrium in 3 cases (3/35; 9% [2%; 23%]). In 10 (10/35; 28% [15%; 46%]) of the cases where a demarcation between the endometrium and myometrium was seen, an additional thin hypoechoic line was detected close to the outer layer within the myometrium. This corresponded to connective tissue and blood vessels located between the inner circular muscular layer and the outer longitudinal muscle layer in the myometrium (Fig. 4).

In the pregnant queens, there was a good association between the US layering and the histopathologic architecture (Fig. 5). Seven
pregnancies were in the fetal stage, with a biparietal diameter larger than 15 mm, whereas the remaining two pregnancies were in a late embryological stage. During the fetal stage, the serosa wall layer was identified as a thin hyperechoic rim. The adjacent inner layer of intermediate echogenicity (hypoechoic to echoic) and thickness corresponded to the myometrium, followed by a thicker hypoechoic layer stippled with numerous hyperechoic foci, some of which extended into the inner layer that corresponded to the endometrium. The innermost and thickest layer was hypoechoic and corresponded to the placenta. The fetal membrane appeared as a thin hyperechoic line between the placenta and fetus. A similar wall layer pattern was observed in the two pregnancies in the late embryonic stages though demarcation between layers was decreased.

The ovaries were located caudal to the caudal pole of both kidneys and were detected in all nonpregnant queens and in only 44% (4/9 [14%; 79%]) of the pregnant queens. Judicious application of transducer pressure was required to avoid displacement of these structures during sonographic assessment. The left ovary was subjectively easier to identify compared to the right and was most often located laterally to the descending colon. The right ovary was detected adjacent to the small intestinal loops using a conventional ventral–dorsal approach. Displacement of the small intestinal loops from the right ovary was achieved more frequently using a

Fig. 1. Transverse images of the uterine body of an active uterus. 1A and 2A, the transition zone between the cervix and the uterine horn is presented with two separated lumen and endometrii (e) (caudal aspect of the uterine horns), surrounded by a single global myometrium (m) and serosa (large dotted line, cranial cervix). 1B and 2B, the uterus body is visualized, with a lumen (thin dotted line), an endometrium, and a myometrium.

Fig. 2. Transverse (1A and 2A) and longitudinal (1B and 2B) images of an inactive uterine horn of 2.5 mm diameter. The interface with the serosa is visible as a thin hyperechoic rim (dotted line and double arrows). A demarcation cannot be visualized between the endometrium and the myometrium.
dorsolateral approach—an alternative approach that may be of benefit if intestinal gas or ingesta precludes assessment of the right ovary. Additionally, the right ovary must be differentiated from the regional lymph nodes (i.e., jejunal or ileocolic).

Follicular structures were identified in 92% (58/63; [82%; 97%]) of the nonpregnant queens, whereas CLs were only identified in 17% (11/63; [9%; 29%]). Both the follicles and the CL were located in the cortex. The follicles appeared as round anechoic cavitary structures that exhibited distal acoustic enhancement (Fig. 6) and ranged in size from <1 mm to 2.3 mm in diameter. All the smallest follicles were histopathologically confirmed as primary follicles.

The CL were always round and easily identified when hyperechoic, large, and/or deformed along the ovarian margins, and they ranged in size from 2.2 to 3.8 mm in diameter. Clear visualization and demarcation of these structures was more challenging and/or not possible when they were iso- or hypoechoic to the ovary (Fig. 7). The CL were identified in 20 cats via histopathology, and only 55% [11/20; 32%; 77%] of these were detected ultrasonographically.

3.2. Description of the normal ultrasonographic measurements

The US measurements of the normal uteri and ovaries are summarized in Table 1. The reference values of the left ovarian length, the right ovarian length, the uterine horn diameter, and the uterine body are 7.1–13.9, 7.3–13.6, 1–5.8, and 1.5–5.3 mm, respectively, in a nongravid uterus. The uterine wall thickness during pregnancy varied from 2.4 to 6.8 mm.

No significant differences between the measurements of the right and left ovaries, the right and left uterine horns, and the transverse or longitudinal uterine sections (Table 2). All the ovarian US measurements made before and after surgery in the water bath were significantly and positively correlated and also positively correlated to the gross macroscopic measurements (p < 0.001), with a correlation coefficient (r) from 0.41 to 0.59 (summarized in Table 3). All the uterine transverse diameter US measurements made before and after surgery in the water bath were significantly and positively correlated and also positively correlated to the gross macroscopic measurements (p < 0.0001), with a correlation coefficient (r) from 0.72 to 0.85 (summarized in Table 3). All the uterine
longitudinal diameter US measurements made before and after surgery in the water bath were significantly and positively correlated \((p < 0.0001)\), with a correlation coefficient \((r)\) from 0.8 to 0.83 (summarized in Table 3). There was an underestimation of all the uterine measurements (diameters) and an overestimation of the ovarian measurements (lengths) before surgery compared to the US and macroscopic postsurgery measurements. The coefficient variations were 8.4%, 8.8%, 19.4%, and 16.2% for the length of the right ovary, the length of the left ovary, the diameter of the left uterine horn, and the diameter of the right uterine horn, respectively. Tapering of the uterine horn toward its cranial part was not observed.

The measurements of the normal uteri were significant and positively correlated to the queens’ weight and follicular size measured on US and did not correlate to the CL size (Table 4). There was also a significant correlation between the uterine measurements and the active or inactive appearance of the uterus on US \((p < 0.0001)\). There was a significant correlation between the uterine measurements the histopathologic luteal status \((p < 0.001)\), with a coefficient of correlation \((\rho)\) from 0.52 to 0.57. There was a significant correlation between the uterine measurements the histopathologic inactive status \((p < 0.001)\), with a coefficient of correlation \((\rho)\) from 0.55 to 0.56. However, there was no significant correlation between the uterine measurements and the following criteria: the season \((p = 0.1)\) and follicular histopathologic status \((p = 0.7)\). The difference between the measurements in spring or autumn was not significant \((p = 0.05)\). No significant correlation was detected between the ovarian measurements and

![Fig. 5. US image of the uterine wall and placenta in the second half of pregnancy (1A and 2A) and the corresponding magnified histologic images (B) (bar = 1 mm). The total thickness of the wall is situated between the two crosses (+). The outer serosa is thin and hyperechoic (small dotted line), the myometrium is hypoechoic (m), the endometrium is thick (e), echoic with multiple hypoechoic foci, and the placenta is thick and hypoechoic (p) with a thin inner hyperechoic line interface (large white dotted line). On the US image, a part of the thoracic cavity of the fetus (f) is seen.](image)

![Fig. 6. Longitudinal US images of ovaries. 1A and 2A, the ovary is inactive, and no follicle or corpus luteum is seen. In 1B and 2B, at least four small follicles are present (round, echoic, in the periphery of the ovary), indicated by arrows. In C, a large round echoic corpus luteum is visible at the cranial pole of the ovary; its margins are shown with the solid white line. The ovaries are outlined with a dotted line on all the images.](image)
any of the parameters tested \( (p > 0.05) \).

4. Discussion

To the authors’ knowledge, this is the first study that describes the ultrasonographic appearance of the normal reproductive tract in queens, with all findings being compared to the histopathology (considered the gold standard). Additionally, this study showed the feasibility of US to characterize the reproductive tract in healthy queens, using a 17 MHz linear US probe. The technique used to visualize the reproductive tract was similar to the one described in bitches [12]. The reproductive tract is always identified and followed for an experienced observer.

The anatomical appearance of the female reproductive tract on US is comparative to the gross anatomical findings [1,13,14]. The transitional zone between the uterine body and the caudal part of the two horns can be readily identified on US in the transverse imaging plane. In this portion, two lumens with two separate endometrii and the inner circular muscularis are observed centrally (caudal portion of the horns) with a single outer longitudinal muscularis layer and serosa, observed at the periphery (cranial portion of the cervix).

Three different US patterns of the uterus were observed. In the first pattern, only the serosa was clearly detected, and a demarcation between the endometrium and myometrium was not identified. This pattern corresponds to that of a nonedematous uterine wall, previously described in cheetahs and dogs in anestrus [15,16]. In the second pattern, three layers could be seen: a hyperechoic outer serosa, an intermediate echoic myometrium, and an inner hypoechoic endometrium. This pattern is similar to that of a nonedematous uterine wall, previously described in cheetahs, lions, and bitches in proestrus and estrus [12,16,17]. The differences in the relative echogenicity between the endometrium and myometrium has been described in cheetahs [16]. The third pattern is similar to the second but has an additional thin hypoechoic layer within the myometrium that corresponds to the vascular layer between the circular and longitudinal muscle fibers of the myometrium on histopathology. This layer has only been described in pigs and sonographically as a heterogeneous uterus [18] observed from estrus to mid-diestrous. Thickening of both, the feline endometrium and myometrium has been histopathologically described during the follicular phase [8]. Thickening of the myometrium during the luteal phase and after puberty in queens has also been described histopathologically [8,19]. This thickening could account for patterns 2 and 3 described in this study. The correlation between the uterine diameters and the wall layering observed in this study

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Table 1

<table>
<thead>
<tr>
<th>Measurements (mm)</th>
<th>Mean (mm)</th>
<th>Standard Deviation (mm)</th>
<th>Reference values (mm)</th>
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<tbody>
<tr>
<td>Left ovarian length</td>
<td>10.5</td>
<td>1.7</td>
<td>[7.1;13.9]</td>
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<tr>
<td>Right ovarian length</td>
<td>10.4</td>
<td>1.6</td>
<td>[7.3;13.6]</td>
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<tr>
<td>Left uterine horn diameter in longitudinal section</td>
<td>2.5</td>
<td>1.6</td>
<td>[0.9;6.3]</td>
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<tr>
<td>Left uterine horn diameter in transverse section</td>
<td>2.4</td>
<td>1.5</td>
<td>[1.0;5.6]</td>
</tr>
<tr>
<td>Right uterine horn diameter in longitudinal section</td>
<td>2.5</td>
<td>1.6</td>
<td>[1.0;6.0]</td>
</tr>
<tr>
<td>Right uterine horn diameter in transverse section</td>
<td>2.4</td>
<td>1.5</td>
<td>[1.0;5.8]</td>
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<tr>
<td>Uterine body diameter in longitudinal section</td>
<td>2.9</td>
<td>1.4</td>
<td>[1.5;5.6]</td>
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<td>2.8</td>
<td>1.4</td>
<td>[1.5;5.3]</td>
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Results from the Pearson correlation test and coefficient correlation value with the associated confidence interval (NA: not available, as macroscopic longitudinal diameter could not be measured).

<table>
<thead>
<tr>
<th>Table 2</th>
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<tr>
<td>Comparison between measurements</td>
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<td>Confidence interval</td>
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<td>[−0.28;0.04]</td>
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<td>[−0.08;0.04]</td>
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<td>0.006</td>
<td>[−0.04;0.05]</td>
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<td>Right and left uterine horns diameter in transverse section</td>
<td>0.63, NS</td>
<td>0.01</td>
<td>[−0.04;0.08]</td>
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<tr>
<td>Right and left uterine horns diameter in longitudinal section</td>
<td>0.92, NS</td>
<td>−0.003</td>
<td>[−0.07;0.06]</td>
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<td>Right and left ovarian length</td>
<td>0.68, NS</td>
<td>−0.0735</td>
<td>[−0.42;0.27]</td>
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Results from the Spearman correlation tests (p-value) and the coefficient correlation (rho) value. The correlation with the weight, size of the largest follicles, and corpus luteum measured in ultrasound are evaluated. NS: nonsignificant.

<table>
<thead>
<tr>
<th>Table 4</th>
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<tr>
<td>Spearman correlations</td>
<td>Weight</td>
<td>US size of the largest follicle</td>
<td>US size of the largest corpus luteum</td>
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<tr>
<td>p</td>
<td>rho</td>
<td>p</td>
<td>rho</td>
</tr>
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<td>Left uterine horn diameter</td>
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<td>p &lt; 0.0001</td>
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<tr>
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<td>0.52</td>
<td>p &lt; 0.0001</td>
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<td>Uterine body diameter</td>
<td>p &lt; 0.0001</td>
<td>0.57</td>
<td>p &lt; 0.0001</td>
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women and ewes [24,25]. The detection of the CL could also be facilitated if the exact location of the tertiary follicles was known—a technique shown to improve the detection rate in small ruminants [26]. However, this would require daily sonographic evaluations, which was not possible with the study design.

Similar to a previous study [10], there was no difference in the uterine thickness when measured in either a transverse or longitudinal plane. When comparing the US images before (in vivo) and after surgery (ex vivo), there is an underestimation of all the uterine diameter measurements and an overestimation of the ovarian length, explaining the relatively high coefficient variation obtained for all the measurements. Higher uterine diameter measurements obtained postsurgery are suspected to be attributed to congestion associated with the ligation of the uterine and ovarian arteries during surgery. Also during surgery, the breakdown of the suspensory ligament may induce shrinking of the ovaries and could account for the underestimation of ovarian length measurements in ex vivo samples. Regardless, the measurements obtained in this study were comparable with the macroscopic measurements previously documented in the literature [1,5]. Ultrasoundographic measurements of the reproductive tract in queens have already shown a low intra- and interobserver variability [5]. Using ultrasonography, the proposed normal left ovarian length [13.6 mm, 11.7–13.1 mm], the right ovarian length is 7.3–13.6 mm, the uterine horn diameter is 1–5.8 mm, and the uterine body diameter is 1.5–5.3 mm.

Unfortunately, this study failed to clearly determine the exact US appearance of the uterus during the histopathologic estrus phases. This finding can be explained by the low number of enrolled queens in the follicular phase. The difference between the active and inactive uterine features is validated. The different US feature between the luteal and follicular phases remains unknown. Due to the selected study population of feral cats, behavioral examination, repeated hormonal assays, and serial ultrasonographic evaluation of folliculogenesis were not possible [2,6,27].

5. Conclusion

In the present study, a detailed description of the normal female feline reproductive tract was provided, and the proposed normal left ovarian length, right ovarian length, and uterine horn and body diameters were determined (7.1–13.9 mm, 7.3–13.6 mm, 1–5.8 mm, and 1.5–5.3 mm, respectively). US can be utilized to evaluate the ovarian follicular structures and assess the CL in some assessments. The US changes observed during the histopathologic phases of folliculogenesis were not possible [2,6,27].

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