MICROANGIOARCHITECTURE OF SEMINAL VESICLE AND PROSTATE GLAND IN COMMON TREE SHREW (*Tupaia glis*)

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This study was aimed at elucidating the blood supply system to the seminal vesicle and the prostate gland in the common tree shrew (*Tupaia glis*). Eighteen male common tree shrews weighing between 110-190 g were used. Their seminal vesicles and prostate glands were prepared for studying with LM and with corrosion cast technique. It was found that the seminal vesicle and prostate glands were supplied by branches of the anterior division of the internal iliac artery. This artery also supplies the pelvic visceral organs. The anterior division of intenal iliac artery gives off three main branches. The first one is the superior vesical artery which gives off five branches to supply urinary bladder, ureter, vas deferens, urethra and finally it courses to the medial side of the seminal vesicle to become the seminal vesicle artery. The second branch of anterior division of internal iliac artery is the inferior vesical artery which gives off five to seven branches. Five to six branches supply the dorsal and ventral surfaces of the distal portion (glandular acini region) of the gland and continue to the intermediate section of the ducts and finally supply the proximal portion of the prostatic ducts adjacent to the prostatic urethra. The remaining branches supply the prostatic urethra and membranous urethra. The third branch of the anterior division of internal iliac artery is internal pudendal artery. The first and the second branches from the anterior division of the internal iliac artery, usually anastomoses with one another, are called the marginal branch of superior vesical artery. This branch gives off several arterioles to supply the greater curvature and the posteromedial side of the seminal vesicle and the rostral region of the anteroventral lobe of the prostate gland. The penetrating arterioles terminate as capillary network. The capillaries supplying the seminal vesicle and prostate gland are without fenestration. The veins from the two glands usually accompany the arteries. The interconnections between veins are usually found in both of seminal vesicle and prostate gland. These veins open into the internal iliac vein before joining the external iliac artery to form the inferior vena cava. The pattern of blood supply of the prostate gland in the common tree shrew is quite similar to that of human but somewhat different from that of rat. The blood supply to the ventral prostate in rats appears as a single trunk with the base near the proximal portion of the prostatic duct adjacent to the prostatic urethra. These vessels eventually branch out into smaller vessels, at the intermediate section of the duct, most of which continue to the distal part (the glandular acini) where they supply the distal region of the prostatic duct and the glandular portion.

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คมกฤษ พิเศษไพศาล : การศึกษาโครงหลอดเลือดโดยละเอียดของ เซมินอลเวสสิเคิล และต่อมโพรสเตต ในกระแต [MICROANGIOARCHITECTURE OF SEMINAL VESICLE AND PROSTATE GLAND IN COMMON TREE SHREW (*Tupaia glis*)]. คณะกรรมการควบคุมวิทยานิพนธ์ : เรือน สมณะ พ.บ., Ph.D., วิชัย เอกทักษิณ M.D., Ph.D., ปานจิตต์ ชุณหบัณฑิต, ปร.ด., วิสุทธิ์ ประดิษฐ์อาชีพ, ปร.ด. 106 หน้า ISBN 974-664-731-8

เมื่อฉีดสารพลาสติกเข้าแทนที่เลือดในหลอดเลือดของกระแต แล้วนำโครงหลอดเลือดในเซมินอลเวสสิเคิล และในต่อมโพรสเตตมาศึกษาด้วยกล้องจุลทรรศน์ และจุลทรรศน์อิเล็กตรอนแบบส่องกราด พบว่า anterior division of internal iliac artery จะแตกเป็นแขนงใหญ่ 3 แขนง แขนงแรกชื่อ superior vesical artery แขนงแรกนี้จะแตกเป็นแขนงย่อยอีก 5 แขนง และจะเรียกชื่อตามอวัยวะที่แขนงนั้น ๆ ไปเลี้ยงตามลำดับได้แก่ urinary branch, ureter branch, branch to vas deferens, branch to ampulla of vas deferens และ urethral branch โดยแขนงสุดท้ายนี่เองที่จะวิ่งเข้าไปเลี้ยงทางด้าน medial ของ เซมินอลเวสสิเคิล จึงตั้งชื่อแขนงนี้ว่า seminal vesicle artery แขนงที่สองของ anterior division of internal iliac artery ชื่อ inferior vesical artery ซึ่งจะแตกให้ 5-7 แขนงย่อย โดย 5-6 แขนงไปเลี้ยงผิวของด้านบน และด้านล่างของต่อมโพรสเตต ซึ่งเนื้อด้านนอกของต่อมโพรสเตตนี้เองที่เป็นบริเวณที่มี glandular acini เป็นส่วนใหญ่ แล้วหลอดเลือดแดงยังวิ่งเข้าไปด้านในซึ่งมีก้านแขนงของท่อต่อมโพรสเตตอยู่ และไปสิ้นสุดบริเวณโคนของท่อหลักของต่อมโพรสเตต (ซึ่งท่อหลักนี้ก็จะเปิดเข้าสู่ท่อปัสสาวะ) อีก 1-2 แขนงที่เหลือก็จะไปเลี้ยงส่วนของ membranous urethra และ prostatic urethra แขนงที่ 3 ของ anterior division of internal iliac artery คือ internal pudendal artery หลอดเลือดหลักที่หนึ่งและสองมักจะเชื่อมกัน โดยเรียกหลอดเลือดที่เชื่อมกันนี้ว่า marginal branch of superior vesical artery หลอดเลือดแดงแขนงนี้จะแตกให้แขนงย่อย ๆ หลายแขนง โดยส่วนหนึ่งของแขนงเหล่านี้ จะไปเลี้ยงบริเวณด้านgreater curvature และด้าน posteromedial ของเซมินอลเวสสิเคิล อีกสองแขนงที่เหลือจะไปเลี้ยงบริเวณส่วนหน้าของ anteroventral lobe ของต่อมโพรสเตต หลอดเลือดแดงที่ไปเลี้ยงเซมินอลเวสสิเคิลและต่อมโพรสเตต จะแตกแขนงเป็นหลอดเลือดแดง ขนาดเล็กๆแล้วค่อยๆลดขนาดลงจนในที่สุดแตกให้เป็นหลอดเลือดฝอย หลอดเลือดฝอยของทั้งเซมินอลเวสสิเคิลและของต่อมโพรสเตตเป็นแบบไม่มีรูพรุนที่ผนัง มักจะเห็นหลอดเลือดดำใหญ่วิ่งแนบสวนทางไปกับหลอดเลือดแดง มักพบการเชื่อมต่อกันของหลอดเลือดดำทั้งในเซมินอลเวสสิเคิล และต่อมโพรสเตต หลอดเลือดดำใหญ่ของเซมินอลเวสสิเคิล และต่อมโพรสเตตจะเปิดเข้าสู่ internal iliac vein ลักษณะของรูปแบบของการแตกแขนงของหลอดเลือดแดงที่ไปเลี้ยงต่อมโพรสเตตของกระแตจะเหมือนในมนุษย์ แต่แตกต่างอย่างเห็นได้ชัดเมื่อเทียบกับหนู rat ซึ่งจะมีรูปแบบที่เริ่มต้นจากโคนท่อหลักของต่อมโพรสเตตแล้วแตกแขนงเป็นแขนงย่อยไปตามกิ่งก้านของท่อย่อยและสิ้นสุดที่ส่วนปลายยอด (glandular acini)

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LIST OF ABBREVIATIONS

A	=	Artery
a	=	arteriole
AA	=	Abdominal aorta
Ac	=	Acetabulum
AG	=	Ampulla gland
AIIA	=	Anterior division of internal iliac artery
ALPD	=	Anterolateral prostatic duct
LSeVA	=	Lateral rami of seminal vesicle artery
B	=	Bulbourethral gland
C	=	Capillary
CA	=	Caudal artery
CIIA	=	Common internal iliac artery
CPD	=	Common prostatic duct
E	=	Ejuculatory duct
EIA	=	External iliac artery
IIV	=	Internal iliac vein
IVA	=	Inferior vesical artery
IVV	=	Inferior vesical vein
K	=	Kidney
L	=	Lumbar

LIST OF ABBREVIATIONS (CONT.)

LS	=	Left seminal vesicle
MgA	=	Marginal branch of superior vesical artery
MSeVA	=	Medial rami of superior vesical artery
Pe	=	Penis
PIIA	=	Posterior division of internal iliac artery
R	=	Rectum
RA	=	Rectal artery
RS	=	Right seminal vesicle
S	=	Seminal vesicle
SA	=	Small artery
SD	=	Seminal duct
SeVA	=	Seminal vesicle artery
SeVV	=	Seminal vesicle vein
SVA	=	Superior vesical artery
SVV	=	Superior vesical vein
T	=	Testis
TA	=	Testicular artery
U	=	Ureter
UB	=	Urinary bladder

LIST OF ABBREVIATIONS (CONT.)

Ut	=	Urethra
V	=	Vein
v	=	Venule
VD	=	Vas deferens

CHAPTER I

INTRODUCTION

The seminal vesicle and prostate gland are the part of male accessory reproductive glands. The seminal vesicle in various animals are somewhat similar. The gland consists of left and right lobes of seminal vesicle. Each lobe is elongated, lobulated and coiled to form the vesicle-like mass lying between the fundus of the urinary bladder and the rectum. The seminal vesicle is obliquely and superiorly placed on the prostate. It does not store sperms as the name implies (1). It secretes a thick alkaline fluid that mixes with the sperm as they pass through the ejaculatory duct into the prostatic urethra. The seminal vesicle has been found in all mammals but is absent in monotreme, marsupial, hare and cetacean (2).

The prostate gland is the midline organ located at the point where the two vas deferens join with the ejaculatory ducts. It is the compound tubuloalveolar gland with several main ducts emptying into the prostatic urethra (2). The gross structures of the prostate gland are variable among the species (3). In rodents, it consists of coagulating gland, dorsal, ventral and lateral lobes. Human prostate gland composes of anterior, posterior, middle and two lateral lobes (4). The prostate gland has been found in most mammals except monotremes (3). It is the only accessory gland in most carnivores as ferret, weasel, dog and bear (1).

The main blood supply to the seminal vesicle and prostate gland in various mammals is from branches of the internal iliac artery. In the rat, the seminal vesicle and prostate gland are supplied by superior vesical, inferior vesical artery and middle hemorrhoidal arteries (5). This is quite different from the dog of which the

prostatic artery originate from the internal pudendal artery (6,7). In human, the seminal vesicle and the prostatic arteries are from the inferior visical artery and the middle rectal artery (8).

The postnatal reproductive development of the tree shrew (*Tupaia belangeri*) conforms to the several prominent patterns therefore it is a useful small animal model for the study of puberty in primates (9). In the later date, the vascular corrosion cast technique has been employed to demonstrate the microangioacrchitecture of various organs in the common tree shrew (10, 11, 12, 13, 14, 15, 16), the animal regarded as primitive primate (17). Moreover, the investigation concerning the detail vascularization of the seminal vesicle and the prostate gland in this animal and other animals has not been investigated. It is of interest therefore to elucidate the complete vascular pattern in the seminal vesical and the prostate gland of the common tree shrew.

CHAPTER II

OBJECTIVES

As very little information concerning the detail vascularization of the seminal vesicle and prostate gland has been reported, it is of interest to elucidate the gross and microscopic anatomy, source of blood supply, ramification of the blood vessels within particular parts and microangioarchitecture of the seminal vesicle and prostate gland in the common tree shrew (*Tupaia glis*)

CHAPTER III

LITERATURE REVIEW

The genital system of male mammals consists of three components. They are : (I) pared testes, the primary sex organs in which spermatozoa are formed and the androgenic hormones are secreted, (II) accessory reproductive organs, a continuous series of ducts in which spermatozoa are transported from the testes, stored in the tail of the epididymis, and finally carried to the exterior when ejaculation occurs, and various glands (ampullary gland, seminal vesicle, prostate gland and bulbourethral gland), the secretions of which provide the carrying medium for the spermatozoa at emission, (III) external genitalia, the penis or copulatory organ and, in most mammals, the scrotum in which the testes come to lodge more or less permanently, or only periodically during the breeding season (3).

The accessory reproductive glands can be grouped logically into those arise embryologically from the mesonephric or Wolffian duct (ductus deferens) i.e., the ampullary gland (glandula vasis deferentis) and seminal vesicles or vesicular gland, and those deriving from the urogenital sinus or urethra, namely the prostate and bulbo-urethral or Cowper's glands (18).

Embryonic Development of the Seminal Vesicle

In the rat, the sexes can first be recognized by (study of) the histological structure of the gonads at $14^{1}/_{2}$ day post coitum. Although the gonads begin differentiation

relatively early in embryonic life, the anlagen of the accessory reproductive gland appear relatively late. The primordium of the accessory gland appeared firstly in the developing male rat is that of the seminal vesicle which begins its development when the fetus is 18 days and 18 hours of age. It appears as a simple diverticulum which grows dorsally and cranially from each Wolffian duct. The lumen of each gland remains nonbranching before birth so that up to that time the seminal vesicles are simple sac-like organs (19). In the mouse the morphogenesis of seminal vesicles begins approximately on 15^{th} day of gestation (vaginal plug = day 0) with dilation of the lumen at the lower part of the Wolffian duct (20). As in the human the seminal vesicle is first appeared during the 13^{th} week of fetal life as lateral evaginations or out pocketings from the lower portion of the Wolffian duct (21)

Embryonic Development of the Prostate Gland.

The anlage of the prostate gland in the male rat can first be seen in the $19^1/_2$ day embryo. The prostatic anlagen extend from the urogenital sinus as several small solid cords of cells. Their arrangement is roughly bilaterally symmetrical in relation to the dorsoventral midline of the sinus. Although the anlagen are not definitely divided into lobes. The coagulating gland (anterior lobe of the prostate gland) can be recognized as a pair of solid cords that extend cranially in to the genital cord ventral to the Mullerian and Wolffian ducts. In later development they come to lie close to the seminal vesicle to which they are bound. The anlagen of the coagulating gland join the sinus cranial to the entrance of the Wolffian ducts and Mullerian ducts. The mid-lobe of the prostate is represented by the bud of the cells that extend laterally from the

sinus (urogenital sinus). The posterior lobe (dorsal lobe of the prostate gland) is identified by the four or five more prominent cords of cells that grow ventrally from the sinus on each side of the midline. The cords of cells that form the duct and acini of the ventral lobe (the last lobe of the prostate gland in rat) bend caudally as they grow while those of the mid-lobe grow laterally and cranially. At birth the acini of the four prostatic lobes (coagulating gland, midlobe, posterior lobe and ventral lobe) are still solid cords of the sinus. There are no sharp divisions into lobes but all four pairs can be recognized (19). In man the prostate gland originates from five independent groups of tubules which begin to develop at the 12^{th} week as follow:

(a) The middle lobes is made up of nine or ten large branching tubules originating on the floor of the urethra between the bladder and the openings of the ejaculatory ducts.

(b) The tubules of the right and left lateral lobes originate in the prostatic furrows (prostatic sinus) and from the lateral walls of the urethra. They are composed of from twenty-seven to forty-six tubules which grow back to form the main part of the base of the prostate.

(c) The posterior lobe is an independent structure being made up of tubules which originate from the floor of the prostatic urethra below the opening of the ejaculatory ducts. They grow back behind the latter structures and are in no sense a glandular commissure as they are definitely separated from the other parts of the gland. The posterior lobe is the part of the prostate palpated per rectum and is an important consideration in the performance of perineal prostatectomy.

(d) The anterior lobe is fairly large until the 16th week, after that it becomes greatly decreased in size and in number of its tubules (4).

Structure and Function of the Seminal Vesicle

Seminal vesicle is situated on each side of the bladder neck. It had been believing as a storage for "semen" from the testis. This is no longer thought to be true although in humans the duct of seminal vesicle joins the ductus deferens to form an ejaculatory duct and consequently sperm are sometimes found in the vesicles post mortem (22). In most species, the secretion from the seminal vesicle flows into the ejaculatory duct, although in some species, the contents are released directly into the urethra, such as the slender loris (Loris tardigradus). This animal lacks of an ejaculatory duct as the ductus deferens terminates separately from the duct of the seminal vesicle in the urethra (2). The seminal vesicle is large in the guinea pig, hamster, rat, boar, bull and ram. It is relatively small in man and entirely absent in the cat, dog, guinea pig, monotremes, marsupials and logomorphs (1, 23). Because of the variability in size of the seminal vesicles, secretion from this gland constitute different percentages of the ejaculate in different species. In man, about 70% of the ejaculate is estimated to be of seminal vesicle origin (24).

Although the seminal vesicle are not entirely necessary for fertility in many species, the secretions from these glands appear to protect the spermatozoa, and enhance their lifespan and fertilizing capacity. Fructose and other substances can be utilized by the spermatozoon for its metabolic processes and thus aids in the maintenance of sperm motility. The buffering power of the relatively alkaline

vesicular secretion helps neutralize the natural activity of the vagina which can be detrimental to sperm viability (25). Seminal vesicle protein is also a major component of the seminal coagulum or plug. Additionally, since the seminal vesicle fluid is ejaculated last and represents the largest portion of the total ejaculate, at least in species such as rat, it helps to flush spermatozoa from the urethra (26). The seminal vesicle is important on the fertility and fecundity of the rodent (27).

Structure and Function of the Prostate Gland

The prostate gland is a compound tubuloalveolar gland. It varies among species and may be classified into three types : (I) disseminated or diffused type with glandular acini that are located within the lamina propria between the luminal basement membrane and the muscle of the urethra; (II) a more discrete gland that is sometimes lobed and remains outside the urethral muscle between the muscle and urethral surface; and (III) a combination of type 1 and type 2. For example, the sheep and goat have a disseminated prostate, whereas the bull and boar prostates possess both a disseminate region and a discrete body (1). Dog and man have solid, compact prostates (28) whereas the rat has four pairs of prostatic lobes including the coagulating glands which is also called the anterior (or cranial) lobes. The other three pairs are termed the dorsal, lateral and ventral lobes (29). In the golden hamster, the prostate gland composes of three pairs of lobes. There are coagulating gland (anterior lobe), dorsal and ventral prostate lobes (30). In guinea pig the prostate gland consists of coagulating gland (anterior lobe), dorsal and lateral prostate lobes (31). In musk shrew (*Suncus murinus*, Insectivora), the prostate gland is a pair glands with one

main excretory duct for each gland. Each gland is divided into ventral and dorsal lobes (32). In tree shrew (*Tupaia belangeri*) the prostate gland is a compact with bilateral bodies drained by a main collecting duct running through the urethral tissue for a short distance and then joining the duct from the opposite side to form a common dorsomedial duct (17). In nonhuman primate, such as, *Macaca mulatta*, Pan troglodytes, *Callicebus moloch*, *Erythrocebus patas* and *Saimiri sciureus*, the prostate gland composes of cranial and caudal lobes (33).

In man, the prostate (although a single, compact structure) can be subdivided into anterior, posterior, middle and two lateral lobes (1, 4, 34, 35). There are also histological and functional differences between these lobes (36, 37, 38, 39). The posterior lobe is a common site for prostatic carcinoma where as the anterior lobe is more susceptible to benigh prostatic hyperplasia (40, 41, 42). Functionally, the necessity of a prostate for fertility is questionable. During ejaculation, prostatic secretion aids in sperm transport through the urethra (25). The removal of the prostate gland and the seminal vesicle in the rat does not cause the impairment of sexual behavior (43) but induced complete infertility (44).

The Vascular Supply of Seminal Vesicle and Prostate Gland

The functions of the seminal vesicle and the prostate gland are normally maintained by androgenic hormone (45, 46, 47, 48) and the blood supply form the pelvic visceral branches. The arterial pattern of the pelvic visceral arteries in various animals is different. Moreover, it is also varieable in the same species. In rabbits, the pelvic visceral arteries consists the umbilical, urogenital and internal pudendal

arteries.The main characteristics observed in the rabbits are as follows: a) The umbilical artery (branch from the proximal part of the internal iliac artery) is permeable in adults (in human it reduces itself to become medial umbilical ligament) and gives rise to the cranial (superior) vesical artery the caudal (inferior) vesical artery that irrigates the pelvic urogenital organs (e.g. urinary bladder, ureter, vas deferens, seminal vesicle and prostate gland, and eventually, the rectum) with six patterns of branching in both sexes. b) Usually, the urogenital artery is the continuation of the visceral branch of the internal iliac artery but some arises from the median sacral artery. In 12 animals (6 bilaterally and 6 unilaterally) the urogenital artery is absent. When present, it forms two branches, a cranial and caudal one that irrigate of the urogenital organs in both sexes. c) The internal pudendal artery is the direct continuation of the internal iliac artery and gives rise to some visceral branches that nourish the penis, bulbourethral gland and rectum (with six patterns of branching) in males, and the vagina, clitoris and rectum (with three pattern of branching) in female (49). In human, the visceral branches of the pelvic cavity derive from the anterior division of internal iliac artery. The posterior division of internal iliac artery gives off only parietal branches whereas its anterior division gives off both parietal and visceral branches. The visceral branches (the arrangement of the visceral branches is variable) of the anterior division of the internal iliac artery are as follow: a) umbilical artery gives off the superior vesical artery. Its distal part is a fibrous cord known as obliterated umbilical artery and forms medial umbilical ligament. b) inferior vesical artery (vaginal in female) supplies the seminal vesicle and prostate gland. c) middle

rectal artery and d) uterine artery. The uterine artery may arise from the internal iliac or from the umbilical artery (50).

The vascular supply and the venous drainage of the urogenital system in various animals have been documented by many investigators (51, 52, 53, 54, 55, 56). It is quite interesting for the venous drainage of the accessory reproductive organs of the rat with special reference to the prostatic metabolism (57) and the study of the venous drainage and the functional control of the canine prostate gland (6). The study of the distribution of the blood vessels of the prostate gland would give important basic knowledge for the retropubic prostectomy, of which a step of the operation is preliminary ligation of the veins on the anterior surface of the prostatic capsule (58). It is also beneficial to understand pathology and the morphogenesis of prostatic carcinoma (40, 33). There are variations of main arterial supply of the prostate and seminal vesicle in human. However, it could be concluded that the main arterial supply of both seminal vesicle and prostate gland is from the inferior vesical artery (a branch of the internal iliac artery) and a few small branches from the middle rectal artery (8).

The main arterial supply the seminal and the prostate gland in the rat is also variable and different from the human. Suzuki and his coworkers (5) found that the arterial supply the seminal vesicle and the prostate gland in rat are from superior vesical and middle hemorrhoidal arteries. They arise from the internal iliac artery (5). However some investigators (29,59) reported that the seminal vesicle and prostate gland of the rat receive blood supply from inferior arising from the superior vesical

artery. Scolnik and his coworkers (60) found that the prostatic arteries in the rat are from the hypogastric (internal iliac) artery.

When the injection with barium gelatin and roentgenography of human prostate gland was performed, Bumpus and Antopol (61) could demonstrate that the distribution of blood supply could be divided into three zone: 1) a peripheral plexus of small arteries; 2) an intermediate zone of essentially parallel vessels coursing towards the urethra; 3) the periurethral or internal plexus. With the same technique, Flocks (62) had reviewed the anatomical arrangement of the arteries within the normal and the hypertrophied prostate glands for the better understanding of the clinical problems attending prostatic resection. The prostate develops as a five-lobed structure consisting of anterior, two lateral, middle and posterior lobe. These lobes originate from epithelial buds in the embryonic deep urethra. Of these, the lateral lobes alone normally reach any size and make up the bulk of the gland. A tough fibromuscular capsule encloses the lobes and sends septa among them. In addition, there are two groups of rudimentary glands which are of great clinical importance, the small group beneath the neck of the bladder (named by Albarran as the subcervical lobe), and the other group beneath the trigone (named by Home as the subtrigonal lobe). For practical purposes, the prostate glands are divided by Adrion into the internal or periurethral gland, the five external or the true prostatic glands and the lateral lobes of which constitute the major portion of the normal gland. He showed that hyperplasia of the prostate gland arises in the inner or periurethral and in Albarran'a and Home's lobes. All of which are relatively insignificant in size in the normal adult (62). Flocks (62) found that the inferior vesical artery, a branch of the internal iliac, passes

medially over the surface of the levator ani muscle to the base of the bladder where it sends branches to the bladder bases, the seminal vesicle, the lower portion of the ureter and to the prostate. There are about four or five branches coursing more or less parallel to each other which for convenience are grouped together descriptively and called the "prostatic artery". The "prostatic artery" gives rise to two groups of arteries which distribute themselves in fairly regular manner throughout the prostate. These are best named as the urethral group and the capsular group. The urethral or penetrating group immediately penetrates the tissue at the prostatic-vesical junction. Here it sends some branches into the lateral lobe and then distributes itself along the bladder neck and urethral surface of the prostate to supply the vesical neck and the inner portion of the prostate. The another group, or the capsular or non-penetrating group, courses along the posterolateral surface of the gland and sends branches ventrally and dorsally to supply the outer portion to the prostate. The external capsular group shows little change with age and with occurrence of hyperplasia but the internal urethral group enlarges significantly with age and very markedly with hyperplasia (62). Since the methods for examining the blood supply of the prostate used by barium sulphate or white lead particle could not fill the capillary network at physiological injection pressures, the reinvestigation of the vascular distribution within the organ, using selectively stains blood pigments by the benzidine-sodium nitroprusside reaction had been preformed (63). This method has the advantage that the venous and arterial system can be distinguished. In addition, it could be found that: 1) the intrinsic vessels of the prostate can be divided into an outer or capsular plexus, an intermediate zone of the vessels, and a urethral plexus, 2) the outer plexus

lies mainly on the lateral surface of the gland, 3) the intermediate zone of vessels comprises of those derived from the capsular plexus and a leash of vessels accompanying the ejaculatory ducts and prostatic utricle and 4) the urethral plexus, towards which the intermediate vessels pass, is mainly derived from the capsular vessels. The plexus accompanying the ejaculatory ducts supplies a region of the urethral crest surrounding the entrance of those ducts into the urethra.

As methyl methacrylate plastic mixture has been shown to be with very low viscosity and could be injected to fill cavities of the hollow organs including capillaries (64), it has been employed in conjunction with the application of the scanning electron microscope to study the distribution of the blood vessels including delicate capillaries such as those in the villi of the small intestine (65). This technique is widely used to study the microangioarchitecture in various organs such as the rabbit urinary bladder (51), evidence for a unique elastic sheath surrounding the vesicular arteries of the rabbit urinary bladder (52), microvascular architecture of the human urinary bladder wall (55), and the microvasculature of the rat vas deferens (56). In 1999, Shabsigh and his coworkers (59) used this technique to observe the blood vessels of the rat ventral prostate gland (a model tissue to study the effects of the androgenic steroids on prostate cells relate to the human prostate gland). They had found that the pattern of blood supply in the ventral prostate gland in the rat appears as a single trunk with the base near the proximal portion of the prostatic duct close to the prostatic urethra. These vesels eventually divide into small vessels at the intermediate section of the duct. Most of which continue to the distal part (the

glandular surface) where they supply the distal region of the prostatic duct and the glandular portion.

In the later date, the technique has been employed to demonstrate the blood patterns of various organs in the common tree shrew (10, 11, 12, 13, 14, 15, 16, 90, 91). The tree shrew is the useful small animal model for the study of puberty in primates (9) and the reproductive system in this animal is of primate character (17). Yet, the microangioarchitecture of the seminal vesicle and the prostate gland in this animal has not been investigated. It is of interest, therefore, to demonstrate the complete vascular pattern of the seminal vesicle and the prostate gland in this animal.

CHAPTER IV

MATERIALS AND METHODS

Seminal vesicles and prostate gland from fifteen adult common tree shrews (Tupaia glis), 110 to 190 g of body weight, were used. The animals were divided into four groups. The first group of two animals was for gross dissection of seminal vesicle and prostate gland under stereomicroscope. The second group of three animals was for histological study of the seminal vesicle and prostate gland. The third group of two animals was for study the internal structure of both glands under scanning electron microscope (SEM). Eight animals of the last group were injected with Batson's # 17 plastic mixture into the blood vessels to elucidate vascular pattern of the seminal vesicle and the prostate gland under stereomicroscope and scanning electron microscope (SEM).

Animals Preparation

Each animal was anesthetized with diethyl ether. The midline incision on the thoracic cage was made to expose the heart. The 0.05 ml of heparin (Leo, 5000 IU/ml) was immediately injected into the left ventricle and allowed to circulate for 1 or 2 min. A blunt needle (18 gauge) was cannulated into the ascending aorta through the left ventricle and held in place with arterial clamp. The animal was perfused with 0.9% NaCl solution through the cannula until the efferent is clear. The blood and

excessive injected fluid was flushed out through the right atrium which had been cut open before.

Specimen Preparation for Studies the Internal Structure

Immediately after perfusing with 0.9% NaCl solution, as described above, both seminal vesicle and prostate gland were fixed by perfusion with 2.5% glutaraldehyde solution via the same cannula. After that both seminal vesicle and prostate gland were removed, cut (coronal section) before putting in the same fixative and left overnight at 4 °C. The specimens were washed three time with 0.1 M phosphate buffere saline (PBS,pH 7.4) post fixed in 1% osmium tetroxide in 0.1 M PBS for 45 min, and finally washing in distilled water,the specimens were kept in deep freezer before being dried in the lyophilizer and viewed under stereomicroscope. Both specimens were mounted on a brass stub with double glue tape and carbon paint and coated with gold/palladium (using Hummer VII sputter coater). They were examined and photographed under a scanning electron microscope (SEM) at an accelerating voltage of 15 kV.

Specimen Preparation for Light Microscopy

Immediately after perfusing with 0.9% NaCl solution, 150 ml of Bouin's solution was injected manually through the cannula to fix the tissues. The seminal vesicle and prostate gland were carefully dissected, excised its covering and immersed in the same fixative overnight. After rinsing with distilled water until the solution was free from yellow color, the specimens was dehydrated in graded series of ethanol, embedded in

paraffin, sectioned at 5-7 μm thick, and stained with hematoxylin and eosin. The serial sections were examined and photographed under a light microscope (LM).

Animal Preparation for Vascular Corrosion Casting

After perfusion as described above was done, 20 ml of fresh prepared Batson's # 17 plastic mixture was injected manually at the rate of 8 ml/min through the abdominal aorta just above the inferior mesenteric artery. The abdominal aorta and the inferior vena cava that inferior to the inferior mesenteric artery was ligated, and the animal was left for 30 min at room temperature to let the casting medium set. The seminal vesicle and prostate gland were carefully removed and immersed in warm water (80°C) for 3 hr to assure polymerization of the casting medium. The seminal vesicle and prostate gland were then corroded with 40% KOH solution in warm water (80°C) for 48-72 h, and then slowly rinsing with distilled water for several changes. Vascular casts of both organs were kept in deep freezer before being dried in the lyophilizer and viewed under stereomicroscope. The vascular casts of both organs were mounted on a brass stub with double glue tape and carbon paint and coated with gold/palladium (using Hummer VII sputter coater). They were examined and photographed under a scanning electron microscope (SEM) at an accelerating voltage of 15 kV.

CHAPTER V

RESULTS

General Appearance of the Seminal Vesicle

The seminal vesicle of the common tree shrew consists of left and right lobes of kidney shape with the approximate dimensions of 5 mm wide, 9 mm long and 3 mm thick (Figs. 1, 4). Its average combined weight is 0.8 g. It locates anteriorly to the prostate gland and between the fundus of the urinary bladder and the rectum (Fig. 2). Each lobe lies laterally to the ampulla of the ductus deferens (Fig. 3). The main duct of seminal vesicle joins the distal portion of ampulla of the ductus deferens to form the short ejaculatory duct (figs. 4, 18, 19, 20).

After the fascial sheath of the seminal vesicle was removed, it was found that each lobe is elongated, lobulated and coiling to form the vesicle-like mass with the collecting duct running along the entire length of the gland. Each lobe composes of eight to ten lobules (Fig. 5). Each lobule consists of multilocular compartments separated by spiral septum (Fig. 7). Each locular compartment is perpendicular to the centrilocular antrum (central locular). These compartment are not completely divided but can be separated by partial interconnection (Fig. 8). So that the secretory fluid from each locular compartment could drain into the antrum and then to collecting duct which finally open to the main duct. This structure is named "Ammunite structure". When the gland is incised, the white thick secretion is seen. The study of thick sections with light microscope shows that its spaceous saccules or alveoli were

packed with spherical bodies or globules resembled fat droplets (Figs. 29, 30, 32). The wall of the seminal vesicle is thick. The outermost capsule is fibromuscular having the coats of connective tissue and muscle fibers (Figs. 29, 30).

The typical epithelium of the seminal vesicle is lined by simple tall columnar cells. The spherical nucleus is prominent with a distinct nucleolus. The nucleus is uniform in size and generally situated toward the base of the cell (Figs. 30, 32). The lumen is filled by numerous secretory granules whichresemble fat droplets (Figs. 29, 30, 32)

General and Microscopic Appearance of the Prostate Gland

The prostate gland of the common tree shrew is situating dorsally to the prostatic urethra (Figs.1, 2, 3). It is a brown-yellow structure resembles a maple leaf (Fig. 4). The approximate dimensions including the left and right parts is 10 mm wide, 5 mm high and 3 mm thick. The average total weight of both left and right parts is 0.9 ±0.1 g.

When the prostatic capsule is removed, it is found that the prostate gland in common tree shrew consists of bilateral left and right anterolateral lobes with their own left and right main ducts opening into the prostatic urethra and the other one is unilobular posterodorsal lobe (Fig. 6). Each anterolateral lobe situates posterior to the neck of urinary bladder, inferiorly to the seminal vesicle and on the dorsolateral side of the prostatic urethra, the ampulla of the vas deferens and the ejaculatory duct. The unilobular posterodorsal lobe of the prostate gland is inferiorly to both left and right anterolateral lobes. This lobe covers along the posterior and lateral surfaces of

the prostatic urethra. Each ejaculatory duct passes through the upper portion of the posterodorsal lobe and terminates in the prostatic urethra just lateral to the verumontanum. The anterolateral lobe of the prostate gland could easily be dissected from the seminal vesicles, ampulla of the vas deferens but it is rather difficult to do so for the posterodorsal lobe. It is noted that the two lobes (the anterolateral and the posterodorsal) are very much associated. In addition, both lobes consist of many infolding lobules interupted by loose fibrous tissue. It is very difficult, therefore, to separate the two lobes apart.

The study of coronal sections of the prostate gland reveals that the prostate gland composes of branching with numerous endpieces or tubuloalveoli (Figs. 9, 10). The whole gland is covered with the fibromuscular capsule (Fig. 24). The cell lining in the tubuloalveoli secrete the fluid into several excretory ducts which finally unite to become lobular duct (Figs. 9, 10, 11). Several lobular ducts of each left or right anterolateral lobe run medially through the dorsolateral urethral stroma and drain into one main collecting duct of each left and right anterolateral lobe which enters into the left and right sinus prostaticus situating distal to the opening of the ejaculatory duct (Figs. 17, 18, 21-24). The common dorsomedial duct of unilobular posterodorsal prostatic lobe receives the secretion from several collecting ducts which run centripetally through the urethral tissue for a short distance and then joins the collecting duct from the opposite side to become the main duct (Figs. 12-17, 22, 23). This main duct opens into the dorsal aspect at the midpoint of the prostatic urethra while the sinus prostaticus open into the prostatic urethra. The prostatic urethra is

joined caudally to the openings of the left and right dorsolateral prostatic ducts (Figs. 23-28).

The study of histological sections clearly reveals that the prostatic urethra passes along the ventral aspect of the prostate gland. The posterior wall of the prostatic urethra contains a distinct median ridge called the urethral crest (Figs. 19, 20) projecting into the urethra. There is a groove on each side of the crest called the prostatic sinus in which the duct of the prostate gland opens (Figs. 24, 27, 28). At its highest point the urethral crest forms an eminence, the colliculus seminalis (verumontanum) (Figs. 24, 25). On the apex of this organ, there is small opening of the prostatic utricle (Fig. 26). On each side of the colliculus seminalis is the opening, (if presents) of the ejaculatory duct (Figs. 25, 26). The secretory part of the prostate gland consists of simple columnar epithelium as that in the seminal vesicle. The nuclei of the epithelial cells are irregular with uniform size and generally situated toward the base of the cells (Figs. 31, 33).

Vascular Pattern in the Pelvic Cavity

It is noted from the stereomicroscopic observation on the vascular cast of pelvic cavity that the abdominal aorta gives off left and right external iliac arteries (Fig. 35). It continues as single common internal iliac artery before breaking into two internal iliac arteries and a caudal artery at the middle point of the last lumbar vertebral (Figs. 34, 35). The internal iliac artery divides into anterior and posterior divisions (Fig. 35). The anterior division contribute the main arterial supply to the pelvic visceral

organs especially most of the urogenital organs but not the kidney, testis and epididymis.

The Microangioarchitecture of Seminal Vesicle with Stereomicroscope/SEM

By means of the vascular corrosion cast technique in conjunction with stereomicroscope at low magnification, it has been shown that the seminal vesicle both in ventral and dorsal aspects of the common tree shrew is rich in blood supply (Figs. 36, 37). The internal iliac artery bifurcates into anterior and posterior divisions of internal iliac artery as in the human. The anterior division of internal iliac artery supplies most of the urogenital complex (ureter, urinary bladder, vas deferens, ampulla of vas deferens, seminal vesicle, prostate gland, bulbourethral gland and prostatic urethra) through the superior vesical artery and inferior vesical artery (Fig. 38).

The superior vesical artery usually arises from the ventral aspect of the anterior division of internal iliac artery (Fig. 39). It sends several branches to supply the ureter, urinary bladder, distal portion of vas deferens, ampulla of vas deferens, prostatic urethra as it courses toward the anterior border of the seminal vesicle and then toward the medial side between the neck of the urinary bladder and the anteromedial area of the seminal vesicle (Fig. 39). Finally, it becomes the seminal vesicle artery when it reaches the lesser curvature of the seminal vesicle (Fig. 39). This artery divides into medial and anterolateral rami (Figs. 39, 40). The medial ramus of the seminal vesicle artery further divides into several branches and penetrate the lesser curvature of the seminal vesicle. One of these branches continues to supply the

main duct to the seminal vesicle. The anterolateral ramus supplies the anterolateral part of the gland (Fig. 40).

The superior vesical artery is always found in common tree shrew but the inferior vesical artery is absent in some cases. When the superior vesical and the inferior vesical arteries are both presented, there will always be communicating branches between the two arteries. Such anastomosis is called the marginal branch of the superior vesical artery. It gives off several arteries to supply the greater curvature and the posteromedial side of the seminal vesicle as well as the rostral region of anteroventral lobe of the prostate gland (Fig. 41). In that case when the inferior vesical artery is missing, the superior vesical artery supplies a variety of urogenital organs ranging from ureter, urinary bladder, vas deferens, ampullar of vas deferens, seminal vesicle, prostate gland, bulbourethral gland and prostatic urethra.

The study of vascular casts with SEM indicates that the medial ramus and the anterolateral ramus of the seminal vesicle artery are quite smaller than the veins accompanying them. They also give off several penetrating branches, which divide into arterioles and small arterioles distributing in the interstitial spaces (Fig. 42). When viewing the cross section of the seminal vesicle vascular casts, it is seen that each arteriole breaks into capillary network surrounding the centrilocular antrum (Figs. 7, 9, 43) and covering the glandular alveoli (Fig. 44). The functional unit of the gland consists of secretory cells and auxiliary structures, namely the basal lamina, the capillaries, fibrocytes, smooth muscle cells, free connective tissue cell, nerve axons and lymphatics. They provide the secretory cells with the required oxygen, hormones, ions, transmitter signals and to the metabolites from the cells. After the

capillaries supply the functional unit, they converge the venous blood into the small venules (Fig. 44) which run into the interstitial space. These small venules drain the blood into the larger venules (Fig. 46) and emerge to the superficial surface to drain the blood into the collecting veins (Fig. 47). The collecting veins empty the blood into the seminal vesicle vein (Fig. 50) and join the superior and inferior vesical veins which usually contain venous valves (Fig. 52) before connecting to the internal iliac vein (Fig. 51). The interconnections among the veins are usually found at the superficial surface of the seminal vesicle (Figs. 48, 49).

When studying the vascular casts carefully, the arteriolar sphincter are found in the branching site of small arterioles (Fig. 53). It is noted that the cast surface of the capillaries supplying within the seminal vesicle are without knob like projections (Fig. 45) indicating that these capillaries are nonfenestrated type.

Microangioarchitecture of the Prostate Gland

The study at dorsal and ventral views of the vascular casts of the prostate gland in the common tree shrew by the stereomicroscope reveals that the gland lies immediately adjacent to the posterior surface of both left and right seminal vesicles. It covers the dorsal and both lateral sides of the prostatic urethra. The prostate gland is higher vascularized than the seminal vesicle. The inferior vesical artery always anastomosis with the superior vesical artery to become marginal branch of superior vesical artery (Fig. 54). The marginal branch of superior vesical artery gives off several branches. One to two branches course along the greater curvature and the posteromedial border of the seminal vesicle and continue to supply the main duct of

the seminal vesicle. That is the main duct of the seminal vesicle receives blood supply from branches of marginal branch and the branches of medial ramus of seminal vesicle artery. The other branches of the marginal branch of the superior vesical artery (Figs. 36, 54) runs along the rostal border of the prostate gland and give off three branches. The first and the second branches supply the anterolateral lobe of the prostate gland (Fig. 59) and continue to supply its main duct. The third branch supplies some parts of the posterodorsal lobe of the prostate gland. The inferior vesicle artery, after anastomosis to the superior vesical artery (as shown with the black arrow in Figure 55) courses along the lateral border of the prostate gland and gives of five to seven branches (Figs. 55, 56). Three to four branches course to the dorsal surface of the prostate gland (Figs. 56, 57). These branches supply some parts of the anterolateral lobe of the prostate gland. Most of the dorsal part of the posterodorsal prostatic lobe is supplied by branch from the marginal branch of superior vesical artery. Other two to three branches supply the ventral aspect of both anterolateral and posterodorsal lobes of the prostate gland as well as its main duct (Figs. 57, 58, 60). The rest of the branches course directly to supply the prostatic urethra and membranous urethra (Figs. 61, 62). With SEM at high magnification, it is shown that the arterial branches of the inferior vesical artery divide into small arteries before giving rise to small arterioles running to the glandular unit (Fig. 63). The arteriole gives off a small arterioles and capillaries supplying the distal portions (glandular acini) of the gland (Fig. 64) and continue to the intermediate section of the ducts and finally supply the proximal portion of the prostatic duct (Fig. 59). The capillaries that supply the glandular unit is converged blood into the small venules (Fig. 64). These

small venules drain the blood into the larger venules on both ventral and dorsal surfaces of the prostate gland. The venules on the ventral and dorsal surfaces empty the blood into the tributaries of the inferior vesical vein (Fig. 65) which drains into the internal iliac vein (Fig. 66). It is noted that the capillaries supplying the prostate gland are without fenestration.

Figure 1. Photograph showing the anatomical position of the seminal vesicle (S) and the prostate gland (P) in the common tree shrew body. K, kidney; U, ureter; UB, urinary bladder; TA, testicular artery and testicular vein; VD, vas deferens; Ut, urethra; B, bulbourethral glands; T, testis; Pe, penis.

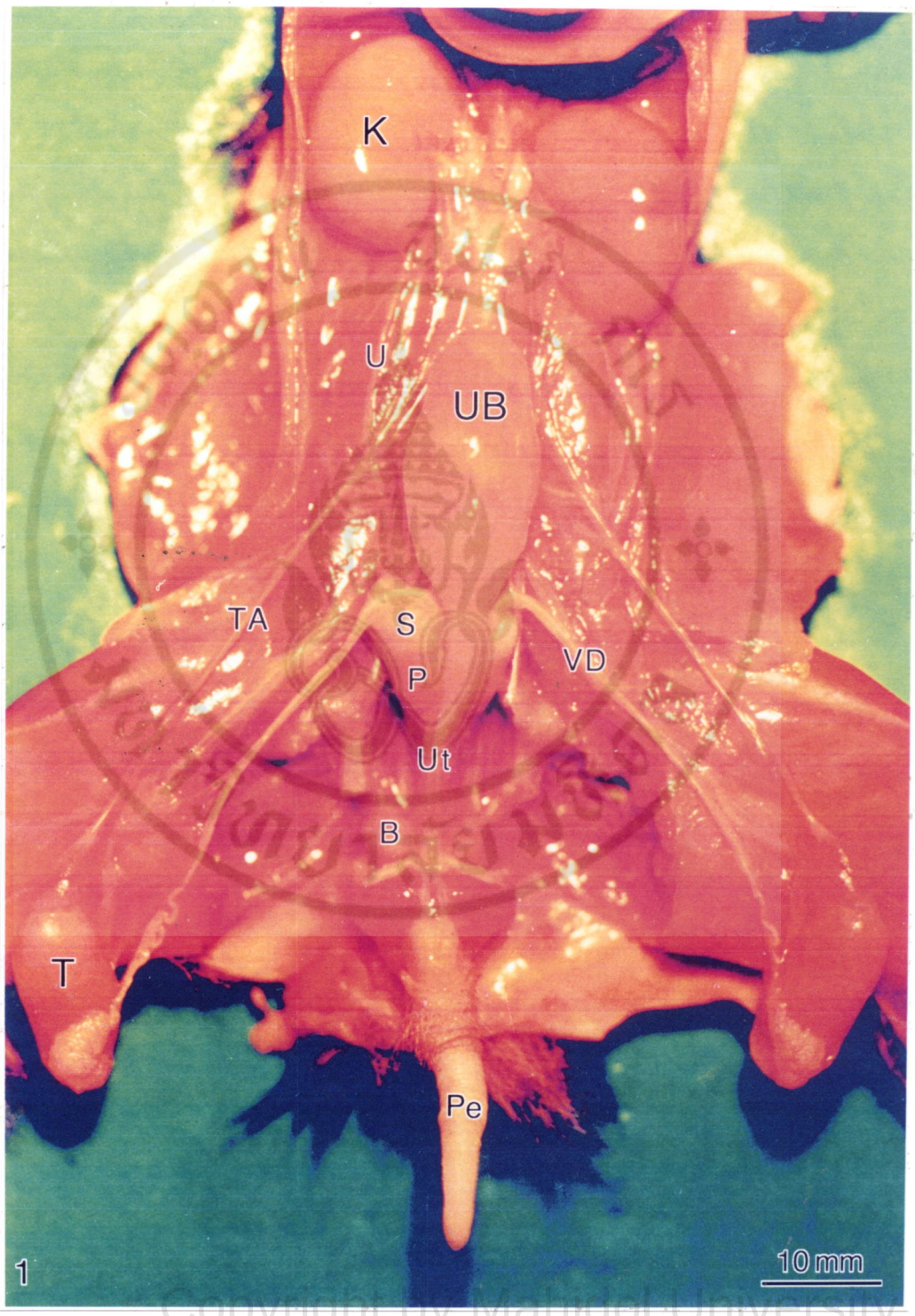


Figure 2. Photograph showing the ventral view of the seminal vesicle and the prostate gland in relation to the urogenital system in the common tree shrew. K, kidney; U, ureter; UB, urinary bladder; TA, testicular artery and testicular vein; S, seminal vesicle; P, prostate gland; VD, vas deferens; B, bulbourethral glands; T, testis; Pe, penis.

Figure 3. Photograph showing the dorsal view of the seminal vesicle and the prostate gland in relation to the urogenital organs in the common tree shrew. K, kidney; UB, urinary bladder; TA, testicular artery and testicular vein, S, seminal vesicle; P, prostate gland; VD, vas deferens; ; B, bulbourethral glands; T, testis; Pe, penis.

Figure4. Photograph, dorsal view, showing the relationship among the seminal (S) vesicle, urinary bladder, vas deferens and the prostate gland (P) in the common tree shrew. UB, urinary bladder; VD, vas deferens; AG, ampulla gland; asterisks, main duct of seminal vesicle.

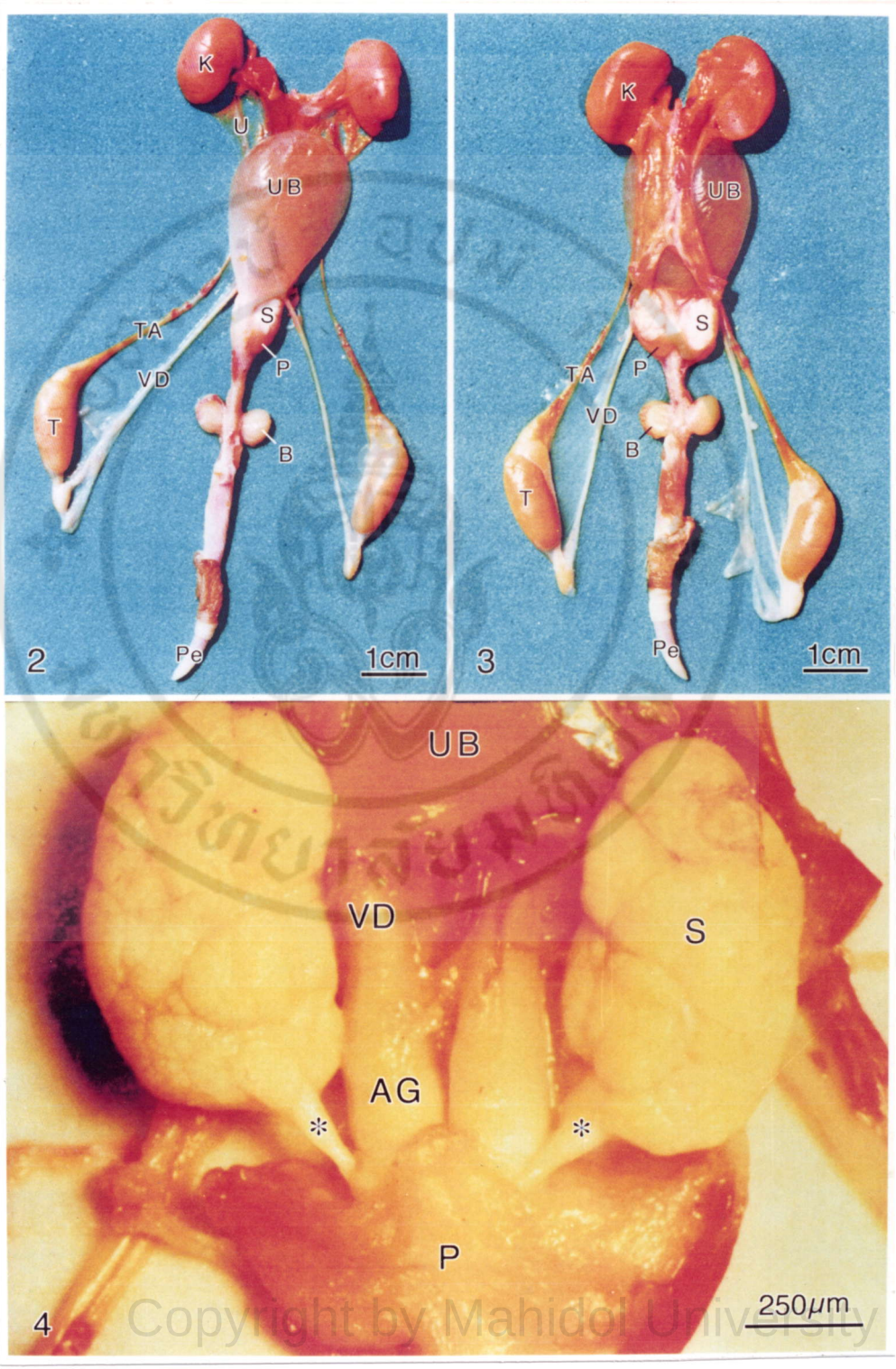
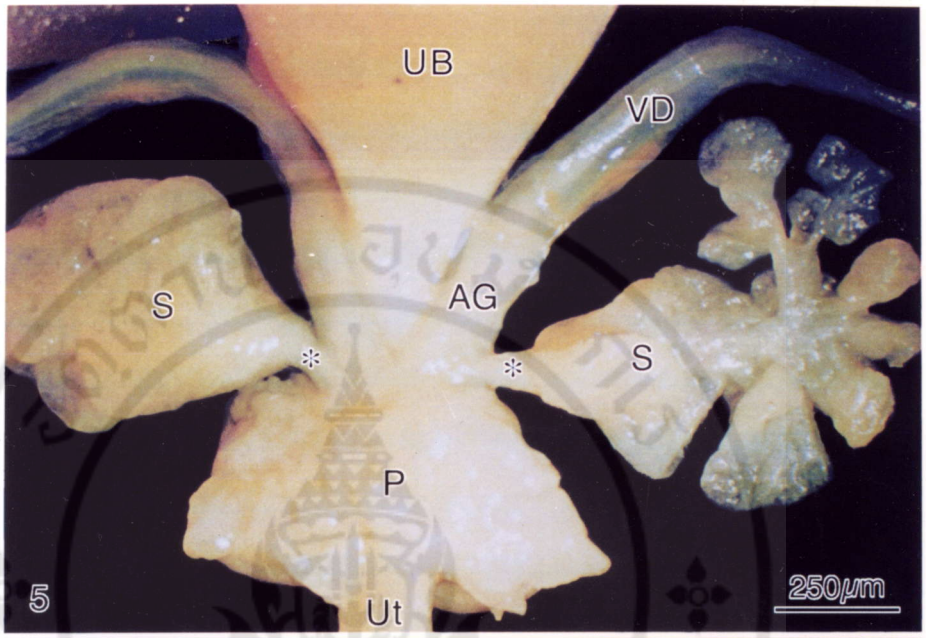


Figure 5. Photograph showing the lobular of the seminal vesicle after dissection. Note the intact seminal vesicle in the left hand side. UB, urinary bladder; VD, vas deferens; AG, ampulla gland; P, prostate gland; asterisks, main duct of seminal vesicle; Ut, urethra; S, seminal vesicle.

Figure 6. Photograph showing the lobular of the prostate gland after dissection. UB, urinary bladder; VD, vas deferens; AG, ampulla gland; P, prostate gland; asterisks, main duct of seminal vesicle; Ut, urethra; black arrowheads, posterodorsal duct of the prostate gland. S, seminal vesicle.



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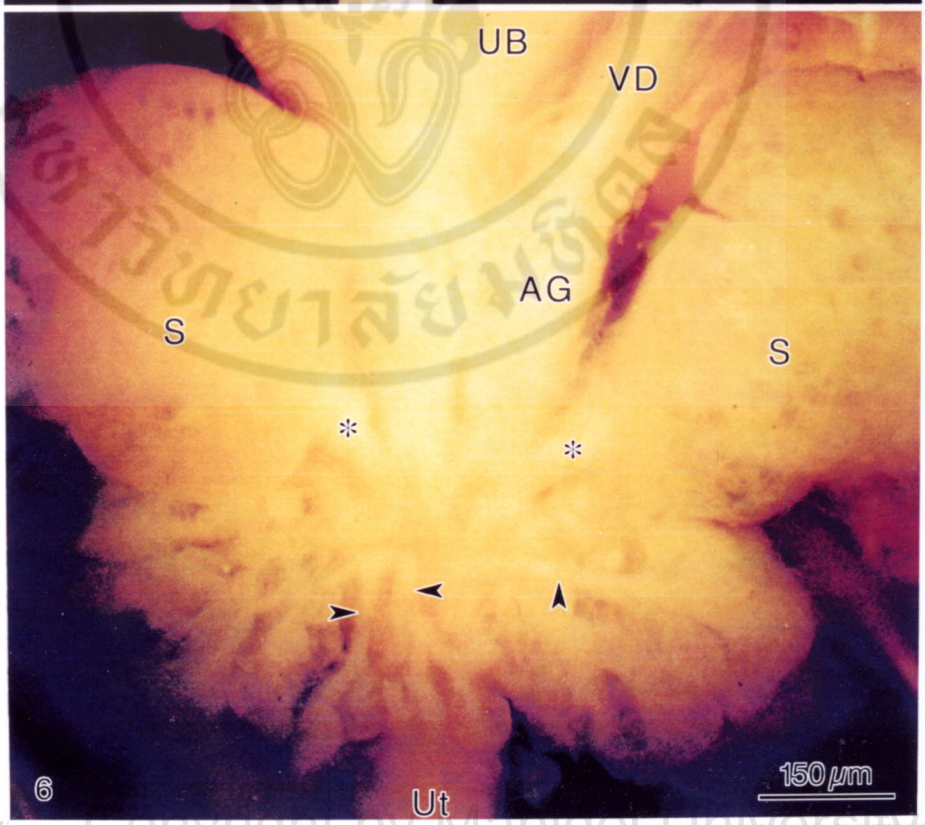

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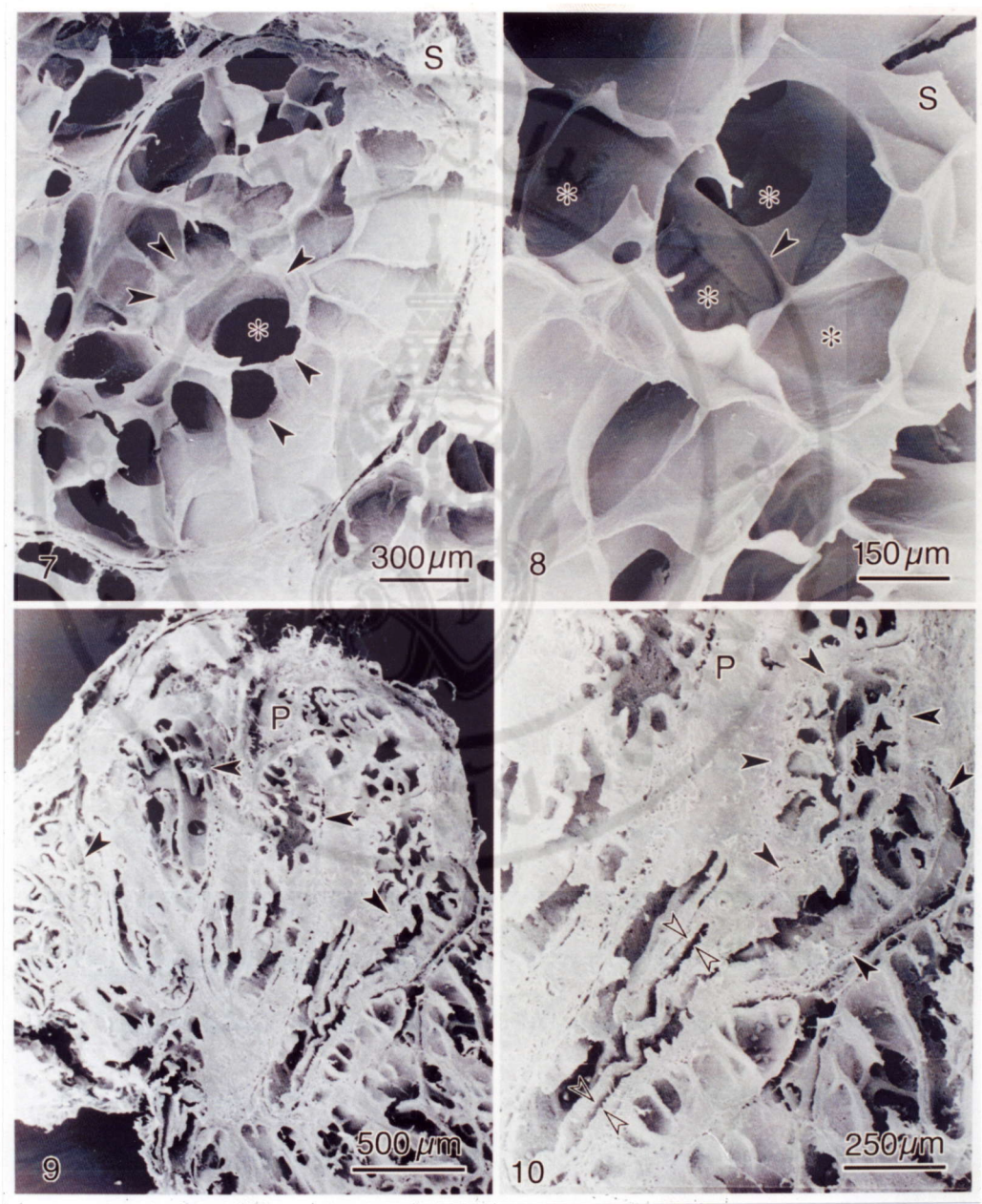
Figure 7. SEM micrograph of the coronal section of the seminal vesicle (S) coated with gold/ palladium Showing he internal structure of the seminal lobule. asterisk, centrilocular antrum; black arrowheads, direction of secretion from the locular compartment drain intothe centrilocular antrum.

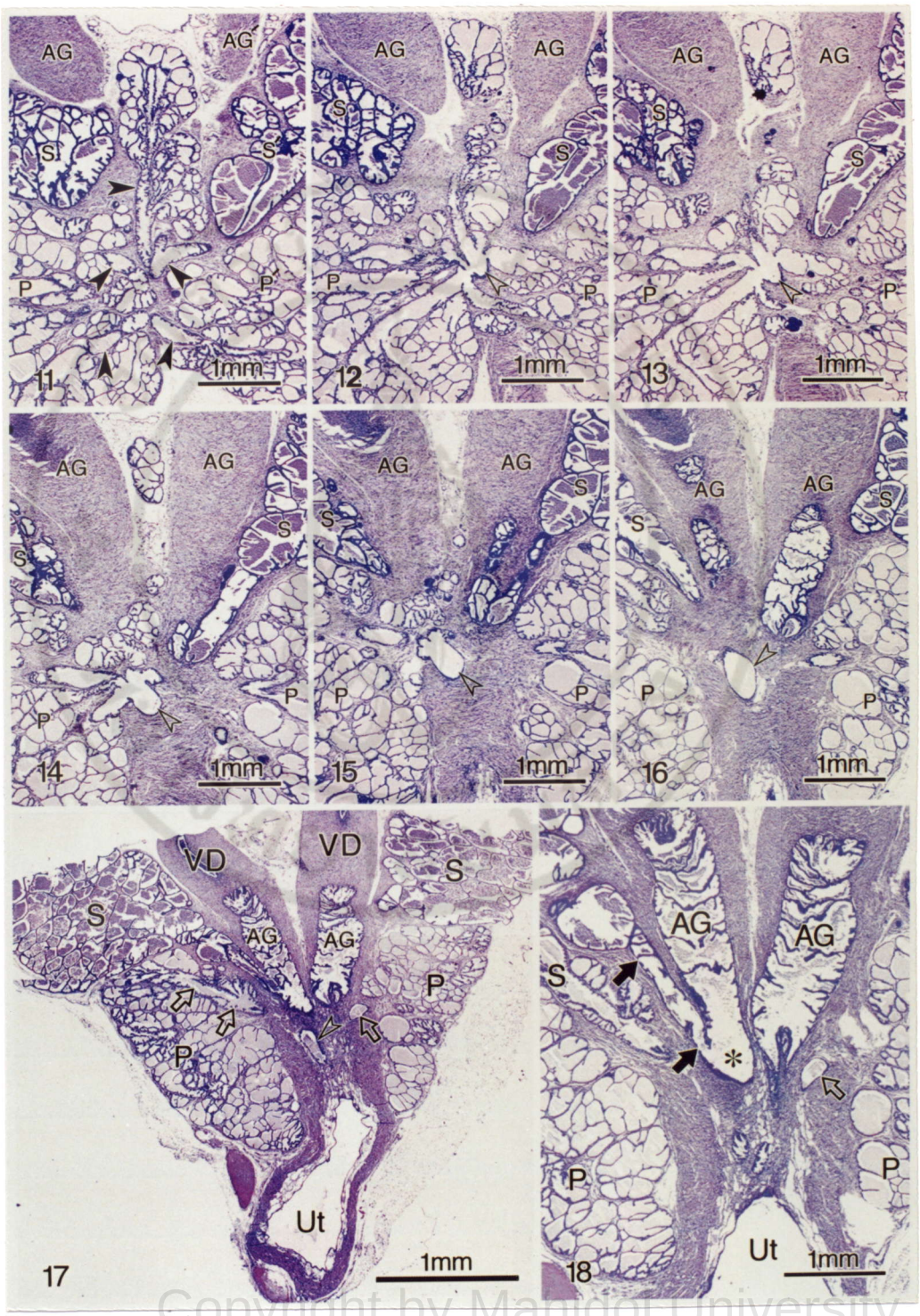
Figure 8. SEM micrograph of the coronal section of the of the seminal vesicle in the common tree shrew, coated with gold/palladium, showing the internal structure of the seminal vesicle locular. S, seminal vesicle; asterisks, locular compartment; black arrowhead, incomplete locular septum or free folding of mucosal fold.

Figure 9. SEM micrograph of the coronal section of the prostate gland (P) in common tree shrew, coated with gold / palladium, showing the internal structure of the prostate gland lobule. black arrowheads, tubuloalveoli.

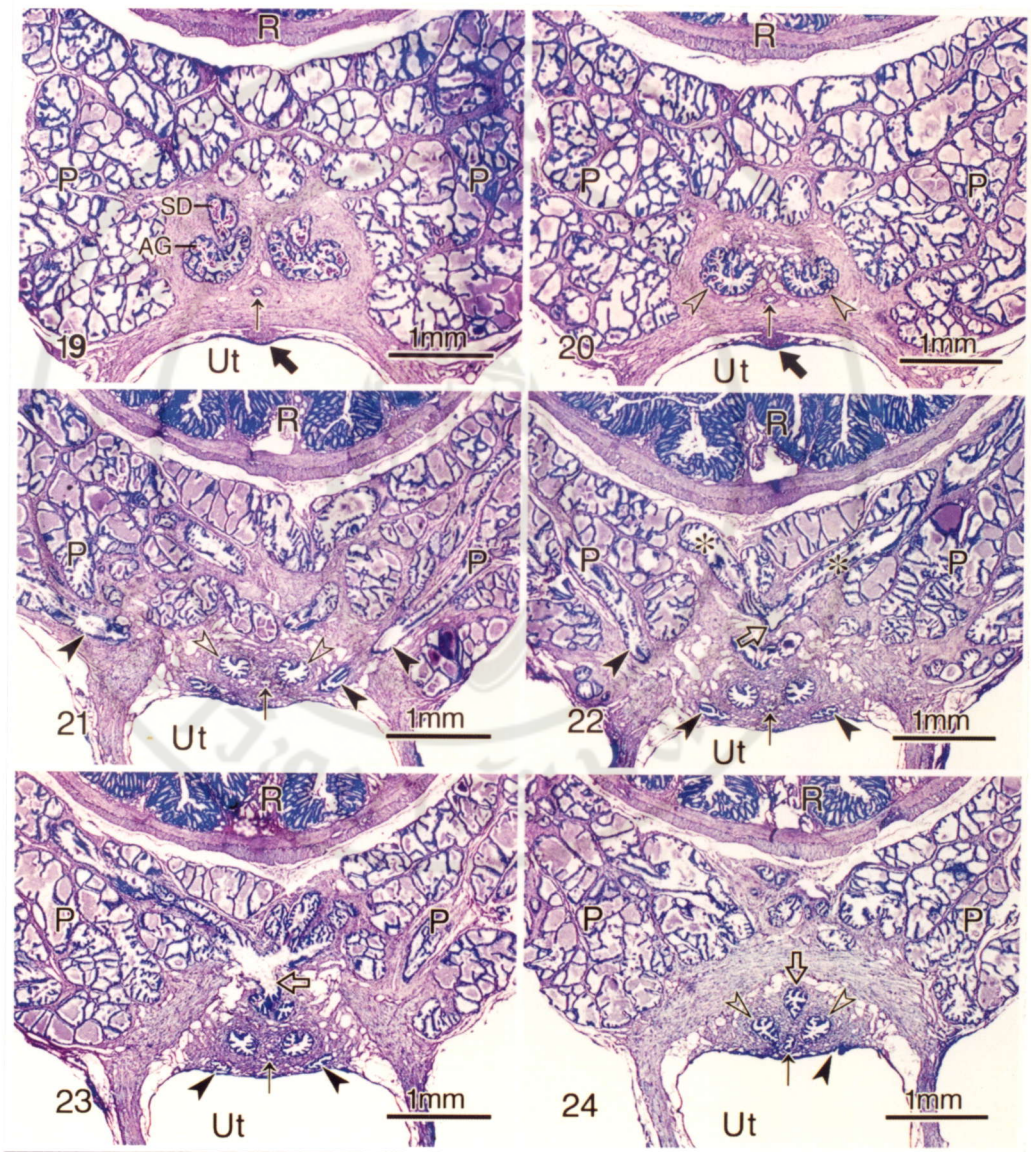
Figure 10. SEM micrograph of the coronal section of the prostate gland (P) in common tree shrew, coate with gold/ palladium, showing the glandular acini and it collecting duct. black arrowheads, glandular acini; white arrowheads, collecting duct.



Figures 11-18. Light micrographs of serial coronal section through the ampulla gland(AG), seminal vesicle (S) and the prostate gland (P), showing the secretory drainage of the seminal vesicle and the prostate gland in the common tree shrew. Ut urethra; VD, vas deferens; black arrowheads, posterodorsal prostatic duct; white arrowheads, common unilobular posterodorsal prostatic duct; big black arrow, seminal vesicle duct; big white arrows, anterolateral prostatic duct; asterisk, ejaculatory duct.



Figures 19-24. Light micrograph of serial transverse section through the rectum (R), prostate gland (P), main duct of seminal vesicle, ampulla gland (AG), ejaculatory duct (white arrowheads); prostatic utricle (thin arrows) and the urethra(Ut) in common tree shrew. SD, seminal duct; black arrowhead, anterolateral prostatic duct; big white arrows, common unilobular posterodorsal prostatic duct; big black arrows, urethra crest; asterisks, posterodorsal prostatic duct.



Figures 25-28. Light micrograph of serial transverse section through the rectum (R), prostate gland (P), ejaculatory ducts, (white arrowheads) prostatic utricle(thin arrows) and the urethra (Ut) in the common tree shrew. big white arrows, common unilobular posterodorsal prostatic duct.

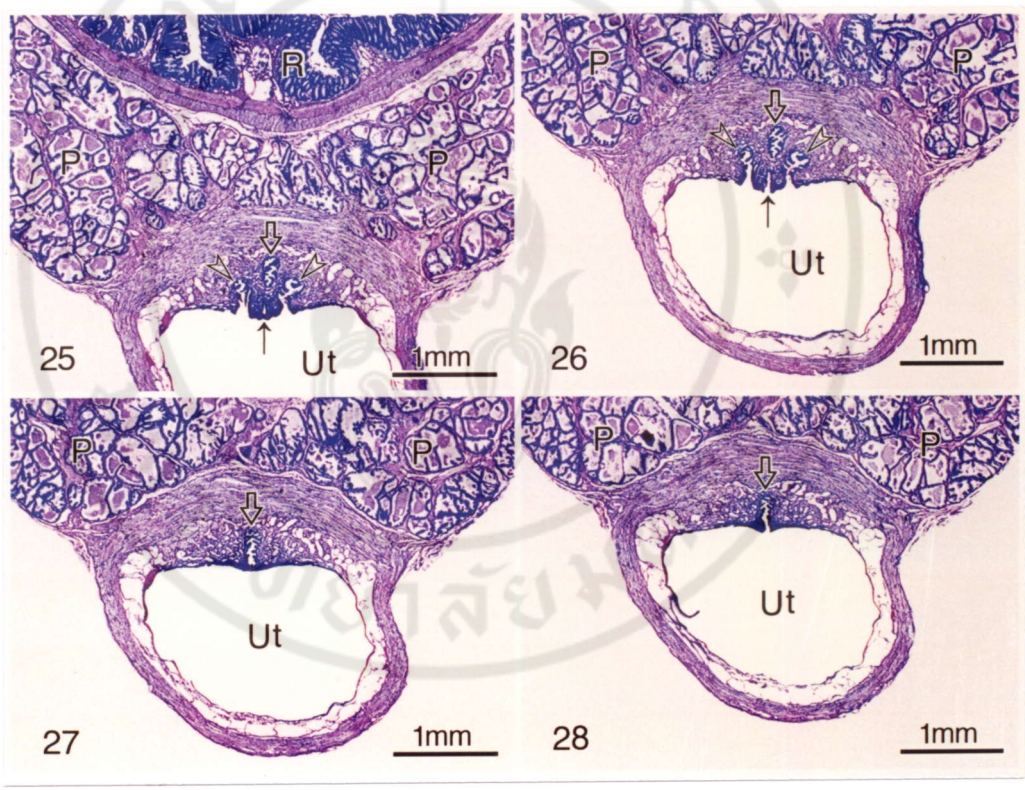


Figure 29. Light micrograph of the seminal vesicle (S) and the prostate gland (P), coronal section, stained with H&E showing the different structure between them in the common tree shrew. white arrowheads, glandular acini of the prostate gland; black arrowheads, locular compartment and its fibromuscular sheath; thin arrow, secretory granules.

Figure 30. Light micrograph of the seminal vesicle (S), stained with H&E showing the secretion in the locular compartment in the common tree shrew. black arrowhead, fibromuscular sheath.

Figure 31. Light micrograph of the prostate gland (P), stained with H&E showing the secretion in the glandular acini in the common tree shrew.

Figure 32. Light micrograph of the seminal vesicle (S), stained with H&E showing the glandular epithelium and the blood vessel (big white arrow) within the mucosal fold.

Figure 33. Light micrograph of the prostate gland (P), stained with H&E showing the glandular epithelium and the capillary (big white arrow, capillary) within the mucosal fold.

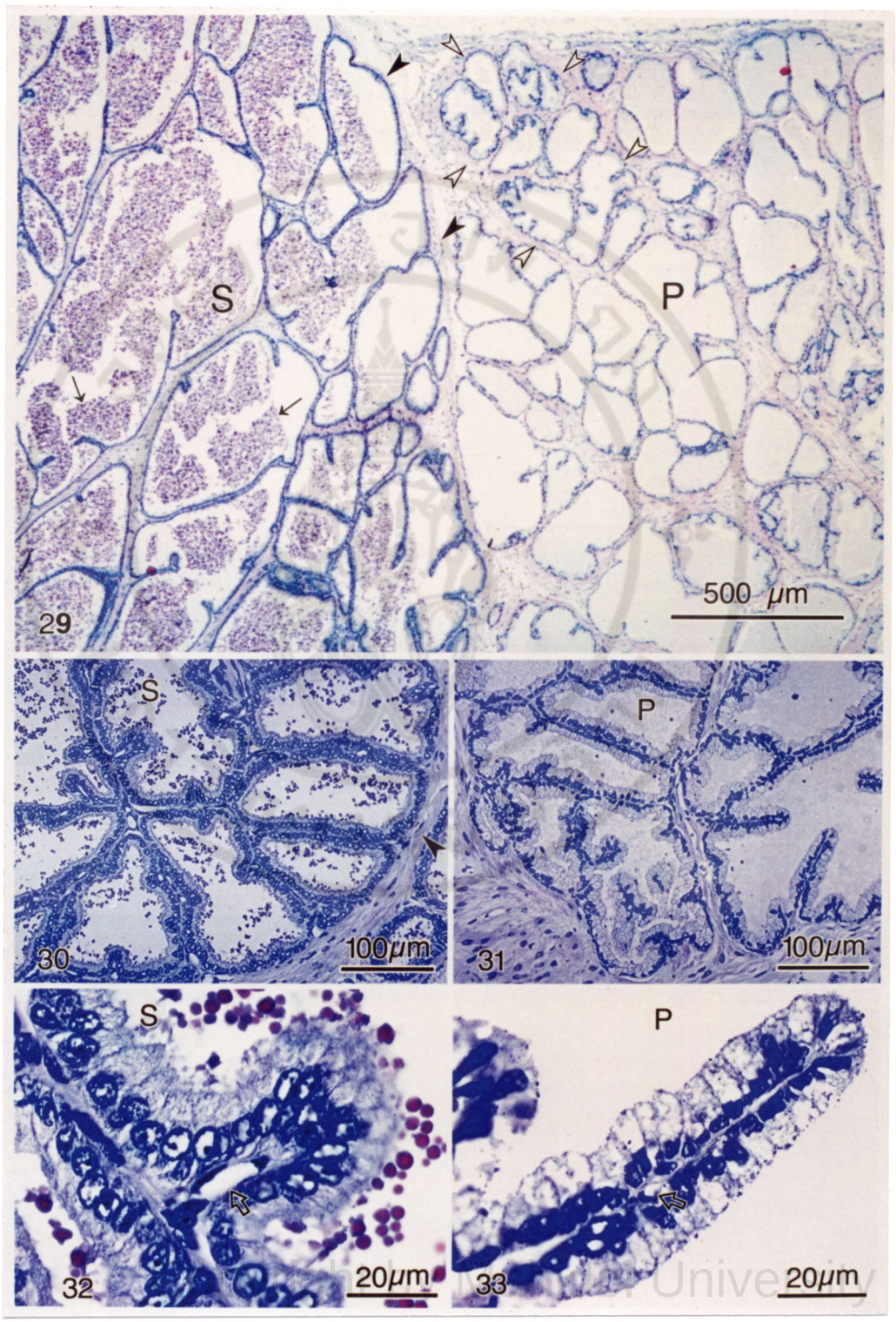
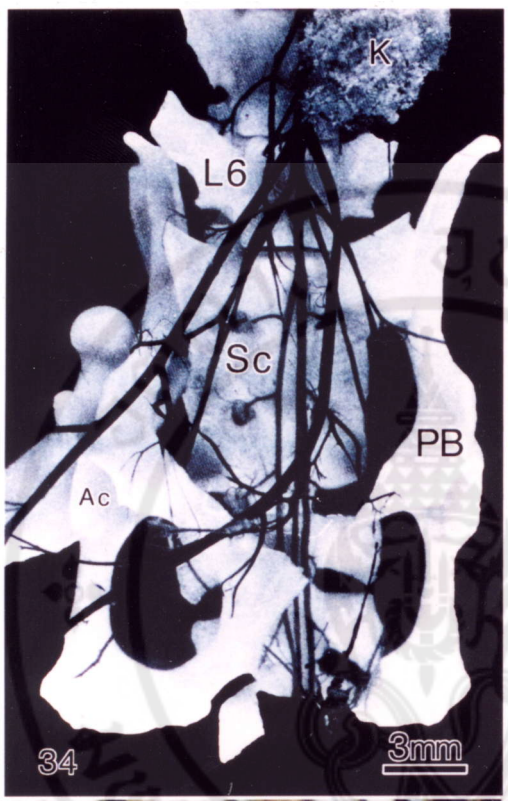

S
P
500 μm
29
S
100μm
30
P
100μm
31
S
20μm
32
P
20μm
33

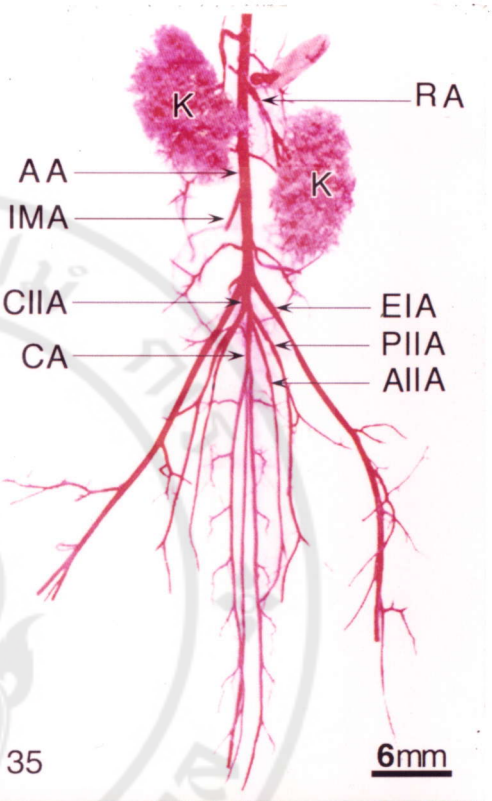
Figure 34. Photograph of the vascular casts showing the end branching of the abdominal aorta within the pelvic inlet in the common tree shrew. Ac, acetabulum; K, kidney; L6, Lumbar 6^{th}; PB, pelvic bone; Sc, sacrum.

Figure 35. Photograph of the vascular casts showing the detail of the end branching of the abdominal aorta in the common tree shrew. AA, abdominal aorta; AIIA, anterior division of internal iliac artery; CA, caudal artery; CIIA, common internal iliac artery; EIA, external iliac artery; IMA, inferior mesenteric artery; K, kidney; PIIA, posterior division of internal iliac artery; RA, renal artery.

Figure 36. Stereomicrograph of the vascular casts coated with gold/palladium, dorsal view, showing the ramification of the blood supply to the seminal vesicle (S) and the prostate gland (P) in the common tree shrew; black arrowheads, arterial branches from the marginal branch of superior vesical artery.

Figure 37. Stereomicrograph of the vascular casts coating with gold/palladium, ventral view, showing the ramification of the blood supply to the seminal vesicle (S) and the prostate gland (P) in the common tree shrew. UB, urinary bladder; Ut, Urethra.





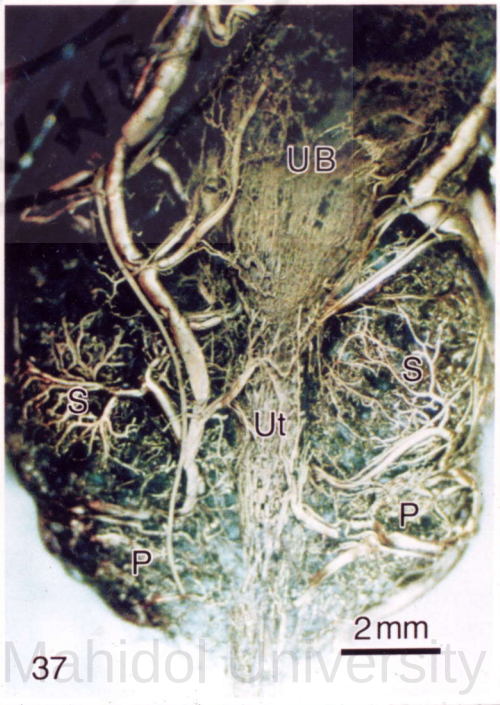


Figure 38. Stereomicrograph of the vascular casts, lateral view showing the major blood supply to the seminal vesicle (S) and the prostate gland(P) in the common three shrew. AA, abdominal artery; AIIA, anterior division of internal iliac artery; EIA, external iliac artery; IVA, inferior vesical artery; SVA, superior vesical artery; UB, urinary bladder.

Figure 39. Stereomicrograph of the vascular casts, lateral view, showing superior vesical artery and its division. LSeVA, anterolateral ramus of seminal vesicle artery; MSeVA, medial ramus of seminal vesicle artery; SeVA, seminal vesicle artery; SVA, superior vesical artery; S, seminal vesicle; UB, urinary bladder.

Figure 40. Stereomicrograph of the vascular casts, dorsal view, showing the medial ramus of seminal vesicle artery (MSeVA) and anterolateral ramus of seminal vesical arteries (LSeVA); S, seminal vesicle.

Figure 41. Stereomicrograph of the vascular casts, dorsal view, showing the marginal branch of superior vesical artery. IVV, inferior vesical vein; MgA, marginal branch of superior vesical artery; S, seminal vesicle; asterisk, branch of MgA.

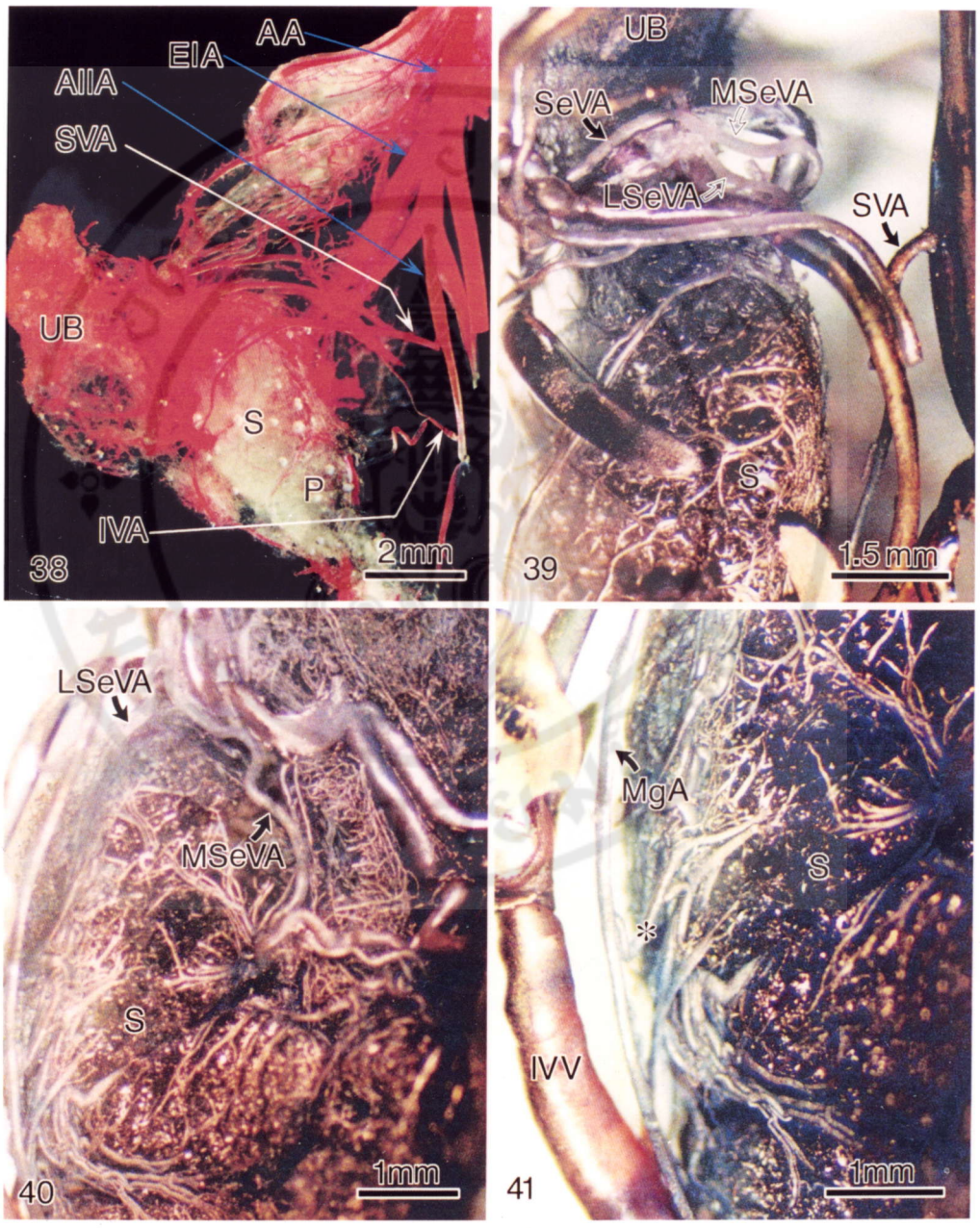


Figure 42. SEM micrograph of the vascular casts coated with gold/ palladium, dorsal view, showing the seminal vesicle artery (LSeVA) accompany to the seminal vesicle vein (SeVV) to supply the seminal vesicle (S).

Figure 43. SEM micrograph of seminal vesicle, transverse section, showing the small artery (SA) breaking into arteriole and small arteriole surrounding the centrilocular antrum. S, seminal vesicle; asterisk, centrilocular antrum; A, artery; V, vein; a, arteriole.

Figure 44. SEM micrograph of seminal vesicle showing the capillary network (black arrowheads) surrounding the locular compartment.

Figure 45. SEM micrograph of the vascular casts in the seminal vesicle illustrating the non-fenestrated capillaries (black arrowhead) in common tree shrew. a, arteriole; v, venule.

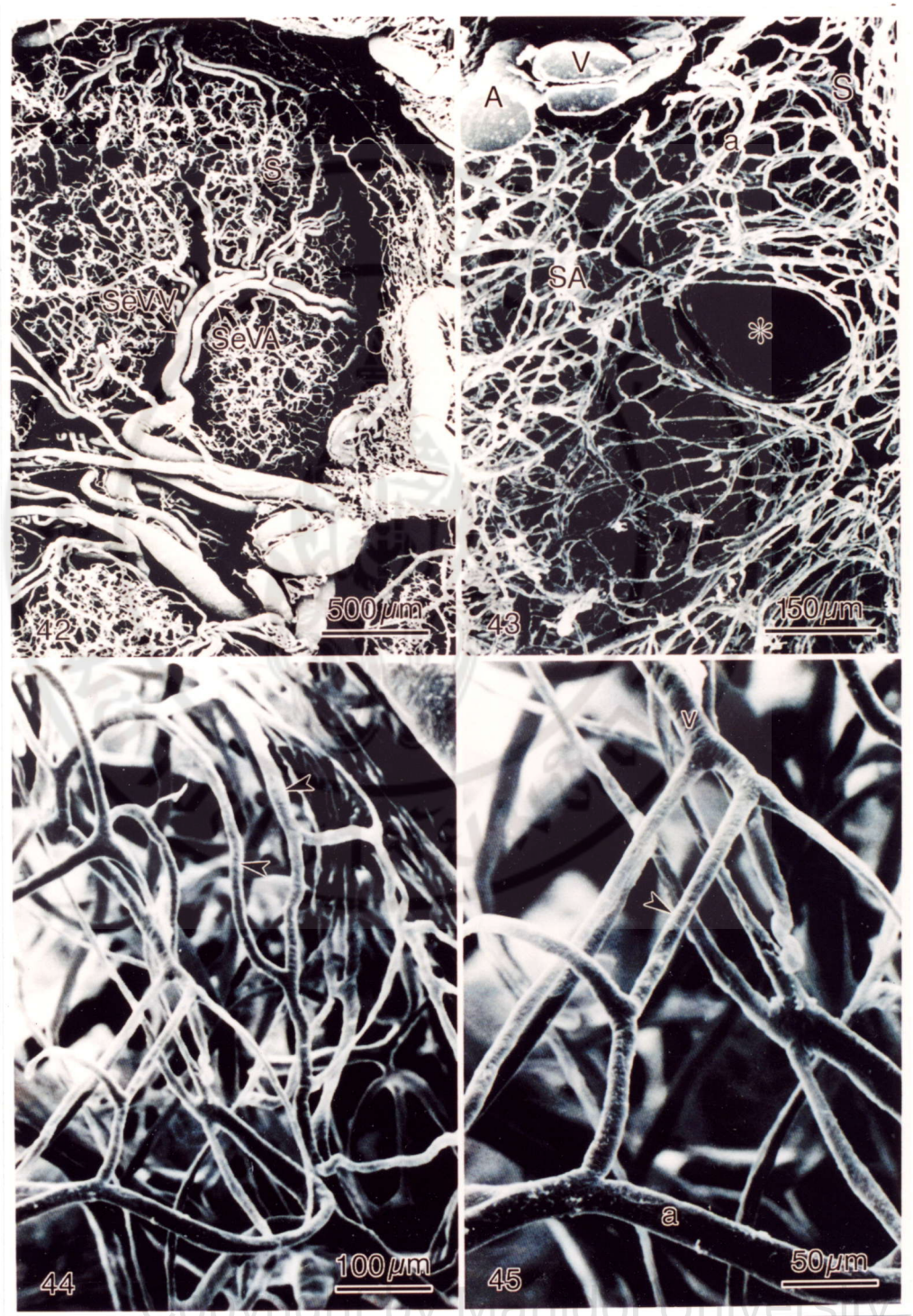


Figure 46. SEM micrograph of the vascular casts in the seminal vesicle showing the venule (v) drain into the vein(V). asterisks, capillary.

Figure 47. SEM micrograph of the vascular casts in the seminal vesicle showing the tributary of vein (asterisks) drain into the large vein (V). v, venule .

Figure 48. SEM micrograph of the vascular casts in the seminal vesicle showing the anastomosis arrowhead among the small vein and the large vein. V, vein; A, artery.

Figure 49. SEM micrograph of the vascular cast in the seminal vesicle showing the anastomosis of the large veins (big black arrow). V, vein.

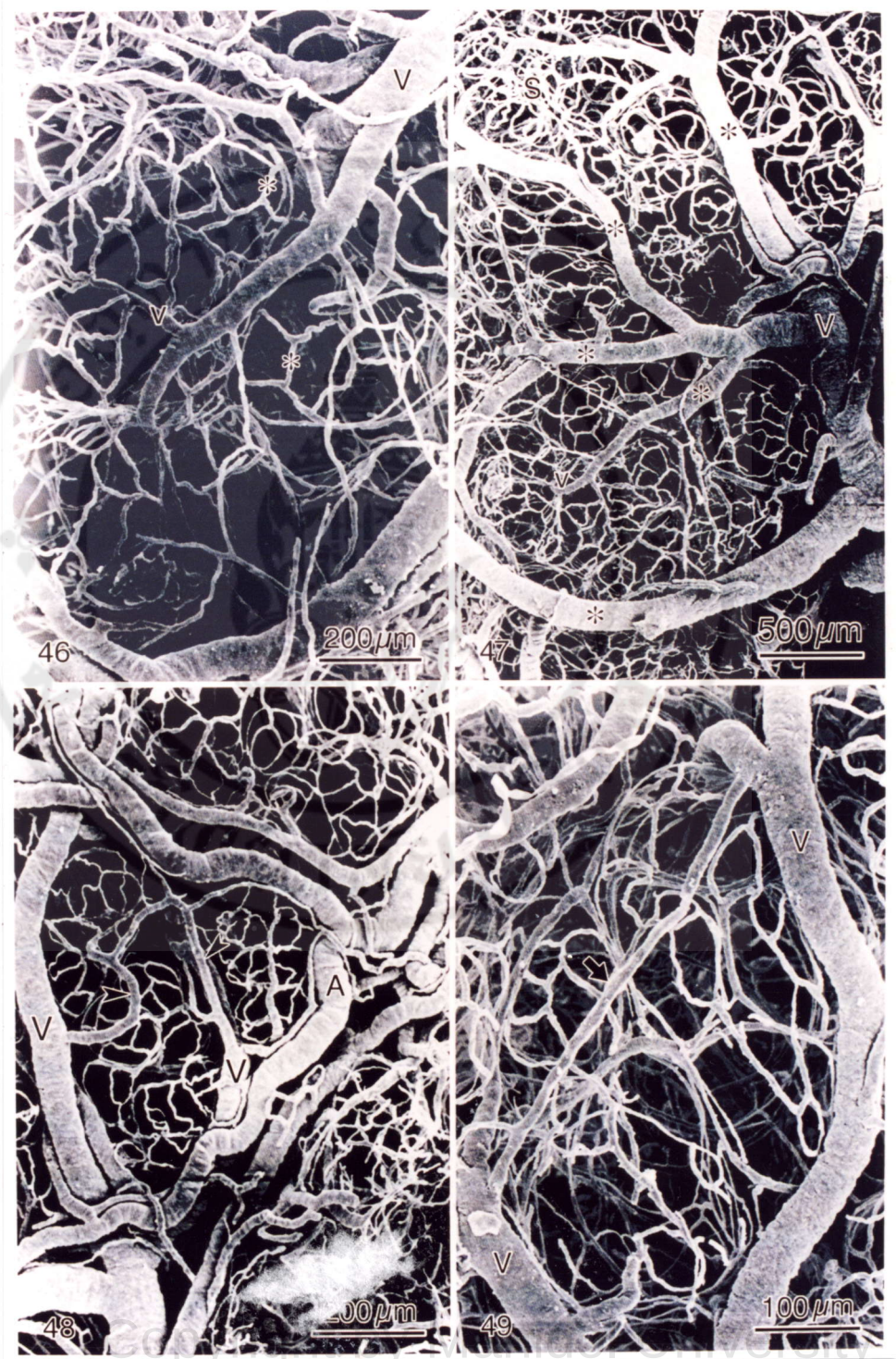


Figure 50. SEM micrograph of the vascular casts showing the tributary (asterisks) of the seminal vesicle vein (SeVV) in the common tree shrew. S, seminal vesicle.

Figure 51. Stereomicrograph of the vascular casts showing the superior vesical vein (SVV) and the inferior vesical vein (IVV) drain into the internal iliac vein (IIV) in the common tree shrew. S, seminal vesicle; P, prostate gland; SeVV, seminal vesicular vein; big black arrow, SVV drains into IIV; big white arrow, SeVV drains into IVV.

Figure 52. SEM micrograph of the vascular casts showing the venous valve (arrowhead) of the superior vesical vein in the common tree shrew. V, vein.

Figure 53. SEM micrograph of the vascular casts showing the endothelial nuclear imprints (thin arrow) and the arterial sphincter (black arrowhead) of the small artery (SA).

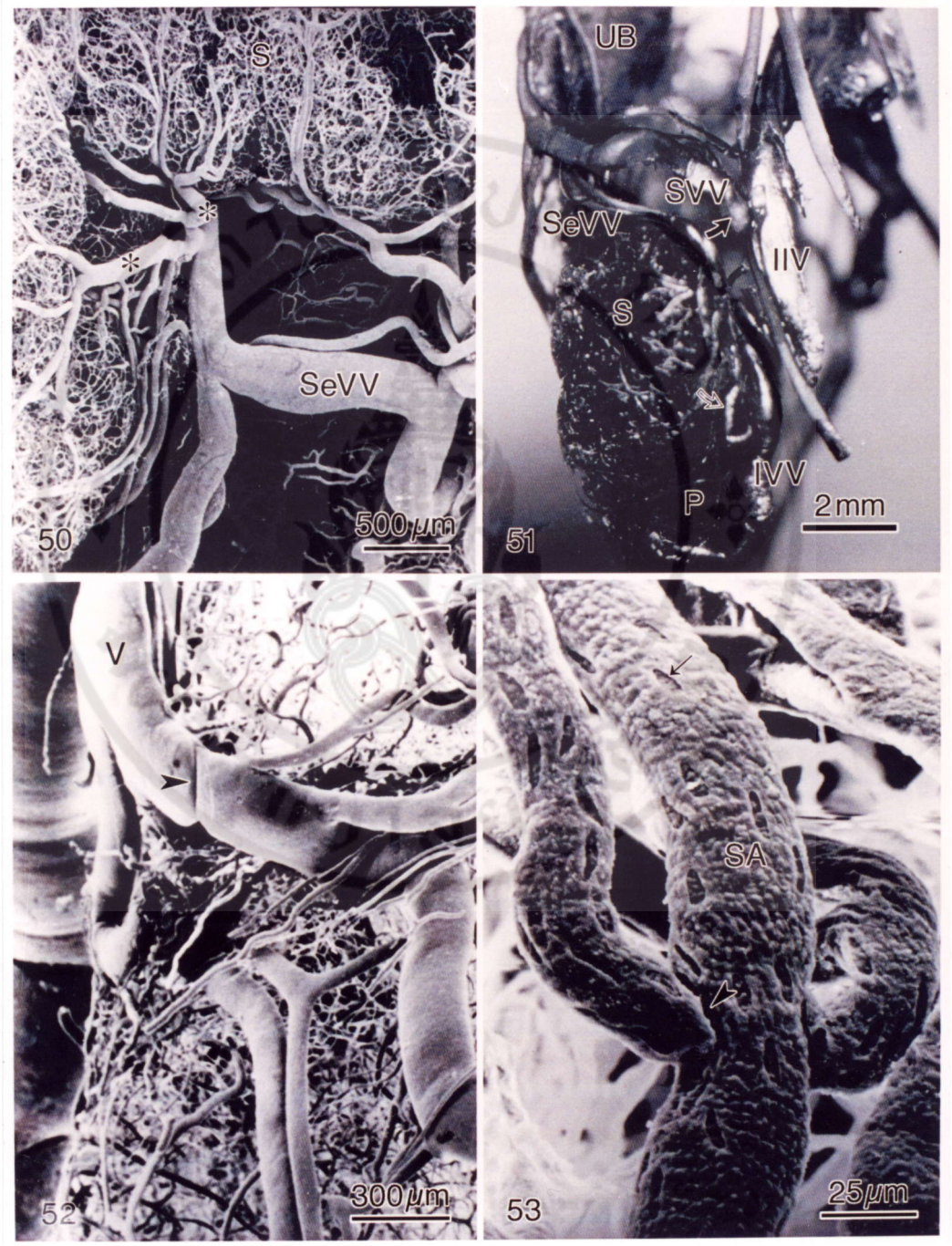


Figure 54. Stereomicrograph of the vascular casts of the prostate gland showing the main artery supplying the prostate gland (p) in the common tree shrew. IVA inferior vesical artery; IVV, inferior vesical vein; MgA, marginal branch of superior vesical artery; white arrowhead, MgA joining together with IVA; black arrowheads , branches of MgA.

Figure 55. Stereomicrograph of the vascular casts of the prostate gland (P), dorsal view, showing the inferior vesical artery (white arrowhead) and its divisions. black arrowheads, dorsal branches of inferior vesical artery.

Figure 56. Stereomicrograph of the vascular casts of the prostate gland (P), dorsal view, showing the dorsal branches of the inferior vesical artery (black arrowheads) accompanying to vein.

Figure 57. Stereomicrograph of major vascular cast of the prostate gland, dorsal view, illustrating the ventral branches of the inferior vesical artery (both big black and big white arrows). IVA, inferior vesical artery; IVV, inferior vesical vein.

Figure 58. Stereomicrograph of the major vascular cast of the prostate gland (P), ventral view showing the ventral branches of the inferior vesical artery (big black arrows) accompanying to vein. asterisk, inferior vesical vein.

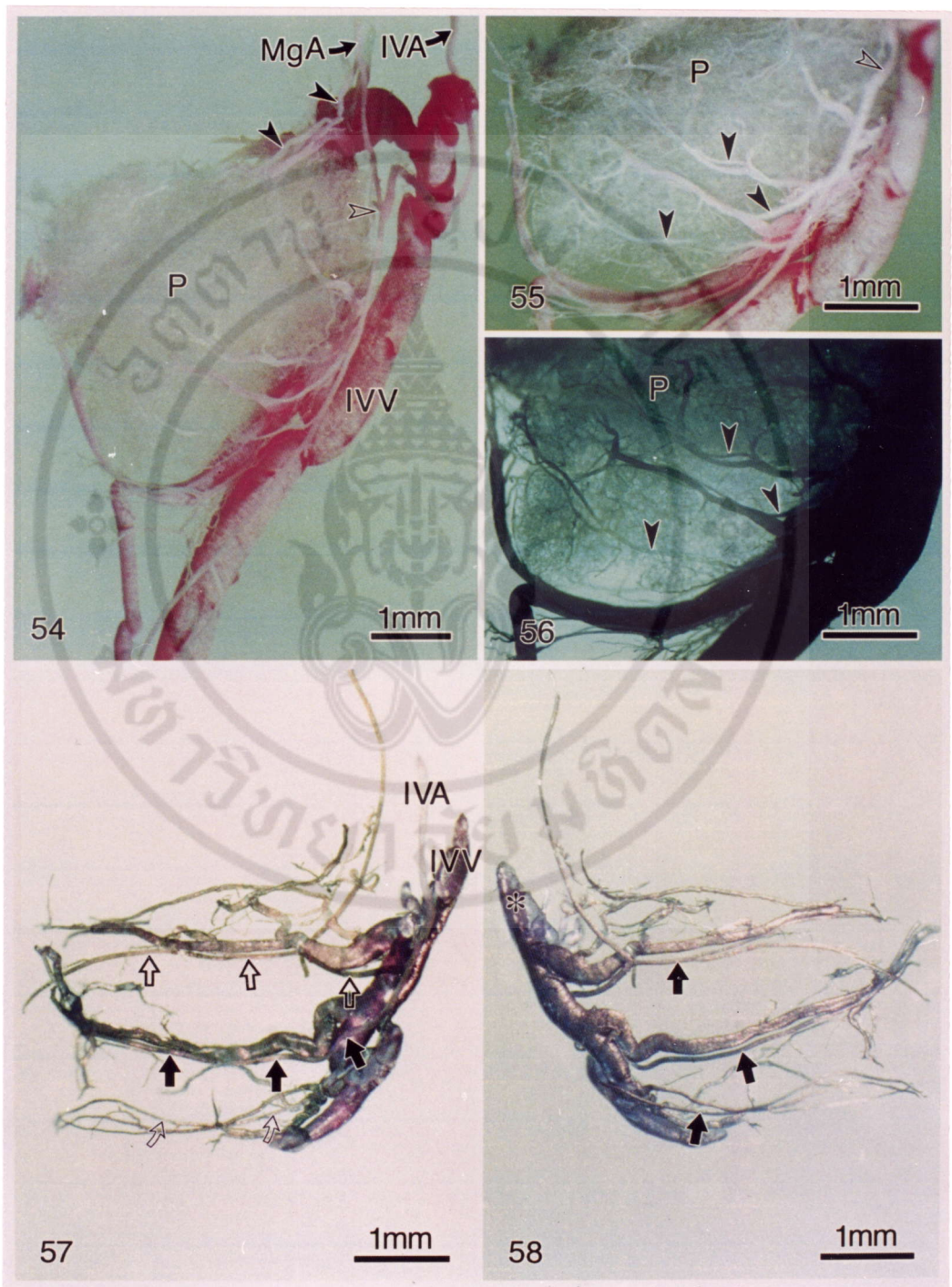


Figure 59. SEM micrograph of the vascular casts, dorsal view, showing the ramification of the blood supply to the prostate gland (P). S, seminal vesicle; IVA, inferior vesical artery; IVV, inferior vesical vein; Ut, urethra; black arrowheads , branches from marginal branch of superior vesicle artery; big black arrow, anastomosis of the dorsal branch of inferior vesical vein; white arrowhead , the venous valve of the IVV.

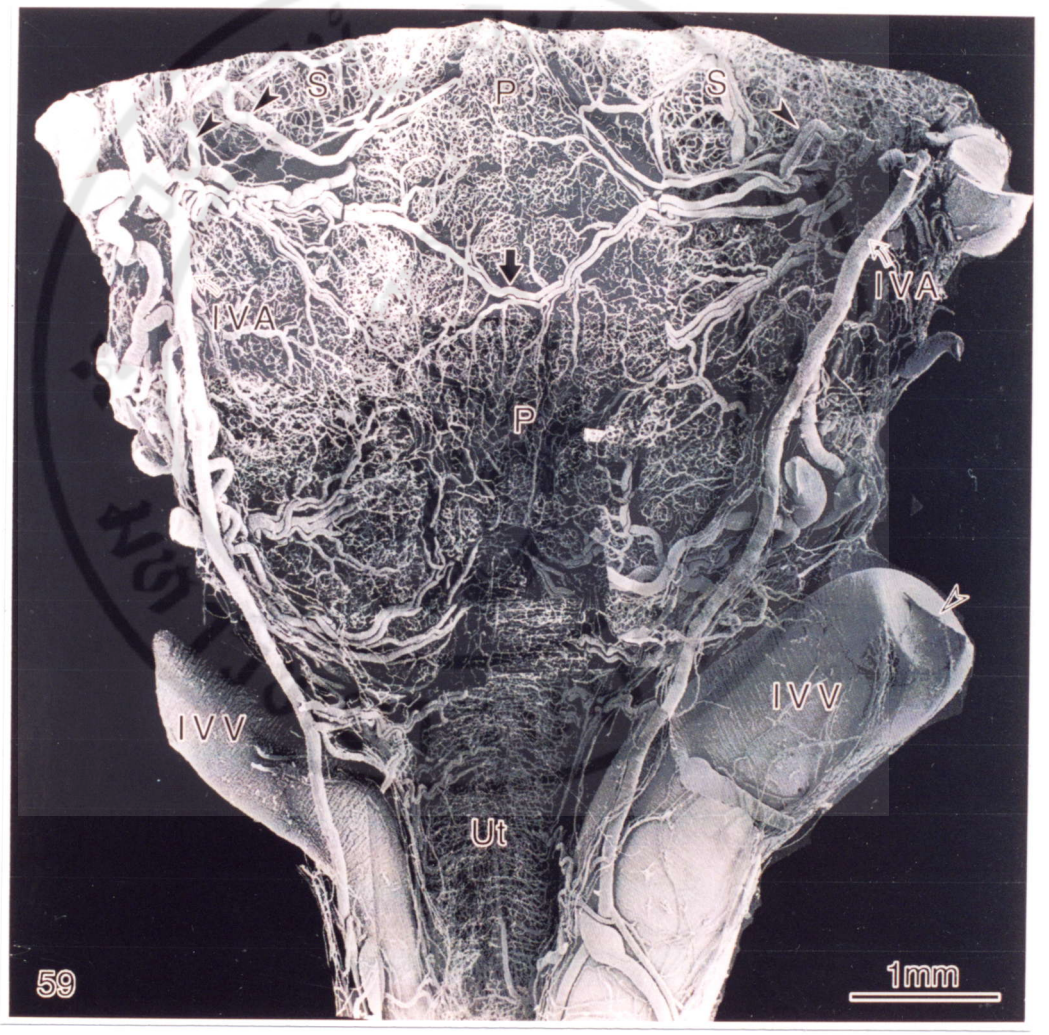


Figure 60. SEM micrograph of the vascular casts, dorsal view, showing the inferior vesical artery (IVA) and its ventral branches of the prostate gland (big black arrows). P, prostate gland; IVV, inferior vesical vein.

Figure 61. SEM micrograph of the vascular casts, dorsal view, showing the inferior vesical artery and its dorsal branch of the prostate gland(big black arrows). P, prostate gland; IVV, inferior vesical vein; Ut, urethra; big white arrows, branches of IVA supplying the urethra.

Figure 62. SEM micrograph of the vascular cast, dorsal view, showing the dorsal branch of the inferior vesical artery (big black arrows) supplying the urethra (Ut). IVA, inferior vesical artery.

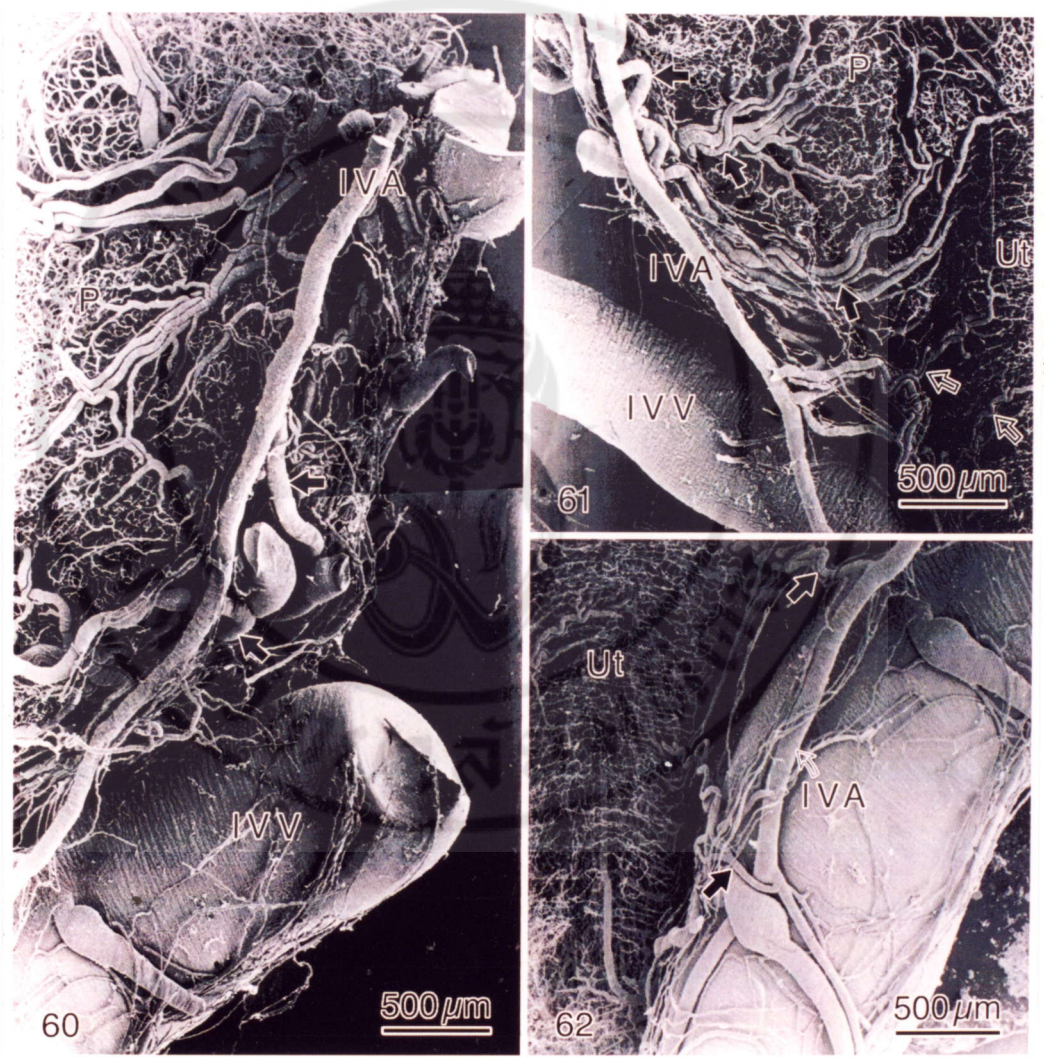


Figure 63. SEM micrograph of the vascular casts showing the arterial supply the glandular part of the prostate gland (P). white arrowheads, arterial branches of inferior vesical artery; black arrowheads, small arteries supplying the glandular acini of the prostate gland; asterisks, glandular acini.

Figure 64. SEM micrograph of the vascular casts showing the arteriole giveing off the small arteriole (a) to supply glandular acini and drain into the venule (v). c, capillary.

Figure 65. SEM micrograph of the vascular casts of the prostate gland (P) showing the venous drainage. A, artery; V, vein; big black arrow, tributaries of vein; asterisks, glandular acini

Figure 66. Stereomicrograph of the vascular casts of the prostate gland (P) showing the inferior vesical vein (IVV) draining into the internal iliac vein (IIV) in the common tree shrew. S, seminal vesicle; UB, urinary bladder.

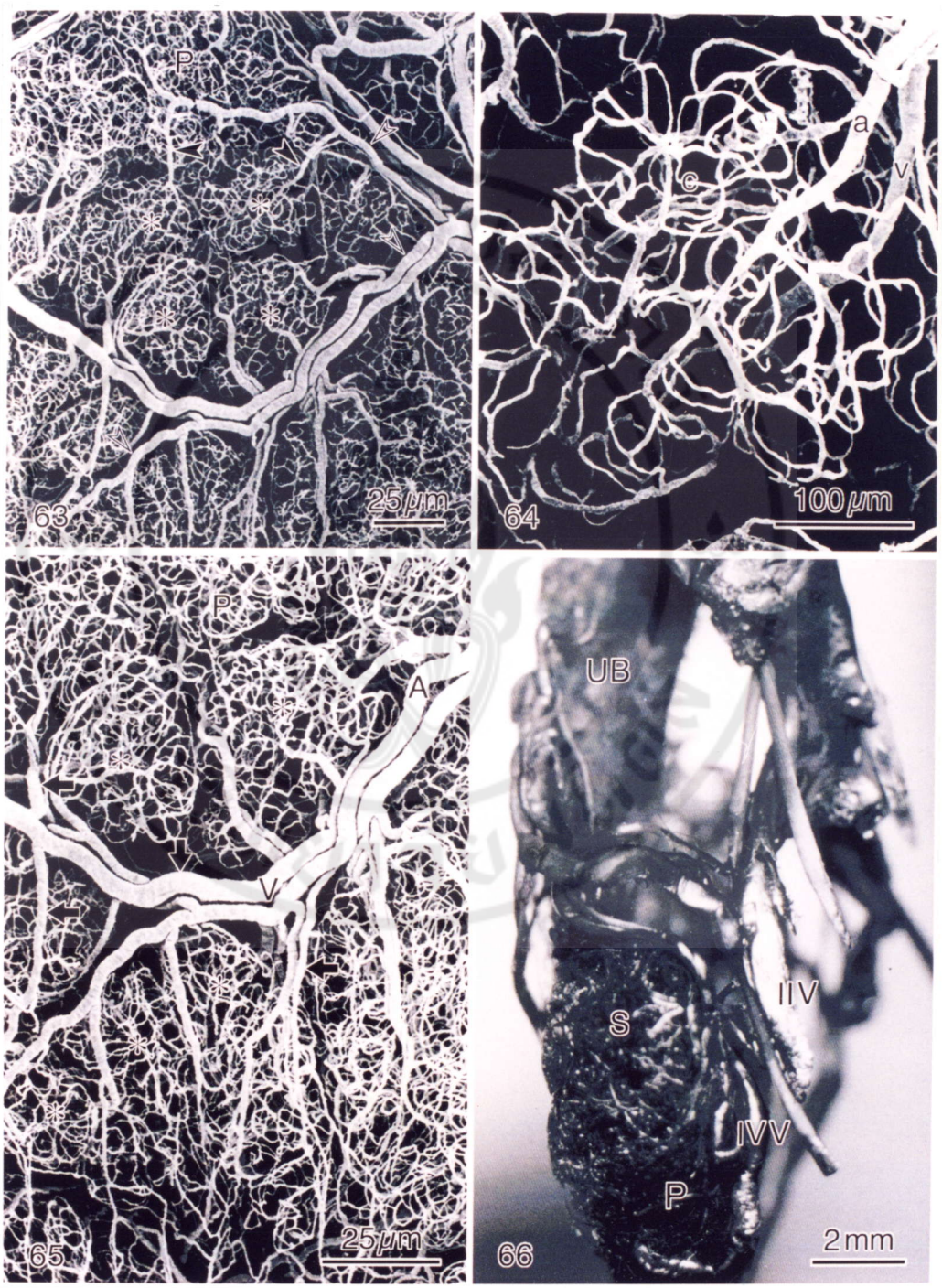
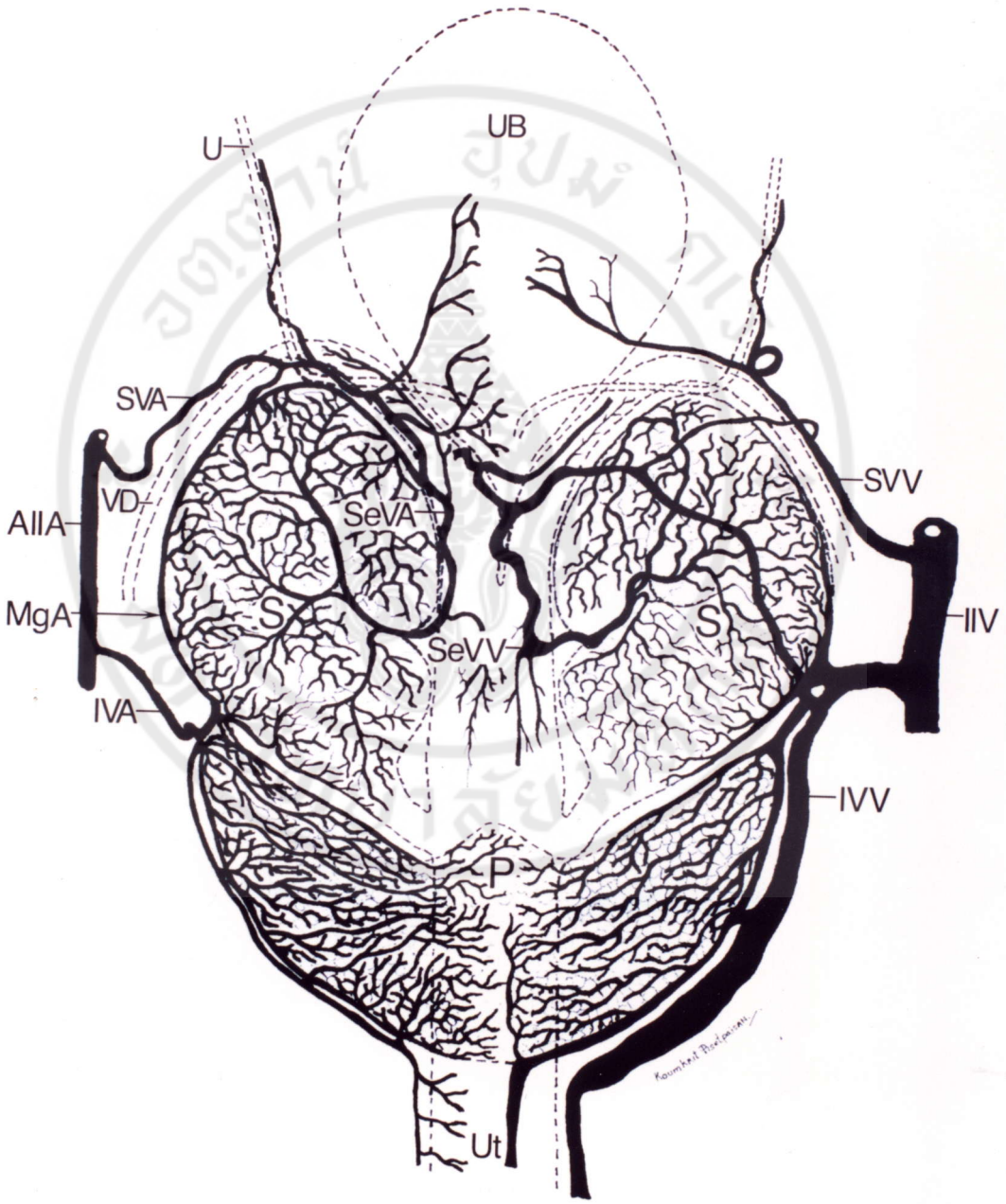


Figure 67. Diagram showing the vascular supply of the seminal vesicle (S) and the prostate gland in the common tree shrew. UB, urinary bladder; SVA, superior vesical artery; SVV, superior vesical vein; AIIA, anterior division of internal iliac artery; SeVA, seminal vesscle artery; SeVV, seminal vesscle vein; IVA, inferior vesical artery; IVV, inferior vesical vein; MgA marginal branch of superior vesical artery; VD, vas deferens; Ut, urethra; U, ureter.



CHAPTER IV

DISCUSSION

The seminal vesicle in the common tree shrew is similar to that of rat (19) and man (21) in that it consists of left and right lobes. Each lobe is elongated, lobulated and coiling to form the vesicle-like mass with the collecting duct running along its entire length. Each lobe of the seminal vesicle, in tree shrew, composes of eight to ten lobules. Each lobule contains multilocular compartments separated by spiral septum. Each locular compartment is perpendicular to the centrilocular antrum (central locular). These compartments are not completely divided but partial separated by partial interconnection. So that the secretory fluid from each locular compartment could drain into the centrilocular antrum and then to the collecting duct which finally empty to the main duct. This structure in the tree shrew is called "Ammunite structure". In Lorisitormes and Lemuriformes, the seminal vesicles are very long while in the Indriida and Lemuridae, unlike other primates, they are bending at the upper poles (2). In Ptilocercus, each gland is divided into two lobes. The upper lobe is termed as vesicular diverticulum and the lower lobe is named vesicular gland (2). In other Primates, they are simple coiled tubular organs. In the gibbon(*Hylobates agilis)* each seminal vesicle is 2 cm long. It is 4.3 cm long when it is uncoiled (2). The seminal vesicles in the common tree shrew and most Primates are relatively large. It is rather small in the apes and man (1). As the seminal vesicle secretes a large portion of the substrate for contribution the coagulating plug. This gland of most

Primates is quite necessary when compares to man and ape. The left and right main ducts of the seminal vesicle in *Tupaia glis* join one another near the caudal ends of the left and right vas deferens to form a left and right common ejaculatory ducts which open into the urethra. This is similar to those of *Tupaia belangeri* (17), rat (19), man (21). However in *Ptilocercus lawii* (tree shrew) the seminal vesicle are divided into upper and lower lobes. The upper lobe joins the vas deferens to form the ejaculatory duct and appears to be homologous to the simple lobular seminal vesicle found in other species of tree shrew. The lower lobe opens directly into the urethra (2). The presence of ejaculatory duct is quite specific for primates but not in most of the lemurs. The seminal vesicle and vas deferens open separately into the urethra (17, 33). The ejaculatory duct is also absent in cat, dog, monotremes, marsupial and some species of primates and lagomorphs. Since their seminal vesicles could not be identified (1).

The secretion found in the lumen of seminal vesicle in most mammals is amorphous whereas that of the *Tupaia glis* is stored as spherical body or globules. The seminal vesicle epithelium in *Tupaia glis* secretes small granular aggregates. Occasionally denser aggregates that is associated with cells having apical Golgi lamellae. In the alveolar lumen, these aggregations unites with each others to form larger granular and some dense globules of up to approximately 15 ? in diameter (66).

The close anatomical relationship between the seminal vesicle and the prostate gland in *Tupaia glis* is also found in *Tupaia belangeri* (17). After fixation, the seminal vesicle and the prostate gland appear as a single structure. However, the

fresh prostate glands of both *Tupaia glis* and *Tupaia belangeri* are distinguishable pink in color with higher degree of vascularity (Fig. 1).

It has been known for several centuries that the prostatic cancer and benign prostatic hyperplasia (BPH) are very common among elderly men. Intensive researches concerning basic knowledge of the human prostate have been undertaken. These cover the developmental aspect (4), the gross anatomy (34, 35, 38), the zonal anatomy (36), normal histology (37, 39), the clinical pathology (39, 41, 42), the basic factors responsible for the initiation and the progress of prostate cancer (67), the morphological and regulatory aspects of prostatic function (68) and the vascular arrangements within the human prostate gland (8, 19, 58, 62, 63). However the studies concerning its endocrine and biochemical functions in situ of living human body are limited and illegal. It is necessary, therefore, to find the suitable experimental animal model. With this respect, the ventral prostate gland of the rat has been used to find out the effects of androgenic steroids on the prostate cells (69, 70, 71, 72, 73, 74, 75, 76, 77, 78).

Recently the findings from two separate groups of investigators indicate the endothelial cells of the ventral prostate lobe are likely to be important targets for the action of androgenic steroids in regulating the size of the mature prostate gland. It has been emphasized that the prostatic vascular system is a primary target of androgen action in this tissue (79, 80, 81, 82, 83).

Moreover, the detail information concerning morphology, cellular heterogeneity and functional activities of the rat ventral prostate have been gained (84, 85, 86, 89). The prostate gland in *Tupaia glis* is different from that in the rodents of which

consisting of bilateral anterolateral lobe and unilobular posterodorsal lobe, while in rat, it composes of anterior, dorsal, lateral and ventral lobes of the prostate gland (29). The anterior lobe of the prostate gland in the rodents concerns with the formation of the vaginal plug or copulation plug. The semen of many species coagulates soon after ejaculation. In the rat and the guinea pig, the vaginal plug which forms after copulation composed of coagulated semen. Camus and Gley, reviewed by Gotterer G. el al. (87) are the first to recognize that the secretion of the seminal vesicle are coagulated by an enzyme called vesiculase present in the prostatic secretion of the rodents. The classical studies of Walker establish that this coagulating enzyme is manufactured solely in the anterior prostate or so-called coagulating gland. In man, the coagulated semen afterwards liquefies. Huggins and his coworkers, reviewed by Gotterer G. et al. (87) have shown quite clearly that the liquefaction of human semen is a proteolytic, and that semen of human and other animals contains a number of proteolytic enzymes. This finding have been confirmed and amplified by Lundquist, reviewed by Willias et al. (87). However, the nature of the reactions responsible for the coagulation of the semen of any species remains unknown (87).

The prostate gland of musk shrew (*Suncus murinus*, Insectivora) differs from that of the *Tupaia glis*. In musk shrew the prostate gland consists of a pair of glands located on each side of the urethra near the neck of the bladder. The left and right gland expands toward the urinary bladder. Each lobe divides into ventral and dorsal lobes. Several ducts from the ventral and dorsal lobes run caudally through the urethral stroma into one main duct which enters the sinus prostaticus (32).

From histological study, of the prostate gland of the *Tupaia glis* could be divided into two parts. The first part or cranial part consists of bilateral left and right anterolateral lobes with theirs own left and right main ducts opening into the prostatic urethra. The second part or caudal part is a unilobular posterodorsal lobe. Each anterolateral lobe situates posteriorly to the neck of the urinary bladder and inferiorly to the seminal vesicle and on the dorsolateral side of the prostatic urethra, the ampulla of vas deferens and the ejaculatory duct. The unilobular posterodorsal lobe of the prostate gland situates inferiorly to both left and right anterolateral lobes cover the posterior and lateral surfaces of the prostatic urethra. The anterolateral lobe of the prostate gland could easily be dissected from the seminal vesicle, ampulla of the vas deferens but the posterodorsal lobe is rather difficult to do so. It is noted that the two lobes (the anterolateral and the posterodorsal) are very much associated. In addition, both lobes consist of many infolding lobules separated by loose fibrous tissue. It is rather impossible, therefore, to completely separate the two lobes apart by dissection. These findings are different from those in the *Tupaia belangeri* that its prostate gland consists of a pair lobe situating on dorsolateral aspect of the anterior portion of the urethra (17). The glandular alveoli drains into a main collecting duct which run through the urethral tissue for a short distance and then joined the duct from the opposite side to form a common dorsomedial duct (17). These authors concluded that the prostate glands of both *Tupaia belangeri* and *Tupaia glis* are confined to a pair of dorsolateral lobes bound to the seminal vesicle by a connective tissue sheath. It is questionable whether the prostate gland in the *Tupaia belangeri* consists of only a pair of dorsolateral lobe while the prostate gland in *Tupaia glis* does not consist of a pair

of posterodorsol lobes only. This seems that the conclusion above concerning the prostate glands of both *Tupaia belangeri* and *Tupaia glis* may not be true. In addition, the statement in the in Comparative Reproduction of Nonhuman Primates (2) that the prostate gland in nonhuman primates (Tupaiidae) being unilobular may not be reliable.

The nonhuman primates could be the good natural animal models for the study of human diseases since their anatomy and physiology are similar to those of man. Several studies of comparative anatomy have shown the homologous features of the nonhuman primate prostates to that of human (33). Physiological and immunological studies indicate various similarities among the prostates of nonhuman primates and man (33). The prostate glands in nonhuman primates such as *Macaca mulatta*, *Pan troglodytes* and *Callicebus moloch,* compose of cranial and caudal lobes. The cranial lobe is lobulated and resembles the seminal vesicle and situates posteriorly to the neck of the urinary bladder, the ampulla of the vas deferens and the ejaculatory duct. The caudal lobe of the prostate, in contrast, is globular with smooth surface situating inferiorly to the cranial lobe. The two lobes are quite intimately associated so that it is difficult to dissect them apart. The ejaculatory ducts pass through the upper portion of the caudal lobe of the prostate gland and open into the verumontanum of the prostatic urethra. This would suggest that the anatomical aspect of the prostate gland in *Tupaia glis* is quite related to those of nonhuman primates as the prostate gland of the *Tupaia glis* composes of two parts and the anatomical position of the first part or cranial part (bilateral anterolateral lobe) is similar to the cranial lobe and of the

second part or caudal part (unilobular posteriodorsal lobe) is similar to the caudal lobe of the prostate gland in nonhuman primates.

In 1912, Oswald SL had studied the development of the prostate gland in human(4). He found that the prostate develops as a five-lobed structure; anterior lobe, two lateral lobes, a middle lobe and a posterior lobe (4). In 1922, Adrion, reviewed by Flocks RH (62) divided the prostate gland of human into two portions. The first portion is the internal or periurethral glands, consisting of subcervical lobe and subtrigonal lobe. The second part is the five external or true prostatic gland. This part composes of an anterior lobe, two lateral lobes, a median lobe and a posterior lobes.

Current concepts of the structural and functional organization of the human prostate are related to endocrine principle which have been studied in experimental animals. Based on embryological and histological studies, the internal structure of the human prostate gland is divided into four subdivisions:

1. The peripheral zone constitutes over 70% of the glandular prostate and almost

   all carcinomas arise here.
2. The central zone constitutes 25% of the glandular prostate. Those are hitological differences between central and peripheral zones.
3. Preprostatic region. Duct development is aborted here, producing only a small transition zone and several tinier periurethral ducts. These small ducts in a restricted area are the exclusive site of nodular hyperplasia (BPH) origin.

4. The anterior fibromuscular stroma forms the entire anterior surface of the prostate as a thick, nonglandular apron, shielding the anterior surface of the three glandular regions (36, 68).

Blacklock and Bouskill, 1977, reviewed by Lewis et al. (33) compared the cranial and caudal prostate lobes of the rhesus monkey to the zonal anatomy proposed by McNeal (41) in the human prostate. They conclude that the cranial lobe is similar to the central zone of man while the caudal lobe resembles the peripheral zone of man. Lewis and coworkers (33) had concluded that the anatomy of the prostate gland in nonhuman primate is the homologous organ of the prostate gland in the human (33). The present study reveals that the prostate gland of common tree shrew could be divided into cranial part (bilateral anterolateral lobe) and the caudal part (unilobular anterodorsal lobe). From the present anatomical study of the prostate gland in common tree shrew as well as the studies mentioned above it is evident that the cranial part (bilateral anterolateral lobe) of the prostate gland in common tree shrew has the similar features to the central zone of human prostate and the caudal part (unilobular posterodorsal lobe) resembles the peripheral zone.

In *Tupaia glis*, the abdominal aorta enters the pelvis and gives off left and right external iliac arteries before continuing as single artery, a common internal iliac artery. The common internal iliac artery, then, breaks into two internal iliac arteries and a caudal artery. This pattern is different from that of man whose abdominal aorta bifurcates into left and right common iliac arteries before giving off external and internal iliac arteries (50). The internal iliac artery of *Tupaia glis* divides into anterior and posterior division of internal iliac artery as in man (50). The anterior

division of internal iliac artery in *Tupaia glis* gives of several branches to supply the pelvic visceral organs as in the man (50).

In rat, the organization pattern concerning the end branches of the abdominal aorta is also variable and different between the *Tupaia glis* and man (88).

In rat, the internal artery (hypogastic artery) is not divided into anterior and posterior division as in *Tupaia glis* and man (29, 60, 88). In *Tupaia glis* the anterior division of the internal iliac artery usually gives off two main branches. The first one is superior vesical artery supplying the seminal vesicle and the prostate gland and the second one is inferior vesical artery supplying the prostate gland. In contrast to the case of man of which the anterior division of internal iliac artery gives off only inferior vesical artery to supply the seminal vesicle and the prostate gland. In some cases the inferior vesical artery in man does not come directly from the anterior division of the internal iliac artery but it branches from the superior vesical artery. In addition, there is some branches of the middle rectal artery supplying them (50). In the rat, although the internal iliac artery does not break into anterior and posterior divisions it gives off the superior vesical artery to supply the urinary bladder, seminal vesicle and prostate gland. The inferior vesical artery is also derived from superior vesical artery. This feature is similar to some cases of man that the inferior vesical artery is a branch of the superior vesical artery. It is noted, however, that most of blood supply of the seminal vesicle and prostate gland in man is from the inferior vesical artery, not from the superior vesical artery. This is not the case of rat of which the seminal vesicle and the prostate gland also receive the blood supply from the middle hemorrhoidal artery (5, 59).

The study of blood supply of the prostate gland and the seminal vesicle by vascular corrosion cast technique had only been done in the rat (5). The study in the tree shrew with this technique revealed the detail blood supply that the superior vesical artery usually arises from the internal iliac artery and after that it gives off the arterial branches to supply the ureter, urinary bladder, vas deferens and the ampulla of vas deferens. Finally, it becomes seminal vesicle artery before breaking into medial and anterolateral rami. The medial ramus supplies the lesser curvature of the seminal vesicle and the anterolateral ramus supplies the anterolateral border of the seminal vesicle. The superior and inferior vesical arteries in *Tupaia glis* usually anastomose to one another to become marginal branch of superior vesical artery. This feature is not present in the rat (5). This marginal branch of superior vesical artery gives off several branches to supply the greater curvature and the posteromedial side of the seminal vesicle and the rostral part of the anterolateral lobe of the prostate gland. However, the arterial anastomosis within the seminal vesicle of the *Tupaia glis* could not be observed.

There are a few long and coiled vessels that seem to collateralize with each other along the greater curvature. The coiling feature of these vessels could cope with the distension of the urinary bladder and may also accommodate different levels of seminal vesicle contraction at the time of ejaculation. It should also be noted in the tree shrew that the small arterioles give rise to the capillary network around the locular compartment as in the rat (5).

The pattern of blood supply in the prostate gland of *Tupaia glis* is quite similar to that of human (8, 19, 58, 62, 63) but somewhat different from that of rat of which the

blood supply to the ventral prostate of the rat appears as a single trunk with the base near the proximal portion of the prostatic duct close to the prostatic urethra. These arteries eventually divide into small vessels at the intermediate section of the duct. Most of which continue to the distal part (the glandular acini) and supply the prostatic duct and the glandular portion in centrifugal direction. In contrast the blood supply to the prostate gland of *Tupaia glis* and human is centripetal type that the arteriole gives off smaller arterioles and capillaries supplying the distal portions (glandular acini) of the gland and continue to the intermediate section of the duct and finally supply the proximal portion of the prostatic duct. However, the penetrating arterioles in the tree shrew terminate into capillary networks surrounding the glandular acini as in rat (59) and man (63).

It is obvious in the tree shrew that the density of capillaries in the seminal vesicle is lesser than that in the prostate gland. This is similar to what has been found in the rat (5). This could be due to the volume of the lumen of the seminal vesicle is approximately 70 % which is much higher than the prostate (with 29 % volume) (23) and the seminal vesicle contributes a large portion of the seminal plasma (25). It is noted that the capillaries supplying both seminal vesicle and prostate gland in the common tree shrew are without fenestration. The venous blood from the seminal vesicle in *Tupaia glis* is drained into superior and inferior vesical veins which then both of them join the internal iliac vein. Their routes are variable but, in general, the passage of vein generally corresponds to those of the arteries (29). In the rat, the venous blood is drained into the inferior vesical vein then into the superior vesical vein and finally into the internal iliac vein. The venous drainage of the prostate gland

in *Tupaia glis* is via inferior vesical vein which finally empties into the internal iliac vein. The vein generally accompanies the corresponding arteries. In rat the venous blood of the prostate gland is drained by the inferior vesical veins which opens into superior vesical vein and finally empties into the internal iliac vein.

The rat ventral prostate is a simple exocrine tissue that contributes a portion of semen during ejaculation. This function is common in all mammals (1). This organ is very sensitive to androgenic steroids (71, 75). It is, therefore, often used as a model to study the cellular effect of androgen (80, 81, 82, 83).

As the reproductive system in the tree shrew is of primate character (17). The animal is used as the model for the study of puberty in primates (9). The anatomical and the vascular arrangement with in the prostate and the seminal vesicle revealed by this study could further support that this animal would be very good model for the study of primate reproductive functions.

CHAPTER VI

CONCLUSIONS

The microangioarchitecture of the seminal vesicle and the prostate gland in the common tree shrew (*Tupaia glis*) was studied by vascular corrosion cast technique with stereomicroscope and scanning electron microscope (SEM). The findings are:

I. The Arterial Supply of the Seminal Vesicle and the Prostate Gland

1. The blood supply of the seminal vesicle and the prostate gland arises from the anterior division of the internal iliac artery.
2. The main blood supply to the seminal vesicle is superior vesical artery. This artery gives off the seminal vesicle artery and the marginal branch of superior vesical artery.
    2.1. The seminal vesicle artery divides into two branches,
        2.1.1 The first branch is medial ramus. It supplies the lesser curvature of the seminal vesicle.
        2.1.2 The second branch is the anterolateral ramus. It supplies the anterolateral side of the seminal vesicle.
    2.2. The marginal branch of superior vesical artery gives off two to three branches. One of these branch supplies the greater curvature of seminal vesicle while the other two branches supply the posteromedial of the seminal vesicle and the rostal part of the

anterolateral lobe of the prostate gland.

3. The major blood supply to the prostate gland is the inferior vesical artery and the minor branch is the branch from the marginal branch of the superior vesical artery.

3.1. The inferior vesical artery gives off five to seven branches. Five to six branches supply the dorsal and the ventral surfaces of the distal portion (glandular acini region) of the prostate gland through to the intermediate section of the duct and finally norish the proximal portion of the prostatic duct near the prostatic urethra. The rest of the branches supplies the prostatic urethra.

3.2. The minor branch of the superior vesical artery supplies the rostral part of the anterolateral lobe of the prostate gland.

II. The Venous Drainage of the Seminal Vesicle and the Prostate Gland

1. All of the venous blood from the seminal vesicle drains in the to seminal vesicle vein which then joins the internal iliac vein.

2. All of the venous blood from the prostate gland drains into the veins accompanying the arteries before joining the inferior vesical vein and finally empties into the internal iliac vein.

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APPENDIX I

The common Tree Shrew

Taxonomic Status

Kingdom : Animal

Subkingdom : Metazoa

Branch : Enterozoa

Division : Bilateria

Section : Eucoelomata

Phylum : Chordata

Group : Craniata

Subphylum : Gnathostomata (Jawed Vertebrates)

Superclass : Tetrapoda

Class : Mammalia

Subclass : Eutheria

Order : Primate or Insectivore or Scandentia

Suborder : 1. Prosimii

Infraorder : Lamuriformes

2. Menotyphla

Family : Tupaiidae

Subfamily : Tupaiinae

Genus : Tupaia

Species : glis

Subspecies : At least 13 subspecies

Synonyms

Serex glis (Diard, 1820)

Tupaia feruginea (Raffles, 1821)

Tupaia m?llendorffi (Matschie, 1898)

Tupaia sordida (Miller, 1900)

Tupaia chrysomalla (Miller, 1900)

Tupaia phaeura (Miller, 1902)

Tupaia castanea (Miller, 1903)

Tupaia pulonis (Miller, 1903)

Tupaia tephrura (Miller, 1903)

Tupaia chrysogastra (Miller, 1903)

Tupaia discolor (Lyon. 1906)

Tupaia siaca (Lyon, 1908)

Tupaia lacernata (Thomas & Wroughton, 1909)

Tupaia cuyonis (Miller, 1910)

Tupaia raviana (Lyon, 1911)

Tupaia pemangilis (Lyon, 1911)

Tupaia obscura (Kloss, 1911)

Tupaia riabus (Lyon, 1913)

Tupaia anabae (Lyon, 1913)

Vernacular Names

Common tree Shrew

Spitzh?rnchen

Tupaia furrugineux

Painted tree shrew

Mill's tree shrew

Tupajas

Topa?es

Tupayes

Tupaide's

Diagnosis

A large tree shrew with a bushy tail that is slightly less to a little more than body length.

Distribution

From Nepal and Sikkim east South China and throughout Southeast Asia to Indonesia but not in Philippine. In Thailand, the following are Thai subspecies that divided into mainland and island supspecies.

Mainland subspecies :

1. *Tupaia glis ferruginea*
2. *Tupaia glis chinensia*
3. *Tupaia glis wilkensoni*

4. *Tupaia glis charissa*
5. *Tupaia glis belangeri*
6. *Tupaia glis laotum*
7. *Tupaia glis olivacea*
8. *Tupaia glis concolor*

Island subspecies :

1. *Tupaia glis larcernata*
2. *Tupaia glis cognata*
3. *Tupaia glis operosa*
4. *Tupaia glis ultima*
5. *Tupaia glis sinus*

Characteristics of common tree shrew

Morphological characteristics

Size	Male	Female
Body length (mm):	161-240	175-240
Tail length (mm):	145-196	140-190
Weight average (g):	177	159

Color: The dorsal parts are red-dish, olive, shades of brown and gray to almost black

: The ventral part is whitish or buff to dark brown

Cranium: Primate-like, rounder, elongated muzzle and small brain case laterally directed orbits but show a part orbital bar

Brain: More complex than that insectivore, the olfactory center reduced, the visual apparatus enhanced, neocortex expanded

Nose: Elongated shrew-like nose terminating in a naked moist snout

Long whiskers: Absent

Eyes: Relatively large, located in the anterolateral side of head and completely encircled by bone

Ears: Quite human inform

Dental formula: Total teeth are 38

Incisor	Canine	Premolar	Molar
2/3	1/1	3/3	3/3

Limbs:

Forelimb: Highly mobility, bones of the forearm articulate to allow pronation and supination. Thumb can oppose to the other digits but limited extent

Hindlimb: Longer than forelimb, tibia and fibula are joined by ligaments that can not rotate. Ankle joint can perform lateral movement

Digits: Five fully formed digits on each hand and foot, all digits bear claws, not nails and fully opposable

Tail: Long and slender, but well haired, the longer hairs are confined to the dorsal surface but the ventral surface lacking long hairs

Chormosome: Diploid number = 60

Reproductive system:

In female: Mammae: 1-3 pairs. Uterus : Bicornuate

In male: Testis: Scrotal testes. Penis : Pendulous penis

***Tupaia glis* is distinguished from other general of tree shrew by this feature:**

1. The lower lobe of the ear is smaller than the upper part.
2. The naked area on top of the nose is cut squarely across instead of being slightly prolonged backward in the midline.
3. The tail is covered with long hairs.

The main similarities between tree shrew and primates :

Skull: Snout relatively short, enlarged, forward-facing orbits. postorbital bar present, pattern of bones in medial orbital wall, enlarged braincase, advanced form of auditory ossicles

Dentition: Tooth comb present in front of lower jaw

Limbs: Highly mobile, ridged skin on palms and soles. five fully formed digits on each hand and foot, grasping hand characteristic

Brain and sense organ: Olfactory apparatus reduced, visual apparatus enhanced avascular area of macula. neocortex expanded, calcarine sulcus present

Reproductive: Pendulous penis. scrotal testes, discoidal placenta and small number of teat

Miscellaneous: Caecum present

The main similarities between tree shrews and insectivore :

1. All digits bear claws and not nails
2. The vision is not fully stereoscopic
3. The auditory bulla is constituted from the entotympanic bones and not the petrosal or petrosal plus the ectotympanic

Ecology and Behavior

The common tree shrews actually spend much of their time on the ground foraging on the forest floor and generally omnivorous, eating anything they come across, including ants, termites, beetles, fruit, spiders, seeds, bugs and even lizards and small rodents. There is no evidence that they shovel through the forest litter as shrews do.

Tree shrews are nervous and aggressive animals. Males will not tolerate the presence of other males, through there seems to be little fighting between the sexes. They typically form pairs which are strongly territorial and follow the same pathways within their territory. They are very fond of water and bath in water-filled hollows of tree.

There is no indication of a breeding season. Pregnancies have been observed to be associated with the period of low rainfall; June, July and August. Nests are built in hole in fallen trees, hallow bamboo or similar site. The gestation period is approximately 41-50 days. The numbers of young are 1-4 (usually 2). Newborn is pink, hairless and has closed eyes. Pigmentation appears on the fourth day. Hair begins to grow on the fifth day. Teeth begin to appear about the eleventh day and the

eyes open on the twenty-fifth day. At sixth months, they are sexually mature. Longevity is 2-3 years, with the maximum of 5.5 years in captivity.

APPENDIX II

Batson's # 17 Plastic Mixture for Vascular Casting

Plastic Mixture Preparation

Batson's # 17 Monomer base solution*	12.5 ml
Batson's # 17 Catalyst*	3.5 ml
Batson's # 17 Promoter*	0.5 ml
Acron Denture Base**	6.5 ml

Prepared in an ice bath, the solution are mixed thoroughly and used immediately.

*Batson's corosion kit can be obtained from :

Polyscience, Inc.

Paul Valley Industrial Park

Warring, Pa 18976 USA

**Acron Denture Base can be obtained from :

Yoawarach

Bangkok, Thailand

APPENDIX III

Bouin's Solution (Bouin, 1897)

Saturated aqueous picric acid	750 ml
40% Formaldehyde	250 ml
Glacial acetic acid	50 ml

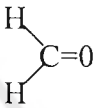
Bouin's solution is not used in histochemistry but preserves morphological features, especially of connective tissue. This fixative is valuable for purely histological work because physical distortion of tissue is minimal. However, intracellular structures other than nuclei are poorly preserved. Specimens are usually fixed in Bouin's solution for 24 hours, but material stored in it for several months is sometimes still useable. Each of Bouin's solution composition is described following:

1.Picric acid {$C_6H_2(NO_2)_3OH$ or 2,4,6-trinitrophenol}

Picic acid is trinitrophenol. It is a much stronger acid than unsubstitited phenol aqueous solution owing to the electron-withdrawing effect of the three-nitro groups on the hydroxyl group:

Trinitrophenol is bright yellow solid. It is dangerously explosive when dry and is therefore stored under water. It is sparingly soluble in water (about 1% at room temperature) but more so in alcohol (nearly 5%) and benzene (10%)

2. Formaldehyde

formaldehyde is a gas (-21°C) with the structural formula 

It is solution in water to containing 37-40% by weight of the gas in water and sold under the name of 40% formaldehyde or formalin. In aqueous solution, formaldehyde is present as methylene hydrate or methylene glycol, the product of the reaction :

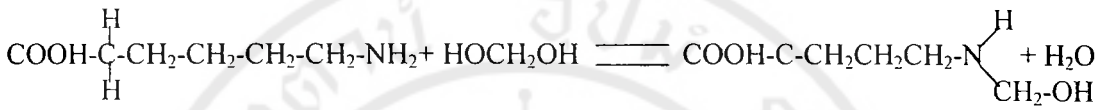
$$H_2C{=}O + H_2O \rightleftharpoons HOCH_2OH$$

Therefore, formalin also contains solution polymers of the form $HO(CH_2O)nH$ (n=2-8), know as lower polyoxymethylene glycol. The polymers are hydrolyzed when formalin is diluted with on excess of water. Thus, trioxymethylene glycol ($HO(CH_2O)3H$) : $HO(CH_2O)_3H + 2H_2O \rightleftharpoons 3HOCH_2OH$. Formalin also contains methanol (commonly about 10% v/v) whieh is added a stabilizer to inhibit the polymerization. Methanol is formed by formaldehyde a hemiacetal (methylal), Which is more stable than methylene hydrate :

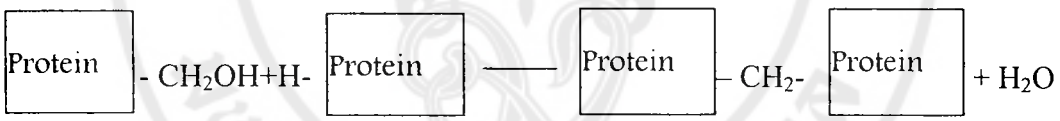
$$H_2C{=}O + CH_3OH \rightleftharpoons CH_2C\begin{matrix}OH\\ \\ OH\text{-}OH_3\end{matrix}$$

The content of formaldehyde in a fixative is best denoted by stating the percentage by weight of the gas rather than the amount of formalin used in preparing the mixture. Thus, 4% formaldehyde is referred to 10% formalin (for the same solution), though the latter designation is in common use.

Formaldehyde reacts with several parts of protein molecules. The methylene glycol molecule added to many functional groups to from hemiacetal and related adducts. For example, with primary amines (N-terminal amino acids and lysine side-chain):



This reaction are all readily reversible by washing in water or alcohol. However, the hemiacetal-like adducts all have freed hydroxymethyl groups and there are capable of further reaction with functional groups of protein :



Thus, different protein molecules can be joined together by methylene bridges, which are chemically stable. Cross-linking of protein molecules by formaldehyde is much slower than the other fixative agents and requires 1-2 weeks for completion at room temperature. For non-histological methods especially for the nervous system, work better after complete fixation very long periods of storage in the formaldehyde solution results in excessive hardening, loss stain ability of nuclei.

Formaldehyde preserves most lipids. The chemical reactions of formaldehyde with lipid under ordinary conditions of fixation are 1). Addition to the amine groups of phosphatidyl ethanolamine which is probably reversible by washing in water 2). Prevention of the histochemical reactivity of plasmologens owing to oxidation, probably to a glycol, of the ethylenic linkage next to the other group.

Formaldehyde dose not react with carbohydrate. All common mucosubstances can be demonstrated after fixation with formaldehyde through appreciable quantities of glycogen are lost. Bouin's solution are preferable to formaldehyde because 1). It protects the tissue against damaging effects of embedding in wax, and 2). Staining with almost of dyes is brighter then after formaldehyde alone. In addition, formalin gives off an unpleasant vapor that causes irritable to the eyes, respiratory epithelium and umpleasant "formalin dermatitis" after immersion of hands in this solution.

3. Glacial acetic acid (CH_3COOH)

Pure acetic acid is called "glacia" because it solidifies at 17°C if water free. It does not fix protein, but it coagulates nucleic acids. The mechanism by which this change is brought about is obscure. Gracial acetic acid is included in fixative mixtures to preserve chromosomes, precipitate the chromatin of interphase nuclei and oppose the shirking actions of other agents such as ethanol and picric acid.

APPENDIX IV

Staining Solusion for Hitological Study

Hematoxylin and Eosin (Carazzi method)

Hematoxylin solution

Hematoxylin (pH 5-7.2)	2 gm
Distilled water	800 ml
Aluminium potassium sulphate	50 gm
Sodium iodate	0.4 gm
Glycerin	200 ml

1) Dissolved the Hematoxylin in 100 ml of distill water

2) Dissolved Aluminium potassium sulphate in 650 ml of distilled water, shake until completely dissolved

3) Add 1 to 2 and add distilled water to make 800 ml and then mixed

4) Add sodium iodate and mixed

5) Add glycerin and mixed

6) Before use, filter

Eosin solution

1% stock alcoholic eosin	
Eosin y. water soluble	1 g
Distill water	20 ml

Ethyl alcohol 95% 80 ml

Dissolved eosin in distilled water, and alcohol

Working eosin solution:

1% stock alcoholic eosin 1 part

ethyl alcohol 85% 2 part

Before used add 0.5 ml of glacial acetic acid to 100 ml of eosin and stir

APPENDIX V

Film Processing for SEM Photograph

Negative Film Processing

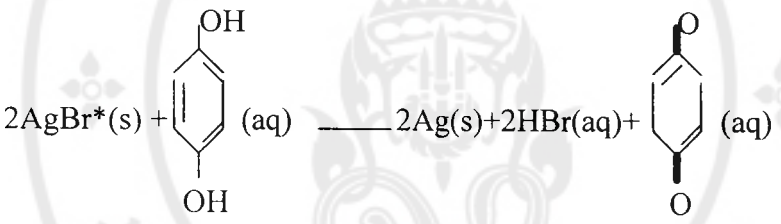
1. Load the exposed film the film holder in the dark room.
2. Wash the film in the cool distilled water (20-21°C) for 1 minute to clear the excessive softening of the emulsion.
3. Develop with Microdol-X (22°C) with continuously stirred for 12.5 minutes to silver metallic under alkaline condition.
4. Wash in the distilled water for 1 minute.
5. Place in stop bath (acetic acid) for 1 minute to stop the reaction of the developer.
6. After washing in the distilled water for 1 minute, the film is immersed in a fixer to convert silver thiosulfate that is water-soluble. This step is under acidic condition which will neutralize excess alkaline developer that preventing film fog.
7. Wash in distilled water before placing in hypoclearing agent for 2 minutes.
8. The well developed film can be visualized under the room light. It is rinsed in the tap water for 10-15 minutes before dipping in the water-repellent fluid (photo flo) for 1-2 minutes to prevent water spots.
9. Finally, the film is dried in the film dryer or left in the opened air.

Note:

1. The process of film development involves a redox reaction. Black and white photographic film contains small grains of silver bromide, evenly over a thin gelatin coating on paper. Exposures of the film to light activates silver bromide as follow:

$$AgBr + Light \longrightarrow AgBr^{*} \text{ (AgBr affected by light)}$$

Next, the exposed film treated with a developer, a solution containing a mild reducing agent such as hydroquinone as follows :



Hydroquinone Quinone

In this redox process, The Ag^{+}ions in the activated AgBr are preferentially reduced to metallic (silver) while hydroquinone is oxidized to quinone. After placing in acetic acid ($HC_2H_3O_2$) to complete reaction with hydroquinone, the unreacted AgBr must be removed from the film by treated with a fixer. The fixer is a solution containing sodium thiosulfate ($Na_2S_2O_3$) to removed the silver ions:

$$AgBr(s) + 2S_2O_3^{2-}(aq) \longrightarrow Ag(S_2O_3)_2^{3-}(aq) + Br^{-}(aq)$$

Enlargement and Printing

The quality of the negative film should be evaluated prior enlarging. To classified the quality according to the contrast are three groups. The low contrast negative film requires high contrast papers (BH papers), while the medium to high

contrast negative film should require the normal to low contrast papers (BN to BS papers). The process of enlargement and printing is done under the safe light as follows:

1. Place the negative film on the negative holder by emulsion down.
2. Turn on the light source of enlarger and open the aperture widely.
3. Adjust the enlarger by either raising up or lowing down for the appropriated size as need. The image is projected on the easel.
4. The sharp grains on the image, seeing with the image focuser, is adjusted by focusing knob.
5. Adjust the easel until the image fills on the paper.
6. Set the appropriate aperture.
7. Turn off the light of the enlarger and set the proper exposure time.
8. Place the photographic paper in the easel, turn on the light of the enlarger and allow exposing it for the desired time.
9. Take the exposed paper and submerged in developer (Dextol:water=1:2).
10. Transfer the developed paper to stop bath for 20 to 30 second minutes.
11. Rinse in running tap water and dip in fixer for fixer for 15 minutes.
12. Wash the photograph in running tap water for 30 minutes to 1 hour.
13. Submerge in a dilute water-repellent agent (Photo flo) for 15 minutes.
14. Dry with the print dryer or air dry and the scanning electron micrograph is now ready for evaluation.

BIOGRAPHY

NAME	Mr. Koumkrit Pisetpaisan
DATE OF BIRTH	27 April 1968
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INSTITUTIONS ATTENDED	Kasetsart University, Bangkok, 1989-1995 : Doctor of Veterinary Medicine Mahidol University, 1998-2000 : Master of Science (Anatomy)
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