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The thyroid and parathyroid glands in the Rhinocerotidae

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(With 13 figures in the text)

As a contribution to rhinoceros splanchnology observations are submitted upon the gross and microscopical anatomy of the rhinoceros thyroid and parathyroid glands, following a particular examination of these organs in examples of the genera *Rhinoceros, Didermocerus, Ceratotherium* and *Diceros*.

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Introduction

From the 16th century—and particularly during the 19th century—rhinoceroses have proved attractive and desirable exhibits in zoological gardens and travelling menageries, and have been shown therein almost continuously. Such exhibits were most commonly examples of the Indian rhinoceros (*Rhinoceros unicornis*) but they included a lesser number of Sumatran rhinoceroses (*Didermocerus sumatrensis*) and a very few Javan rhinoceroses (*Rhinoceros sondaicus*). Their precise number is difficult of assessment but Reynolds (1960) estimated that, by that date, European and United States menageries alone had harboured some 127 animals, viz. 85 Indian, 35 Sumatran and 6–7 Javan rhinoceroses. Hence over the years a not inconsiderable number of (Asian) rhinoceroses had died in captivity, yet despite their popular and zoological appeal comparatively little had been recorded of their internal organization. This may reflect the difficulties inseparable from rhinoceros anatomization—the manipulation of a heavy, unwieldy carcase, the impracticability of its embalming in whole or in part, museum requests for skeletal material, the prior claims of pathology and, too often, procedural haste occasioned by rapid decomposition. It may also reflect (with notable and rare exceptions) a general lack of anatomical interest, contrasting markedly to that bestowed upon the equally bulky, but well-anatomized, elephant.

That any dependable corpus of rhinoceros morphology is at all available stands almost exclusively to the permanent credit of the Zoological Society of London. For from its inception the Society regularly procured every rhinoceros form practicable, promoted the study, description and delineation of its living animals and ensured the maximal utilization of such prosectorial material as became available. Under the aegis of this enlightened policy the Society effected an unrivalled and substantial contribution to zoological science by the research conducted upon its own rhinoceros material and (chiefly) by its own officers.

Such research, the foundation for all subsequent investigation, is epitomized in the classic memoirs of Owen (1852) on *Rhineroceros unicornis*, of Garrod (1877) and Beddard & Treves (1887) on *Rhinoceros sondaicus* and of Garrod (1873, 1878) Forbes (1881) and Beddard & Treves (1889) on *Didermocerus sumatrensis*—memoirs which collectively constitute the recorded splanchnology of the Asian rhinoceroses. (The African rhinoceros genera, *Ceratotherium*, *Diceros*, still await their monographer.) Yet since relatively few specimens of any single rhinoceros species have been thus far anatomized and since systemic completeness cannot be expected from the dissection of any individual specimen, there is both scope and need for further and more detailed enquiry if the Rhinocerotidae are not to become extinct without our more adequate understanding of their morphological constitution. The thyroid and parathyroid glands of this group have not hitherto been the subject of specific investigation and the literature references to their gross and microscopical anatomy are meagre—Owen (1852), Burne (1905), Cave (1953), Cave & Aumonier (1963, 1966). By the way of supplementation, therefore, the present observations upon the morphological constitution of these organs in the Rhinocerotidae are accordingly submitted.

Historical

The earliest authenticated rhinoceros dissection was conducted in the Jardin des Plantes, Paris, in 1793 by Felix Vicq-D'Azyr (assisted by Mertrud and S. Rousseau) upon an adult male Indian rhinoceros which had lived in the Royal Menagerie at Versailles from 1772 to 1793, and whose skeleton is preserved (No. A 7974) in the Musée d'Anatomie Comparée, Paris. Vicq-D'Azyr prepared a manuscript account of the anatomical findings, illustrated by 34 folio plates executed by the celebrated Maréchal and by P. J. and H. J. Redoubté but his death the following year (20 June 1794) left text and plates unpublished and now preserved in the Archives of the Paris Muséum National d'Histoire Naturelle. The plates, listed by Gervais & Gervais (1875), include but one of the tongue, pharynx and larynx and one only of the thoracic organs; they are uninformative concerning thyroid/parathyroid anatomy.

Contemporary publication would have rendered Vicq-D'Azyr's account the first authoritative memoir on rhinoceros anatomy in general and that of *Rhinoceros unicornis* in particular.

The earliest British publication of rhinoceros anatomy was the "anatomical description" of Leigh Thomas (1801) of a three years old male Indian specimen. This, though technically anatomical, is relatively valueless and little more than a cursory notice of the more obtrusive features of the abdomino-thoracic viscera, a detailed autopsy report rather than an informative morphological study. It ignores the thyroid gland.

The credit for providing the first acceptable published account of rhinoceros splanchnology goes therefore to Richard Owen (1852) whose classic memoir (Owen, 1852) remains the standard of comparison for subsequent enquiry in this field. Owen utilized the carcase of an adult male Indian rhinoceros and the reproductive organs of a female animal. The male specimen was the first rhinoceros to be acquired (1834) by the Zoological Society of London, in whose menagerie it lived until November 1849. Its image appears on the reverse of the Society's medal (1837) in the mammal group of Thomas Landseer" design and its skeleton is preserved (No. 51.11.10.2 (722 g)) in the British Museum (Natural History). The reproductive organs, from a travelling menagerie animal, were specimens

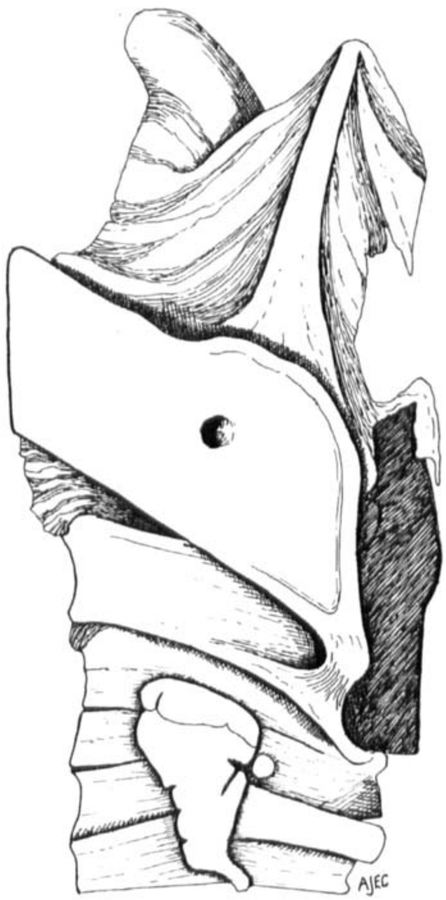


FIG. 1. *Rhinoceros unicornis* (L 333.1). Preserved larynx, with attached thyroid sinistral lobe and parathyroid gland.

in the Royal College of Surgeons Museum, whereof Owen was then Conservator. The whole material was investigated during the 1849–50 winter, and the resultant paper was communicated to the Society 12 February 1850. Published 2 March 1852, this paper appears as Article III of Part 2 Vol. 4 of the Society's *Transactions*, and the complete volume being published between 1851 and 1862, the title page reads 1862 and Owen's memoir is generally assigned in the literature to this later, but misleading date.

Though comprehensive, this Owen memoir necessarily omitted consideration of certain anatomical fields (e.g. the musculature, vasculature, peripheral nervous system). Apart, however, from its pioneer contribution to rhinoceros morphology it is historically notable as contributing to general zoological science. For it includes Owen's discovery of the mammalian parathyroid glands (Fig. 1).

The credit for such discovery is commonly but erroneously attributed to Ivar Victor Sandström (1880) who had noted the parathyroids in man and other mammals, but had given them no distinctive name, had not appreciated their true physiological significance and had regarded them as undeveloped (embryonic) portions of the thyroid gland. Such an interpretation of parathyroid tissue was maintained throughout the 19th century (e.g. by Baber (1881), Horsley (1885), Gley (1891)) and even into the 20th century (e.g. by Forsyth (1908)). The separate anatomico-physiological nature of the parathyroid glands was not proclaimed until 1895 (Köhn, 1895; Welsh, 1898) and only in 1896 was the now canonical name "parathyroid" introduced by Vassale & Generali (1896). That Owen neither named nor recognized the true nature of the glands detected in his rhinoceros specimen in 1850 nowise, therefore, invalidates his claim to priority in the discovery of the mammalian parathyroid. Moreover Owen fully appreciated the anatomical novelty of his discovery, made special reference to it later (Owen, 1868), and in the interim carefully preserved the specimen itself in the Royal College of Surgeons Museum (Physiol. Ser. No. L333.1: Old Cat. 772P). That Owen's "small compact yellow glandular body, attached to the thyroid at the point where the veins emerge" was indeed the parathyroid gland was confirmed by subsequent anatomical and histological examination of comparable structures in additional Indian rhinoceros specimens (Cave, 1953). The right parathyroid's absence from Owen's preserved spirit specimen suggests this to have been the gland originally discovered. Possibly its accidental section during dissection revealed its distinctive interior colour and consistency, which differ so markedly from those of adjacent thyroid or lymph node tissue. Had the parathyroids concerned been topographically intra-thyroidal they might understandably have escaped detection.

TABLE I

Rhinoceros specimens examined. The first three numbers in the reference column are those of spirit preparations in the Physiological Series, Royal College of Surgeons Museum: the remainder are private reference numbers

No.	Species	Sex	Age (years)	Name	Ref. no.	Source	Date
1	Indian	♂	20	—	L 333.1	Zool. Soc. Lond.	1849
2	Indian	♂	40+	Jim	L 332.1	Zool. Soc. Lond.	1904
3	Indian	♂	20	—	L 331.1	Zool. Soc. Lond.	1932
4	Indian	♂	20	Felix	R 41	Zool. Soc. Lond.	1941
5	Indian	♂	15	Hush	R 45	Zool. Soc. Lond.	1945
6	Indian	♂	18	Mohan	R 21	Zool. Soc. Lond.	1964
7	Indian	♂	15	Manik	R 75	Zool. Soc. Lond.	1975
8	Sumatran	♀	12	—	R 62	Basel Zool. Garten	1962
9	Sumatran	♀	13+	Subur	R 72	Copenhagen Zoo	1972
10	White	♀	11	Bebe	R 162	Zool. Soc. Lond.	1964
11	White	♂	3	—	R 20	Zool. Soc. Lond.	1964
12	Black	♀	2	—	R 19	Zool. Soc. Lond.	1960

Material and methods

The material studied (Table I) comprised both museum spirit preparations and organs procured fresh at autopsy: it represents a series of 12 animals, mostly adults, viz. 7 Indian, 2 Sumatran, 2 African White, 1 African Black rhinoceroses.

Sumatran rhinoceros material from Basel was made available by courtesy of Dr L. Forcart, Curator of the Department of Zoology, Basel Naturhistorisches Museum and was accompanied by paraffin blocks of tissues of the animal secured at autopsy by Dr S. Lindt, of the Veterinar-pathologisches Institut of the University of Berne. (Dr Lindt later provided histological preparations of various Indian rhinoceros organs from an animal not included in this present survey.)

Sumatran rhinoceros material from Copenhagen was generously loaned by Prof K. G. Wingstrand, of the Institute of Comparative Anatomy, University of Copenhagen.

All other (Indian, African) rhinoceros material, including that preserved in the Royal College of Surgeons Museum, came from the menagerie of the Zoological Society of London.

Fresh material was generally formalin preserved until its later dissection, this being supplemented, where desirable or practicable, by the histological examination of particular tissues or structures.

Observations

*On the Indian rhinoceros (**Rhinoceros unicornis**)*

(The sole literature references to thyroid gross anatomy in the Indian rhinoceros are those of Owen (1852) and Cave (1953), neither descriptively complete.)

Specimen 1. (L 333.1). Male. c. 18 years. Zool. Soc. Lond. 1849

The first rhinoceros to be at all adequately anatomized (by Owen, 1849–50) and in which the mammalian parathyroid gland was first observed. Of the thyroid apparatus Owen (1852) gave but a brief, unillustrated account, omitting mensural, vascular and other particulars. The thyroid gland comprised "two elongate subtriangular lobes extending from the sides of the larynx to the 4th tracheal ring", narrowing caudally and there united by a thin narrow oblique isthmus. The lobulation of the parenchyma was specially noted. Bilaterally "a small compact yellow glandular body was attached to the thyroid at the point where the veins emerge". This was the parathyroid gland, of which nothing further was recorded. Its anatomical novelty and its glandular nature were recognized by Owen's special preservation of it as a spirit specimen in the Royal College of Surgeons Museum (Physiological Series, L 333.1: Old Catalogue 772P).

This specimen, still extant, shows the now colourless and somewhat folded thyroid left lobe and attached parathyroid: the isthmus and bloodvessels have been removed. The lobe is some 75 mm long × 50 mm in maximal (cranial) width, with a lobulated and fissured surface and a deeply crenated dorsal border. Close to the cranial end of this border lies the spheroidal parathyroid gland, some 11 mm in diameter (Fig. 1).

Specimen 2. (L 332.1). Male ("Jim"). 40+ years. Zool. Soc. Lond. 1904

This specimen (now lost from enemy action) was a spirit preparation in the Royal College of Surgeons Museum (Physiological Series, L 332.1) particularly examined in 1940. It comprised the thyroid left lobe and attached parathyroid gland and showed the cut ends of bloodvessels protruding from the parenchyma. The lobe was of rounded triangular outline, showed blunt cranial and caudal poles and was joined to its fellow by a thin, flat, horizontal caudal isthmus. Attached to, or nestling within, the cranial end of its convex dorsal border was a spheroidal parathyroid gland, some 10–12 mm in diameter (Fig. 2). This same border was pierced by a smaller cranial and a larger caudal artery, each accompanied by venae comitantes. Whether these arteries represent branches of a common stem or the canonical superior and inferior arteries of description is somewhat uncertain, although the latter interpretation appears the more probable.

Histological examination of the contralateral parathyroid (Burne, 1905) revealed its parenchymal cells to be mostly arranged in clusters surrounding a narrow lumen (Welsh's type 4 parathyroid) but a minority of cell clusters to lack any lumen (Welsh's type 3 parathyroid).

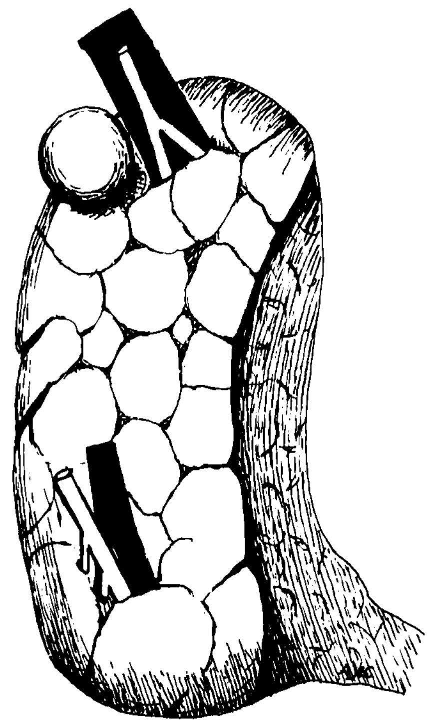
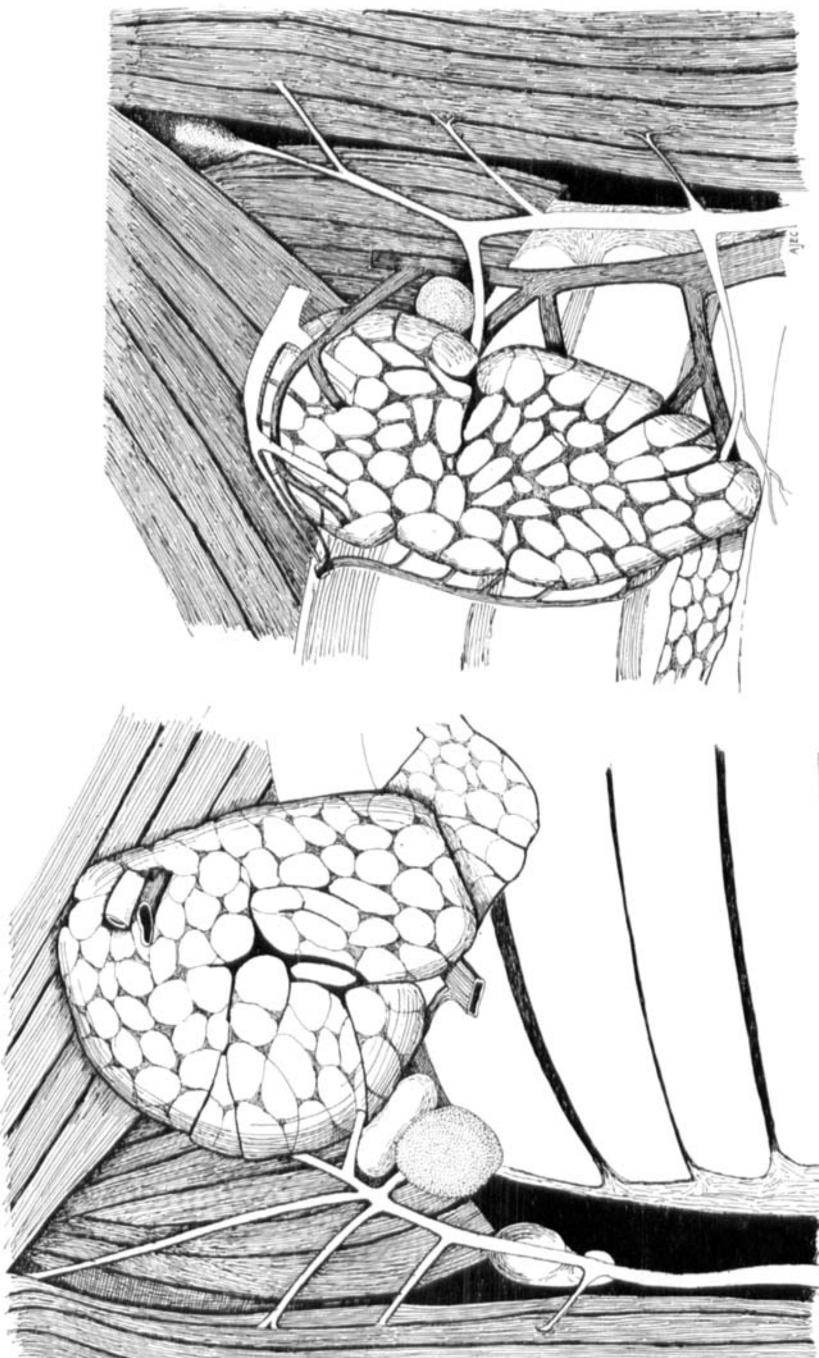


FIG. 2. *Rhinoceros unicornis* (L 332.1). Dorsal aspect of thyroid dextral lobe, with arteries (white), veins (black) and epithyroidal parathyroid gland.

Specimen 3. (L 331.1). Male. 20 years. Zool. Soc. Lond. 1932

A spirit specimen in the Royal College of Surgeons Museum (Physiological Series, L 331.1) preserves the caudal moiety of the larynx and adnexa of this animal. The preparation illustrates the prosectorial artistry of the former Physiological Curator of the Museum, the late Mr R. H. Burne.

The thyroid lobes, extending from the cricoid cranial rim to the fourth tracheal ring, are of asymmetrical configuration and disposition—the left being of cranio-caudal pyriform shape with typical cranial and caudal poles, the right being transversely elongate (50 mm long × 60 mm broad), more convex externally and having broader, blunter poles.



(a) (b)

FIG. 3. *Rhinoceros unicornis* (L 331.1). Sketches of preserved specimen showing (a) dextral, (b) sinistral thyroid lobes with arteries (white), veins (line shaded), lymph nodes and parathyroid gland (stippled).

The parenchyma of both lobes is uniformly and prominently lobulated and that of the right is deeply fissured. The lobar caudal extremities are connected by a thin, 10 mm broad, horizontal isthmus (Fig. 3).

Each thyroid lobe is supplied by a superior and an inferior thyroid artery from the common carotid. Bilaterally the superior artery is the larger vessel, of the calibre commonly observable in rhinoceroses, and pursues a direct, relatively short course to the gland. By contrast, the inferior thyroid artery is a long, slender vessel, arising low from the carotid and ascending behind the thyroid gland to be distributed less thereto than to neighbouring organs (oesophagus, pharynx, larynx, lymph nodes).

On the right the superior thyroid artery terminates within the thyroid cranial region without, apparently, supplying interim branches thereto: the inferior thyroid artery ascends dorsal to the gland, gives two branches to the caudal pole, another to the parathyroid gland and a series of branches and twigs to the pharynx, oesophagus and trachea.

On the left the superior thyroid artery pursues a curvilinear course over the thyroid cranial pole, giving two terminal branches thereto and a branch which disappears through the crico-tracheal membrane.

The right thyroid veins have been removed. On the left a canonical superior thyroid vein accompanies the corresponding artery, descends behind the cranial pole and enters the jugular vein. A more voluminous inferior thyroid vein also enters the jugular: it is formed by the union of two large veins from the mid-lobar region whose common stem is joined by that formed by the union of two smaller veins from the caudal pole.

A curious, inexplicable, vein ascends the ventral border of the thyroid left lobe to disappear through the crico-tracheal membrane.

Two (dextral and sinistral) undoubted parathyroid glands are present. Each is an encapsulated, flattened spheroidal body, some 12 mm in diameter, with a mammillated external surface and a yellow, spongy interior. Each is related to the homolateral thyroid dorsal border, the right gland immediately behind the caudal pole, the left gland adherent to that border half way along its length. The parathyroid nature of these two bodies is confirmed by microscopical examination, which reveals masses of cells divided into lobules by a connective tissue framework. Caudad of the right parathyroid gland lies a rounded body of very similar gross appearance, which histological examination shows to be largely composed of adenoid tissue. Each parathyroid gland is supplied by the inferior thyroid artery—the right by a direct, substantial branch, the left by fine twigs from that vessel's thyroid branch. No parathyroid veins remain in the preparation.

Specimen 4. (R 41). Male ("Felix"). 20 years. Zool. Soc. Lond. 1941

The thyroid lobes, asymmetrically shaped, overlie the cricoid cartilage and first four tracheal rings. The right lobe, broad and notably convex, has a narrow cranial and a wide caudal pole: the flatter, more elongate left lobe shows a broadish cranial and a narrow, acuminate caudal pole: the caudal poles are united by a thin, fairly broad (13 mm) and horizontal isthmus (Fig. 4). Each lobe is markedly lobulated, moderately fissured and dorsally crenated: an ill-defined "hilum" marks each mid-lobar region.

The common carotid provides superior and inferior thyroid branches to each lobe. The superior thyroid artery gives three terminal branches to the cranial region of the appropriate lobe. The right inferior thyroid artery provides a fine branch to the parathyroid gland and thereafter trifurcates into terminal branches to the thyroid caudal region. The left inferior thyroid artery gives a slender penultimate branch to the left lobe dorsal border, itself enters the lobe "hilum" in superficial relation to the left parathyroid gland and therein subdivides (Fig. 4).

The thyroid veins drain into the jugular vein. The numerous veins of the right lobe form recognisable superior, middle and inferior thyroid veins which join laryngeal and other local veins to form a common venous tributary of the jugular vein. From the left lobe (double) superior middle and inferior thyroid veins emerge to form with adjacent veins a "common" inferior thyroid tributary of the jugular.

The two parathyroid glands are independent, encapsulated bodies associated with the thyroid dorsal border. Each is a yellowish flattened spheroid some 12 mm in diameter: the external surface (cleared of fascia) is finely granular or mammillated, the sectioned

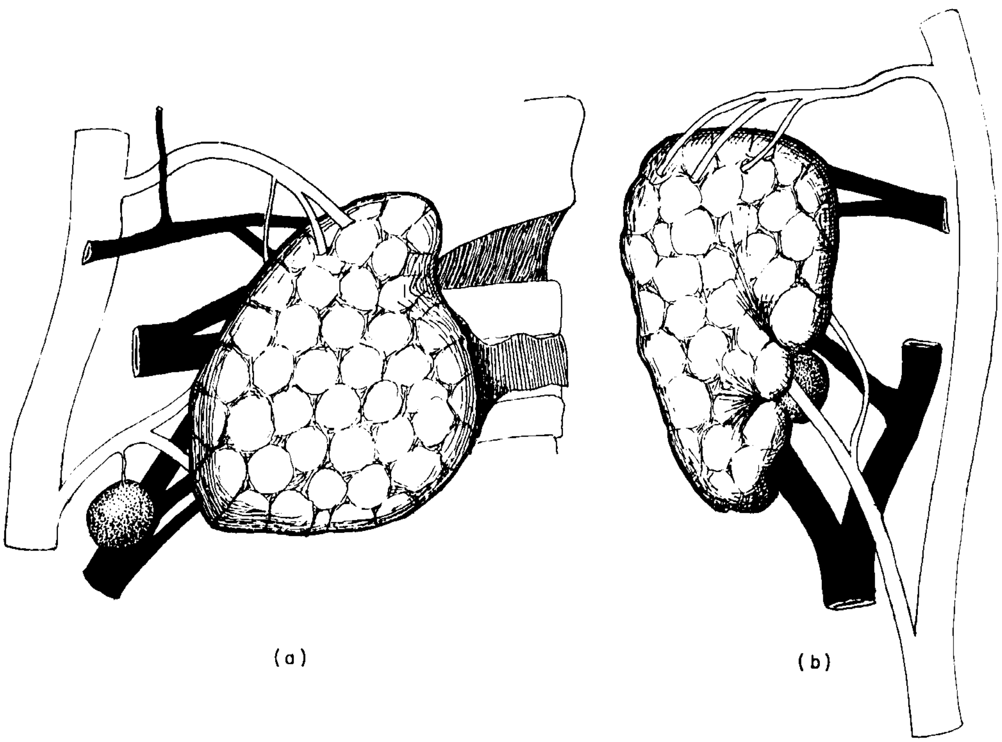


FIG. 4. *Rhinoceros unicornis* (R 41). Showing (a) dextral, (b) sinistral thyroid lobes with arteries (white), veins (black) and parathyroid gland (stippled).

interior shows a finely lobulated, gamboge yellow, spongy parenchyma. The right parathyroid lies vein-entangled in the thyroid sheath behind the thyroid caudal pole: the left parathyroid is epithyroid in position, being partly embedded within the "hilum", immediately deep to the inferior thyroid artery. The right gland receives a substantial twig from the homolateral inferior thyroid artery, the left gland receives numerous very fine twigs from the corresponding artery. The fine parathyroid veins drain into the inferior thyroid venous system.

Specimen 5. (*R 45*). *Male* (*"Hush"*). *15 years. Zool. Soc. Lond. 1945*

This specimen is remarkable for (a) the intrathyroidal position of the parathyroid glands (b) the extra-glandular anastomosis of superior and inferior thyroid arteries. Details are recorded of the vasculature of the thyroid right lobe only.

The thyroid gland comprises two symmetrical lobes of elongate inverted pyriform shape, covering laterally the cricoid cartilage and attached musculature and the first four tracheal rings. Each lobe is demarcated into cranial and caudal moieties by a constricted middle region, whose deep surface reveals a vague, depressed "hilum": each cranial pole is blunt

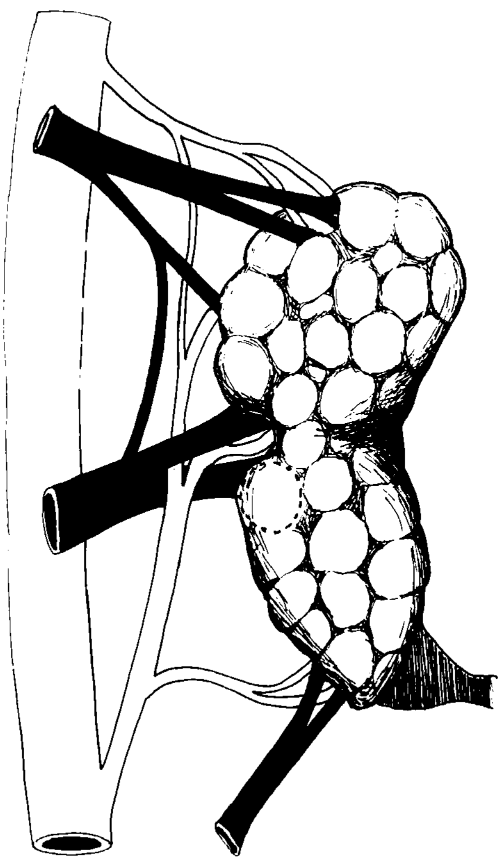


FIG. 5. *Rhinoceros unicornis* (R 45). Thyroid dextral lobe with intra-thyroidal parathyroid gland (broken outline), arteries (white) and veins (black). Anastomoses between superior and inferior thyroid arteries and between superior and middle thyroid veins.

and broad, each caudal pole is sharp and narrow (Fig. 5). The thyroid parenchyma is uniformly and markedly lobulated, is moderately fissured and is somewhat crenated dorsally: the caudal poles are connected by a thin, horizontal 7 mm broad isthmus across the fourth tracheal ring.

Two arteries from the common carotid—superior and inferior thyroid arteries—supply the thyroid dextral lobe: these vessels are unusual in manifesting a mutual extra-thyroidal anastomosis (Fig. 5). The superior thyroid artery arches ventrally towards the cranial pole, and trifurcates into (a) a slender descending anastomotic branch (b) two terminal branches into the gland pole. The homolateral inferior thyroid artery is the dominant artery of supply: it ascends from the carotid and gives off (a) a dividing branch to the caudal pole, (b) a direct "hilar" branch, (c) a much smaller branch to the thyroid cranial moiety, (d) a finer anastomotic branch to the corresponding branch of the superior thyroid artery.

Veins of fair size emerge from the lobar dorsal aspect—from the gland cranial moiety, from the "hilum", and from the lobar caudal moiety: these vessels unite to constitute recognizable superior and middle thyroid veins: an independent inferior thyroid vein emerges from the caudal pole. All these vessels drain ultimately into the jugular vein.

The right and left parathyroid glands are intrathyroidal: each is wholly embedded within the thyroid caudal moiety, close to its dorsal border and immediately below the "hilum". Some 10–12 mm diameter, each rounded parathyroid is encapsulated, presents a finely granular (mammillated) exterior after capsule removal and on section reveals a bright yellow, finely lobulated and typically spongy parenchyma.

The parathyroid blood supply is not recorded: inferentially it derived from the inferior thyroid arteries. The parathyroid venules entered the thyroid veins before these emerged from the gland substance.

Specimen 6. (R 21). Male ("Mohan"). 18 years. Zool. Soc. Lond. 1964

The two lateral lobes of the thyroid gland connect by a caudal isthmus. Each lobe (75 mm long × 45 mm maximal breadth × 22 mm maximal thickness) is of somewhat irregular reniform shape, being reflected upon itself by a deep ventral fissure separating its more massive cranial from its caudal portion. Other fissures further partially subdivide the lobes, producing imbricating lappets of thyroid tissue: the lobar ventral borders are thin and crenated, the dorsal thick and rounded. The blunt thyroid cranial pole overlies the cricoid ring and its attached musculature, the flattened caudal pole overlies the third tracheal ring; this latter pole is ventrally prolonged into a thin horizontal isthmus, 9 mm broad, occupying the 3/4 tracheal ring interspace (Fig. 6).

The dull brown colour of the thyroid parenchyma appears slaty-grey through the translucent collagen gland capsule, and the gland tissue is finely lobulated by septa therefrom. Around the thyroid gland the cervical fascia forms a typically dense sheath: the thyroid perivascular fascia is thickened ligamentously.

The thyroid arterial supply, arising directly from the common carotid, differs bilaterally. Dextrally, a single thyroid artery, from the carotid's ventral aspect, curves caudally towards the thyroid cranial pole, supplies branches thereto and then follows the lobe's dorsal border. It supplies muscular, inferior laryngeal, glandular, tracheal, oesophageal and parathyroid branches (Fig. 6). A very slender artery (? a. thyroidea inferior propria), arising far caudally from the common carotid, fails to attain the thyroid lobe and is expended upon the oesophagus and trachea. Sinistrally two definitive thyroid arteries (a larger cranial and a lesser caudal) arise separately from the common carotid. The cranial vessel (a. thyroidea superior) proceeds directly to the thyroid cranial pole and divides close thereto into glandular branches: the more slender caudal vessel (a. thyroidea inferior) ascends from its low carotid origin towards the thyroid caudal pole, supplying oesophageal, pharyngeal and tracheal twigs, a special parathyroid branch and two terminal (thyroid) branches (Fig. 6). Extraglandular anastomosis is not observable on either lobe. The

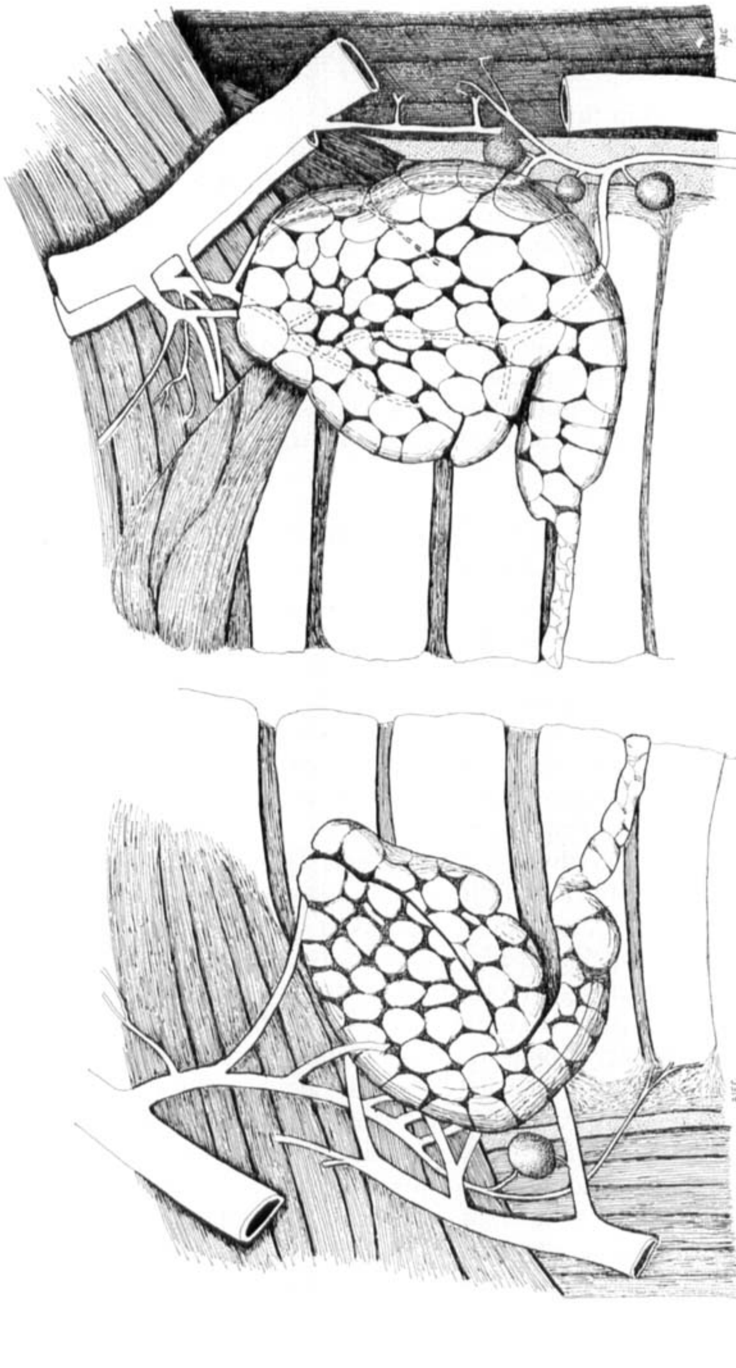


FIG. 6. *Rhinoceros unicornis* (R 21). Showing (a) thyroid dextral lobe with single parathyroid gland and single artery, (b) thyroid sinistral lobe with supernumerary parathyroids and dual arterial supply. Intra-thyroidal arterial anastomoses indicated in broken outline.

thyroid venous return into the jugular vein is, dextrally, by a single terminal "common" thyroid vein, receiving pharyngeal, inferior laryngeal, tracheal, oesophageal, thyroid and parathyroid tributaries, sinistrally by distinct superior and inferior thyroid veins.

Histologically the thyroid tissue presents a typically mammalian picture. Its relatively small vesicles are cubical-epithelium lined, and filled with a homogeneous colloid material; intervesicular blood vessels abound, supported by a minimum of connective tissue provided by the septa from the capsule.

The parathyroid glands, associated with the caudal moieties of the thyroid lobes, are numerically exceptional. Dextrally a single parathyroid gland lies in fat against the trachea within a tangle of blood vessels immediately caudad of the thyroid caudal pole. This pea-shaped, encapsulated organ, of 11 mm diameter, receives a dissectable and exclusive branch from the thyroid artery and sends a relatively large single vein into the most caudal vein draining the thyroid lobe (Fig. 6). Externally it is brownish yellow, internally its spongy parenchyma is bright yellow.

Sinistrally, three separate parathyroid glands are present—two against the dorsal border of the thyroid caudal pole, the third more caudally situate alongside the inferior thyroid blood vessels. These three bodies are individually smaller than their contralateral single counterpart, but of identical shape, colour and consistency: histological examination confirms their true parathyroid nature. The more cranially situate two of the three sinistral parathyroid bodies—some 4 to 5 mm only in individual diameter—may well represent a single but divided parathyroid gland, in which case two parathyroids only—one cranial and juxta-thyroid, the other topographically infra-thyroid—are present sinistrally (Fig. 6).

Each of the four parathyroids of this specimen is an encapsulated, highly vascular, imperfectly lobulated organ. The thin fibrous capsule sends septa into the parenchyma, many such carrying numerous, relatively large blood vessels. The parathyroid lobules are composed of cells of fairly uniform shape and size, disposed as solid clusters surrounded by extremely fine areolar tissue. Only sporadically do these cell clusters display an apparent lumen. In their surrounding delicate areolar tissue, as in the interlobular septa, elastin is present. The clusters are surrounded by sinusoids rather than by true capillaries. In some of the sections examined oxyphil cells are recognizable but tissue preservation is not good enough to allow reliable identification of cell types. Present histological findings agree essentially with those of Burne (1905).

Specimen 7. (R 75). Male ("Manik"). 15 years. Zool. Soc. Lond. 1975

The thyroid gland comprises two juxta-tracheal lobes united cranially by an isthmus. Each lobe has a triangular outline, presenting cranial, dorsal and ventral borders, convex superficial and concave deep surfaces, blunt cranial and caudal poles and a uniform parenchymal lobulation; each is also considerably fissured, the resulting lappets of gland tissue overlying adjacent districts of its substance. The right lobe (67 mm long × 55 mm broad × 25 mm maximal thickness) overlies the cricoid ring and first two tracheal rings: the left lobe (58 mm long × 55 mm broad × 25 mm maximal thickness) overlies additionally the third tracheal ring. The caudo-ventral portion of each lobe, demarcated from its main mass by a 27 mm long cleft, ascends cranialwards to meet its fellow and so form the isthmus, 35 mm long and (in the midline) 6 mm broad × 2 mm thick.

The thyroid gland tissue is tightly enclosed in a thin, strong, whitish collagenous capsule which renders the dull brown coloured parenchyma slaty-blue on initial inspection.

The even lobulation of the parenchyma is produced by the multiple septa penetrating from the capsule. A dense, strong perithyroid sheath surrounds the thyroid vascular pedicles. The pretracheal fascia (some 5 mm thick) shows a deeper fibrous, and a superficial fatty-areolar layer and supports numerous lymphatic vessels descending from the thyroid lobes and elsewhere.

The left thyroid arteries are wanting, following autopsy. Dextrally, canonical superior (cranial) and inferior (caudal) thyroid arteries proceed from the common carotid artery towards the respective thyroid poles. The superior artery has two (terminal) branches—a more slender caudal branch directly into the gland and a stouter cranial branch giving off muscular, intralaryngeal, and crico-tracheal branches before entering the gland dorsum (Fig. 7). The homolateral inferior artery, a large, ascending vessel, divides caudad of the thyroid caudal pole into inferior laryngeal and thyroid branches, both of good calibre. The first of these disappears underneath the cricoid lamina, the second enters the lobe dorsum without providing any recognizably distinct twig to the parathyroid gland. No extra-glandular anastomosis occurs between these superior and inferior thyroid arteries. (Of the absent sinistral thyroid arteries a pharyngeal branch and various muscular branches alone remain—derived presumably from a canonical superior thyroid artery.)

The pattern of thyroid venous drainage differs on the two sides, two definitive thyroid veins (superior, inferior) being present dextrally, a single terminal thyroid vein sinistrally.

On the right the superior thyroid vein receives three independent tributaries from the thyroid gland, as well as muscular, crico-tracheal and laryngeal tributaries (Fig. 7). The inferior thyroid vein begins as two caudal polar veins, a triradicular caudal vein (whose middle radix is a distinct, relatively large parathyroid vein), and a more cranially situate vein. These unite and thereafter receive a large descending pharyngeal vein, an inferior laryngeal vein (from under the inferior constrictor's lower border), plus oesophageal and muscular veins. The resultant "common" inferior thyroid vein pursues a long oblique trans-tracheal course to the jugular vein.

On the left, a voluminous descending pharyngeal vein and a large inferior laryngeal vein unite into a common trunk which duly receives two very large veins from the mid-region of the thyroid lobe (Fig. 7).

Recognizable, often dissectable, lymphatic vessels emerge in leashes from the thyroid cranial and caudal poles (from the latter especially). The cranial polar leash accompanies the superior thyroid blood vessels to lymph nodes situated relatively high in the carotid (deep cervical) chain. The caudal, more diffuse, lymphatic leash passes first to small epitracheal nodes and thence either to the nodes lower down in the carotid chain or directly into the cervical (jugular) lymph duct.

A single parathyroid gland is present bilaterally, associated with the caudal moiety of the relevant thyroid lobe. The ovo-spherical right organ (13×11 mm diameter) occupies the superficial aspect of the lobar caudal pole, the spherical left organ (12 mm diameter) the dorsal border of the corresponding pole (Fig. 7). Each parathyroid consists of an encapsulated yellow, spongy parenchyma, rendered golden brown through an intrinsic fibrous capsule. No recognizably distinct parathyroid artery is discoverable to either gland. A relatively large parathyroid vein drains each gland into the inferior thyroid venous system and parathyroid lymphatic vessels join the caudal polar lymphatics of the thyroid gland.

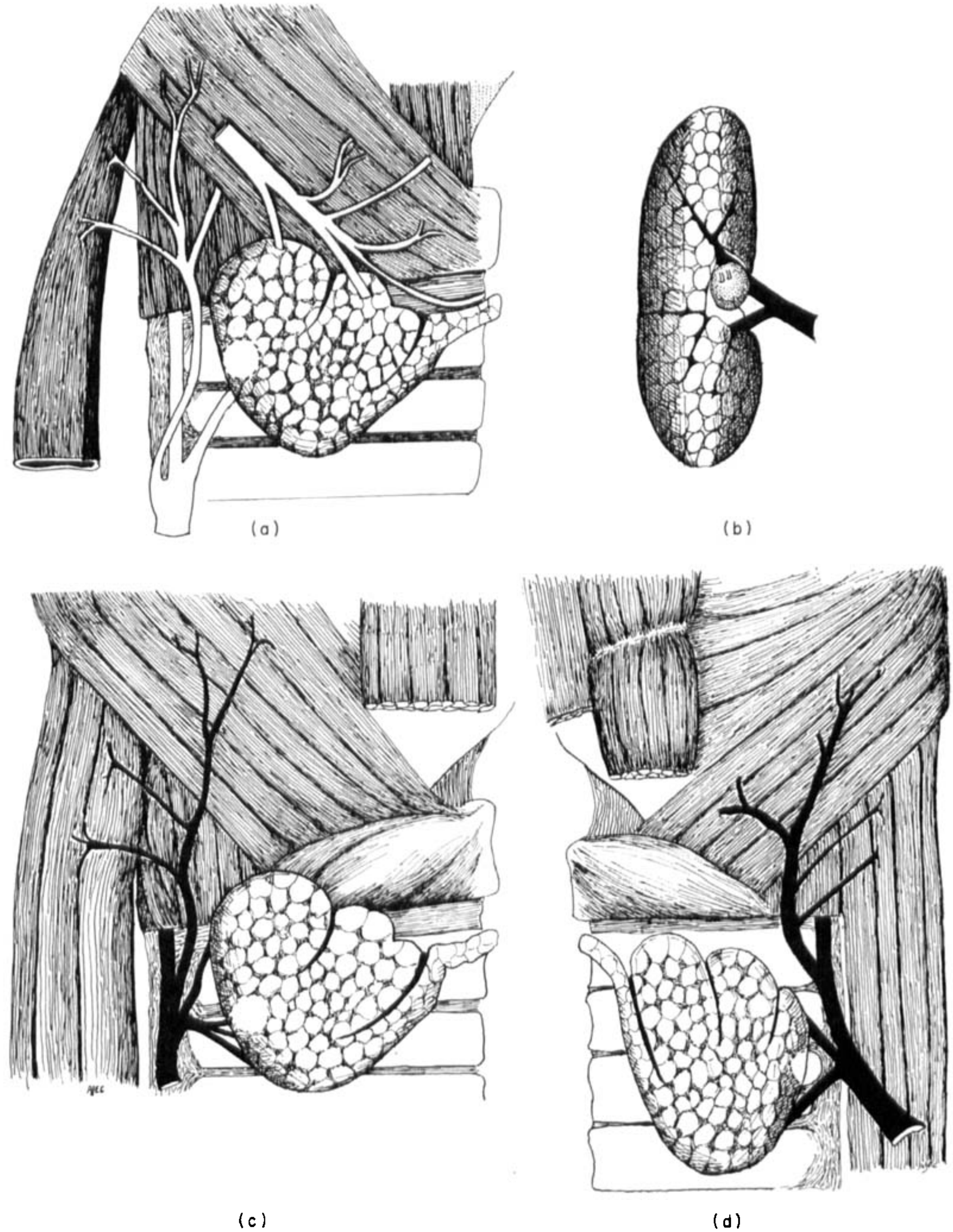


FIG. 7. *Rhinoceros unicornis* (R 75). Showing (a) thyroid dextral lobe arteries. (b) dorsal aspect of thyroid sinistral lobe with parathyroid gland (stippled) *in situ*, (c) veins of larynx, pharynx and thyroid dextral lobe and intrathyroidal parathyroid gland (white) and (d) common thyroid vein draining larynx, pharynx, oesophagus and thyroid sinistral lobe and partly embedded parathyroid gland (white).

*On the Javan rhinoceros (**Rhinoceros sondaicus**)*

The sole memoirs on the splanchnology of the Javan rhinoceros are those of Garrod (1873) and Beddard & Treves (1887). Garrod anatomized the flayed carcase of a young female animal from Jamrach's menagerie: Beddard & Treves that of a young male animal from the menagerie of the Zoological Society of London (March 1874–January 1875), the first example of this species to be acquired by the Society. Both memoirs concentrate upon the abdominal and reproductive organs and neither makes reference to the thyroid gland or even to the larynx.

Nothing therefore is recorded concerning the thyroid/parathyroid morphology of the Javan rhinoceros and this deficiency in knowledge is unlikely to be remedied. Relevant wet specimens are wanting in the likeliest museums, no Javan rhinoceros is presently (1975) in captivity and the wild population (currently estimated at some 40 animals in the Udjong Kulan Reserve, Western Java, and a possible 25 animals in the Leuser Reserve, Northern Sumatra) is, despite protection, drifting persistently towards extinction.

*On the Sumatran rhinoceros (**Didermocerus (Ceratorhinus) sumatrensis**)*

(The recorded splanchnology of the Sumatran rhinoceros includes brief accounts of the penis (Bell, 1793) brain (Garrod, 1878) male generative organs (Forbes, 1881) and thoraco-abdominal viscera (Garrod, 1873; Beddard & Treves, 1889; Cave & Aumonier, 1963). Excluding reference to its histology (Cave & Aumonier, 1963) the thyroid gland is unmentioned in this literature.)

Specimen 1. (R 62). Female 13–15 years. Basel Zoologischer Gärten. 1961

The thyroid gland comprises two somewhat reniform lateral lobes, unconnected by any isthmus. Each lobe overlies the dorso-lateral aspect of the first four tracheal rings, wholly ventral to the oesophagus. The right, much fissured, and caudally folded, measures 69 mm cranio-caudally, and varies in width from 32 mm cranially, to 26 mm at its "waist", to 43 mm caudally. It is thin (5 mm) and flat, with a peripheral border sharp everywhere save dorsally, where, thicker and considerably crenated, it gives attachment to its vasculature. The dark, purply-brown thyroid parenchyma is tightly enclosed in a thin, tough collagenous capsule, whence septa penetrate and finely lobulate its substance. No pseudohilum is detectable. The whole gland is thickly ensheathed by condensed cervical fascia, supporting the thyroid blood vessels, lymph nodes and the parathyroid glands. A superior and an inferior thyroid artery (presumably from the wanting common carotid artery) enter the dorsal border of the lobe, the former vessel dividing beforehand; emergent veins resolve into single superior and middle thyroid veins and a duplicated inferior thyroid vein, all tributaries of the jugular vein. Tiny parathyroid veins enter the inferior thyroid vein (Fig. 8).

Histologically the thyroid parenchyma displays an impressive vascularity. Its component vesicles are remarkably small (i.e. considerably smaller than those of *Homo*) and are separated by an abundant intervesicular connective tissue. The colloid content of some vesicles appears as closely-packed rounded droplets, that of others as an eosinophilic homogeneous substance.

The right parathyroid gland alone is identifiable, though presumably it had a contralateral fellow. Ovoid in shape (12×4 mm), it adheres to the dorsal border of the homolateral thyroid lobe. It receives a recognisable twig from the inferior thyroid artery and sends its venules into the inferior thyroid veins (Fig. 8). Its microscopical structure has been described elsewhere (Cave & Aumonier, 1966). An enclosing fibrous capsule sends interiorly septa containing blood vessels. The yellowish-beige parenchyma, best preserved subcapsularly, shows the chief cells to be somewhat diffusely arranged with a tendency towards cluster-, rather than cord-formation. Lipid material in the surface cells (lost during preparation) may have given these a somewhat orange colour. The central portion

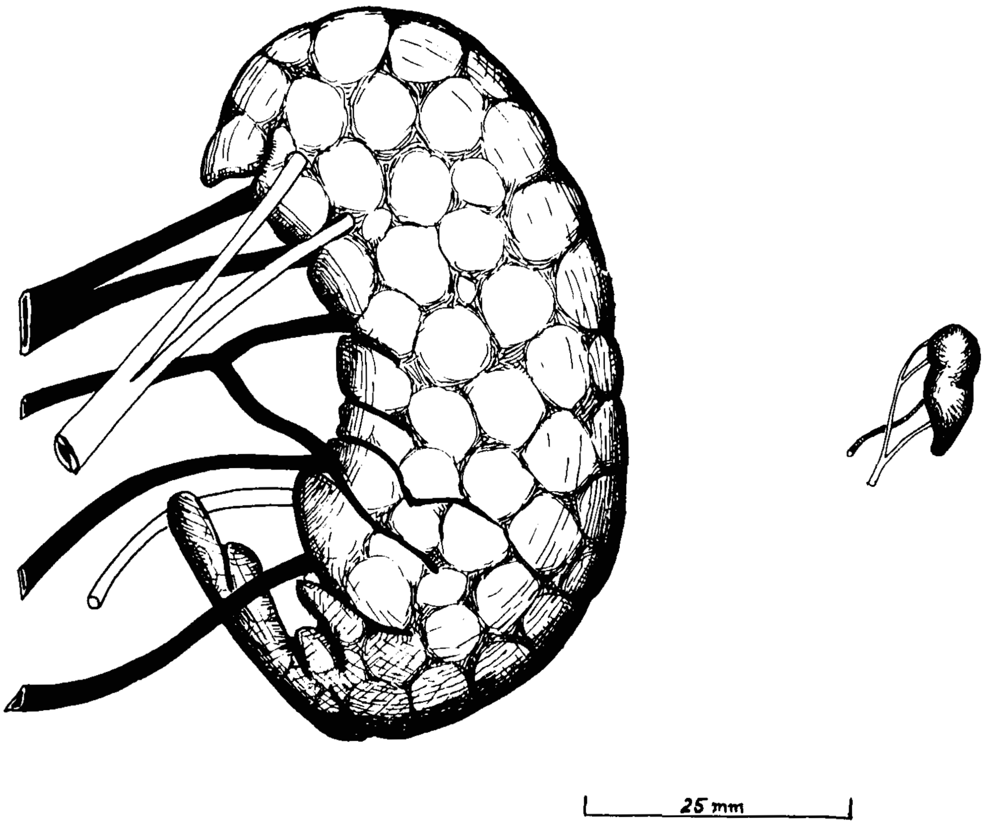


FIG. 8. *Didermocerus sumatrensis* (Basel). Thyroid dextral lobe and sinistral parathyroid gland with arteries (white) and veins (black).

of the parathyroid parenchyma shows invasion by lymphoid tissue and the abundance of haemosiderin peripheral thereto may reflect pathological change.

The local juxta-thyroid lymph nodes are relatively small, discrete, ovoid bodies, multiply connected with the deep cervical nodes. They are peculiar histologically in that, unlike the previously examined nodes of *Rhinoceros unicornis*, *Diceros bicornis* and *Ceratotherium simum*, they manifest no positive evidence of haemolymph function (Cave & Aumonier, 1962), a difference which may, however, reflect nothing more than pathological or senile change.

Specimen 2. (R 72). Female ("Subur"). c. 13 years. Copenhagen Zoo. 1972

The thyroid gland is bi-lobed and lacks an isthmus. Each lobe, of inverted pyriform shape, is 65 mm long with a wider (45 mm) cranial and a narrower (25 mm) caudal portion. Its dull purplish-brown parenchyma is encapsulated in thin, tough collagen and is finely lobulated by septal off-shoots from the capsule. An extracapsular sheath of dense cervical fascia supports both the lobe and its vasculature. The lobe border is sharp and thin, save dorsally, where it is thicker but not especially rounded. The lobe is everywhere convex superficially, concave deeply. Its deep aspect is applied directly to the caudal part of the cricoid ring, the hindmost fibres of mm. crico-pharyngeus and crico-arytenoideus lateralis, the crico-thyroid capsule, the first three tracheal rings and the recurrent laryngeal nerve. From a vague "hilum" on this deep surface emerge several small veins

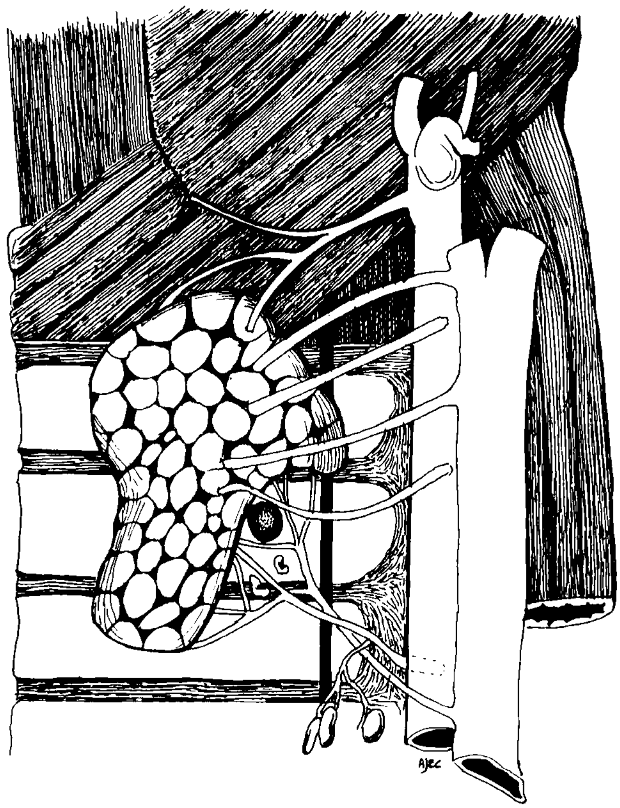


FIG. 9. *Didermocerus sumatrensis* (Copenhagen). Semi-diagrammatic dissection sketch of thyroid sinistral lobe, parathyroid gland (stippled), bloodvessels and lymph nodes. The common carotid (with prominent carotid sinus) gives four branches to the lobe: the jugular vein receives three tributaries therefrom.

(thyroid venous plexus) enmeshing the homolateral parathyroid gland and a few small, discrete lymph nodes (Fig. 9).

Thyroid and parathyroid glands are supplied directly from the common carotid artery by a cranio-caudal series of equally-spaced, roughly-parallel arteries, which reach and penetrate the thyroid tissue in unbranching independence (Fig. 9). The first (most cranial) of these arteries arises directly from the ventral aspect of the common carotid immediately prior to that vessel's division into occipital, internal and external carotid arteries; it curves ventro-caudally towards the thyroid cranial pole and divides into (a) two branches to the gland (b) an inferior laryngeal artery which gives twigs to the local musculature and enters the larynx through the crico-thyroid membrane. The terminal branches of this first thyroid artery being of equal calibre, the parent vessel may be interpreted as a genuine supreme thyroid artery or an inferior laryngeal artery direct from the common carotid, supplementing the thyroid blood supply.

The second artery of the cranio-caudal series arises directly from the common carotid's lateral aspect, proceeds directly ventralward to the thyroid gland without branching and disappears into the gland substance. The third member of the series, of similar origin and termination, pursues a slightly longer, more sinuous course. These two (i.e. second and third) arteries may represent either the duplication of a canonical superior thyroid artery or genuine superior and middle thyroid arteries. The fourth (most caudal) member of the series is unmistakably an inferior thyroid artery proper. Arising from the common carotid's deep aspect it takes a direct branching course to the caudal moiety of the gland. It gives off (a) a short branch rapidly subdividing into tracheal, oesophageal and lymph node twigs, (b) a branch into the thyroid "hilum", (c) a dividing terminal branch to the thyroid caudal pole. Larger-calibred than its fellows, this artery appears to be the dominant channel of supply. Arterial anastomosis is absent externally, but demonstrable within the gland tissue.

The thyroid terminal veins are three, viz. superior, middle and inferior; all drain into the jugular vein. The superior vein emerges from the thyroid cranial pole, receives no observable laryngeal tributaries and accompanies the most cranial thyroid artery. The middle vein emerges from the superficial surface of the thyroid lobe at the junction of wide (cranial) and narrow (caudal) portions and courses dorsally to the jugular between and parallel to the second and third members of the arterial series. The inferior—and largest—vein drains the obtrusive thyroid venous plexus. This last is a tangle of multiple, short veins from the "hilum" and caudal moiety of the thyroid lobe, which overlies the recurrent nerve and enmeshes the homolateral parathyroid gland plus three or four lymph nodes of recognizably separate size, shape and colour (Fig. 9).

Each of the two parathyroid glands present lies dorsal to the thick dorsal border of the homolateral thyroid lobe. Small (9 mm diameter), encapsulated and pea-shaped, its spongy parenchyma is yellowish-pink on section. Its artery of supply is not determinable but its venous drainage is demonstrably into the thyroid plexus and inferior thyroid vein.

The perithyroid lymph nodes disposed about the thyroid caudal pole and within the venous plexus are small, discrete, ovoid bodies varying in size from 18×8 mm to 24×9 mm, each fat-enwrapped and well capsulated. Microscopically these nodes manifest a somewhat atypical arrangement of their lymphoid tissue.

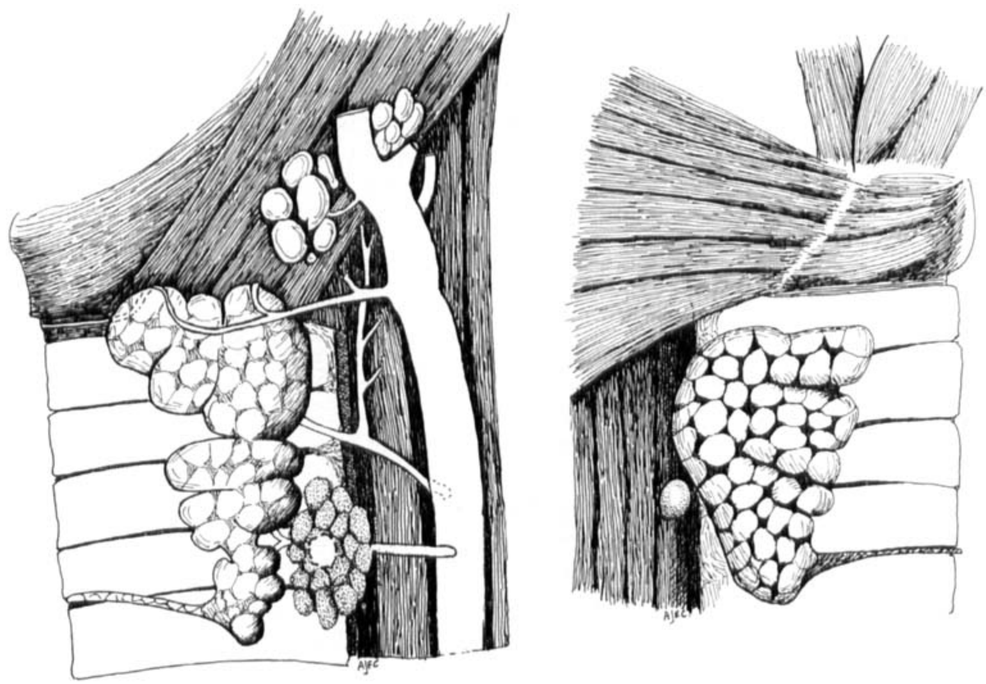
Histologically the thyroid parenchyma presents a typically mammalian appearance: the parathyroid parenchyma shows cells disposed in clusters—but unsatisfactory preservation precludes more detailed commentary.

On the African White rhinoceros ***(Ceratotherium simum)***

(The gross anatomy of the thyroid and parathyroid glands in this form is hitherto unrecorded.)

Specimen 1. (R 162). Female ("Bebe"). 10–11 years. Zool. Soc. Lond. 1962

The bilobed thyroid gland is invested, particularly dorsally, in a strong sheath of cervical fascia, which condenses supportively around the thyroid vasculature. A thin, tough collagenous capsule proper directly invests the brownish gland tissue which is rendered finely and uniformly lobulated by septa penetrating therefrom. The lateral lobes differ somewhat in gross appearance: the right is of compact pyriform shape, widest and thickest cranially and deeply fissured ventrally: the left is more tadpole-shaped, more evenly elongate and much fissured both ventrally and dorsally (Fig. 10). Each is some 80 mm long, 50 mm wide cranially and 20–25 mm wide caudally: its caudal pole joins its fellow by a horizontal isthmus (2 mm thick, 5 mm broad) occupying the 4th/5th tracheal interspace. The deep concave lobar surface contacts the dorso-lateral aspect of the trachea,



(a) (b)

FIG. 10. *Ceratotherium simum* (R 162). Dissection sketches of asymmetrical thyroid lobes and the associated parathyroid glands. The thyroid sinistral lobe (a) receives three branches from the common carotid (which ends amidst the anterior cervical group of lymph nodes): the associated parathyroid (broken outline) is fat-embedded dorsally. The dextral lobe (b), cleaned of blood vessels is more compact and retains *in situ* the homolateral parathyroid gland.

overlies the recurrent nerve and abuts posteriorly upon the carotid sheath in the tracheo-oesophageal furrow. The caudal portion of this deep surface displays an ill-defined "hilum", giving exit to several small veins.

Descriptively the gland's arterial supply is by separate superior, middle and inferior thyroid arteries from, respectively, the ventral, deep and superficial aspects of the common carotid artery. The superior and middle arteries pass directly to the cranial portion of the homolateral thyroid lobe, the inferior thyroid artery to the smaller caudal portion: none branches or anastomoses outside the gland capsule. Morphologically however these arteries require other interpretation. Topographical evidence suggests the acceptability of the descriptively superior artery as a canonical a. thyroidea superior. But the descriptively middle vessel manifests a distribution pattern typical of a canonical a. thyroidea inferior, so that it must be considered such despite an unusually high carotid origin. By this origin it is disadvantaged in its supply of the caudal portion of the thyroid lobe, but the disadvantage is offset by the provision of a supplementary branch of the common carotid (the descriptively inferior artery) which, in the more usual arterial arrangement, would have constituted a glandular branch of a canonical a. thyroidea inferior. From the union of numerous and various-sized veins from the deep surface and dorsal border of the gland emerge definitive superior and inferior thyroid veins, direct tributaries of the jugular vein. Small, discrete, oval lymph nodes occupy the fat-laden fascia dorsal to each lobe. Histologically, the thyroid tissue shows a marked venous congestion. Its colloid containing vesicles (10 of which average 66 μm in diameter) appear as (1) typical cubical epithelium-lined spaces containing typical dark-staining homogeneous colloid material, or as (2) vesicles containing pale-staining granular colloid, or as (3) vesicles containing a mixture of dark and pale colloid. In some histological fields no definite vesicular structure is discernible, regular spaces being replaced by "sheets" of epithelium, suggestive of the emptying and subsequent mutual collapse of several contiguous vesicles. Engorged blood vessels are prominent and numerous on the periphery of such epithelial "sheets" and the general histological picture is indicative of pathological change.

A single, rounded, parathyroid gland, some 12 mm in diameter, and yellowish upon section, lies close to the dorsal border of each thyroid lobe, buried in the local fat-laden fascia and united by fine veins to the larger tributaries of the inferior thyroid vein. Its proper artery is not detectable. Histologically the parathyroid gland manifests a typically mammalian pattern (Cave & Aumonier, 1966) save for an unusual preponderance of collagen. Its parenchyma is diffused within a collagenous matrix and is disposed less as cell clusters separated by fibrous septa than as solid, anastomosing cell cords, composed of light chief cells infiltrating masses of collagen. Some cell-clusters are detectable, but whether genuine clusters or obliquely sectioned cell-cords is uncertain.

Below their well formed fibrous capsule the parathyroid parenchymal cells show a pale cytoplasm surrounding small, rounded nuclei. The gland tissue is extremely vascular, being characterized by a fair abundance of small thick-walled arteries and the surrounding of the cell cords by large and thin-walled sinusoids. Reliable identification of cell types is precluded by imperfect preservation of the gland tissue.

Specimen 2. (R 20). Male. 3 years. Zool. Soc. Lond. 1964

Peculiar features of this specimen are (a) an exceptional abundance of adipose tissue, (b) congenital absence of half the thyroid isthmus, (c) prolongation of the median crico-thyroid ligament into the thyroid sheath, (d) the obtrusive cranio-caudal disposition of the thyroid bloodvessels.

Fatty tissue, soft and butter-coloured, abounds in the various intermuscular, crico-thyroid and crico-tracheal intervals, in the pretracheal fascia and around the thyroid sheath. It also occurs between thyroid sheath and capsule, and even deep to the capsule, one notably large intraparenchymal globule simulating an intra-thyroidal parathyroid gland.

The dextral moiety only of the thyroid isthmus is present—an extremely narrow, tenuous strip of parenchyma (53 mm long × 3 mm wide × 1·5 mm thick). This strip derives from the lobar caudal region, ascends the lobe to midpoint of its ventral border whence it ascends obliquely across the trachea to terminate blindly between the first and second rings. There is no trace of any sinistral isthmus moiety, past or present. Such obviously obtained during thyroid gland ontogeny but must have undergone prenatal absorption with the main stem of the thyro-glossal duct.

The median crico-thyroid ligament is a tough elastic felting of distinctly pinkish colour,

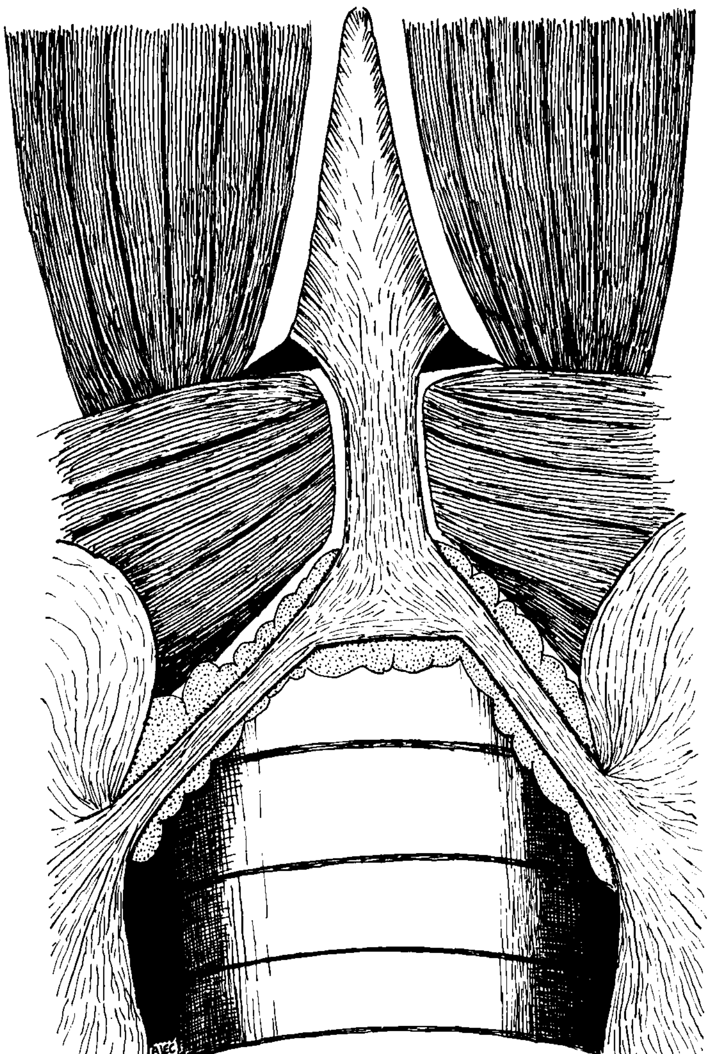


FIG. 11. *Ceratotherium simum* (R 20). Showing ventral aspect of laryngotracheal region with prolongation of median crico-thyroid ligament to each thyroid lobe sheath.

which contrasts markedly with that of the local connective tissue. The ligament occupies the narrow triangular interval formed by the cranial border of the cricoid cartilage and the approximating (ascending) caudal borders of the thyroid cartilage laminae, being 60 mm long × 25 mm in basal width. Caudally it gives off a narrow strip (40 mm long ×

12 mm wide) which descends over, and adheres to, the midventral aspect of the cricoid cartilage, between the two crico-thyroid muscles. Over the cricotracheal membrane and separated therefrom by a thick fatty cushion the caudal end of the strip expands into a triangular piece some 25 mm long × 30 mm broad. From this expansion, bilaterally, a prolongation some 7 mm wide proceeds caudo-laterally for some 50 mm, skirting the crico-thyroid muscle to blend perceptibly with the thyroid sheath (Fig. 11). The thyroid bloodvessels display a striking cranio-caudal disposition, all discoverable arteries ascending cranially to the gland and its numerous large veins forming a descending (caudally directed) cascade. No artery descends to the gland and no vein proceeds cranialwards from it. This vascular arrangement clearly indicates (what dissection confirms) the vascularization of the gland by an inferior thyroid artery only.

Because of isthmus congenital deficiency the two thyroid lateral lobes are discrete. Remarkably symmetrical in size and shape these overlie the dorso-lateral aspects of the cricoid cartilage and first five tracheal rings, the origins of the mm. crico-pharyngei, the lowest fibres of the mm. crico-thyroidei and the recurrent laryngeal nerves: dorsally each abuts against the oesophagus. In shape each lobe presents an isosceles triangular outline, with base uppermost and angles rounded—having thick, rounded cranial and dorsal borders, and a thin, sharp ventral border (Fig. 12(a), (b)). In length, maximal (cranial) breadth and maximal thickness the right lobe measures 83 × 56 × 20/25 mm, the left lobe 76 × 60 × 20/25 mm. From the cranial base the dorsal and ventral borders converge into an acuminate caudal pole, immediately caudad of which lies the homolateral parathyroid gland, obscured by a packed cluster of lymph nodes.

The thyroid parenchyma is very finely lobulated: each lobe mass is partially but deeply fissured, much grooved externally and prolonged ventrally into digitiform processes. The thyroid sheath and perivascular fascial condensations are extremely thick, strong and fat-laden: the sheath is reinforced on its deep and superficial aspects by the above-men-mentioned prolongations from the median crico-thyroid ligament, a reinforcement emphasized by the pinkish colour of the ligamentous tissue. The thin, strong, whitish collagenous capsule adheres firmly to the gland tissue and sends the customary multiple septa into the substance thereof.

A single parathyroid gland is present bilaterally, situated immediately caudad of the thyroid caudal pole. Of laterally compressed spheroidal shape, each gland is pale stone-yellow in colour and 11–12 mm in diameter: each is encapsulated, ensheathed in fat and perithyroid fascia and hidden within a cluster of mutually contiguous lymph nodes capping the thyroid caudal pole. At least one artery (7 mm long) enters the parathyroid equator dorsally from a branch of the caudalmost artery supplying the thyroid gland and at least one recognizable parathyroid vein joins the ventralmost vein leaving the thyroid caudal pole (Fig. 12 (c), (d)).

The perithyroid lymph nodes are unusually disposed, being mutually adpressed into a virtually solid mass, indenting the superficial surface of the caudal portion of the lateral lobe and forming a helmet to its caudal pole. Densely enwrapped, both singly and collectively, in thyroid sheath fascia, these nodes overlie and surround the homolateral parathyroid gland: they receive substantial twigs from the caudal pole arteries and send fine veins into the caudalmost thyroid veins.

Each thyroid lateral lobe is vascularized exclusively by a canonical a. thyroidea inferior,

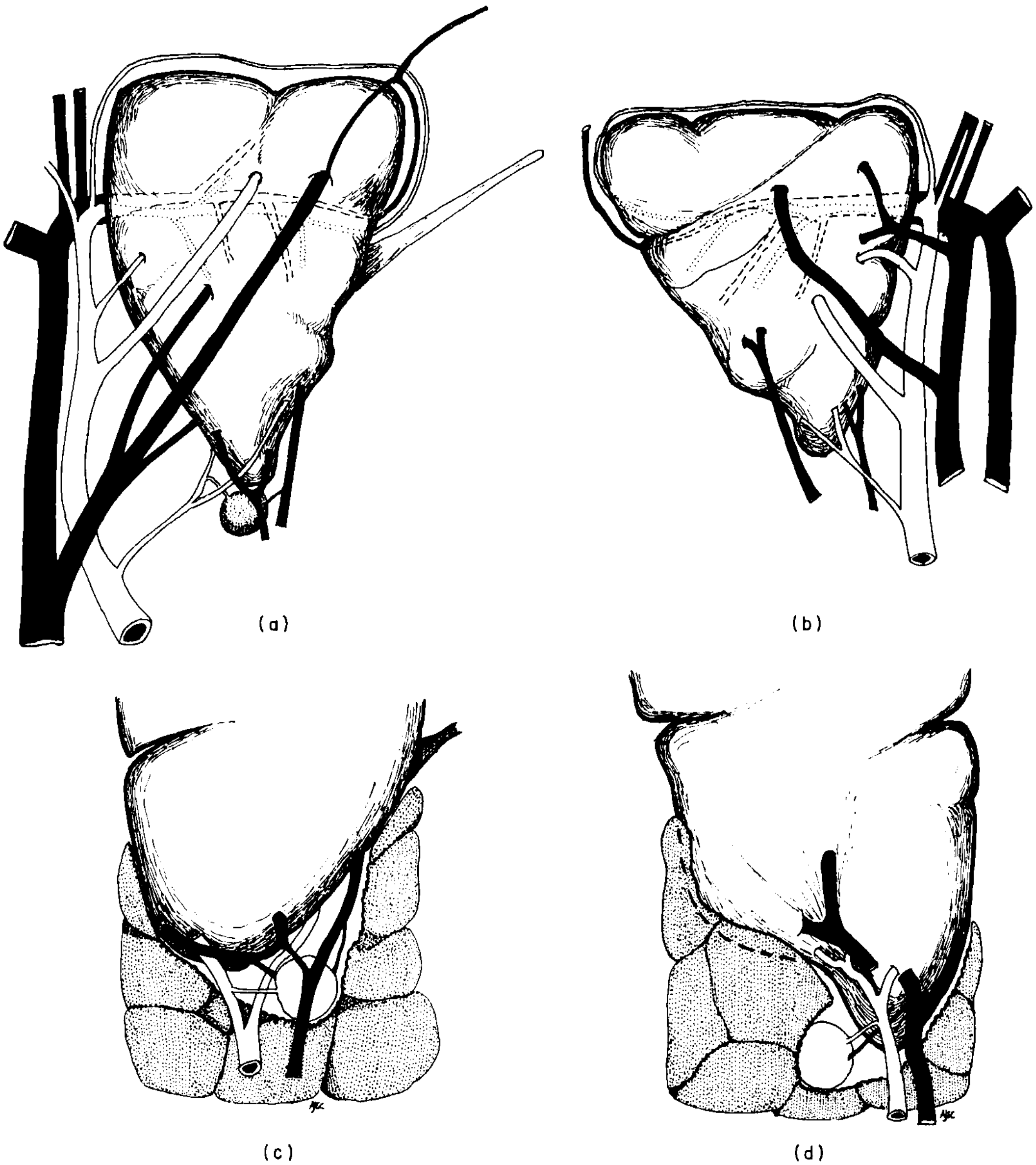


FIG. 12. *Ceratotherium simum* (R 20). Showing (a) dextral, (b) sinistral thyroid lobe vasculature, and topography of (c) dextral, (d) sinistral parathyroid gland. Arteries (white), veins (black), lymph nodes (stippled).

ascending obliquely thereto from a low carotid origin. There is no trace of any a. thyroidea superior and the laryngeal region is vascularized independently from the common carotid. The pattern of distribution of each a. thyroidea inferior shows a remarkable symmetry, including the unusual passage of the main arterial stem deep to the thyroid lobe (Fig. 12(a), (b)).

Following closely the dorsal border of the thyroid lobe, each a. thyroidea inferior gives off, in caudo-cranial sequence of origin, the following branches:

(a) ramus caudalis: a vessel arising caudad of the thyroid gland, ascending obliquely thereto, and dividing into terminal dorsal and ventral sub-branches, each of which enters the substance of the caudal pole: the dorsal sub-branch provides a substantial artery (a. parathyroidea) to the parathyroid gland,

(b) ramus superficialis major: a relatively large vessel which crosses the superficial surface of the thyroid lobe in oblique dorso-ventral direction to sink, without subdivision or exterior anastomosis, into the thyroid lobe about its middle,

(c) ramus superficialis minor: a shorter, smaller, cranially convex branch, which enters the thyroid substance undivided close to the lobar dorsal border,

(d) ramus profundus: an unusual continuation of the parent artery transversely (dorso-ventrally) across the deep surface of the thyroid lobe: about the junction of cranial third with caudal two-thirds of the lobar dorsal border the main stem of the a. thyroidea inferior curves ventralwards at a right angle and travels across the deep surface of the lobe to its ventral border. During this transverse course it gives off both cranial and caudal sub-branches, each of which runs a distance upon the gland's deep surface before entering its substance. The diminished ramus profundus emerges at the lobar ventral border to turn cranialwards and to anastomose finally with the ramus marginalis,

(e) ramus marginalis: a small branch, arising as the parent artery begins its rectangular bend, which follows the dorsal and cranial borders of the thyroid lobe to anastomose with the reduced continuation of the ramus profundus,

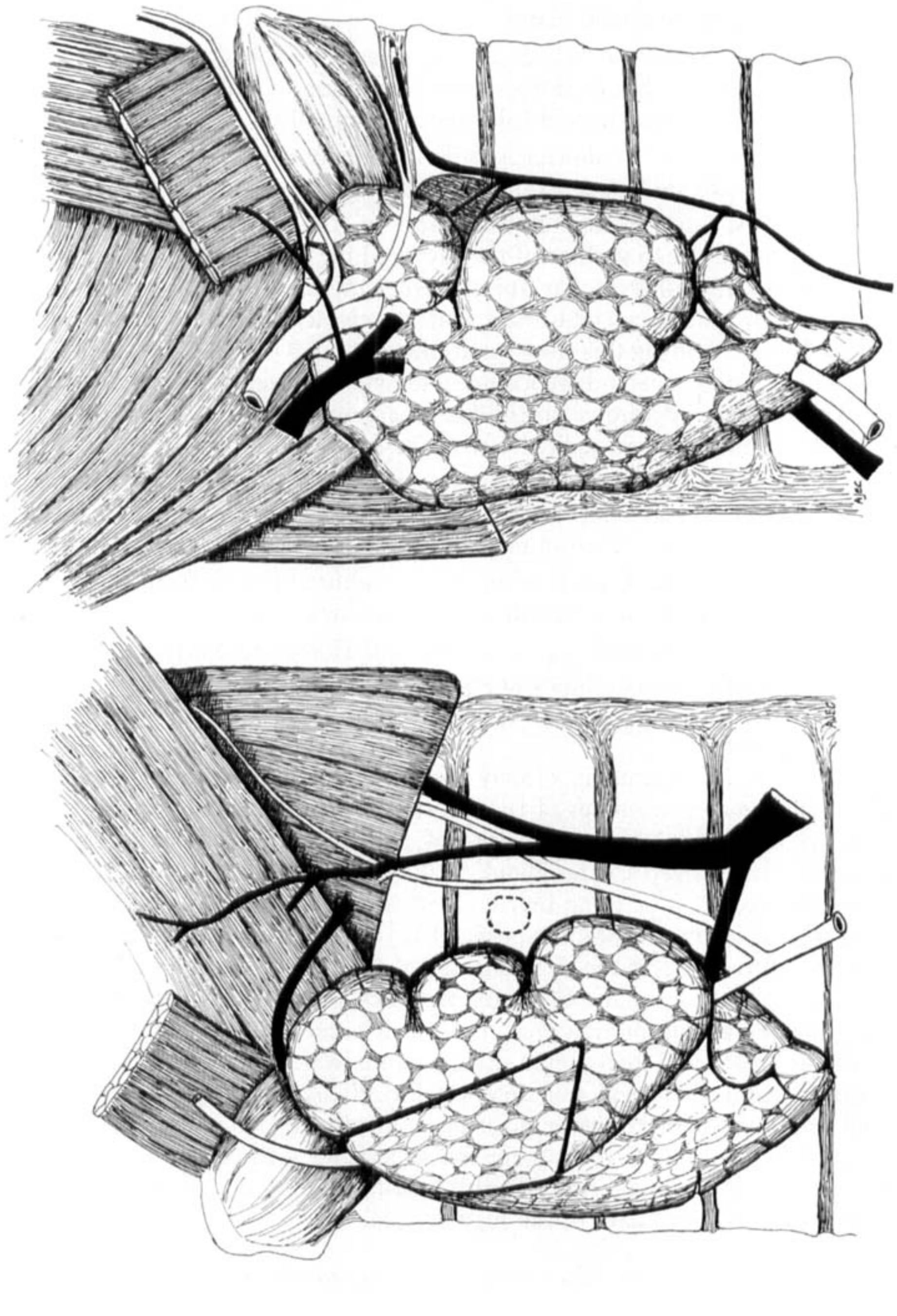
(f) ramus ascendens: a long branch of moderate calibre, arising from the beginning of the bend of the parent artery and proceeding cranialwards to the pharynx or oesophagus.

The deep (transverse, retroglandular) course of the inferior thyroid artery is exceptional, likewise the well-developed anastomosis along the cranial border of the thyroid lobe: this unusual disposition of vessels would appear to be compensatory for the absence of any a. thyroidea superior.

The thyroid venous arrangements closely parallel the arterial, the principal veins being manifestly the venae comitantes of the arteries. Thus the cranial peripheral arterial anastomosis is accompanied by the remnants of a companion venous channel whose ventral component passes deep to the gland as the vena profunda. The cranial venous anastomotic channel receives the crico-thyroid vein and (dextrally at least) connects with the longest and largest of the emergent superficial thyroid veins. The vena profunda runs ventro-dorsally in a furrow upon the deep surface of the lobe: it receives relatively voluminous tributaries from the cranial and caudal moieties of the lobe, at the dorsal border of which it appears as a considerable vessel. Here it receives two medium sized veins descending from the larynx and then curves sharply caudalwards (being double sinistrally). At its curvature a huge oesophageal vein enters it dorsally. Accompanying the stem of the inferior thyroid artery the v. thyroidea inferior proceeds directly caudalwards and receives as tributaries (a) two long, large veins from the superficial surface of the thyroid lobe, (b) two veins from the lobe caudal pole which run a fairly long course before joining it. The inferior thyroid veins terminate in the jugular vein.

*On the African Black rhinoceros (**Diceros bicornis**)*

(The gross anatomy of the thyroid and parathyroid glands in this form is hitherto unreported.)



(b)

(a)

FIG. 13. *Diceros bicornis* (R 19). Showing topography and vasculature of (a) sinistral, (b) dextral thyroid lobe. Note v. thyroidea ventralis. Arteries (white), veins (black), parathyroid gland situation shown by broken circle.

Specimen 1. (R 19). Male. 2–3 years. Zool. Soc. Lond. 1960

Autopsy procedure has damaged the thyroid vasculature, caused loss of the right parathyroid gland and the reduction of the left to remnants of characteristic parenchyma amid the veins dorsal to the corresponding thyroid lobe.

The two thyroid lateral lobes are devoid of annectant isthmus: of pyriform shape they are equal in mass but dissimilar in outline. Each laterally overlies the cricoid cartilage and first four tracheal rings, displays a bluntly rounded, expanded cranial pole, an acuminate caudal pole and a uniformly convex superficial surface: each is considerably fissured and imbricated, some left lobe fissures penetrating to the "hilum" region (Fig. 13).

The dextral lobe cranial region is entered by a relatively large artery—supplying also the laryngeal muscles and membranes by ventral branches. Of these the first (ramus crico-thyroideus) runs cranio-ventrally between the crico-thyroid and sterno-hyoid muscles to the middle of the crico-thyroid membrane: the second (r. crico-thyroideus muscularis) crosses the crico-thyroid muscle to enter its caudal border: the third (r. crico-trachealis) runs ventrally along, then into, the crico-tracheal membrane. (More substantial laryngeal branches were provided by the now-lost proximal portion of this thyroid cranial artery.) The lobar caudal pole is entered by a single artery, equal in calibre to the cranial glandular artery.

Corresponding cranial and caudal arteries appear in the thyroid sinistral lobe, the caudal vessel demonstrably a branch of a canonical a. thyroidea inferior of low carotid origin and of characteristic distribution to pharynx, larynx and thyroid gland. This inferior thyroid artery supplied the (now mutilated) sinistral parathyroid gland and it is likely that a corresponding parathyroid vascular arrangement obtained contralaterally.

From the cranial end of the dextral lobe two radicles of a single, large superior thyroid vein emerge: the formed vein receives a long crico-thyroid and various muscular tributaries and drains into the jugular vein. An unusual and slender vein (v. thyroidea ventralis) emerges through the crico-tracheal membrane, descends the ventral border of the thyroid lobe, collecting a succession of fine tributaries and disappears towards the inferior thyroid vein. (A comparable anomalous vein occurs sinistrally in Indian rhinoceros specimen L 331.1 of the present series.)

The thyroidal sinistral lobe shows a single, large vein emerging from both the cranial and the caudal pole, the caudal gland vein uniting with a very large laryngo-pharyngeal vein to form a "common" inferior thyroid tributary of the jugular vein (Fig. 13(a)).

The available evidence indicates, therefore, the vascularization of each thyroid lobe by canonical superior and inferior arteries from the common carotid and the lobar venous drainage to be effected by definite superior and inferior thyroid veins into the jugular vein. It appears practically certain that each parathyroid gland was supplied by the homolateral inferior thyroid artery and drained into the radicles of the inferior thyroid vein.

Summary

The thyroid/parathyroid glandular apparatus has been examined in seven Indian, two Sumatran, one African Black and two African White rhinoceroses, and the following conclusions drawn.

The rhinoceros thyroid gland is invariably bilobed and usually provided with an interlobar annectant isthmus. The lobes are generally symmetrically positioned but remarkably

variable in individual configuration, though always remaining "thyroid" (shield shaped). Lobe configuration is influenced by the pressure of adjacent structures and the lobe parenchyma is more or less compressed inside an unyielding collagenous capsule, capsule-removal permitting considerable unravelling of the lobar mass. The thyroid lobe is commonly much fissured, the dorsal border crenated and imbricating lappets of gland tissue are frequently present. An ill-defined "hilum" is generally detectable about the middle of the lobe's deep surface. The always tenuous isthmus connects the lobar caudal regions whatever its point of departure from the lobar ventral border. The isthmus was congenitally absent wholly in three specimens (two Sumatran, one African Black) and partly in one (African White) specimen.

In one specimen (African White rhinoceros) the always thick, tough thyroid sheath received an accession of elastic fibres from the median crico-thyroid ligament: the fascial condensations (ligamenta loborum lateralium) around the thyroid vascular pedicles are always pronounced.

The brown thyroid parenchyma (appearing slate-blue through the intact capsule) is notably lobulated by penetrating septa from the capsule. In all rhinoceros forms examined the gland manifests a uniform and typically mammalian structure: the component vesicles are relatively small, cubical epithelium-lined and filled with eosinophilic colloid material of homogeneous (sometimes granular) appearance.

The gland is vascularized exclusively from the common carotid artery, most commonly by canonical superior and inferior thyroid arteries, sometimes mainly or wholly by one or other of these, more rarely by multiple carotid branches. The arterial pattern, though tending towards a norm, varies between individuals of the same species and even between the two lobes of a particular gland. In 18 individual lobes examined superior and inferior thyroid arteries obtained in 11 lobes (eight Indian, one Sumatran, one African Black), a superior thyroid artery alone occurred in one (Indian rhinoceros) lobe, an inferior thyroid artery alone occurred in two lobes (of one African White specimen) and multiple thyroid arteries occurred in four lobes (one Sumatran, one African White specimen). Whilst intraglandular arterial anastomosis in profuse extraglandular anastomosis of the thyroid arteries is exceptional. Topographical evidence suggests that the superior (cranial) thyroid artery is the primitive, basic carotid supply to the gland and that the inferior (caudal) thyroid artery is primarily a pharyngeal vessel with a secondary association with the thyroid gland.

Thyroid gland venous return is into the jugular vein. The thyroid veins are expectedly large and numerous: their pattern is variable with a tendency towards reproducing the arterial pattern and the establishment of definitive superior and inferior thyroid veins. A "common" inferior thyroid vein generally ensues from the union of the most caudal gland vein with large independent or confluent venous channels descending from larynx, pharynx and oesophagus.

A curious vena thyroidea ventralis occurred in one Indian rhinoceros and in one African Black rhinoceros examined.

The canonical number of parathyroid glands is two (a right and a left) in all rhinoceros forms studied. Exceptionally, additional parathyroid bodies occur, representing either additional gland tissue or subdivision of an original complement. The parathyroid gland, a yellowish compact, encapsulated, laterally-compressed spheroid, is invariably associated with the thyroid lobe dorsal border (generally the caudal moiety thereof). Topographically the gland is usually parathyroidal, but an epi-thyroidal and (more rarely) an intrathyroidal disposition may obtain. The extra-thyroidal parathyroid is independently vascularized by the most caudal of the thyroid arteries: the intrathyroidal by fine vessels from the intraglandular anastomosis. Independent parathyroid veins join the inferior thyroid vein or one of its radicles. Externally the parathyroid shows a finely granular surface: its spongy parenchyma is of characteristic gamboge yellow colour: histologically the gland is imperfectly lobulated, its lobules consisting of solid clusters of fairly uniform cells (sometimes displaying a lumen) separated by very fine areolar tissue containing sinusoids. In well preserved material oxyphil cells are recognizable.

Commentary

The two fundamental requirements of the endocrine thyroid/parathyroid glandular apparatus are an abundant, constant arterial supply to maintain metabolic activity and a rapid copious venous drainage to discharge metabolic products directly and immediately into the blood stream. The observations recorded above demonstrate how admirably and unfailingly these requirements are met in the rhinoceros organs and how subservient to physiological function are mere topographical arrangements. For in relation to thyroid function such matters as lobe configuration, number of supplying arteries and disposition of emergent veins are of but secondary importance.

Nevertheless since function determines morphological pattern a distinctive thyroid/parathyroid topographical canon tends to emerge and most commonly to achieve realization. Thus, despite an extraordinary range of variation, the thyroid lobe manages to retain its characteristic "thyroid" (shield shaped) configuration: the parathyroid gland remains commonly para-thyroidal in position: despite inevitable variation in the thyroid arterial pattern, that pattern tends persistently towards a norm of two vessels (aa. thyroideae superior et inferior): despite the influence of the laryngeal veins upon the caudal thyroid vein, the gland veins show a marked tendency to parallel the arterial pattern.

All thyroid arteries come directly from the common carotid artery and all thyroid/parathyroid venous return is into the jugular vein.

Although their precise location is functionally unimportant, the parathyroid glands manifest a striking constancy, in number, appearance and situation. Whether (as most commonly) para- or epi-thyroidal in position or (rarely) intra-thyroidal, these glands maintain a constant close association with the thyroid dorsal border.

The vascular and other variations noted in the material studied are not confined to any single rhinoceros genus, and despite the limited number of specimens examined an overall impression is gained of great constancy of arrangement of the thyroid/parathyroid apparatus throughout the Rhinocerotidae.

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