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Further Studies on the Kidney of the Hook-Lipped African Rhinoceros, *Diceros bicornis*

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ABSTRACT **A healthy, pregnant *Diceros bicornis* (No. 29455), with histologically normal but relatively large kidneys containing a correspondingly large number of nephrons, died suddenly from an injury. Renal lobation was studied partly from serial transverse cuts across the kidney. The fibromuscular pelvic conduits, which are a craniocaudal bifurcation of the ureter, are associated with prominent longitudinally disposed paraconduital veins which anastomose with the interlobar veins. The arcuate veins open widely into the paraconduital veins. The latter drain into the major tributaries of the renal vein at the renal sinus. The interlobar arteries enter the parenchyma through the interlobar septa. These arteries release internal perforator branches, through the septa, which pass to the corticomedullary border, branch along that border as arcuate arteries, and release cortical branches centrifugally. All these branches give off twigs to the glomeruli.**

Relative renal mass of mammals is inversely proportional to their adult body mass. This is indicated by a regression line which includes rhinoceroses. *D. bicornis* No. 29455, accordingly, has exceptionally large kidneys.

The mesonephros of the 75 mm fetus of *D. bicornis* has mature glomeruli and tubules. The metanephros has pelvic conduits, paraconduital veins, but, as yet, no medullary loops.

Key words: Rhinoceros *Diceros bicornis*, Kidneys, Blood supply, Glomeruli, Renal collecting system

After completion of the previous work on the kidney of *Diceros bicornis* (Maluf, 1991a), it became desirable to study the following: (1) Relations of the renal lobes to one another and to the pelvic conduits; (2) Status of the prominent longitudinally disposed veins which are closely related to the pelvic conduits; (3) Confirmation of passage of the interlobar arteries through the interlobar septa.

The histologically normal kidneys of a healthy pregnant *D. bicornis* appeared exceptionally large, making it desirable to put them into perspective with sizes of the kidneys of other mammals including rhinoceroses. Additionally, her 75 mm fetus required description of the meso- and metanephros.

MATERIALS AND METHODS

D. bicornis (necropsy No. 29455), pregnant, and of normal adult weight (1,132 kg), died suddenly from a ruptured liver caused by her mate. Her frozen right kidney was received from San Diego. Also received were the entire right meso- and metanephros and testis of her fetus, fixed at necropsy in 4% formaldehyde, and histological sections of her left kidney similarly fixed. The adult kidneys, strikingly large (Table 1), were essentially normal histologically and of similar shape and nearly identical size.

The right kidney was thawed at 4°C. The cannulated ureter, main branches of the renal artery, and tributaries of the renal vein were perfused with several changes of 10% formaldehyde using light digital pressure. A pyelogram was done (see Fig. 5) using 60% Hypaque® meglumine (Winthrop).

Gross studies were done under fiberoptic illumination at magnifications of ×7–30. The illustrations of the uncut kidney (Figs. 1, 2) and of the transverse cuts (Figs. 3, 4) were drawn to natural size by precise measurements. This also applied to the dissections for which a pair of watch-maker's forceps and a fine straight ophthalmic scissors were essential.

Stains for histological sections of the left kidney and for the fetal organs were hematoxylin and eosin. Sections of the right kidney were stained with Masson's trichrome and with Verhoeff's. Shrinkage of tissues before and after histological sectioning was less than 10%.

The glomerular capsules, mostly spheroidal, were measured from histological sections of the left kidney. Only the largest glomeruli were used as it was consid-

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TABLE 1. Data leading to glomerular counts per kidney of Rhinocerotidae

Species, age (years), sex	No. of necropsy and kidney	Net mass of single kidney (g)[1]	Mass of two kidneys (% of body mass)	Diameter of glomerular capsule (μm) (average)	Glomeruli per gram cortex	Mass of glomeruli/ kidney in grams	No. of glomeruli in one kidney
Diceros bicornis 15, F	29455 (right)	3,048	0.54	265 ± 17 (n = 18)	11,327	184	18,401,844
D. bicornis, 12, F	17983 (right)	1,855	0.28	258.6 ± 12.4 (n = 18)	11,144	98.3	13,292,921
D. bicornis, 16, F	20317, (left)	2,598	0.43	246.5 ± 14.8 (n = 30)	7,071	101	12,104,696
D. bicornis, stillborn at term, M	31680 (right)	131.0	0.92[2]	97.2 ± 5.3 (n = 18)	238,290	5.15	13,225,095
Rhinoceros unicornis, died at term, M	31596 (right)	166.3	0.43	97.15 ± 3.13 (n = 18)	129,308	6.52	13,047,177
R. unicornis, 3.5, F	21835 (left)	1,480	0.28	189.6 ± 8.8 (n = 18)	14,080	65	16,107,981
Ceratolherium simum cottoni, 39.2, M	28818 (right)	2,831	0.28	306.0 ± 18.9 (n = 38)	6,152	192.6	12,348,482
Dicerorhinus sumatrensis, 8, F	30915 (right)	1,541	0.46	157.3 ± 9.1 (n = 18)	14,080	31.4	14,558,720

[1]Both kidneys were described at necropsy as approximately equal in size. The single kidneys had been stripped of perirenal fascia, ureter, and major hilar blood-vessels, thus obtaining the "net renal mass."
[2]". . . seems small for a term rhino," K.G. Osborn, D.V.M., pathologist.

ered that they were cut through their meridian. The largest diameter and that at a right angle to it were averaged. The volume of a sphere in mm^3 was multiplied arbitrarily by 1.060 to obtain its mass in mg.

Separation of cortex from medulla was from transverse slices of the frozen cranial half of the kidney (Figs. 1, 2). Distinction between cortex and medulla was by texture and arcuate vessels. The following structures were set apart for separate weighing and were not included as renal parenchyma: (1) Interlobar arteries and surrounding interlobar septa; and (2) pelvic conduits. The tissues were mopped carefully with absorbent paper and weighed to the nearest mg. The above non-parenchymatous tissue (207 g) was subtracted from the net renal mass (Table 1) in differentiating cortex from medulla.

Counting of glomeruli has been described in detail (Maluf, 1989a, 1991a). Pieces of central cortex, checked by dissecting microscope to exclude possible residual medulla, were carefully mopped on absorbent paper and weighed to the nearest mg and then disintegrated at room temperature with 7.4 N (27%) HCl. The resultant suspension was diluted with 0.9% NaCl to known volume and counts of glomeruli in fifty 0.010 ml aliquots, drawn by a calibrated pipette, were made microscopically.

Primary branches of the renal artery and main tributaries of the renal vein were injected with aqueous acrylic emulsions which had the consistency of thin cream: cobalt blue into the veins and cadmium red into the arteries. The injections were done shortly after the radiographs and were helpful during dissections.

RESULTS

General

The kidneys of *D. bicornis* No. 29455 were normal histologically and comparatively large (Table 1). They formed 0.54% of the well-nourished body mass, although stripped of all perirenal fascia.

The kidney, which is multilobar, is C-shaped (Figs. 1, 2) such that the cranial (CF) and caudal (CD) poles are apposed with assistance of an essentially fat-free and relatively avascular fascia. This fascia extends also across the deep fissures which are established by the C-formation and which are evident at the dorsal surface (Figs. 2, 3, and 4, Z).

The medial border is thicker than the lateral and is composed of two sets of lobes in juxtaposition (Figs. 3, 4) which tend to form a median longitudinal sulcus (Figs. 2, 3, and 4, S). The lateral border, on the other hand, is made of a series of single lobes which extend across both ventral and dorsal surfaces of the kidney (Figs. 3, 4). The wide renal vein, RV, and its primary tributaries span the length of the hilum (Fig. 1).

Interlobar septa separate the cortices of adjacent lobes (Figs. 3, 4; Fig. 7, ST). Lobes 18 and 26 (Fig. 1) are relatively long. A cut across their lengths shows that they are indeed single lobes with uninterrupted cortices and medullae. Lobes 27 and 28 (Fig. 1), on the other hand, are distinct and separated by an interlobar septum and so are lobes 15 and 16 (Fig. 1). A few lobes span across from the greater to the lesser curvature of the kidney (Fig. 1, lobes 12, 13, and 26). All lobes are exposed at the renal surface, there being no buried lobes. A few lobes extend from ventral to dorsal surface of the kidney (e.g., lobe 30, Fig. 4). In general, the lobes inosculate with one another. Relations of the lobes to the pelvic conduits and to the paraconduital veins are described below.

Ureter and Pelvic Conduits

The ureter enters the mid-portion of the kidney at the lateral margin of the hilum (Fig. 1, U). Without expanding into an appreciable pelvis, the ureter bifur-

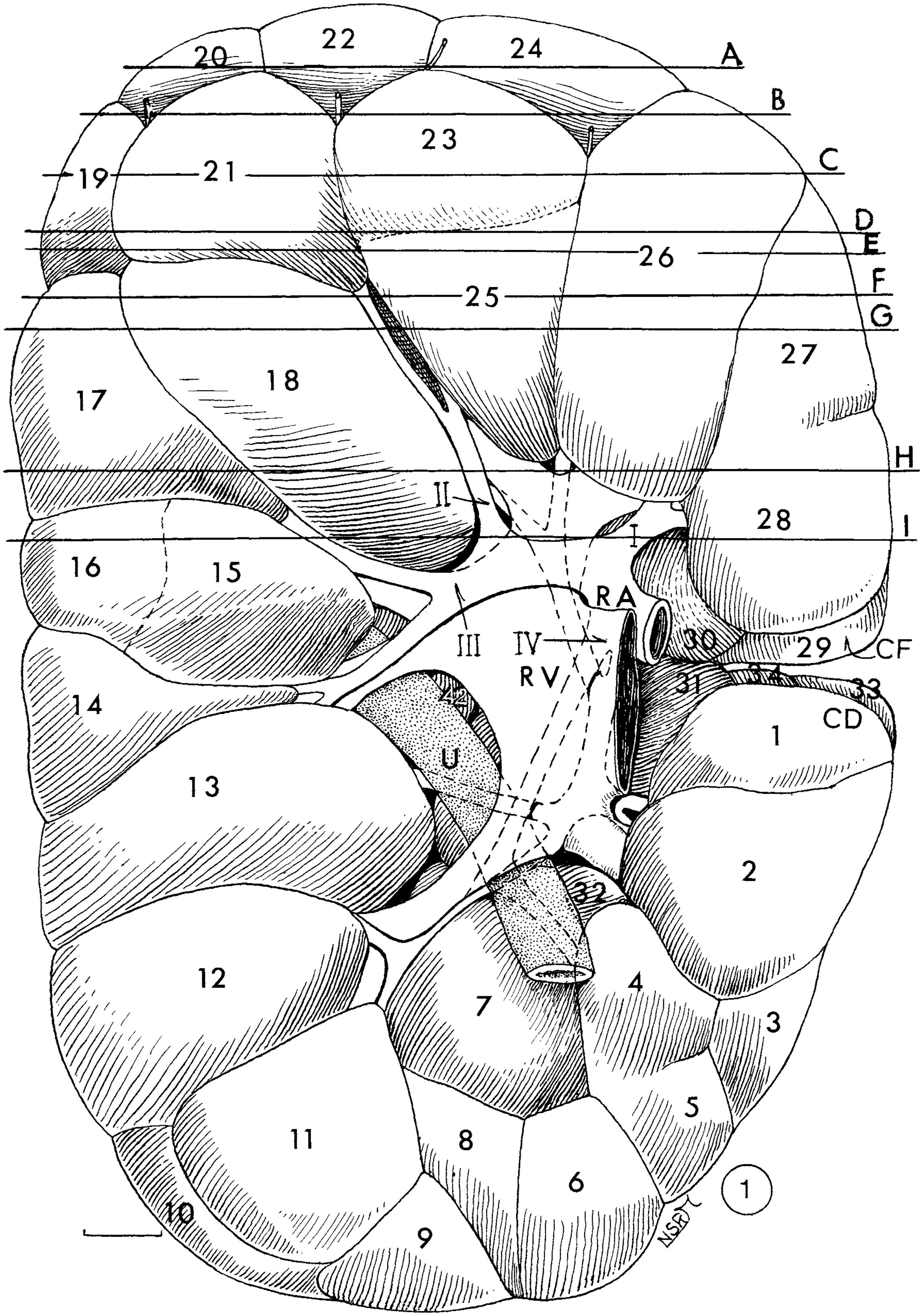


Fig. 1. *Diceros bicornis* No. 29455. Ventral aspect of right kidney stripped of perirenal fascia but not of renal capsule. The hilum has been carefully dissected. Lines *A* to *I* indicate level of the transverse cuts. CD, caudal pole; CF, cranial pole; RA, renal artery; RV, renal vein; U, ureter. Primary branches of the renal artery are in Roman numerals I–IV. Lobes are in Arabic numerals. Bar = 20 mm.

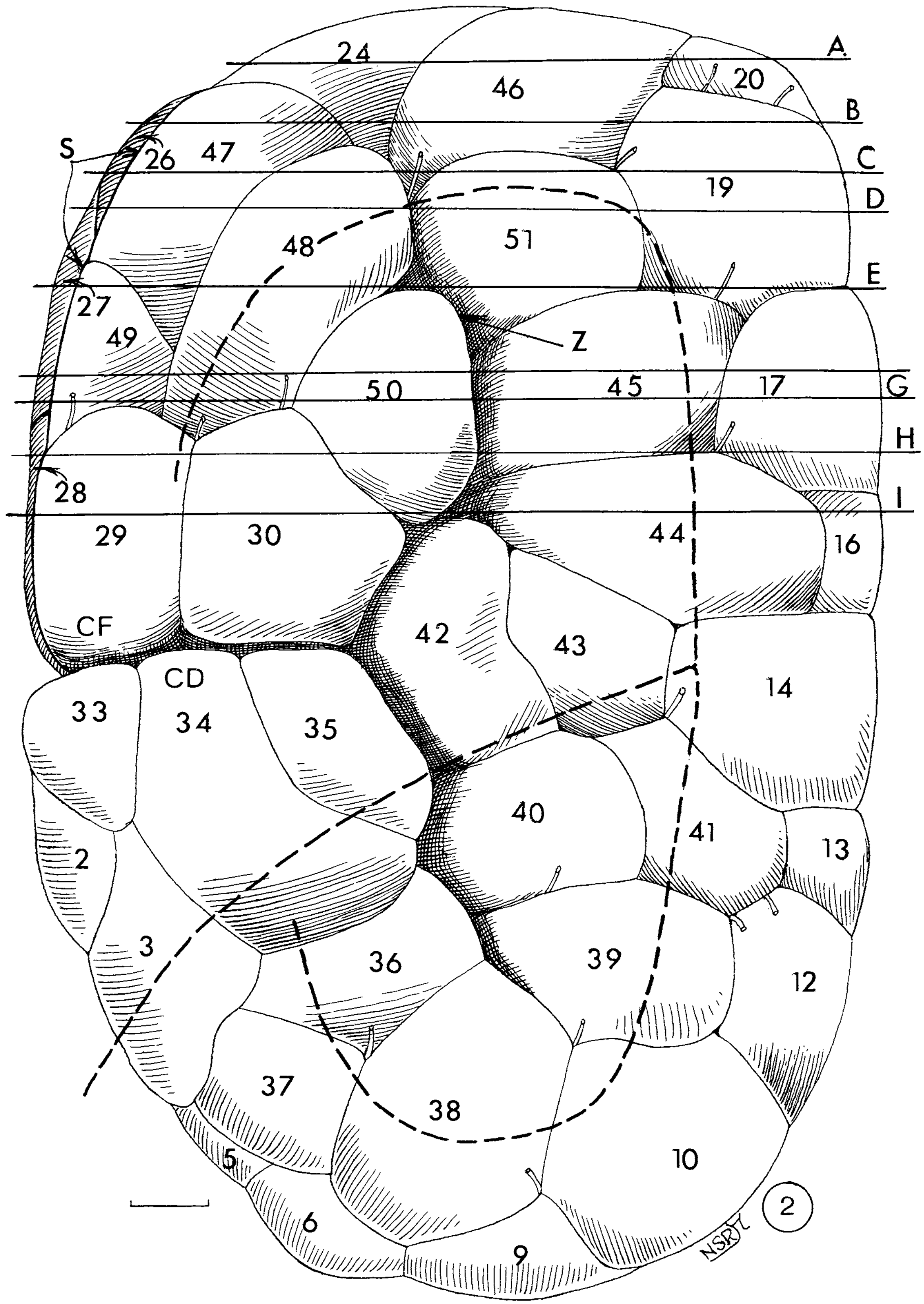
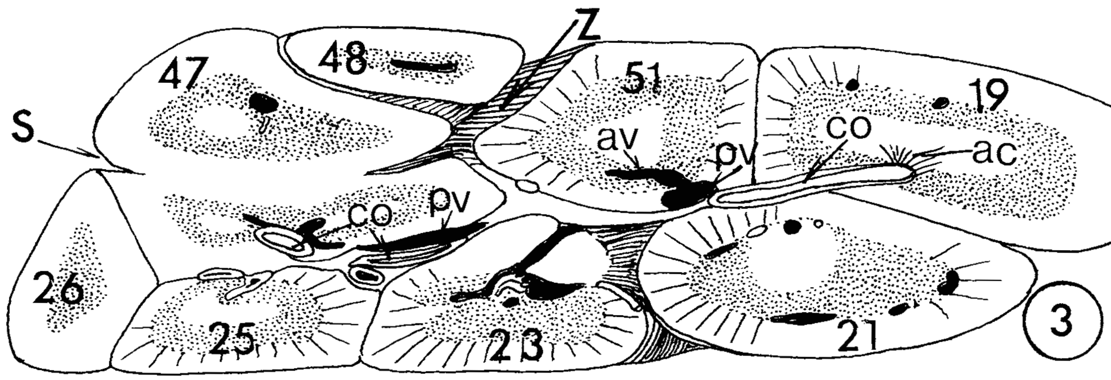


Fig. 2. *Diceros bicornis* No. 29455. Dorsal aspect of right kidney stripped of perirenal fascia but not of renal capsule. Lines *A* to *I* indicate level of the transverse cuts. The course of the pelvic conduits and ureter is indicated by the broken line. CD, caudal pole, CF, cranial pole; S, longitudinal sulcus, Z, deep fissure. Bar = 20 mm.



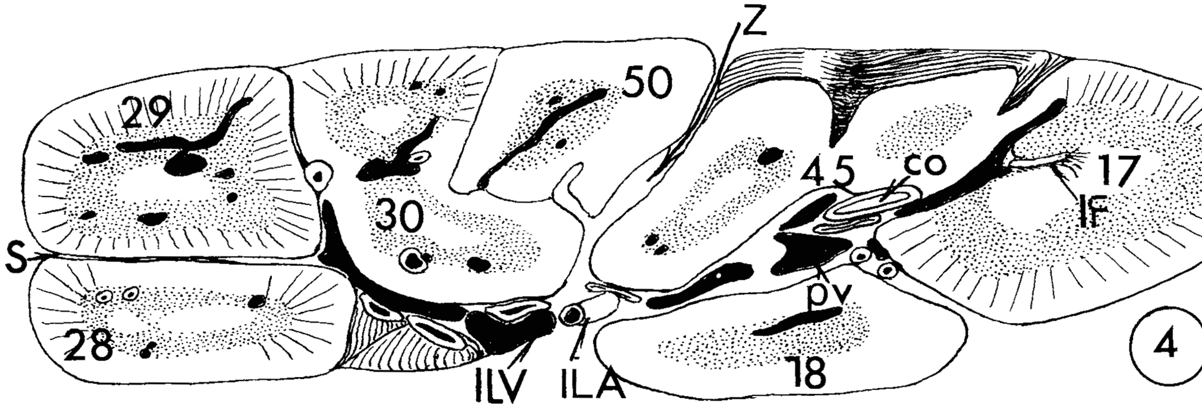


Fig. 3. *Diceros bicornis* No. 29455. Caudal face of transverse cut through cranial half of right kidney at level of line D of Figures 1 and 2. The dorsal surface of the kidney is on top and the medial border is at the left. The lobes are numbered as they are in Figures 1 and 2. Veins are in solid black; major arteries are as black tubes with white contours; the pelvic conduits, CO, are as hollow tubes. The dorsal renal cleft is shown by the arrow, Z. ac, area cribrosa; av, arcuate vein; CO, pelvic conduit; pv, paraconduital vein; S, longitudinal sulcus. Bar = Same as Figs. 1 and 2.

Fig. 4. *Diceros bicornis* No. 29455. Caudal face of transverse cut through cranial half of right kidney at level of line H of Figures 1 and 2. The dorsal surface of the kidney is on top and the medial border at the left. The lobes are numbered as in Figures 1 and 2. Note that the cranial end of the conduit, at the medial border of the kidney, is no longer in this cut (see also Fig. 2). CO, pelvic conduit; IF, infundibulum; ILA, interlobar artery; ILV, interlobar vein; pv, paraconduital vein; S, longitudinal sulcus, Z, dorsal renal cleft. Bar = Same as Figs. 1 and 2.

cates intrarenally into a cranial, P_1, and a caudal, P_2, fibro-muscular conduit (Fig. 5) of almost equal length. The renal lobes discharge their excretion into these conduits.

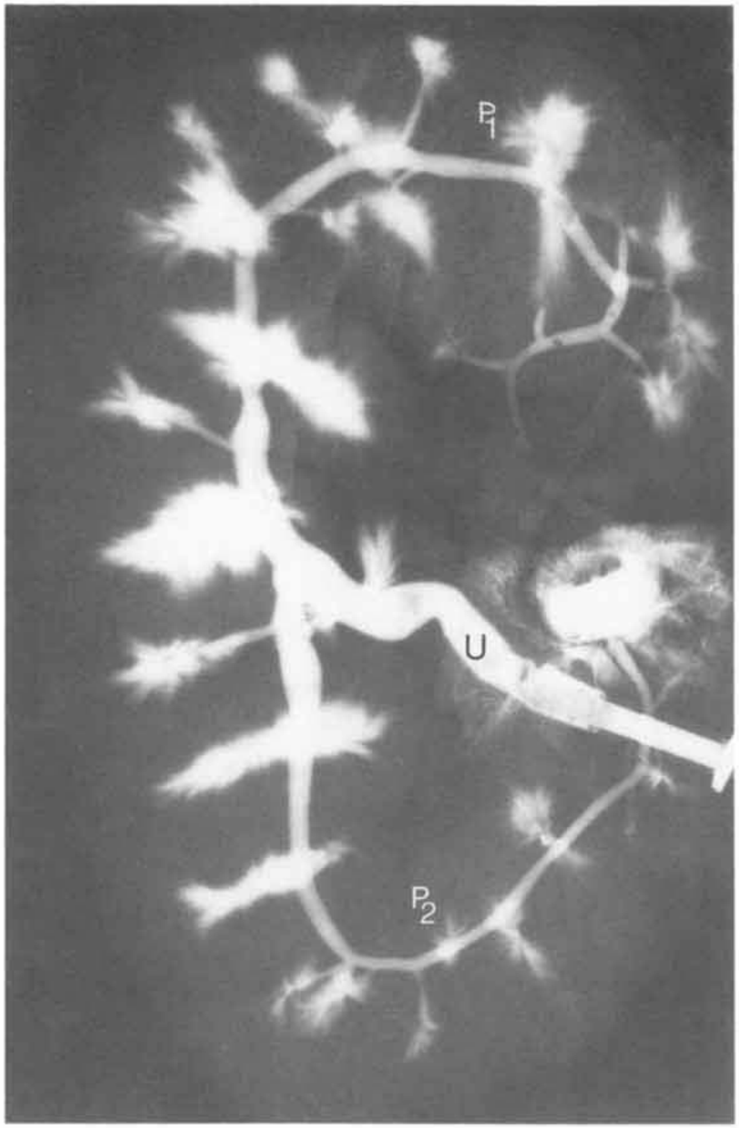
The muscular bundles of the hilar portion of the ureter are arranged grossly in a circular manner, but as shown by higher magnification ($\times 450$), these bundles are composed mostly of longitudinal and oblique muscle fibers. Fibers of collagen are interposed. The wall of the urothelial-lined pelvic conduits is, by contrast, mainly a compact layer, about 305 μm thick, of longitudinal and oblique muscle fibers with almost no collagen. The conduits course through the center of the kidney almost equidistant from the greater and lesser curvatures (Fig. 2; Fig. 3, CO). This distance of about 43 mm is essentially the height of the lobes. The conduits are also almost equidistant from the dorsal and ventral surfaces of the dorso-ventrally flat kidney (Figs. 3 and 4, CO). The conduits taper down from the ureteral bifurcation, where they are about 10 mm in internal diameter, to the cranial and caudal poles where they become about 4 mm (Fig. 5). Assuming an average internal diameter of 7 mm and knowing their lengths (273 and 282 mm), measured by a malleable ruler, their capacity is only about 8.7 cm^3.

There are 24 primary ostia at the conduits. These are 1 to 3 mm wide, have no valves, and occur at all arcs of the conduits. They lead into an infundibulum of varying length (less than 1 to 2.1 mm) which bifurcates once or twice at the cranial and caudal poles. Branching of infundibula results in separate lobes opening at a common ostium. This, in part, results in disparity between number of lobes (51) and primary ostia (24). Such disparity occurs in the other species of rhinoceros, especially in *Rhinoceros unicornis* which has a greater number of lobes (Maluf, 1987; and unpublished findings).

Cortex

The cortex is about 60.1% of the renal parenchyma. Interlobar septa separate the cortices of adjacent lobes (Figs. 3, 4; Fig. 7, ST) except for scattered relatively minor interruptions of the septa. The thickness of the cortex at the periphery of a lobe (7–11 mm) tends to be greater than the cortex between lobes (5–8 mm).

The glomeruli tend to be spheroidal with an average



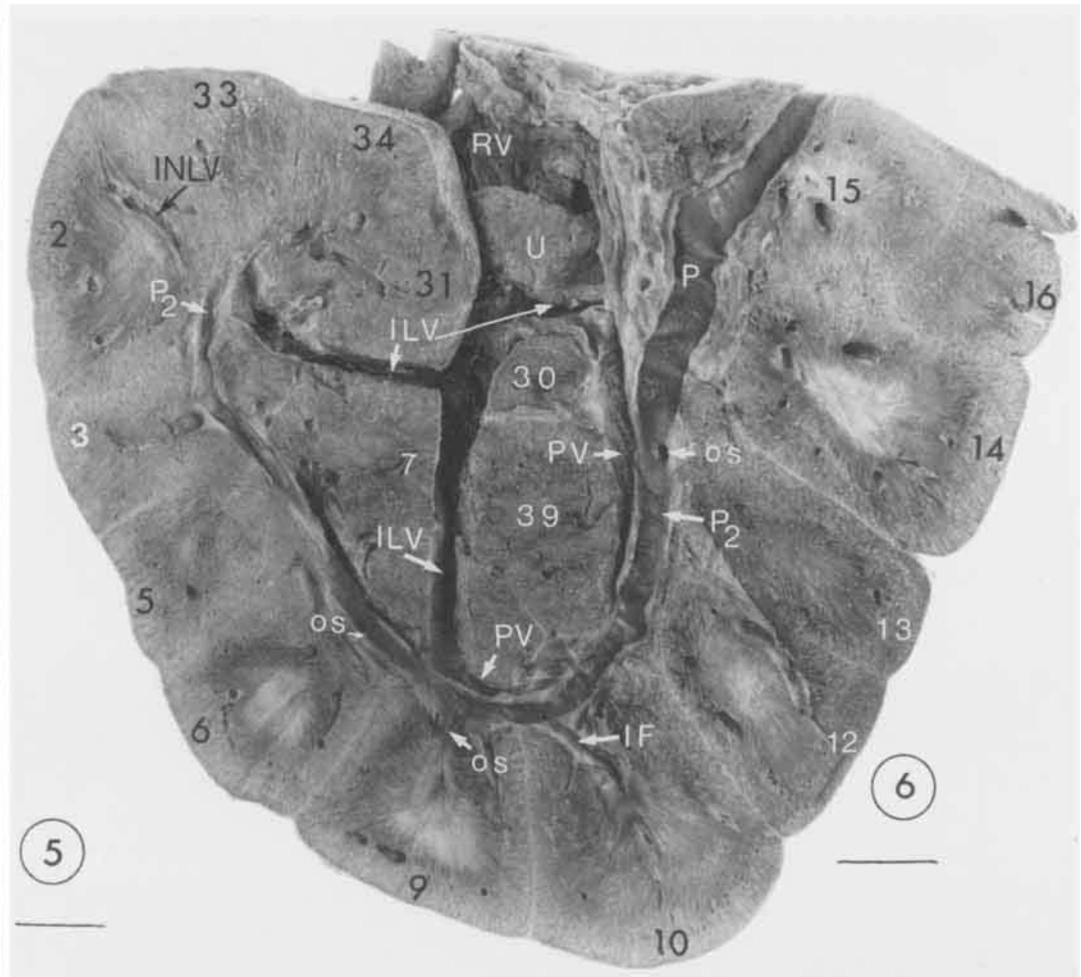


Fig. 5. *Diceros bicornis* No. 29455. Right pyelogram. Reflux has occurred into the collecting ducts: extravasation has occurred at the end of caudal pelvic conduit P_2. Branching of ducts is present especially at the end of the cranial pelvic conduit, P_1. U, ureter. Bar = 31 mm.

Fig. 6. *Diceros bicornis* No. 29455. Dorsal surface of ventral coronal half of right kidney. The pelvic conduit, P_2, is shown throughout its course. The interlobar veins, ILV, are large and drain the paraconduital veins, PV, and thus drain the intralobar and arcuate veins. IF, infundibulum; OS, ostium, P, pelvis; RV, renal vein; U, ureter. Bar = 16 mm.

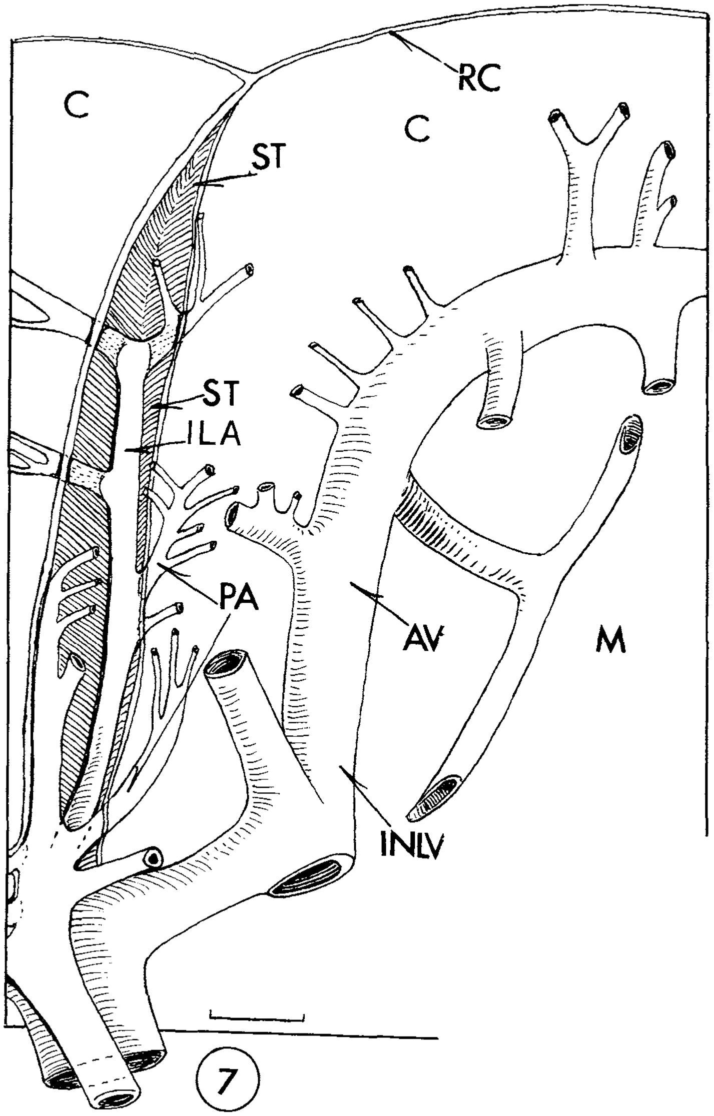


Fig. 7. *Diceros bicornis* No. 29455. Dissection showing interlobar arteries, ILA, in interlobar septum, ST. Perforating arteries, PA, pierce the septum and pass directly to the cortices, C, of adjacent lobes. The large arcuate vein, AV, has a thin translucent wall which thickens, it should be noted, toward the medulla, M. INLV, intralobar vein; RC, renal capsule. Bar = 5.9 mm.

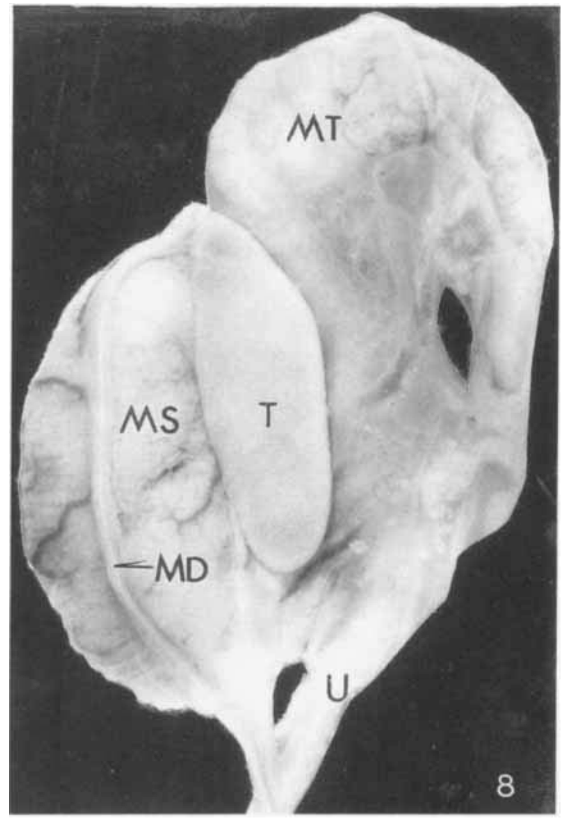


Fig. 8. *Diceros bicornis* No. 29455. Male fetus (75 mm). Ventral aspect of right metanephros, MT; mesonephros, MS; testis, T; MD, mesonephric duct; U, ureter. Bar = 2.1 mm.

diameter of 265 ± 17 μm (n = 18). There is no significant difference in their size across the thickness of the cortex. There are about 11,327 glomeruli per gram of cortex and about 18 million glomeruli per kidney (Table 1). The glomerular mass is about 6% of the renal parenchyma.

Medulla

The medulla is 39.9% of the renal parenchyma. This is a relatively large fraction. In the writer's experience this fraction is outstripped by the adult manatees (Maluf, 1989a). In the two other adult *Diceros bicornis* females the medulla averaged 34.9% of the parenchymal mass (Maluf, 1991a). The swamp-dwelling Asiatic rhinos, *Rhinoceros unicornis* (Maluf, 1987) and *Dicerorhinus sumatrensis* (unpublished observations), show medullae of 24.7 and 32.9% of renal mass, respectively.

Arteries

There is a single renal artery (Fig. 1, RA) which has an outer diameter of 16 mm and a muscularis thickness of 957 μm. The artery appears relatively narrow for a kidney with a net mass exceeding 3,000 g. At the hilum it supplies four major trunks (Fig. 1, I to IV) which divide into secondary and tertiary branches. The latter, as interlobar arteries (Fig. 7, ILA), enter the renal parenchyma through the interlobar septa (Fig. 7, ST). Within the septa, the interlobar arteries (outer diameter 2.4 ± 9 mm; n = 15) branch and yield internal perforating arteries (Fig. 7, PA; in outer diameter 0.88 ± 0.27 mm; n = 21) which enter the adjacent cortices carrying part of the interlobar septum with them. These arteries release small branches to the glomeruli in their course to the cortico-medullary border where they branch further along that border as arcuate arteries. These send out, centrifugally, "interlobular" or cortical radial branches toward the cortical periphery. The interlobar septa are fused tightly where no interlobar artery courses. This manner of arterial supply to the renal lobes is identical to that in two other species of rhinoceros, *Rhinoceros unicornis* and *Ceratotherium simum* (Maluf, 1989b, 1991a).

Veins

The renal veins are followed as passing from periphery to center. *Venae stellatae* do not exist in any of four species of rhinoceros examined by the writer. The veins begin near the renal capsule and pass perpendicularly through the cortex, as "interlobular" or cortical radial veins which open into the arcuate veins. The interlobular veins, 70 ± 28.6 μm (n = 6) wide, are lined only by endothelium and are applied against the tubules of the cortex and, in places, against a part of the glomerular capsules. Where associated with an arcuate artery, the corresponding vein is generally wider and central to the artery. The arcuate veins course generally between cortex and medulla but, together with arcuate arteries, may run within the periphery of the outer medulla. The wall of the arcuate veins, where it lies against the medulla, is often conspicuously thickened by fibromuscular bundles which run parallel with the veins.

The arcuate veins, as intralobar veins (Fig. 7, INLV), open via wide (over 2.0 mm) orifices, into the paraconduital veins (Fig. 3 and 4, pv; and Fig. 6, PV) which are a chain of prominent veins running close to the pelvic conduits. The paraconduital veins (diameter 7.3 ± 2.6 mm; n = 4) are major anastomotic links between the interlobar veins (Fig. 6, PV) and are thus analogous to the paraforniceal veins of the human renal pelvis (von Lenhossék, 1876; Hauch, 1904; von Möllendorff, 1930; and others).

The interlobar veins converge toward the six primary tributaries of the renal vein (Fig. 1, RV), the wall of which consists mainly of scattered longitudinal muscle bundles of varied thickness with an admixture of collagen fibers. In the center is a layer of circular muscle about 44 μm thick. Elastic fibers occur among the collagen fibers in all layers.

Renal Mass as Fraction of Body Mass

The relatively large but otherwise normal kidneys of *D. bicornis* No. 29455 (Table 1) make it desirable to put this fact into perspective. Hence the graph of Figure 14 which represents data for the kidneys of adult mammals collected from Welcker and Brandt (1903), Spector (1956), and Maluf (1987, 1989, 1991a,b; and unpublished findings). The small mammals, with higher metabolic rates per unit body mass (Benedict, 1938; Brody, 1945; Schmidt-Nielsen, 1983) have a higher renal mass relative to their body mass. The latter relationship tends to follow a hyperbolic curve (not shown) represented by equation:

$$RM = 1.43 - 0.197 \log_{10} BM \quad (1)$$

in which RM is the adult total renal mass as percent of body mass and BM is the adult body mass in grams. The relationship between $\log_e$ of renal mass as percent of body mass is a regression line (Fig. 14) such that

$$\log_e RM = 0.617 - 0.134 \log_e BM \quad (2)$$

$$\text{or, } RM = e^{0.617} BM^{-0.134} \quad (3)$$

$$= 1.853\, BM^{-0.134} \quad (4)$$

By any one of these equations the relative mass of the kidneys of an adult mammal may be estimated from its body mass in grams. Thus the relative renal mass of *D. bicornis* No. 29455 would be expected to be 0.29% rather than the actual 0.54% (Table 1 and Fig. 14). Correspondingly, she has a high total glomerular count which is essentially normal per gram of cortex (Table 1).

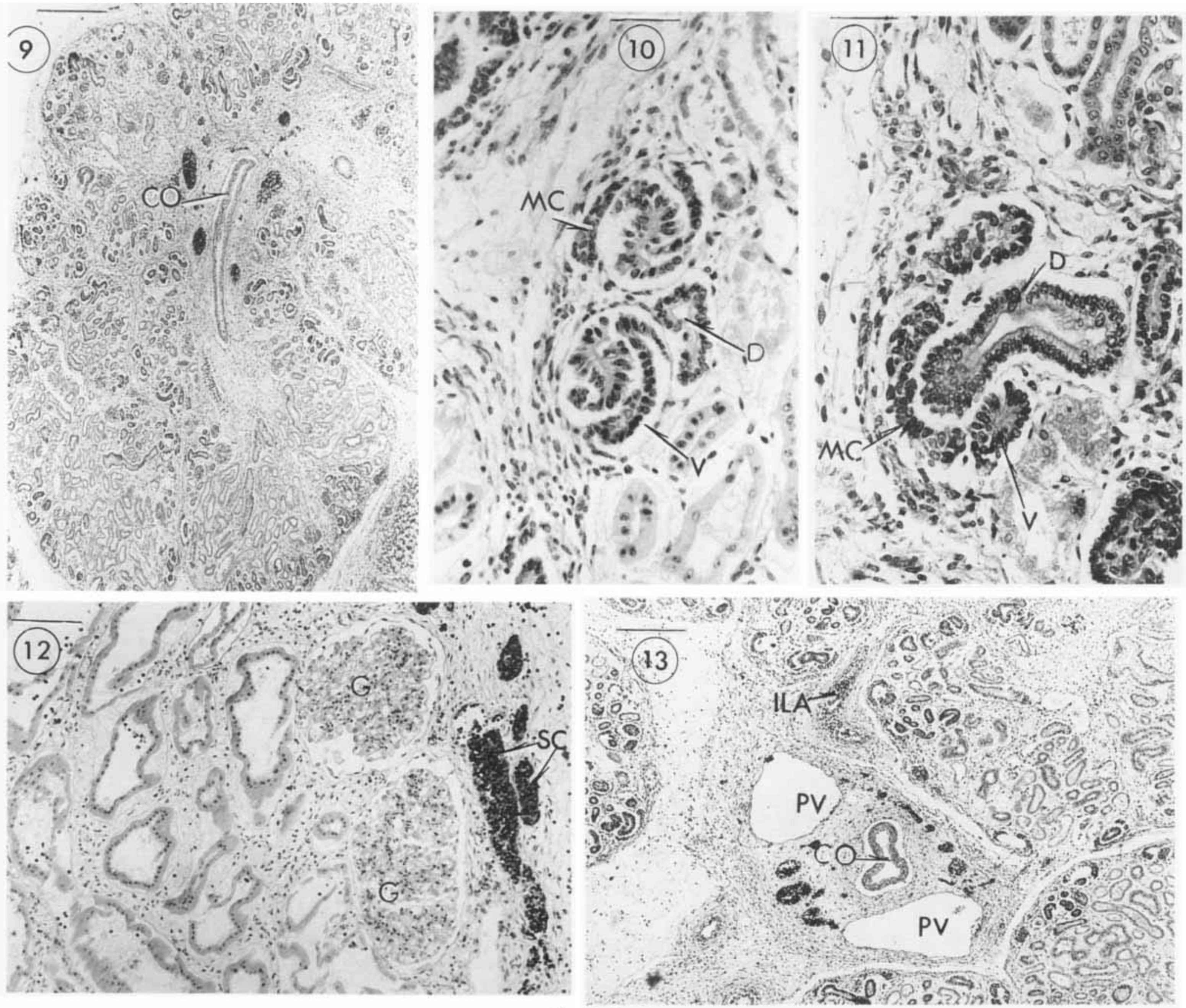
The Fetal Kidney

The right metanephros of the 75 mm (crown-rump) fetus from *D. bicornis* (No. 29455) is 10.5 mm long and 8.0 mm at widest (Fig. 8, MT). The right mesonephros, MS, is almost as long and wide and is close against the metanephros. The testis (Fig. 8, T), proven histologically, lies in the crevice between meso- and metanephros ventrally. It is 8 mm long and 2.7 mm wide; at its cranial end it is fused with the mesonephros. The mesonephric duct (Fig. 8, MD) extends from the cranial end of the testis across the ventral surface of the mesonephros and crosses the ureter caudally.

The metanephric renal capsule is about 23 μm thick with long flat nuclei. The metanephros has no medulla as yet and no medullary loops but lobation is evident (Fig. 9). Almost all nephrons are in stage No. 1 of Osathanondh and Potter (1966) and correspond to those of a 30 mm (C-R length) 60-day human fetus (compare Tuchmann-Duplessis et al., 1967; Hamilton and Mossman, 1972; Potter, 1972). Development of nephrons is in the expected mammalian manner with collecting ducts (Figs. 10 and 11, D), apparently inducing metanephric caps, MC, and metanephric vesicles, V. The S-formation is about 190 μm in outer diameter. The pelvic conduit (Fig. 13, CO) is 76 μm in outer diameter; its cells are columnar (21 μm tall and 4.8 μm wide) with nuclei toward their base. The associated paraconduital veins (Fig. 13, PV) are wide. The ureter, surrounded by a definitive layer of mesenchyme 87 μm thick, is 320 μm in outer diameter. Its urothelium is composed of about three layers of cuboidal cells. Fine blood vessels occur peripheral to the mesenchyme.

The mesonephric renal capsule is 52 μm thick and resembles that of the metanephros. The glomeruli are relatively large and oval (Fig. 12, G) with diameters of 233 to 296 μm and with glomerular capsules of flat cells. The mesonephric tubules are 100 μm wide and made of cuboidal cells 9.5 μm tall and 18 μm wide. Subcardinal veins are prominent (Fig. 12, SC). The mesonephros is thus evidently a mature functional organ.

Details of the meso- and metanephros described here supplement the general embryology of a 22 mm embryo of an African "*Rhinoceros bicornis*" (probably *Diceros bicornis*) by Davies (1952).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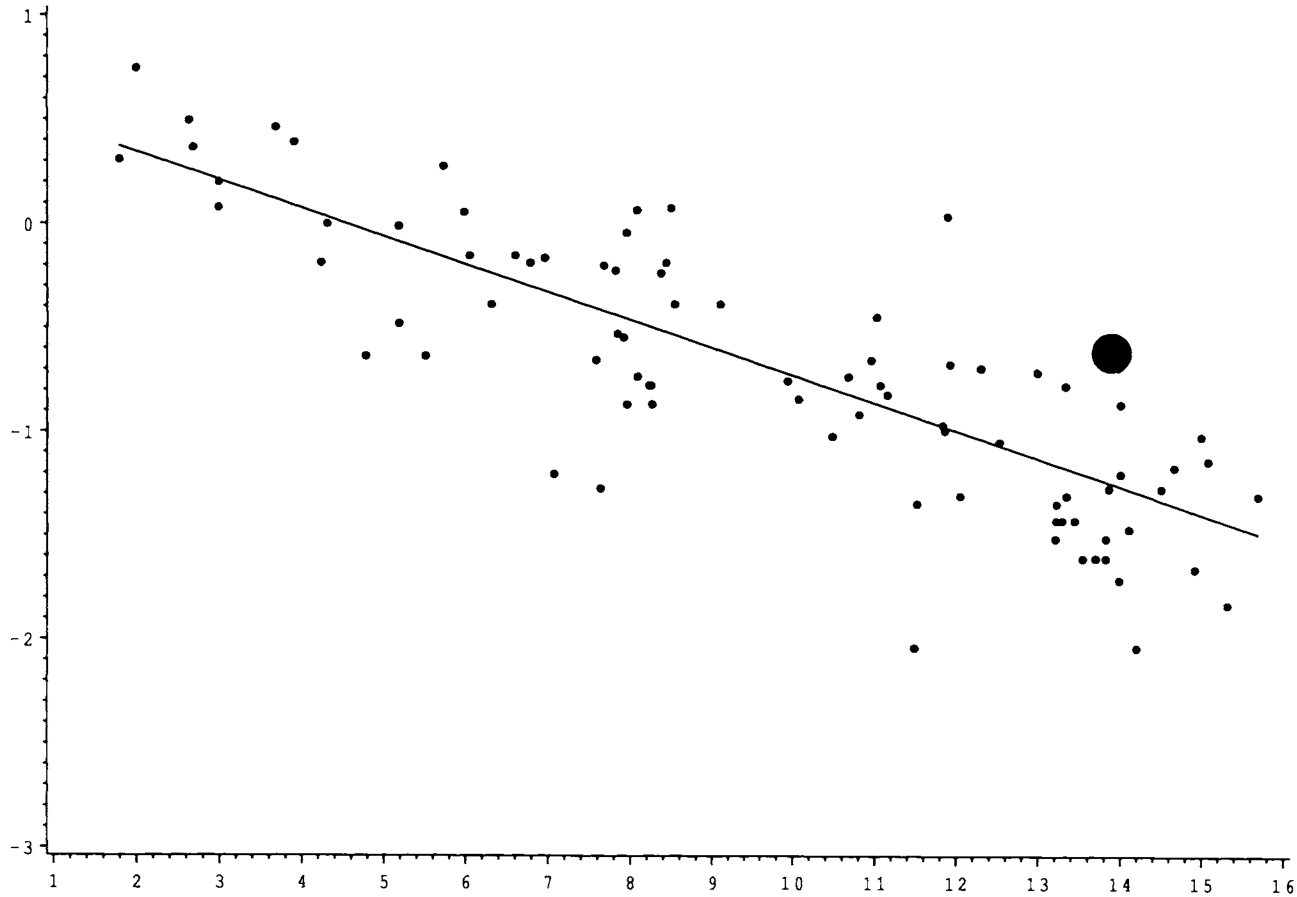

Fig. 14. $\log_e$ of both kidneys of adult mammals as percent of body mass (ordinate) vs. $\log_e$ body mass in grams (abscissa) from mouse (body mass = 14 g) to elephant (body mass = 6.6×10^6 g). Formula is on page 45. The large circle is for *Diceros bicornis* No. 29455.

DISCUSSION

Nephromegaly and Relative Renal Mass

A seemingly valid postulate is that an organ supporting a function in a normal adult is no larger than needed to satisfy the limit of performance (Weibel, 1987). Nephromegaly has been variously defined as "enlargement of the kidney" (Dorland, 1988), "extreme hypertrophy of one or both kidneys" (Stedman, 1946), and "enlargement of the kidney, usually as the result of compensatory hypertrophy after surgical removal or disease of the other kidney" (Churchill, 1989). The present writer's definition specifies a marked increase in the number of nephrons and excludes compensatory enlargement, which does not include an addition of nephrons.

An acromegalic man has had kidneys of twice normal size but normal histologically except for increased length of at least the proximal convoluted segment (Grafflin and Turley, 1939). Glomerular counts, however, were lacking and thus it was not known whether there was an increase in the number of nephrons. Other forms of bilateral congenital renal enlargement in humans have been associated with abnormalities of renal structure (Beckwith, 1969; Voland et al., 1985; Heptinstall, 1992). Glomerular mass was increased but actual counts were not done.

The body mass of *D. bicornis* No. 29455 was 1,132 kg and thus within normal range for the species (1,088 to 1,366 kg; personal communication from R. Rieches, curator of mammals at the San Diego Zoological Society). She had relatively large histologically normal kidneys with a correspondingly large number of nephrons (Ta-

Fig. 9. *Diceros bicornis* No. 29455. Male fetus (75 mm). Histological section of part of metanephros. Lobation, renal capsule, and pelvic conduit, CO, are apparent. Bar = 372 μm.

Fig. 10. *Diceros bicornis* No. 29455. Male fetus (75 mm). Portion of metanephros. D, future collecting duct; MC, metanephric cap; V, vesicle. Bar = 90 μm.

Fig. 11. *Diceros bicornis* No. 29455. Male fetus (75 mm); portion of metanephros. D, collecting duct; MC, metanephric cap; V, vesicle. Bar = 36 μm.

Fig. 12. *Diceros bicornis* No. 29455. Male fetus (75 mm). Histological section through part of medial border of mesonephros. G, glomerulus; SC, subcardinal venous plexus. Bar = 118 μm.

Fig. 13. *Diceros bicornis* No. 29455. Male fetus (75 mm). Histological section of central portion of metanephros. CO, pelvic conduit; PV, paraconduital vein; ILA, interlobar artery. Bar = 220 μm.

ble 1; glomeruli per gram of cortex). According to the pathologist, K.G. Osborn, the left kidney weighed 3,320 g and the right 3,370 g. Upon stripping the right kidney of perirenal fascia and hilar structures it weighed 3,048 g (Table 1).

The writer finds other reported weighings of the kidneys of adult rhinos: Owen (1862) noted both kidneys of *Rhinoceros unicornis* to be 5,000 g or 0.22% of body mass. Quiring (1938) found the kidneys of a pre-adult *D. bicornis* (body mass 765 kg) to be 0.39% of body mass. Player (1973) found the kidneys of a bull broad-lipped rhinoceros, *Ceratotherium simum* (body mass of 2,001.4 kg), to be 9,070 g (weighed in the field) or 0.46% of body mass. Such variation of relative renal mass is puzzling especially since Quiring (1938) found that among twenty species of hoofed mammals, the kidneys showed a lower coefficient of variation with body mass than brain, heart, liver, and lungs. MacKay and MacKay (1927a,b,c), using an inbred strain of albino rats, showed that renal mass, as a fraction of body mass, fell with post-uterine growth. It was 0.52% in the 35 g rats and 0.29% in the adult 200 g rats. Renal mass as a fraction of area of body surface, however, remained fairly constant. Similar constancy of relative renal mass was noted by Taylor et al. (1923) in rabbits. The species *Canis familiaris* varies in size from the Chihuahua to the Pyrenees. Large dogs have larger kidneys with more glomeruli (nephrons) than small dogs and the number of glomeruli is more closely related to body surface than to body mass (Kunkel, 1930). The kidneys of *D. bicornis* No. 29455 are markedly larger than the apparent norm for the species and have a correspondingly large number of nephrons (Table 1 and Fig. 14).

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