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A Study of the Urogenital Systems of Emys blandingii, with Observations on the Occurance of Mullerian Ducts in Males

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A STUDY OF THE UROGENITAL SYSTEMS OF EMYS BLANDINGII, WITH OBSERVATIONS ON THE OCCURRENCE OF MULLERIAN DUCTS IN MALES.[1]

FRANK A. NICHOLSON AND P. L. RISLEY

INTRODUCTION

It is somewhat surprising that accurate information concerning the urogenital systems and cloacae of male and female turtles is not readily available to the student of comparative anatomy. Literature pertaining to the urogenital system of turtles is concerned mostly with species alien to North America, and is mainly in foreign publications; also, most illustrations do not give clear or precise impressions of these structures. The information available either is of a too general nature and includes somewhat superficial observations on numbers of species, or is concerned with only a single aspect of the entire system. In view of this, it appears that additional observations on the urogenital systems of male and female turtles with special reference to the cloacal region may be of general interest, and also of some value in establishing specific sexual differences.

Thanks are due to Dr. P. L. Risley, under whose direction the work was undertaken, for guidance and sincere interest in the observations and preparation of this report, and to Dr. F. B. Moreland for the supply of *Emys blandingii* used.

MATERIALS AND METHODS

The information here recorded was obtained as a result of systematic study of four species of North American turtles: *Emys blandingii, Pseudemys scripta, Clemmys insculpta,* and *Chrysemys marginata.* Since the supply of *Emys blandingii* was more complete, and dissections showed that the structures were fairly typical of the other species as well, both description and figures apply to that species in particular. Both sexes were available in all species used.

The methods: The plastron was removed from each animal and the posterior portion of the turtle was dissected out of the carapace. The pelvic girdle was then split through the middle; the

1 This study has been aided by grants from the National Research Council, Committee for Research in Problems of Sex (administered by Professor E. Witschi).

entire urogenital system and cloaca were dissected from the surrounding musculature and connective tissues.

Observations, aided by specific measurements when possible, were made to determine wherein the systems and structures of the two sexes were similar, or showed significant differences.

OBSERVATIONS

Since no significant species differences appeared, an average sized male specimen of *Emys blandingii* was selected as typical of the group for purposes of description, illustration, and comparison with one of the larger females. Measurement of male and female individuals indicates that the females of this species are slightly larger than the males. Comparative measurements of specimens studied are presented in Table I.

Table I — Data showing some relative sizes of body and cloacal lengths in Emys blandingii in mm.

A. Male	Carapace		Plastron					
	L	Wi	L	Wi	An-T	Cl.L	U.S.-G	G-An
	205	131	190	105	46	54	28	26
	201	136	188	110	47	59	30	28
	208	140	185	110	44	53	27	26
	193	126	180	116	41	66	33	33
	193	129	174	104	37	64	33	32
	203	137	182	109	33	65	35	31
					248	361	186	176

Average cloacal length---60.2
Average length from glans to urinary sinus---31.0
Average length from glans to anus---29.3
Average length from anus to tip of tail---41.3

B. Female	Carapace		Plastron					
	L	Wi	L	Wi	An-T	Cl.L	U.S.-G	G-An
	214	187	208	122	53	55	35	20
	233	158	230	130	54	41	21	21
	233	158	228	128	—	51	21	27
	182	122	175	100	40	41	22	20
	202	130	192	108	46	48	26	22
	200	132	187	109	45	60	35	28
					238	296	163	138

Average cloacal length---49.3
Average length from glans to urinary sinus---27.1
Average length from glans to anus---23
Average length from anus to tip of tail---47.6

(L) is the measurement of length.
(Wi) is the measurement of width.
(An-T) is the anus to tip of tail measurement.
(Cl.L) represents the total cloacal length from the most anterior extremity of the urogenital sinus to the anus.
(U.S.-G) represents the distance between the most anterior extremity of the urogenital sinus and the glans.
(G-An) represents the measurement from the glans to the anus.

In both sexes the paired kidneys of the turtle are elongated, triangularly flattened, lobed organs of a reddish-brown color, that lie retroperitoneally on each side of the spinal column ventral to the ribs in the posterior part of the pleuroperitoneal cavity where they fit snugly against the carapace. Adjacent mesially at the anterior ends are the posterior tips of the lungs. The kidneys display three lobate surfaces: one dorsomedian with a mesial apex, a rounded lateral, and a slightly concave ventral surface. The ureter of the male rises from the middle of the ventral surface, extends posteriorly from the pelvis of the kidney for about 15 mm. along the side of the vas deferens, and enters the cloacal wall dorsal and medial to the genital papilla. In the female the ureter arises from the mid-ventral surface of the kidney and proceeds posteriorly in a spiral turn around the side of the oviduct to enter the cloacal wall dorsally. The ureter of the female is approximately 20 mm. in length from the pelvis of the kidney to the point where it enters the cloacal wall.

Upon the concavity of the ventral face of each kidney in the male are the yellow, oval testes which are bound to the kidneys by mesorchia. Each testis is about the size of one of the more mature ovocytes in the ovary of the female (Fig. 1, A and B). Each mesorchium extends laterally and mesially over the surface of the epididymis and kidney to become continuous with the lateral body wall and the dorsal mesentery of the intestine; anteriorly and posteriorly they are continuous with the parietal peritoneum.

The testes are masses of seminiferous tubules that connect with

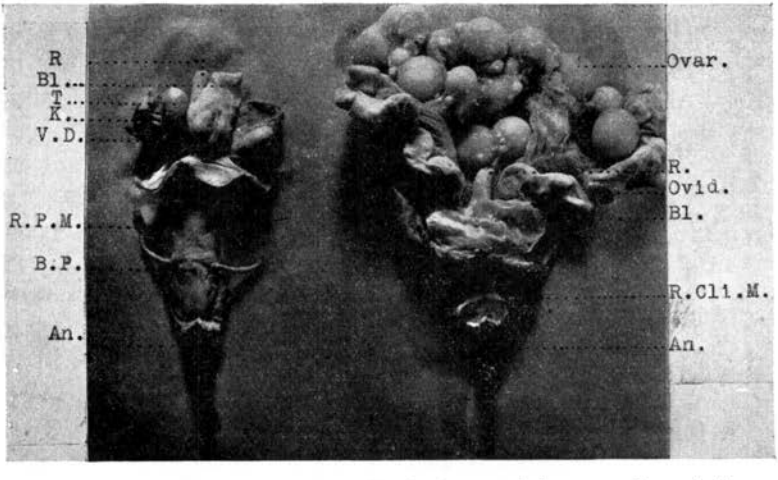

Fig. 1. Photographs of (A) male and (B) female urogenital systems. Ventral view.

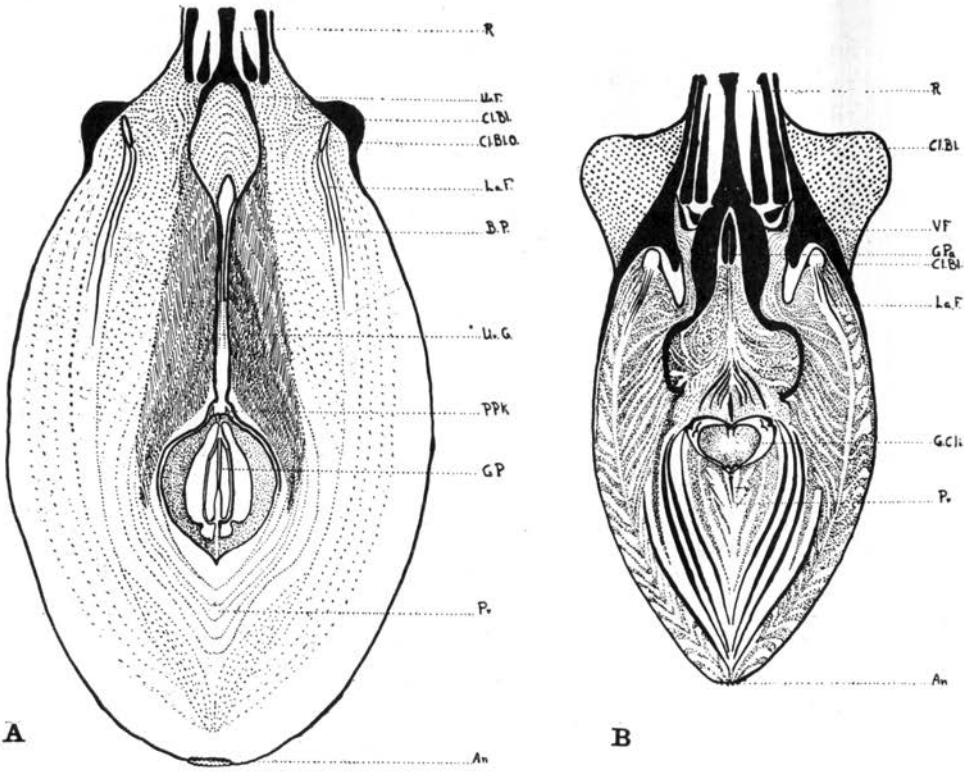

Fig. 2. The open cloaca of (A) male and (B) female turtles showing internal structures. In (A) note the large glans penis (G. P.), the urogenital groove (Ur. G.), and the small urethral folds (Ur. F.). In (B) the vaginal folds (V. F.), the glans clitoris (G. Cli.), and the minor folds that compose the inner surface of the cloaca are of interest.

EXPLANATION OF ABBREVIATIONS USED IN FIGURES 1, 2, 3, 4, 5

An. — Anus
An.E. — Anal Epithelium
Bl. — Bladder
B.P. — Body of the Penis
Bl.S. — Bladder Stalk
C.F. — Corpus Fibrosum
Cl.Bl. — Cloacal Bladder
Cl.Bl.O. — Cloacal Bladder Opening
K. — Kidney
G.Cli. — Glans Clitoris
G.P. — Glans Penis
G.Pa. — Genital Papilla
G.Pa.O. — Genital Papilla Opening
La.F. — Lateral Fold
Ovar. — Ovary
Ovid. — Oviduct
PPC. — Papilla of Peritoneal Canal
Pr. — Prepuce
R. — Rectum
R.Cl.M. — Rector Clitoris Muscle
R.P.M. — Rector Penis Muscle
Ur.G. — Urethral Groove
Ur.F. — Urethral Fold
Ur.O. — Ureter Opening
V.F. — Vaginal Fold
V.D. — Vas Deferens

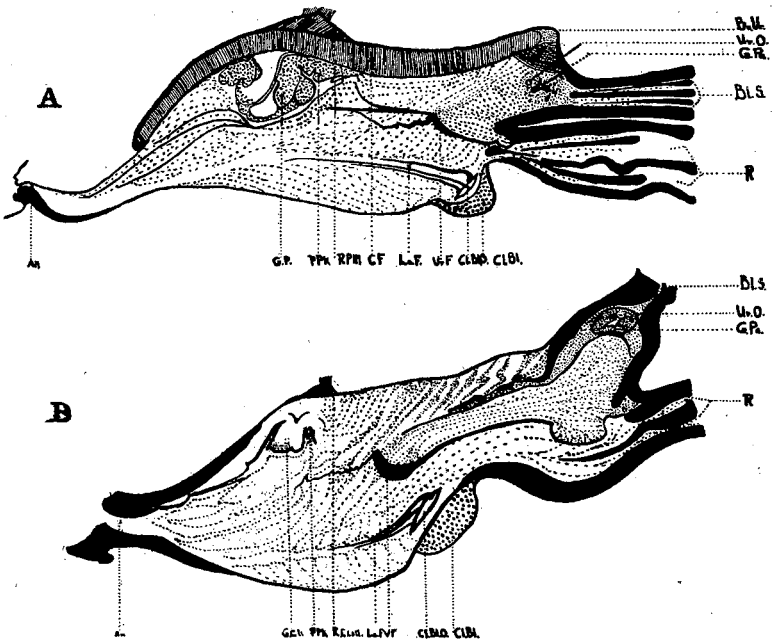

Fig. 3. Mid-sagittal views of the cloaca of (A) the male and (B) the female.

rete tubules extending from the dorso-mesial face of each testis through the apposed layers of the mesorchium to continue as ductuli epididymides. The ductuli epididymides then unite with a common ductus epididymis or vas deferens. The vas deferens (Wolffian duct) is a single, continuous, multi-coiled tube showing alternate patches of black, grey, and white pigmentation as it spirals posteriorly from the testis and enters the cloacal wall laterally and slightly anterior to the entrance of the ureter. The total length of the Wolffian body or epididymis is about 25 mm.; its diameter is about 5 mm. When uncoiled the Wolffian duct extends for about 300 mm. as a common duct from the testis to its entrance into the cloacal wall; its diameter is about 1 mm. In volume the Wolffian body is about the size of the testis; the Wolffian body and testis together have approximately the same volume as the kidney.

The ovaries are loose membranous organs that spread laterally and ventrally over the kidneys and the posterior portion of the lungs. Aside from extending further anteriorly they are located in the same relative position as the testes of the male, but are much greater in volume. They are supported by mesovaria; the anterior portion of the mesovarium supports the more mature eggs, and the mesial borders, bound together by loose connective tissue, bear

immature eggs. Lateral and anterior extensions of the mesovaria are continuous with the mesotubaria which support the oviducts.

The oviducts, or Mullerian ducts, are paired, coarsely coiled, unpigmented tubes. Anteriorly, each begins with a broad, open ostium tubae abdominale that is generally folded back mesially upon itself in the mid-portion of the pleuro-peritoneal cavity. Grossly, it is divisible into two portions — a thick muscular uterine posterior part, and a thin-walled folded infundibular part anteriorly. Each duct extends posteriorly and laterally through the cavity through a distance of about 120 mm., passes over the ventral surface of the kidney to which it is bound by an extensive mesotubarium, and enters the anterior wall of the cloaca ventro-laterally.

In both sexes the intestine extends from the meshes of the dorsal mesentery as a straight tube between the kidneys, transforms into the rectum as it rises dorsally, and enters the cloaca mesially and dorsal to the urogenital ducts. The urinary bladder is directly ventral to the rectum. It is a thin-walled sac, usually bi-lobed, that enters the cloacal wall mid-ventrally between the urogenital ducts by means of a short connecting neck about 7 mm. in length.

Upon making a mid-longitudinal incision of the dorsal cloacal and rectal walls the inner surface of the rectum or coprodeaum is exposed dorso-anteriorly. The rectum is an extension of the intestine; its inner wall is characterized by longitudinal folds. Most conspicuous is a central fold on the floor; it broadens out posteriorly and bifurcates to continue with the roofs of the urethral or vaginal folds according to the sex. On entrance into the cloaca the other rectal folds extend posteriorly and terminate at the mouths of the cloacal bladders on the right and left sides.

By incising anteriorly the ventral rectal wall and the dorsal wall of the bladder stalk, the urodeaum is exposed. This is the urogenital sinus, a dilation for the entrance of the genital and urinary ducts within the antero-ventral sector of the cloaca. When spread open it appears as a pear-shaped recess: in the male its maximal width and length is about 8 x 10 mm., in the female the corresponding measurement is about 14 x 20 mm. (Fig. 4, A and B).

From each lateral wall of the urogenital sinus and slightly anterior rises a papilla that projects posteriorly. This papilla has formerly been described as the urogenital papilla. Dorsal to the base of this papilla is the orifice of the ureter. Careful dissection

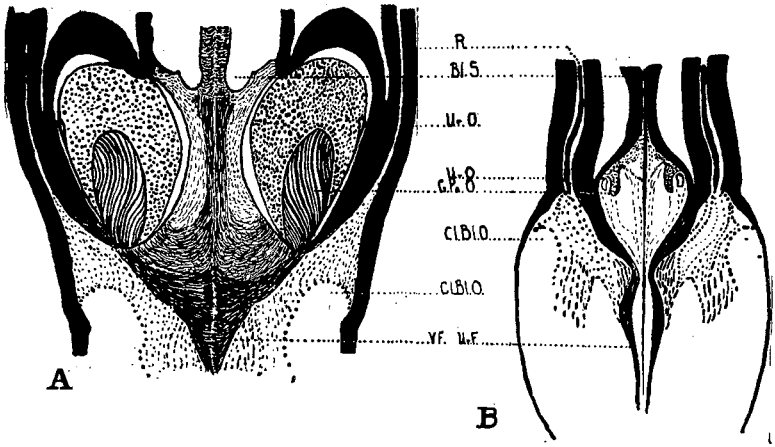

Fig. 4. The open urogenital sinus of (A) the male and (B) the female. Note the relation between the genital papilae (G. Pa.) and the urinary openings (Ur. O.).

through the lateral wall shows that the papilla is an extension of the sex duct only, the opening of which is at the posterior extremity of the papilla. Because the ureter is distinctly separate from the papilla, the papilla is more accurately a genital papilla, and is so designated.

In the male the genital papilla is a simple tapering projection of the cloacal wall and bears the aperture of the sperm duct, while in the female the papilla is of a much larger size and increased complexity. Since the Mullerian duct, accommodating the passage of eggs, is a much larger structure than the Wolffian duct, it is obvious that the lumen and orifice will also be larger. The papilla of the female is a large, expanded, fleshy structure; it gains complexity since its inner surface is thrown into well-marked folds that are continuous through the cloacal wall to the more expanded uterine portion of the oviduct in the peritoneal cavity. These folds are more numerous and have a finer texture than the coarse glandular folds of the oviduct.

Two median folds spring from the mid-dorsal wall of the urogenital sinus as an arch-like structure, the sides of which separate, flare laterally, and then taper off medially into the urogenital groove. In the male they extend posteriorly about 15 mm. and become confluent with the margin of the urogenital groove which has its origin at the base of the urogenital sinus. Because of the sex and their relation to the urogenital orifices, these folds in the male are termed the urethral folds. In the female these folds are larger structures from their origin; as they flare, they describe

a greater arc, but they swing abruptly toward the urogenital groove after extending only about 10 mm. posteriorly. Because of their greater fleshiness and their relation to the urogenital orifices in the female, they may well be called the vaginal folds in contrast to the urethral folds of the male.

The urogenital groove (Fig. 2, A and B) has its origin at the base of the urogenital sinus; its position on the floor of the cloaca continues posteriorly to the base of and into the glans penis or clitoris according to the sex. In the male this groove receives the semen from the sinus, and is the path of conveyance to the glans penis. Though varying somewhat in individuals, it is approximately 25 mm. in length, and has a depth of about 4 mm. In the female the length of this groove is approximately 15 mm.; the face of the groove is composed of minor folds that are directed from the center in a posterolateral direction; the depth is shallow.

Arising from the floor of the cloaca near the termination of the urogenital groove in the male is the heart-shaped glans penis. It is composed of three irregular, concentric folds or sheaths. The outermost and largest is more uniformly pigmented than the smaller, middle sheath; the innermost and smallest is entirely devoid of pigmentation. Its greatest length and width is about 12 x 10 mm. In the female the glans clitoris (homologue of the male glans penis) is a rather small, simple, heart-shaped, irregularly pigmented structure arising from the floor of the cloaca at the temination of the urogenital groove. In shape the glans clitoris is nearly a reproduction of the glans penis; however, in size it is approximately three times smaller with a maximal length and width of about 5 x 3 mm. (Fig. 5, A and B). In structure it is a single raised fold devoid of pigmentation centrally.

The body of the heart-shaped glans penis is situated in a pronounced, heavily pigmented depression of the cloacal wall; posteriorly it is flanked by minor epithelial folds that invest the organ and form a hood or prepuce, which is the foremost part of the penis when erect and extruded.

The glans clitoris is also inset in a heavily pigmented depression of the cloacal wall, and embedded in minor epithelial folds that form a preputium clitoris. These folds are not as prominent as the corresponding folds of the male, but are developed in about the same relative degree as the glans clitoris. The prepuces of both sexes are distinguished with the glandes from the remainder of the cloaca by their deeper, greyish-black pigmentation.

At the base of the glandes and on both sides of the urogenital

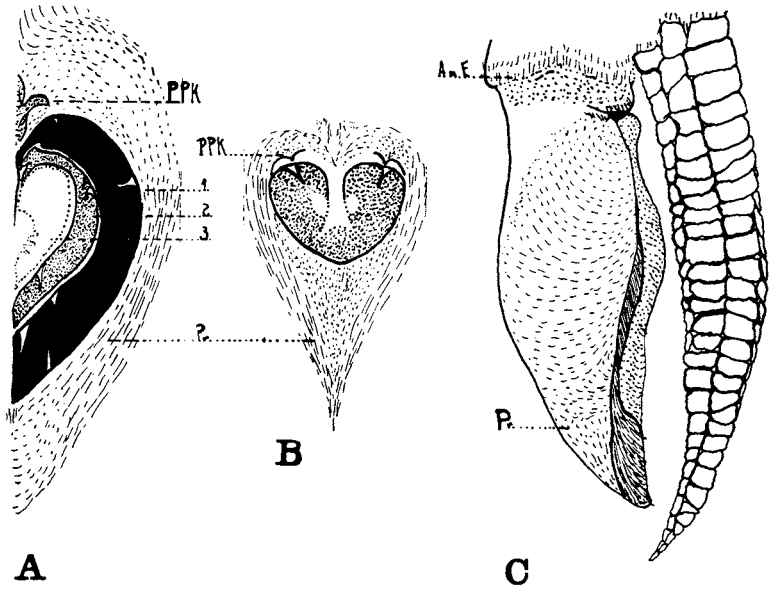

Fig. 5. (A) Right half of the glans penis and prepuce; figures 1, 2, and 3 denote the folds of the organ. (B) The glans clitoris and preputium clitoris. (C) The extruded penis and the tail. The glans is concealed with the enclosure of the prepuce.

groove on the preputial folds are minute papillae. These papillae are the terminations of the peritoneal canals, extensions of the coelomic cavity, opening on either side of the bladder stalk and extending posteriorly through the ventral wall of the cloaca. By using a 20 cc. syringe, attempts to inject colored solutions through the canals were unsuccessful. Evidently the canals end blindly in both sexes.

The body of the penis originates near the anterior extremity of the ventral cloacal wall as a pair of bulbular, knobby prominences just posterior to the urogenital sinus. It consists essentially of a tough corpus fibrosum and spongiosum that embraces the urogenital groove. It tapers to a point that terminates in the folds of the prepuce about 12 mm. behind the posterior tip of the glans penis, and has a length of about 60 mm.

On the external cloacal wall of the male, ventrally and at the level of the base of the glans, is inserted in a broad, triangular, fan-shaped manner the long rector penis muscle which directs the extrusion of the penis. It extends posteriorly, loops laterally around the pubis caudalis muscle, and proceeds anteriorly into the pelvis where it arises from the surface of the 8th thoracic vertebra in the vicinity of the kidney. A rector clitoris muscle is present

in the female having the same origin and insertion; however, the base of this muscle at its insertion above the clitoris is about one-third the size of that of the male. In cross section the body of the muscle is correspondingly about one-third the diameter of its male homologue (Fig. 1, A and B).

The rector penis muscle functions mainly as a retractor (Gadow (3)); when the penis is extruded this muscle is retracting and employing the pubis caudalis muscle as a fulcrum for leverage to hoist the lower portion of the pelvis forward and project the anterior portion posteriorly while the tail is being bent ventrally. Consequently, the body of the penis issues from the anus, everts the prepuce and extends the glans. The penis then, when extruded, appears as a freely projecting, blood congested body from the ventral wall of the cloaca through the anus (Fig. 5, C).

The cloacal bladders, or anal pouches, may be described as sac-like recesses opening on each side of the cloaca near its anterior extremity; they occupy the groin, project into the peritoneal cavity, and are covered by the peritoneum. The openings of these bladders are continuous with lateral folds of the cloacal wall that extend anally and serve to shut off the bladders from communication with the inside of the cloaca. In the female the bladders are capable of greater expansion than those of the male as shown by inflation. The lateral cloacal folds are also more prominent in the female.

In cross section the cloacal wall of the female is thicker, and the minor folds that compose the face of the cloaca are more distinct. If the cloaca is expanded, the minor folds unfurl to make the cloaca more roomy. The cloacal wall of the female, by virtue of its more prominent folds, allows for the greater degree of expansion necessary for the passage of the rather large eggs.

Relative Lengths of the Cloaca In Male and Female Turtles

Measurements were made in order to specify some of the sex differences that appear in the cloacae (Figs. 2 and 3). The relative length and width of the tail which is greater in both respects in the male than in the female, have been characters recognized and utilized in the identification of sex in turtles for a long time. Measurements upon *Emys blandingii* show, however, that this difference does not hold when applied to specific regions of the tail because the post-anal length is greater in the female and the pre-anal cloacal length is greater in the male.

Table I has been arranged to show the sex differences in lengths of several tail and cloacal regions in several representative specimens. It can readily be seen that an average value of the total cloacal length is greater in males than in females. When the cloacal length is divided into regions extending from the anterior extremity of the urogenital sinus to the base of the glans, and from the base of the glans to the anus, the average lengths of both measurements are greater in the male than in the female.

In the male the average length from the glans to the urinary sinus was found to be 31 mm. In the female the same average measurement was found to be 27.1 mm. Thus the difference was 3.9 mm. in favor of the male. However, of greater significance is a difference of 6.3 mm. in the average lengths from the glans to the anus of the two sexes. In the male the average was 29.3 mm., and in the female 23 mm. The closer agreement in the values of the anterior region is correlated with the fact that the urinary sinus of the female is proportionately greater in length, while the distance from the sinus to the base of the glans is proportionately shorter than the corresponding length in the male, due to the longer extent of erectile tissue making up the body of the penis in the latter. The glans penis and prepuce are much larger and more extensive than the glans and preputium clitoris, thus accounting for the greater difference in the posterior region.

From the above values it is found that the average length of the cloaca is about 22 per cent greater in the male. The average length from the urogenital sinus to the base of the glans is about 14.4 per cent greater in the male than in the female; the average length from the base of the glans to the anus is 27.4 per cent greater in the male. From the anus to the tip of the tail, the average length is 41.3 mm. in the males and 47.6 mm. in the females, or 15.2 per cent greater in the females. The females used in this study have an average carapace length that is 5 per cent greater than that of the males.

Oviducts In Males

Inspection of the mesenteries associated with the kidneys of the adult male turtles revealed in seven cases of *Emys blandingii* the presence of rudimentary oviducts. Such structures were not present in other males of this species, or in males of other species studied.

Review of the literature reveals that Van Wijhe (12) observed similar structures in juvenile males of three species; *Emys*

europaea, Chelys fimbriata, and *Chelonia sp.* Rudiments of Mullerian ducts in males of other vertebrates have first been described for Selachians by Semper, and for Amphibians by Spengle. Van Wijhe also described the presence of rudimentary Wolffian ducts in three species of juvenile female turtles: *Trionyx sp., Emys europaea*, and *Chelonia* sp.

Records of oviducts in adult males are as follows: Fantham (2) described two cases of hermaphroditism in the reproductive organs of *Testudo graeca.* Matthey (5) described a case of intersexuality of the sex glands of *Emys europaea.* In two of these cases the left gonad was a well defined ovotestis, and in each case ovocytes were found on the testis surface. Cases of hermaphroditism have been recorded for *Lacerta agilis* by Jaquet (1893), for *Lacerta saxicola* by Lantz (1923), and for *Lacerta viridis* by Regamey (1931) (cited from Risley (9)). Thus it is seen that a few cases of adult hermaphroditism are known among the reptiles.

In the normal male the mesorchium binds the dorso-mesial face of the testis to the ventral face of the kidney; it extends laterally and anteriorly, and joins the body wall and dorsal mesentery re-

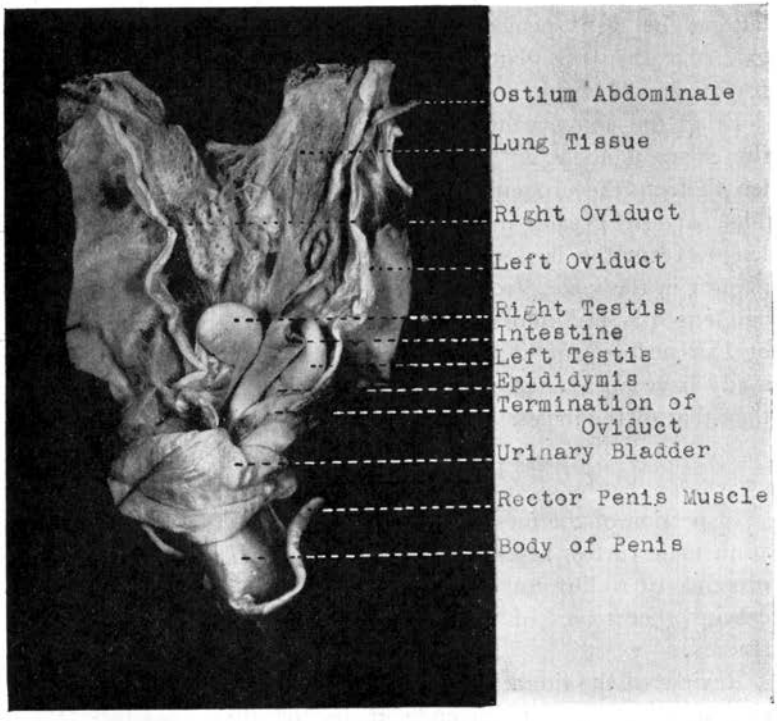

Fig. 6. Photograph of male urogenital system with largest rudimentary oviducts.

spectively. In the unusual males a mesenterial extension along the epididymis beginning at the base of the bladder stalk extends cephalad anterior to the testis where it joins an anterior extension of the mesorchium. In the lateral extremity of the mesentery is the rudimentary oviduct (Fig. 6).

The specimen (Fig. 7, I) displaying the largest rudiments had a carapace size of 214 x 141 mm. and a plastron 197 x 107 mm. The

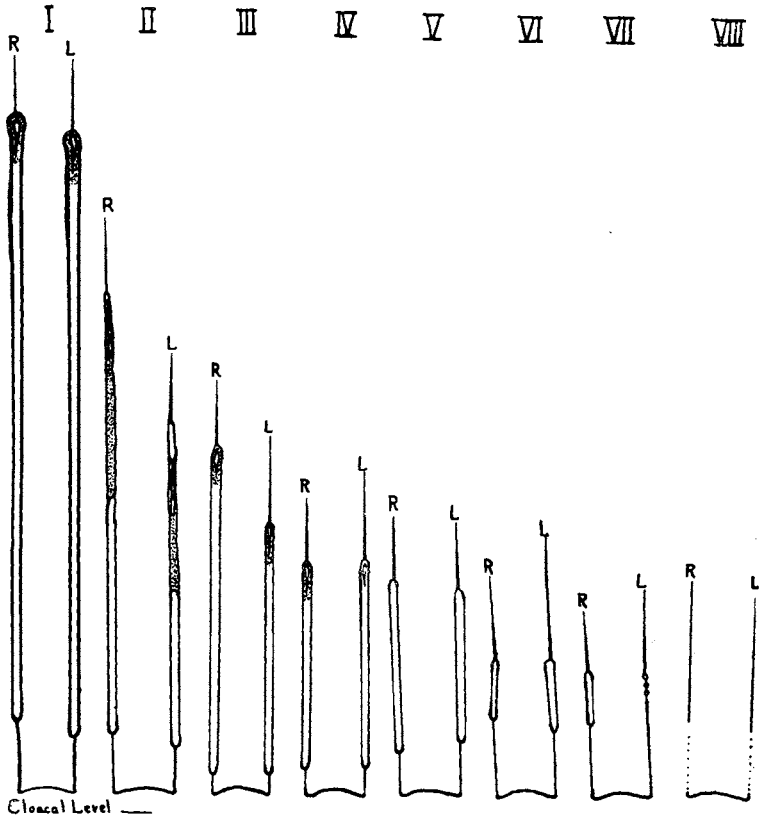

Fig. 7. Diagram showing relative lengths of oviducts in males. Outline drawings of uniform magnification showing the relative degree of development of the Mullerian ducts in adult males of *Emys blandingii*. Maximal development is observed in specimen I, and minimal in specimen VIII where only the mesotubaria remain.

rudimentary oviduct on the left side began posteriorly in a rounded, blind end about 16 mm. anterior to the entrance of the vas deferens into the cloacal wall; it extended along the side of the epididymis, lateral to the testis, and terminated in a rather large, open ostium abdominale near the mid-ventral surface of the lung.

Its entire length was about 150 mm. On the right side the rudimentary oviduct arose as a rounded, blind tube in its mesorchium near the center of the Wolffian body and about 21 mm. anterior to the cloaca. It extended cephalad, past the testis, and terminated near the mid-ventral region of the right lung; its entire length was about 150 mm.

In specimen V (Fig. 7) both ducts presented about the same appearance and occupied the same relative positions as those described for the specimen above. The anterior extensions of the ducts were in contact with a part of the ventral surfaces of the posterior tips of the lungs. The length of both ducts was about 52 mm., and they extended posteriorly to within 7 mm. of the anterior extremity of the cloaca. Each duct ended blindly posteriorly, but was in communication with the body cavity anteriorly by an ostium abdominale which was visible to the naked eye. Its carapace size was 196 x 135 mm., and its plastron was 171 x 106 mm.

In specimen IV (carapace: 193 x 129 mm.; plastron: 174 x 104 mm.) the remains of the Mullerian duct on the left side resembled a coarse white thread that began posteriorly about 15 mm. anterior to the entrance of the vas deferens into the cloacal wall. It extended past the anterior extremity of the kidney and its entire length was 38 mm. Its posterior tip rounded off and terminated blindly; its cephalic end, anterior to the testis, curled back upon itself and terminated in a very small ostium abdominale. Microscopic sections of a portion of this duct show a distinct lumen lined by a characteristic ciliated epithelium of high columnar cells, and typical muscle layers as in the normal oviduct. The right Mullerian duct rounded off and ended blindly about 12 mm. from the junction of vas deferens and cloacal wall. It terminated anteriorly in an ostium abdominale; its entire length was about 44 mm.

Specimen VI (carapace: 208 x 140 mm.; plastron: 178 x 105 mm.) presented still smaller rudiments. The left ended blindly about 17 mm. in front of the anterior extremity of the cloaca, and extended anteriorly for about 18 mm. where it again ended blindly near the testis. Posteriorly the right duct rounded off and ended blindly about 20 mm. from the anterior end of the cloaca, and its length was about 13 mm.

Male VII (carapace: 223 x 150 mm.; plastron: 210 x 116 mm.) was found with remnants of the lateral mesotubaria, the borders of which were thickened. A short, continuous segment of the Mullerian duct on the right side was more distinct than on the left. In the vicinity of the left kidney and opposite the left testis there

appeared three very small nodules representing the left rudiment.

Specimen III (carapace: 195 x 129 mm.; plastron: 178 x 115 mm.) bore rather large rudiments. The Mullerian duct on the right side was 85 mm. in length, on the left side 65 mm. Each duct bore a rather large ostium abdominale anteriorly, but ended blindly posteriorly near the cloaca.

Specimen II was the last studied (carapace: 207 x 135 mm.; plastron: 185 x 108 mm.). The Mullerian duct on the right side was about 115 mm. in length, on the left side about 75 mm. Each duct showed a distinct demarkation from the heavy, muscular uterine portion to the thinner-walled funnel portion; they ended blindly posteriorly near the cloaca. Three other males bore only small, short mesotubaria, but showed no visible indication of an oviduct. Figure 7 shows the varying degrees to which these structures are developed in the various specimens as arranged in descending order.

Inspection of the mesenteries supporting the ovaries of adult female turtles revealed no cases in which there was a rudiment of a Wolffian duct that was recognizable grossly. Histological examinations were not undertaken. However, Evans (11) reports four cases from 24 adult female *Chrysemys bellii*, three of which developed rather large Wolffian ducts after injections of gonadotropic hormone.

Retention of Mullerian ducts in turtles, while previously reported in three adult cases as reviewed above, is evidently not general in most species. In the second case described by Fantham (2) no evidence of the presence of ova in the testis was found. In both other cases previously described, however, the presence of the oviducts was associated with hermaphroditism of the gonads. In the present specimens no evidence of ovocytes was observed, although it is possible that microscopic study might reveal their presence, since they sometimes appear deeply embedded in the testes (Risley (9)).

In *Emys blandingii* 7 males of the 17 studied showed the presence of Mullerian ducts; three others showed the presence of the mesotubaria. Mullerian ducts or their vestiges were not observed in any of the adult males of the other species studied. It thus is significant that 58.8 per cent of the specimens of the strain of Emys blandingii used in this study possessed Mullerian ducts or their vestiges; 41.2 per cent possess distinct Mullerian ducts, and 17.7 per cent possess only the vestiges of mesotubaria. The literature reports cases in only two other species of turtles in which

such rudiments occur in the adult: *Testudo graeca* and *Emys europaea*. It appears that there is a significantly greater tendency for the retention of Mullerian ducts in the males of *Emys blandingii* than in other species.

Although the cause of retention of these rudiments in males is unknown, it seems probable, according to Witschi (13), that in semi- and undifferentiated races of frogs oviducts develop in proportion to the length of the ovarian phase of the testis development. If this phase persists for an unusual length of time, oviducts may become almost as large as in normal females. The variation in the size of the rudiments observed in the several *Emys* mentioned above may possibly be recognized as an index of a corresponding variation in the time or degree of persistance of ovarian tissue in the gonads. In some turtle testes rudiments of an ovarian cortex may persist at least until the time of sexual maturity (Risley (9)), and its presence may influence the degree of persistance of the oviducts.

Witschi (13) distinguishes two distinct periods in the development of secondary sex organs in frogs. Since their origin and early differentiation and growth occur similarly in both sexes and independently of the gonads, the first period is designated as "self-differentiating." The second phase is called the "sex-controlled period," since further development is correlated with the hormonal secretions of the male or female gonad. The length of the self-differentiating period is greater in undifferentiated races and shorter in differentiated races. It seems possible to interpret the persistance of the oviducts in a high percentage of the males of Emys blandingii in several alternative ways.

Since most turtles pass through an undifferentiated hermaphroditic phase in embryonic development (Risley (9)), as in semi- or undifferentiated frog races, the different sizes of the oviducts observed in the male specimens may be the result of a variation in length of time or degree of development of the ovarian phase in the development of the male gonad. It must also be due in part to a failure of the normal regression of the oviducts following testis differentiation. An over-lapping of the action of these two factors in time, the former normally acting earlier in the sex-controlled period to promote growth, the other acting later to inhibit growth but failing to initiate resorption, might result in an equilibration and the resultant maintenance of the oviducts in the male sex. On the other hand, since it is well known that injections of synthetic male hormone will stimulate the growth of the oviducts in most

female animals (Burns, 14), it is possible that, in these cases, an early advent of male hormone production before the normal reduction of the oviducts is completed might be a causative factor in the permanent retention of the oviducts of the males.

Since the oviducts are not only retained but in some cases seem to have sustained a complete histological differentiation, it seems evident that hormones produced by the cortex of the testis, or the testis itself, must have been in some way responsible for their maintenance. There is no apparent correlation between size of the rudiments and age of the specimens, since all specimens were adults.

Summary and Conclusions

1. The testes are small, compact, and bound to the faces of the kidneys; the ovaries are large, membranous, and loose, contain many ova, and spread through the peritoneal cavity.

2. The Wolffian ducts of the male are short extensions from the highly coiled epididymides; the Mullerian ducts of the female are elongated, fleshy, convoluted tubes that terminate anteriorly in folds as ostiae tubae abdominale.

3. The kidneys of the two sexes are quite similar; however, the ureter of the female is generally slightly longer than that of the male.

4. The rectum and urinary bladder are similar in the two sexes.

5. The urogenital sinus of the female is about twice as long and broad as the sinus of the male. Within the sinus the genital papilla, bearing the aperture of the oviduct, is much larger in the female; it is thrown into many folds. In the male it is a small pointed extension f the cloacal wall and bears the aperture of the sperm duct.

6. The urethral folds are homologous to the vaginal folds; they are longer in the males, but not as broad or as fleshy as in the females.

7. The lateral cloacal folds of the two sexes are similar, but slightly more prominent in the female.

8. The glans penis and preputium penis are about three times the size of the glans clitoris and preputium clitoris. The rector penis muscle is also about three times the size of the rector clitoris muscle.

9. The cloaca of the male is about 22 per cent longer than the cloaca of the female; however, the cloaca of the female is capable of greater lateral expansion.

10. Rudimentary Mullerian ducts occur in a large proportion of the adult males of *Emys blandingii*, and it was possible to arrange them in an order of increasing development. Males of

other species studied showed no indications of the rudiments. Rudiments of Wolffian ducts were not observed in any of the females.

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