On the structure and affinities of the musk-deer (Moschus mosciferus, Linn.) / by William Henry Flower.

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On the Structure and Affinities of the Musk-Deer (*Moschus moschiferus*, Linn.).

By William Henry Flower, F.R.S., V.P.Z.S., &c.

Almost all our knowledge of the visceral anatomy of the Musk-Deer is derived from Pallas*. It is nearly a century since his classical work was published; and it does not appear that any other anatomist has had an opportunity of dissecting an animal of the species, the subject which furnished the material for the following notes having been the first which has ever been brought alive to Europe. Its arrival in the Society's Menagerie was thus announced by our Secretary in the 'Proceedings' for May 13th, 1869:—

"A female Musk (*Moschus moschiferus*), presented by Major F. R. Pollock †, Commissioner at Peshawur, and most carefully conveyed to this country by Lieut. C. H. T. Marshall, F.Z.S., from whom it was received March 31st. This animal had been captured in June 1867, in the hills of Cashmere, by Major Delmé Radcliffe, of the 88th Regiment, who shot both the parents, and brought it when quite a kid to Peshawur. It was now about two years old, and was believed to be the only Musk ever brought to Europe alive."

A very good figure, drawn from the living animal in a characteristic attitude, appeared in the 'Illustrated London News' for April 24th, 1869. I call particular attention to this, as all other published figures of the Musk-Deer appear to have been taken from skins or stuffed specimens, and give but an indifferent idea of the general external appearance of the animal.

It unfortunately died on October 27th of the same year, of pleuro-pneumonia and acute peritonitis, being then rather more than two and a half years old. All the permanent teeth were in place and the epiphyses of the long bones completely united, though those on the bodies of some of the dorsal vertebræ and on the pelvis were still separable.

The animal measured from the tip of the nose to the root of the tail 33 inches, and (being in an extreme state of emaciation) weighed 14lbs. 8oz.‡

External Characters.

Under this heading I have only thought necessary to record such characters as are not readily observed in mounted skins of the animal, which are now tolerably abundant in museums.

* Spicilegia Zoologica, fasciculus xiii (1779).

† Now Sir Richard Pollock, K.C.S.I.

‡ Since the greater part of the following description was written, a male Pudu (*Cervus humilis*) died at the Society's Gardens; and Mr. Garrod has been so obliging as to forward it for my inspection. I have thus an opportunity of adding some comparisons between the viscera of the Musk and those of another Deer of about the same bulk; for though the former, having longer limbs and neck, has the appearance of being a considerably larger animal, there is but little difference in the size of the trunk.

There was no suborbital gland or crumen *, no vestige of the abdominal musk-sac of the male†, nor of the gland described by Brandt on the outside of the thigh‡, nor of the tail-glands described by Hodgson§, in both cases in male animals; nor were there any interdigital glands in either feet, the depressed space between the toes, where the glands usually open, being covered with hair‖.

The teats were two in number¶, placed on the hinder part of the abdomen, between the thighs, 1 inch in front of the anterior margin of the symphysis pubis, $3\frac{1}{2}$ inches in front of the vulva, and $\frac{6}{10}$ inch apart; each was $\frac{1}{2}$ inch in length, soft, flaccid, slender, cylindrical, slightly tapering, and with a rounded apex. They were placed upon a nearly bare oval space, $2\frac{1}{4}$ inches across, and 1 inch from before backwards, having only a few long fine silky hairs upon it. The space between this and the vulva was covered with hairs resembling those of the remainder of the abdomen, though softer and finer, especially at the hinder part.

A heart-shaped patch, $\frac{7}{10}$ inch in diameter, surrounding the vulva, was covered with soft skin, perfectly bare, beset, especially near its margin and anterior portion, with numerous yellowish-white sebaceous glands. Within, but near the front end of this bare place, is situated the prominent conical eminence, formed by the anterior union of the labia, with a few short hairs upon it. Close behind this is the apex of the clitoris, at the anterior margin of the vulval orifice. The extremely short perinæum, the margin of the anus, and the prominences formed by the tuber ischii, were covered with very short, flattened, adpressed hairs, which pass into those which clothe the triangular under surface of the very brief tail. It is not quite correct to describe, as is usually done, the long hairs of the tail as only covering the upper surface and sides of the organ, for they pass under and completely surround the extreme tip. The skin adheres very closely to the end of the very slender, elongated, terminal caudal vertebra.

* In the Pudu the crumen is a distinct involution of thickened integument, lodged in a deep pit in the bone, with an aperture half an inch in length. The lining membrane is white and corrugated, and has a few short, pointed, black hairs scattered over it. This organ, though generally present in the *Cervidæ*, is rudimentary or absent in the Roe and in the South-American Deer of the section *Coassus*. It is also absent in *Hyomoschus* and *Tragulus*.

† For an account of this organ and its peculiar secretion, which constitutes the "musk" of commerce, with references to previous descriptions, see A. Milne-Edwards's valuable memoir entitled "Recherches sur la Famille des Chevrotains," Ann. des Sciences Nat. 5e série, tome ii. (1864), which also contains a description of the osteology of *Moschus*, and a short *résumé* of Pallas's observations on its splanchnology.

‡ J. F. Brandt, "Note sur la découverte d'une glande particulière qui se trouve sur la face extérieure de la cuisse du *Moschus moschiferus*," Bull. Scientif. de l'Acad. d. St. Pétersb. tom. i. 1836, p. 174.

§ B. H. Hodgson, "On a new organ in the genus *Moschus*," Bengal Journal Asiatic Soc. x. 1841, p. 795.

‖ In the Pudu there are no distinct pouches in this situation; but the skin in the depression between the toes on the dorsal surface of all the feet is bare, and evidently has a free sebaceous secretion. This may be considered the most rudimentary or earliest stage of an interdigital gland.

¶ In the male Pudu there were four.

The feet of the Musk-Deer, as was well observed while the animal was alive, are remarkable, not only for their size and the great development of the outer hoofs, but also for their freedom of motion and capability of being widely extended and closed again, so that it seemed to have the power of grasping projecting rocky points between its four outspread toes—a power which must be of great assistance in steadying itself in its agile bounds among the crags of its native haunts*.

Anatomy of the Oral and Cervical Regions.

The exposed parts of the crowns of the upper canine teeth were 0″·2 long, conical, compressed, curved, directed inwards and somewhat backwards, with their apices truncated†.

The papillæ lining the cheeks are 0″·15 long, conical, very sharp-pointed, becoming smaller behind. In the floor of the mouth a single row of broad, conical, flattened papillæ, with prolonged and very delicate points, extends on each side of the root of the tongue, reaching backwards nearly as far as the last molar tooth, and forwards to within $\frac{1}{2}$ inch of the incisors. These were broader and flatter in front, and smaller and more slender behind. The longest measure 0″·1 in length. Near the front of the under surface of the attached part of the tongue were a few similar but smaller papillæ, forming a second (upper) line or series.

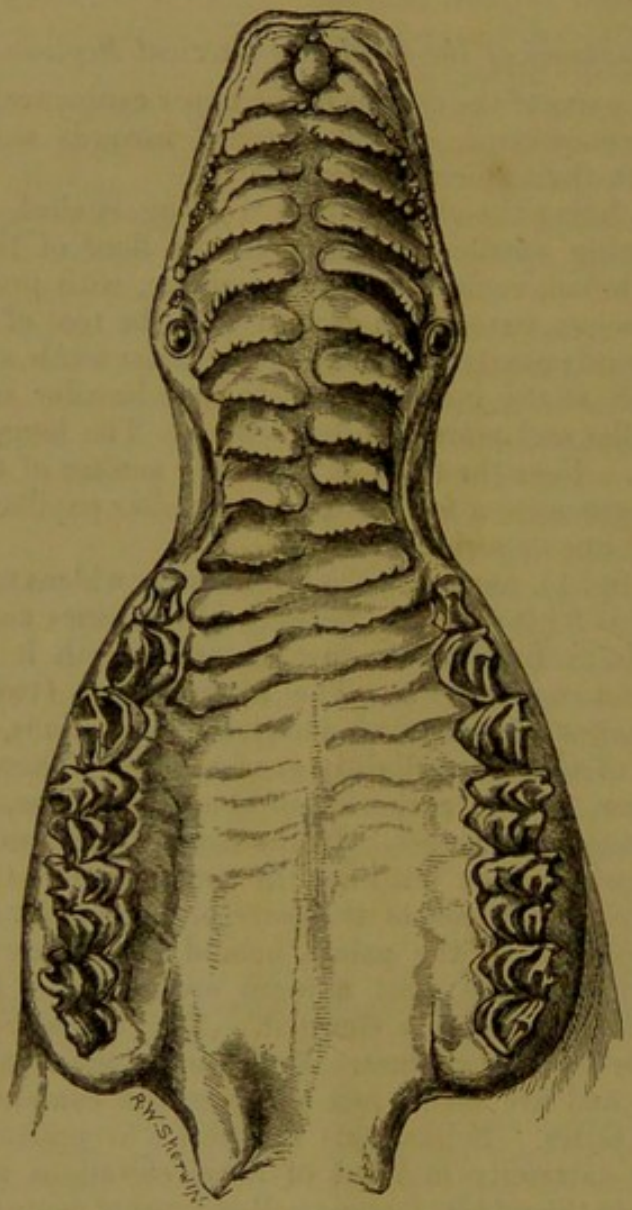
The palate (fig. 1), narrow in front, gradually widens to the canine teeth, where it is 0″·9 across. Between the canines and molars it contracts to 0″·7. Between the first premolar teeth it is 1″·1 and between the last molar 1″·3. The anterior part (two thirds) is covered with callous, retroverted, imbricated elevations, the hinder sharp margins of which are slightly denticulated. These are placed in a double row, one on each side of the middle line, which they touch but scarcely pass across. In the front of the mouth they are arranged in regular pairs; but after the third those of the left side are placed a little in advance of the corresponding right ridges; and at the narrowest part of the palate, behind the canine teeth, they regularly alternate. The most anterior are narrowest from before backwards and most strongly elevated. They become broader as well as flatter behind the canines. Between the premolars they gradually subside, and are finally lost opposite the commencement of the true molar series. Behind this the palate is perfectly smooth. At its anterior extremity in front of these elevations is a smooth surface, having in the middle line a small somewhat hourglass-shaped prominent pad ·2″ long from before backwards and narrower from side to side, bordered on each side by the opening of the duct to the nasal passage.

* My friend Mr. F. Jeffrey Bell has dissected the muscles of the feet, and intends shortly to give to the Society an account of their structure and arrangement.

† In the old male Pudu there were no signs of upper canines—an exception to the general but by no means universal rule in the *Artiodactyles*, that the tusks are developed in inverse ratio to the frontal appendages.

The number of ridges in front of the first premolar is ten on each side; and five or six may be counted behind; but the last are very indistinct. The soft palate extends about an inch behind the last molar, roofing over a portion of the fauces, which is much contracted and tubular, and ends by a straight sharp border.

Fig. 1.



The palate, natural size.

The general form of the palate differs from that of the Roe, and more resembles that of *Tragulus* in the widening opposite the canines, evidently in relation with the great development of these teeth in the male. It also differs from the Roe and approaches *Tragulus* in the ridges being less regularly placed and less strongly imbricated and denticulated. In the last-named animal the ridges, though strongly

marked, are, as in the Suina, neither overlapping nor toothed on the edge *.

The tongue (fig. 2) is $4\frac{1}{2}''$ long, narrowest ($0''{\cdot}8$) at the middle, rather spatulate, widening to $1''$ near the front, and terminating by a rounded depressed apex. In the anterior third there is a faint median depressed line. Posteriorly it presents the usual intermolar elevation.

Fig. 2.

Dorsal surface of tongue, natural size.

Minute conical filiform papillæ cover the whole dorsal surface, except quite at the base. These are much larger and further apart on the posterior median elevation than elsewhere. Small, white, circular, fungiform papillæ are pretty regularly scattered over the surface; and posteriorly, close to the lateral margin of the dorsum,

* In the Pudu the ridges of the palate are more developed and more strongly toothed than in *Moschus*, and therefore more typically Cervine, but they are less regular than in the Roe.

where the other papillæ are becoming few and small, is on each side a longitudinal row of five rather small circumvallate papillæ, not quite symmetrically disposed and slightly converging posteriorly*. The tongue is attached in front, $\frac{3}{4}$ inch behind the incisor teeth, by a soft broad fold of membrane without any distinct frænum.

The parotid gland is large and straggling, composed of loosely connected acini. It extends from the angle of the jaw, $1\frac{1}{2}$ inch backwards and upwards to the top of the neck behind the ear, a small slender branch projecting forwards and upwards in front of the cartilaginous meatus. The duct leaves the most inferior part of the gland below the angle of the jaw, passes upwards obliquely across the horizontal ramus with the facial artery and vein one inch in front of the angle, and at first following the anterior border of the masseter muscle, then running forwards, enters the mouth quite at the upper part of the cheek opposite the third premolar tooth. An oval patch of buccal glands, nearly an inch from before backwards, is situated in the cheek, around and chiefly below the entrance of the parotid duct.

The submaxillary gland lies immediately below the parotid. It is also very large and with large acini, but of more compact form, being triangular, the shortest side or base of the triangle (1″·3 long) being turned backwards and lying against (for its upper half) the transverse process of the atlas. The apex (distant 2 inches from the middle of the base) lies beneath the horizontal ramus of the jaw. The upper border is in contact with the digastric muscle, the lower border with the sterno-hyoid. The gland lies immediately upon the larynx, with the sterno-thyroid, thyro-hyoid, and the constrictors of the pharynx. A small, detached, oval, glandular piece lay on the upper border of the posterior belly of the digastric muscle, on the right side only. The duct leaves the inner surface of the gland, $\frac{3}{4}$ inch behind the apex, passes outside the central tendon of the digastric muscle (*i. e.* between it and the ramus of the jaw), then crosses beneath it and runs forward, surrounded by the long sublingual gland (3 inches in length), to open quite at the fore part of the floor of the mouth, beneath one of the before-mentioned papillæ, $\frac{1}{4}$ of an inch behind the incisor teeth.

The tonsillar glands open by a pair of large distinct orifices, one in front of the other in the usual situation, without any elevation. The œsophagus is lined with very dense epithelium thrown into longitudinal rugæ.

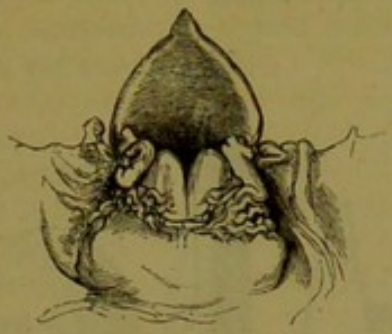
The larynx did not appear to present any thing specially to distinguish it from that of other Deer. The epiglottis (fig. 3) is triangular, with a pointed apex†.

* The arrangement of the circumvallate papillæ thus agrees with the *Cervidæ*, and differs entirely from that of *Tragulus* and *Hyomoschus* (see P. Z. S. 1867, p. 955).

The tongue of the Pudu is rather shorter and thicker than that of the Musk-Deer, and not so spatulate at the anterior extremity. The papillæ are similarly arranged; but the fungiform are more conspicuous, especially on the intermolar elevation; and in the middle of the tongue, near the front, they are conical and recurved, though at the apex and sides perfectly circular in outline.

† In the Pudu the epiglottis has a rounded free border. In the Wapiti it is bifid.

Fig. 3.



Epiglottis and opening into larynx, natural size.

The thyroid body is much flattened and oval and of very loose texture, extending from the top of the first tracheal ring to the bottom of the eighth, 0″·8 long and 0″·4 across at the thickest part.

The number of rings in the trachea, above the part where the branch to the upper right lobe of the lung is given off, is 49, between this branch and the bifurcation 11; total 60*. Some of the rings are single at one side and bifurcated at the other; thus the third ring is single on the left and double on the right side, and the succeeding ring has the opposite arrangement. These double rings have been counted as two in the enumeration given above.

Thoracic Viscera.

The hinder margin of each lung is entire. The lower lobes are nearly equal in size (the left slightly the largest), of the usual triangular form, being divided off from the rest of the organ by a nearly horizontal fissure, which does not extend quite to the root of the lung behind, though further on the right than the left side. Near the upper part of the inner border of the right lobe, attached by a narrow neck, is the so-called "azygos lobe" (fig. 4, *A*) deeply fissured on its anterior surface.

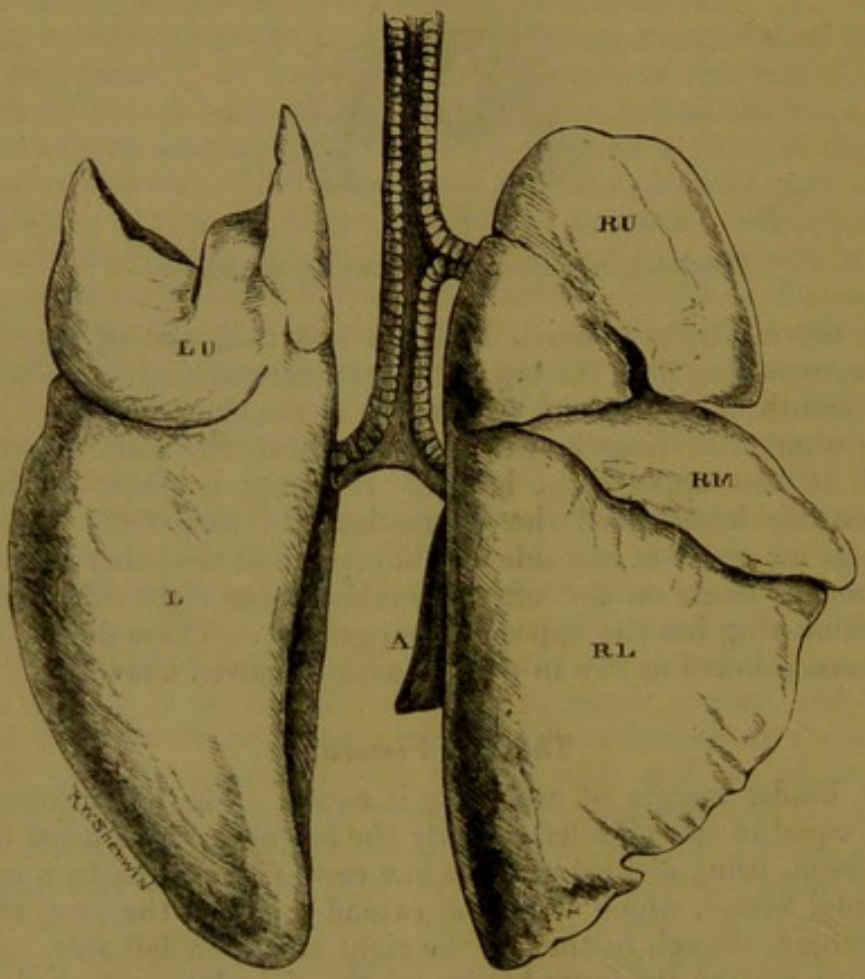
Above the horizontal fissure the arrangement on the two sides is very different. On the right side there are two distinct lobes, the cleft between them extending almost to the root of the lung; the upper one (*R U*) roughly triangular, with the apex upwards and supplied with air by the upper branch of the trachea. It is constricted across its middle into an upper and lower portion. The lower one, or middle right lobe (*R M*), is tongue-shaped, with its apex directed forwards, and while connected at its base with both the upper and lower lobes, it receives its main supply of air from a branch from the principal right bronchus.

The upper portion of the left lung consists of a single lobe (*L U*), but with a short cleft on its anterior border, dividing it partially into a long, narrow, tongue-shaped, inferior portion, with the apex projecting forwards and corresponding to the middle lobe of the right side

* In the Pudu the number of rings of the trachea is almost exactly the same as in *Moschus*. I counted fifty above and ten below the upper right bronchus.

(though rather smaller), and an upper triangular portion, very much smaller than the right upper lobe*.

Fig. 4.



The lungs, posterior aspect; half natural size.

LU, left upper lobe; *L*, left lower lobe; *RU*, *RM*, and *RL*, right upper, middle, and lower lobes; *A*, azygos lobe.

The heart (fig. 5) is an elongated cone in form, measuring $2\frac{1}{2}''$ in length, $1''{\cdot}9$ from side to side at greatest breadth, and $1\frac{1}{2}''$ from before backwards when undistended.

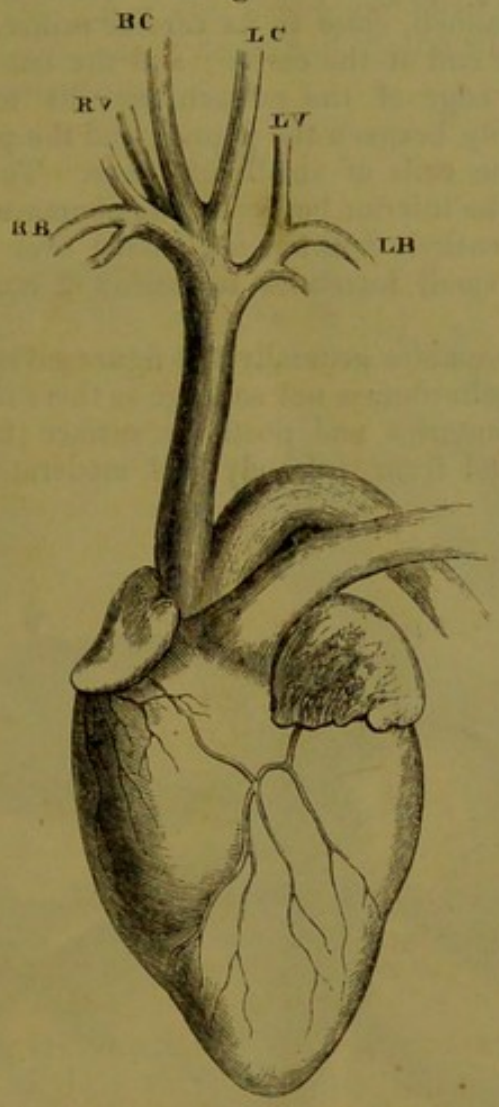
A single common anterior arterial trunk is given off from the aorta at its commencement. After a course of $1''{\cdot}3$ in length, and having a diameter of $0''{\cdot}27$, this gives off the left brachial (*L B*) from which the left vertebral is derived (*L V*). About a quarter of an inch beyond, the right brachial (*R B*) comes off; and immediately after, the trunk bifurcates into the two common carotids (*R C* and *L C*). The right vertebral (*R V*) is given off from the innominate trunk behind the origin of the right subclavian †.

* The lungs of the Pudu have the same general arrangement as those of *Moschus*; but the right middle lobe is very little divided from the right lower.

† In the Pudu, the anterior aortic trunk proceeds for $0''{\cdot}9$, then gives off the left brachial, then after a further course of $0''{\cdot}5$ gives off the right brachial and

Measurements of the red corpuscles of the blood gave an average diameter of $\frac{1}{7000}$ of an inch, or about the same as those of the Brocket-Deer (*Cervus nemorivagus*), and considerably larger than those of any *Tragulus* yet examined*.

Fig. 5.



The heart and origin of the great arteries, two thirds natural size.

R B, right brachial; *R V*, right vertebral; *R C*, right carotid; *L C*, left carotid; *L V*, left vertebral; *L B*, left brachial.

Abdominal and Pelvic Viscera.

The dissection of the abdominal viscera was somewhat interfered with by the extensive peritonitis which had prevailed shortly before death, all the intestines being glued together by effusion of lymph. On opening the cavity the liver was found to be entirely concealed

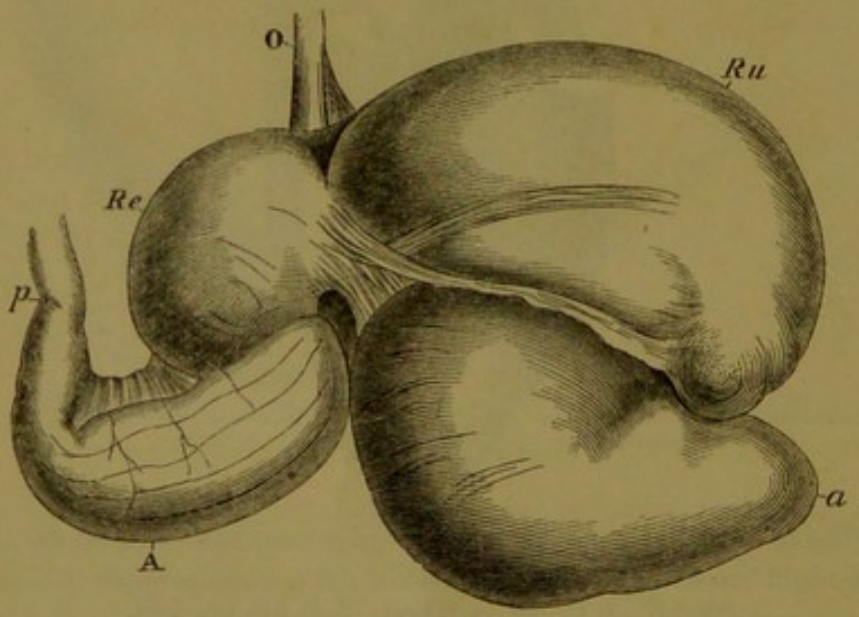
continues for a shorter distance before it bifurcates into the carotids. The vertebrals are given off from the brachials before the internal mammary. The arrangement, therefore, is the same in principle as in the Musk.

* See G. Gulliver, "On the size of the Red Corpuscles of the Blood of *Moschus*, *Tragulus*, &c.," P. Z. S. 1870, p. 92.

beneath the cartilages of the right ribs, scarcely passing beyond the middle line. Next appeared a small portion of the abomasus emerging from beneath the edge of the liver and passing across to the left side. Beyond this and occupying all the middle part of the cavity from side to side was the large paunch, extending to within 4½ inches of the symphysis pubis. The spleen, attached along the left side of the paunch, close to its cardiac orifice, could be seen at the diaphragmatic end of the cavity; and the left kidney projected from behind the edge of the paunch near its hinder end. The portion of the cavity between the paunch and the pubis was filled up superficially by the coils of small intestines. The great omentum descending from the inferior border of the abomasus, extremely thin and delicate and entirely without fat, passed over the right side of the paunch and small intestines to within 2 inches of the symphysis pubis.

The stomach resembles generally the figure given of it by Pallas, except that the psalterium is not so large as there represented. The drawings of the anterior and posterior surface (figs. 6 & 7), taken after it was removed from the body and moderately distended, are

Fig. 6.



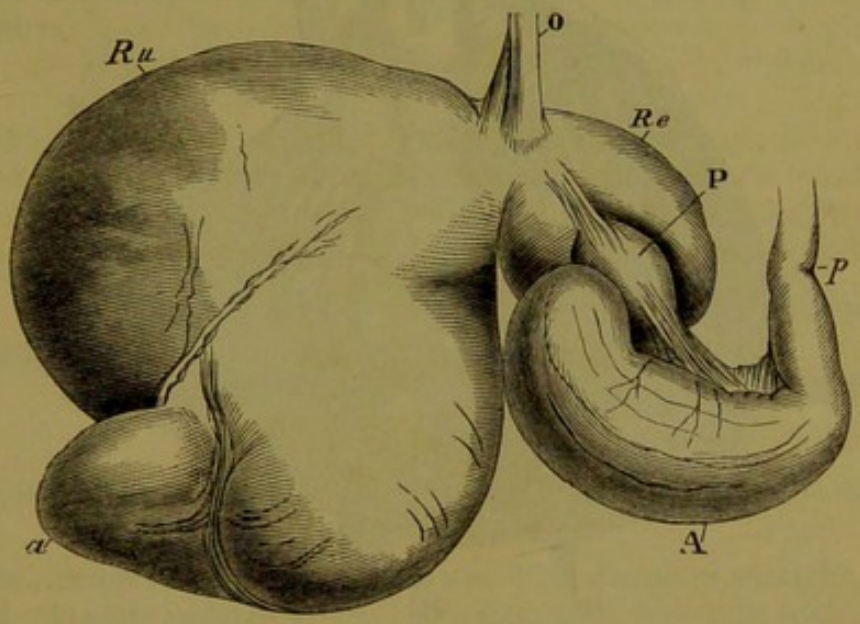
Anterior or ventral aspect of the stomach, one fourth natural size.
O, œsophagus; *Ru*, rumen; *a*, its distal apex; *Re*, reticulum; *A*, abomasus; *p*, pylorus.

more correct. The coats of the organ throughout are very thin compared with those of other ruminants which I have examined. How far this might have been an individual peculiarity, or a consequence of the morbidly emaciated state of the animal, I do not know.

The *rumen*, or paunch (*Ru*), is about 8 inches in transverse diameter. It has the usual form, divided by an oblique constriction

into an upper and lower cavity; or perhaps it can be more correctly described as an elongated conical pouch, folded sharply on itself in a sigmoid manner, with constrictions projecting into the interior, at the inner bends of the folds. The lowest constriction, situated on the left border of the organ, is deep, and the projecting pouches above and below it very distinct; and their apices, having different directions, cross each other, the upper one projecting forwards, and the lower or larger one (the fundus or distal end of the whole cavity, figs. 6 & 7, *a*) turning backwards.

Fig. 7.



Posterior or dorsal aspect of the stomach, one fourth natural size.
O, œsophagus; *Ru*, rumen; *a*, its apex; *Re*, reticulum; *P*, psalterium; *A*, abomasus; *p*, pylorus.

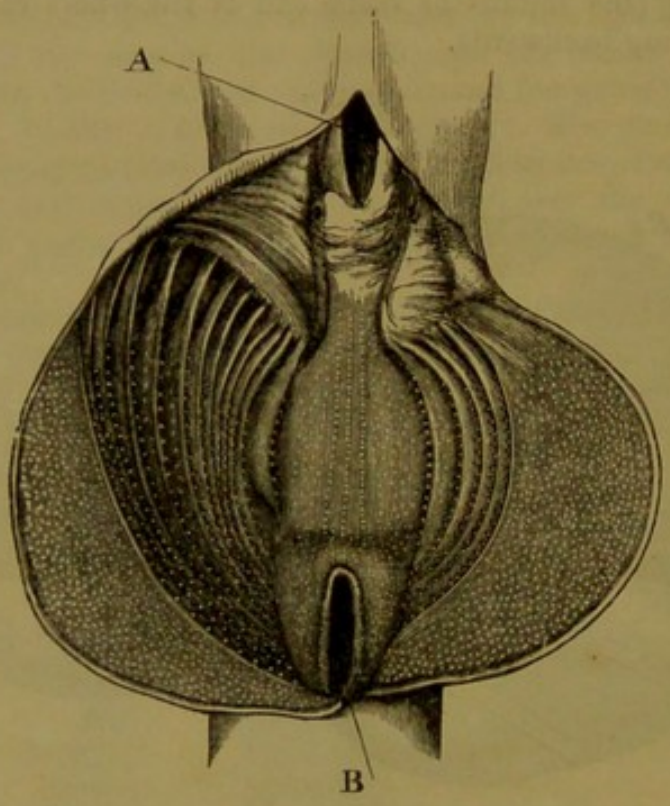
The villi lining the interior of the rumen are slender and cylindrical and very slightly clavate. They nowhere exceed 0″·15 in length, and are largest at the anterior and lower part of the upper pouch. As usual, they are exceedingly short, though not absent, on the edges of the projecting ridges, and over certain points become very fine and sparsely scattered, as on the posterior surface, a little way above and below the constriction, in two rather distinct patches at each place, and more especially at the apex of the lowest or terminal pouch. On the middle of the anterior surface, immediately above the constricting band, where this is subsiding at its left extremity, is a small oval orifice, $\frac{1}{10}$ inch long, placed transversely, leading into a little (apparently) glandular pouch in the walls of the stomach. The diminished size and concentric arrangement of the villi immediately around this opening evidently show that it is a natural structure.

In the *reticulum* (*Re*), the ridges enclosing the polygonal spaces

are extremely shallow; they, as well as the intermediate spaces, are thinly beset with small sharp-pointed papillæ.

The *psalterium* (*P*) is externally 1″·7 long and 1″ wide, of the usual flattened oval or, more properly, kidney-shaped form. It contains within (fig. 8) nineteen deep crescentic lamellæ, symmetrically

Fig. 8.



The interior of the psalterium, longitudinally opened along the anterior surface, natural size.

A, the opening from the œsophagus; *B*, the orifice leading to the abomasus.

arranged, the largest, or those at the centre of the free convex border of the cavity, ½ an inch in height, their free edges all projecting equally, and, unlike those of Ruminants generally, without any intermediate shorter lamellæ. The lateral surfaces and edges of the lamellæ are thinly covered with small conical tubercles; but the bottom of each interspace is quite bare. This cavity communicates with the next by a distinct circular orifice ·3″ in diameter*.

The *abomasus* (figs. 6 & 7 *A*) is of quite the usual form. Its lining membrane presents parallel, narrow, but much elevated, longi-

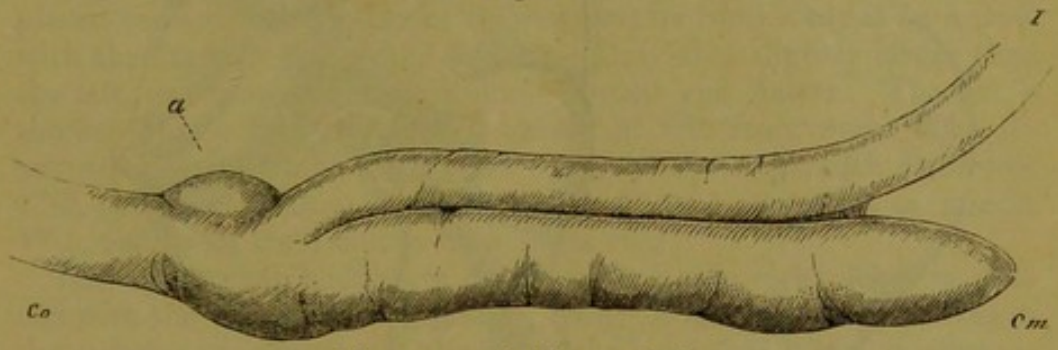
* The description of the psalterium of the Musk-Deer by Pallas differs so much from the one given above, that I think it is desirable to insert it here, that the attention of future observers may be directed to the subject.

"*Psalterium* reniforme, chymo sicco suffertum et durum in omnibus inveni. Intus foliatum est, *lamellis* totius cavi fere latitudinem occupantibus, lunatis, 23 ad 25, præter accessorias plicas exiguas. Laminæ omnes duriusculæ, punctis acutissimis utrinque scabræ, ut triturantes diceres, solis cornibus extremis glabræ; cæterum confertim parallelæ, chymo sicco incrustatæ. Inter majores laminas rugæ intercalares, vel lamellulæ accessoriæ angustiores."

tudinal ridges or folds, about twelve in number, beginning at the fundus (which projects beyond the opening from the psalterium) and gradually subsiding towards the pylorus*.

The small intestine was of nearly uniform diameter, ·4″ inch, when filled with water, and when unravelled 23 feet in length. The colon, when disengaged from its spiral coils, was 13 feet in length, making a total intestinal length of 36 feet, or about thirteen times the length of the animal from snout to root of tail. The colon, commencing at 1 inch in diameter, gradually and slightly increased for the space of 3 feet, then contracted rather suddenly to about half that diameter, and so continued until 2 feet from its termination, where it gradually dilated into a capacious rectum. Its walls throughout were thin and smooth†.

Fig. 9.



The cæcum, half natural size.

I, ileum; *Co*, colon; *Cm*, apex of cæcum; *a*, glandular pouch at commencement of colon.

The cæcum (fig. 9) was 6″ long and $\frac{3}{4}$″ in diameter, straight, cylindrical, obtusely pointed at the extremity, with very thin coats. The ileum enters very obliquely and is bound closely to it by a mesenteric

* The stomach of the Pudu, in general form and in the size of its compartments, both absolute and relative, closely resembles that of the Musk-Deer; but its walls are considerably thicker and its epithelium lining more developed. In the *rumen* the villi are not only longer but thicker and more distinctly clubbed, so that they lie close together, completely concealing the intermediate surface from which they grow, which is not the case in the Musk-Deer. In the *reticulum* the divisions between the spaces are nearer together, more pronounced, and beset with more numerous and coarser papillæ. The *psalterium* is almost of exactly the same size as in the Musk-Deer, but differs greatly in structure, inasmuch as the lamellæ (as in most Ruminants) are of two kinds, large and small alternating; indeed, in the interspaces are very short ridges, which might be said to constitute a third or smallest order of lamellæ. Excluding the latter, the lamellæ are altogether of the same number (19) as in the Musk. In accordance with the general character of the lining membrane of the stomach, the papillæ covering them are larger and coarser than in the latter. The *abomasus* differs in the greater thickness of its lining membrane, and the irregularity or even reticulating character of the ridges.

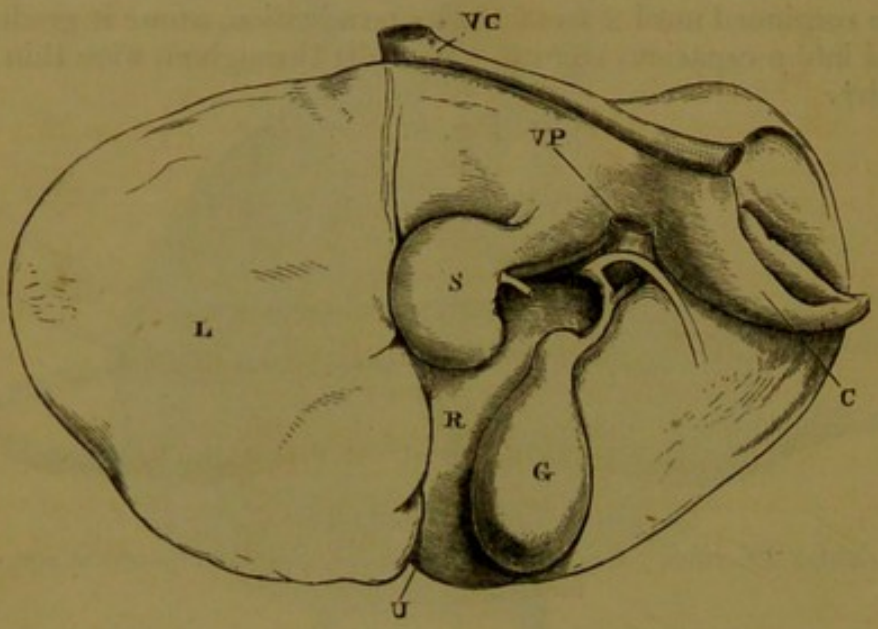
In a *Gazella dorcas* dissected at the same time, the *psalterium* was rather smaller than in the Musk, and its lamellæ less developed, being smaller and somewhat irregular, but without any distinct alternation of small and large plates. The bottom of the intermediate surface, as well as the sides and edges of the plates, were covered with pointed papillæ.

† The colon of the Pudu forms a very simple helicine coil, composed of two complete circles in one direction and of two in the other.

band to within an inch of its termination. The attached border of the colon immediately beyond the ileo-cæcal valve has an oval dilatation, 0″·8 in length and 0″·6 in breadth, with thickened glandular walls, which Pallas compares to the similar but more marked glandular dilatation in the *Leporidæ*, and which, as he says, he has observed in no other ruminant*.

The pancreas is flat, broad, of irregular outline, and of loose texture.

Fig. 10.



Under surface of liver, half natural size.

L, left lobe; *R*, right lobe; *S*, Spigelian lobule; *C*, caudate lobe; *VC*, vena cava; *VP*, vena portæ; *G*, gall-bladder; *U*, umbilical fissure.

The liver (fig. 10) presents the usual simple form of that of the Ruminants†. Its general outline is an irregular oval, 6″·2 in extreme breadth and 3″·7 in depth. Its diaphragmatic surface shows only the well-marked umbilical fissure about an inch in depth, and dividing it into right and left segments, of which the former does not greatly exceed the latter in size. Extending from the bottom of the fissure to the posterior or attached border, the delicate suspensory ligament (so often completely atrophied in Ungulates) is distinctly seen. There are no traces of lateral fissures. On the under surface the left lobe is simple, with a thin nearly semicircular free edge. The right is much thickened at its posterior border, and has attached to it very distinct Spigelian and caudate lobes. The former, represented in most Ruminants by a mere smooth tract, has attached to it a flattened quadrate

* In the Pudu the cæcum is not quite so long and of greater diameter than in *Moschus*, being 5″ in length and 2″ in breadth. It has the usual obtusely ended cylindrical form, and wants the dilatation at the commencement of the colon observed in the Musk.

† See "Lectures on the Comparative Anatomy of the Organs of Digestion of the Mammalia," Medical Times and Gazette, Sept. 21st, 1872.

lobule, connected with the rest of the lobe by a narrow neck arising from its right anterior corner and overhanging the portal fissure. The caudate lobe is narrow, tongue-shaped, with its pointed tip extending just beyond the border of the right lobe. There is no cystic fissure on the edge of the lobe, but a very well-marked fossa on its surface, in which lies a wide pyriform gall-bladder, the form of which and the arrangement of the hepatic and cystic ducts are shown in the figure. The common bile-duct, after a course of 2 inches, passes, somewhat dilated, for ½ inch through the intestinal wall and opens by a wide aperture guarded by a semilunar fold*.

The spleen is attached to the left side of the paunch, close to the cardiac orifice. It is much flattened, 3½″ long and 2″ broad, obtusely pointed at its upper and truncated at its lower end†.

The kidneys are simple and smooth externally. The right kidney is placed so much in advance of the left that its hinder end is on a level with the anterior end of the former. It is also slightly larger than the left, and more regularly kidney-shaped and flatter. The left is thicker from before backwards, narrow at the front end. The dimensions of the right kidney are—length 1″·85, breadth at middle 1″·2, thickness 0″·95; of the left—length 1·75″, breadth at middle 1″·1, thickness from before backwards 1″·1.

The suprarenal bodies are close together, the right being in contact with the corresponding kidney, lying on its inner border between the anterior extremity and the hilus, the left being ¾ inch in advance of the left kidney. Each body is flattened, oval, or somewhat reniform, about 0″·5 long and 0″·3 broad; the left slightly larger than the right‡.

The ovaries are small, flattened, pisiform bodies, 0″·25 in greatest diameter. The vagina and uterus have the usual characters seen in unimpregnated female Ruminants §.

* The liver of the Pudu is slightly smaller than that of *Moschus*; it is more extended transversely, and differs mainly in the greater size and more quadrate form of the caudate lobe, the total absence of any pedunculated Spigelian lobule (as in most if not all other Deer), and the absence of a gall-bladder. There is no suspensory ligament.

† The spleen of the Pudu is much flattened and of nearly circular outline, though rather narrower and thicker at the upper than the lower end. Its diameter averages 3 inches.

‡ The kidneys and suprarenal bodies of the Pudu closely resemble those of the Musk in form and situation.

§ According to Pallas, the male Musk has Cowper's glands, and a small filiform termination (6 lines in length) to the glans penis.

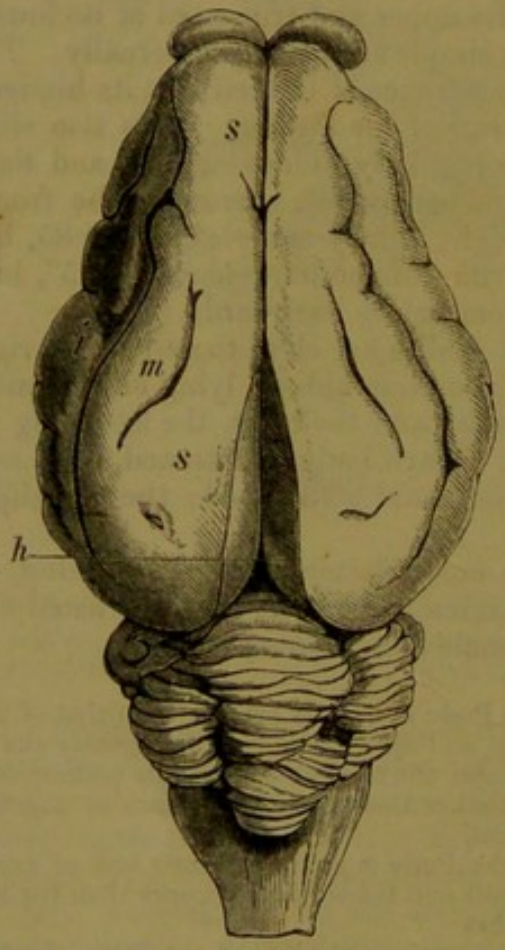
In the Pudu the vasa deferentia are enlarged and flattened for the last inch of their course, attaining a width of a quarter of an inch. The prostate consists of two nearly globular lobes, each of about the size of peas, and a smaller middle lobe placed at the union of the vasa deferentia. The walls of the "membranous urethra" are very thick. Contrary to what obtains in Deer generally, there is a pair of Cowper's glands with a thick muscular covering, also about the size of peas, but somewhat flattened and triangular in outline. The penis is large and thick, and the glans fleshy and conical, without any terminal prolongation.

It may be mentioned that in *Hyomoschus*, Cowper's glands are well developed. the penis is long and slender, and, as in Pigs, has a spiral or corkscrew-like termination.

The Brain.

The brain presents the usual characters of that of an ordinary Deer (*Cervus mexicanus*, Mus. Roy. Coll. Surg. no. 1328 E *a*, was the species with which I compared it most closely), but, in accordance with its smaller size, much reduced in complexity of surface indentations. A natural group like the *Cervidæ*, containing animals varying much in dimensions, is well adapted to demonstrate how closely the amount of convolution bears relation to the bulk of the hemisphere, the primitive pattern being exactly the same in all. The

Fig. 11.



Upper surface of brain, natural size.

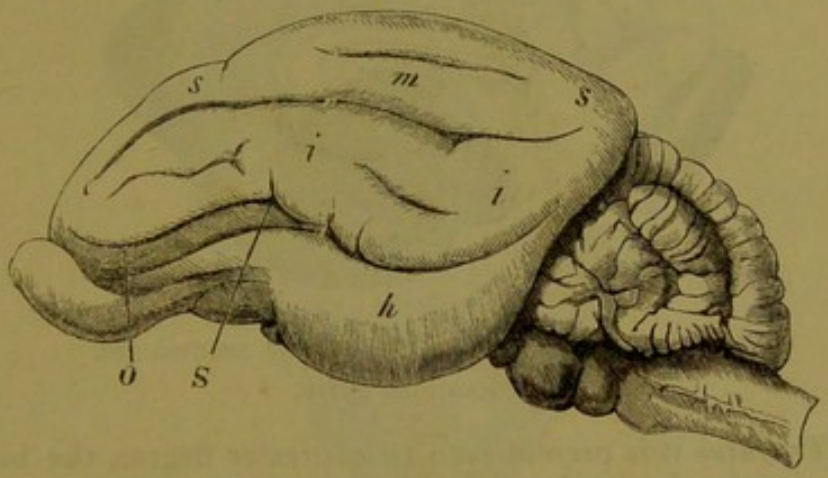
s s, superior external gyrus; *m*, middle external gyrus; *i*, inferior external gyrus; *h*, hippocampal gyrus.

brain of *C. tarandus* (Mus. Roy. Coll. Surg. no. 1328 E) is far more abundantly supplied with secondary surface-windings (even so as very much to obscure the general outline of the pattern) than is that of *C. mexicanus*. The latter and *C. dama* (Leuret & Gratiolet, 'Anat. Comp. du Système Nerveux,' pl. x.) are almost exactly alike. *C. capreolus* (ibid.) is more simple, and *Moschus moschiferus* still more so.

The most obvious division of the external surface of the hemisphere is into three longitudinal tracts. The lowest (*h*), continued from the

olfactory bulb in front, dilates to form the smooth "temporal lobe," and, curving upwards and inwards, appears on the internal surface of the hemisphere, and passes above the corpus callosum to the anterior extremity of the organ. In this part of its course it is bounded above by the "calloso-marginal sulcus" (Huxley). This gyrus I have previously spoken of as "hippocampal," because the hippocampus major is formed by the sulcus on its concave surface*. Above this, and separated from it by a very distinct horizontal sulcus, is a broad tract (*i*), extending from the front to the back of the brain, of nearly equal width throughout. Rather in front of the middle of this is

Fig. 12.



External surface of brain, natural size.

s s, superior external gyrus; *m*, middle external gyrus; *i i*, inferior external gyrus; *h*, hippocampal gyrus; *S*, Sylvian fissure; *O*, supraorbital sulcus.

the very insignificant Sylvian fissure (*S*), anterior to which a longitudinal sulcus (*supraorbital*, *O*) marks off, as in the Carnivora, a narrow strip, the supraorbital gyrus of Leuret, which in *Proteles* appears to be the reflected commencement of the superior gyrus, but in the Deer looks more like a dismemberment of the inferior outer convolution.

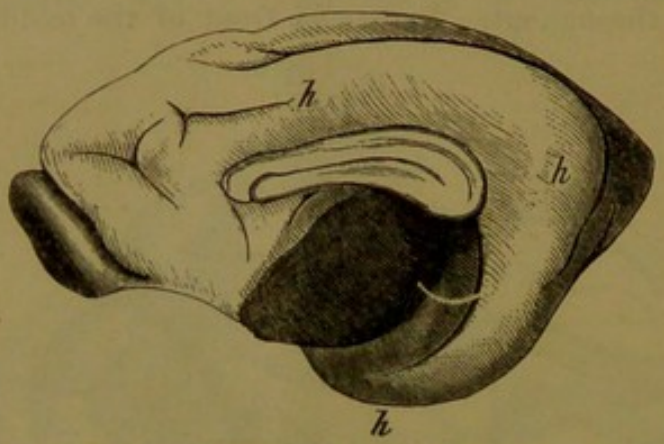
The remainder of the outer surface of the hemisphere is occupied by a tract, broad behind and narrow in front (*s m s*), extending the whole length of the hemisphere. In the simpler form of brains of the group this might be considered a single convolution; but already in *Moschus* a longitudinal fissure towards the posterior end separates two tracts, which become so marked in the larger species that Leuret considers them two distinct gyri (*s* and *m*). However this may be, they always become confluent towards the anterior part of the brain.

As regards the convolutions, then, the brain of *Moschus* is essentially a simplified (because small) Deer's brain. There is, however, one point of importance in which it differs from the other Deers' brains examined; and that is the very high position of the calloso-marginal sulcus, which in its posterior half becomes visible on the

* "Anatomy of *Proteles*," P. Z. S. 1869, p. 479.

upper surface of the brain, together with a narrow strip (fig. 11, *h*) of the internal or hippocampal gyrus. In the Mexican Deer the sulcus certainly rises quite to the upper edge of the internal surface of the hemisphere; but neither in this species nor in the Roe (according to Leuret's figure) is any part of the hippocampal gyrus exposed near the middle line. What makes this character interesting is

Fig. 13.



Internal surface of cerebral hemisphere, natural size.
h, hippocampal gyrus.

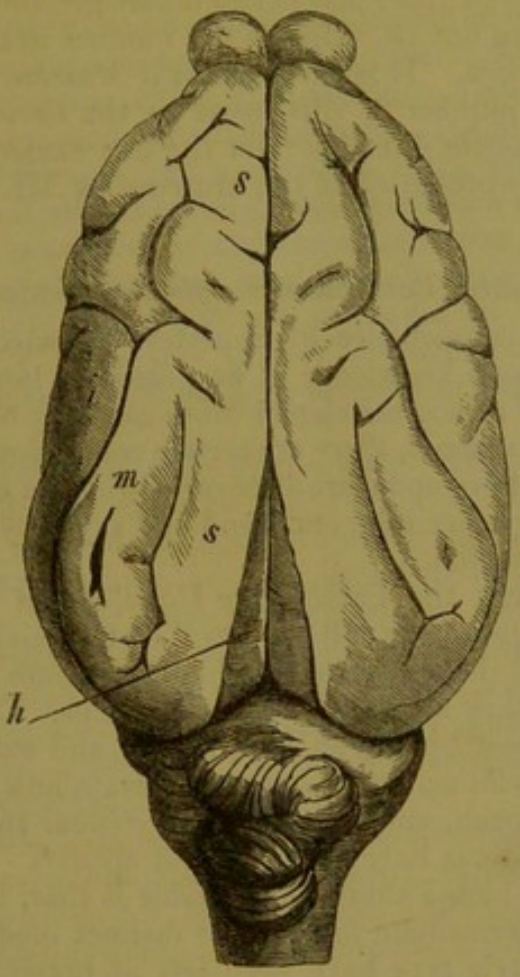
that in *Tragulus* it is present even to a greater degree, the hippocampal gyrus bordering the posterior half of the great longitudinal fissure forming a prominent feature in the upper surface of the brain. In other respects the brain of *Tragulus*, as far as its surface-markings are concerned, is a simplified miniature of that of the *Cervidæ*. The inferior external longitudinal convolution is distinctly marked from the superior; but the latter has scarcely a trace of a division into two, though at first sight the abnormal position of the calloso-marginal sulcus might be taken for one. Whether this is any special evidence of affinity between *Moschus* and *Tragulus*, cannot be decided until the brains of other small species of *Cervidæ* have been examined. In the mean time, I can only point it out and await future opportunities of investigation. The comparison of cerebral convolutions as evidence of affinity is a subject in which, without very careful or extended research upon ample materials, the investigator is apt to be led astray, but one which, under favourable conditions, may lead to valuable results*.

* The opportunity of examining the brain of the Pudu Deer has afforded the means of solving the question stated above. It is slightly larger, both relatively and absolutely, than that of the Musk, as the following dimensions show:—

	Moschus moschiferus ♀.	*Cervus humilis* ♂.
	in.	in.
Length of skull from front of præmaxillæ to occipital protuberance	6·1	5·8
Length of cerebral hemisphere	2·1	2·4
Greatest breadth of cerebral hemispheres	1·7	1·8

It is chiefly distinguished by the greater breadth of the frontal lobes (see

Fig. 14.



Upper surface of brain of Pudu Deer (*Cervus humilis*), natural size.
Letters as before.

The Skeleton.

The skeleton of *Moschus* has been described by A. Milne-Edwards, though somewhat briefly except as regards the skull. I will only add a remark upon the number of the ribs. He says:—"D'après Pallas, le nombre des paires de côtes varierait de 14 à 15; tandis que chez les Cerf leur nombre est ordinairement de 13, bien qu'on trouve (chez le Renne, par exemple) parfois 14." In the skeleton which

fig. 14); the general arrangement of the sulci is the same; but they are somewhat more complex, almost equalling in this respect those of the Roe. It differs, however, from the latter (if Leuret's figure can be trusted) in the greater breadth of the anterior part of the superior gyrus, and especially in the appearance of a considerable-sized strip of the internal or hippocampal gyrus on the upper surface of the hemisphere bordering the hinder part of the great longitudinal fissure, exactly as in the Musk-Deer. This character thus forms no special approximation to the *Tragulina* in the last-named animal, but is probably common to all the smaller *Cervidæ*. The chief characteristics of the brain of the Musk, as distinguished from the other members of the family to which it belongs, are the simplicity of the surface-markings and narrowness of the anterior lobes—indications of a lower or more primitive type.

has been so long mounted in the Museum of the College of Surgeons there are certainly 14 ribs; but in two others presented by Mr. Bryan Hodgson there are but 13, which is the number in the female subject of the present notice. It is curious that if *Moschus* sometimes varies in excess of the number of ribs usual to the *Cervidæ*, *Hydropotes* differs in the opposite direction; for the fine skeleton of a male of that species lately presented to the Museum by Mr. Swinhoe has but 12 pairs.

Systematic Position and Affinities of Moschus.

Although, in consequence of imperfect knowledge or imperfect reasoning upon such knowledge as we possess, a large portion of our present system of zoological classification can only be looked upon as tentative and provisional, there are certain conclusions which we have good reason to believe no future discoveries will ever change, and upon which we can therefore take our stand and say they are questions of fact and not of opinion.

One such is that the Paridigitate Ungulates of Cuvier (the ARTIODACTYLA of Owen, the "Bisulques" of Gervais) form a definite natural group, all the members of which are more nearly related to each other than they are to any other mammals. Of no large group do we know the past history so thoroughly; and our knowledge of it has enabled us to fill up almost every important link since the middle of the Eocene epoch, and to show the gradual steps by which its different modifications have been brought about*.

Another fact which I think indisputable is that, by the extinction of the various intermediate forms, four distinct modifications of the original Artiodactyle type have been left at present inhabiting the earth's surface, which are the *Suina* (including the Pigs and Hippopotamus), the *Tylopoda*† (the Camels and Llamas), the *Tragulina*‡ or Chevrotains, and the true Ruminants (called also *Pecora* and *Cotylophora*).

* Our present state of knowledge on this subject has been very ably and ingeniously expounded by Dr. W. Kowalevsky in his "Monographie des genus *Anthracotherium*, Cuv., und Versuch einer natürlichen Classification der fossilen Hufthiere," Palæontographica, xxii. 1873. An abstract will be found in a paper by the same author "On the Osteology of the *Hyopotamidæ*," Proc. Roy. Soc. vol. xxi. p. 147, 1873.

See also W. H. Flower, "On Palæontological Evidence of Gradual Modifications of Animal Forms," Proceedings of the Royal Institution of Great Britain, April 25th, 1873.

† Illiger, 'Prodromus,' 1811. *Phalangigrada* and *Digitigrada*, proposed subsequently, have no advantage over the earlier name.

‡ The known members of this group, constituted of the genera *Tragulus* and *Hyomoschus*, are so closely allied as to form a single family, which, according to the most convenient rules of zoological nomenclature, would be called *Tragulidæ*; but I use the above termination as implying that they constitute a zoological division of more than family importance, equivalent, in fact, to the three others mentioned above. Although the French word *Chevrotain* and the Latin *Tragulus* may have had originally nothing to do with these animals, it is very desirable, in default of any better designation, to keep them for their exclusive use, and never for the future to allow such unfortunate expressions as "Pigmy Musk-Deer" to remain to convey false notions of zoological affinities.

Any system of classification which ignores these facts cannot pretend to be founded upon the teaching of nature.

There has scarcely been a more troublesome and obdurate error in zoology than that which, based on the observation of certain comparatively unimportant external characters, placed the *Tragulina* and *Moschus* in one and the same genus*. It has been troublesome not only as preventing a just conception of the relations of existing Artiodactyles, but also in causing great confusion and hindrance in palæontological researches among the allied forms; and most obdurate, inasmuch as all that has been recently done in advancing our knowledge of both groups has not succeeded in eradicating it, not only from nearly every one of our zoological text-books, either British or continental, but even from works of the highest scientific pretensions.

In the admirable memoir of Adolphe Milne-Edwards already referred to, which contains so much solid information about the Musk-Deer and the *Tragulina*, and in which the distinctions between them are so clearly pointed out, the influence of the old traditions prevailed; and in his final revision of the order of Ruminants (p. 118) the *Tragulidæ* constitute only one of the families of the suborder Unguligrada, the *Moschidæ*, *Cervidæ*, *Antilopidæ*, *Capridæ*, *Bovidæ*, and *Girafidæ* (so far more closely allied to one another) being the others, while the Camels are separated as a distinct suborder, Phalangigrada.

In a later work, however, published by the same eminent zoologist in conjunction with his illustrious father ('Recherches pour servir à l'histoire naturelle des Mammifères,' 1868), in the preliminary sketch of the classification of the Mammals, a complete reformation is made, *Moschus* being included among the *Pecora* or ordinary Ruminants, while the "*Chevrotains proprement dits*" constitute an order apart, called "*Tragulides*," placed between the former and the "*Pachydermes bisulques*."

Whether or not we give the term "order" to these groups† matters less than that we recognize their natural character, and feel satisfied that the wide separation thus made between animals formerly thought to be so closely allied is justified by our increased knowledge of their structure. I will therefore endeavour, more fully than has hitherto been done, to give the reasons upon which this view is based, which will be the first step necessary for defining the position of *Moschus*.

* *Moschus* and *Tragulus*, previously used as synonyms, were first separated by Dr. J. E. Gray, in 1836 (P. Z. S. vol. iv. p. 63), as sections or subgenera of the genus *Moschus*; but the importance of their distinguishing characters was not recognized, as *Memminna* was made another section of equal rank. Pucheran first proposed to place *Tragulus* in a family apart from *Moschus*, chiefly on account of the different structure of the stomach ("Monographie des espèces du genre Cerf," Compt. Rend. de l'Acad. des Sciences, 1849, t. xxix. p. 773, and Archives du Muséum, 1852, t. vi. p. 285).

† I think myself that this application of the term is hardly consistent with its general use among the other Mammalia, and that "suborder" would be preferable.

In the following characters *Moschus* agrees entirely with all the *Pecora* and differs from the *Tragulina*.

1. The placenta is cotyledonous*, whereas in the *Tragulina* it is diffuse, as in the *Suina* and *Tylopoda*.

2. There is a complete psalterium or third cavity to the stomach.

3. The left brachial artery arises from a common innominate trunk, instead of coming off separately from the aortic arch as in *Tragulina*, *Tylopoda*, and *Suina*†.

4. The odontoid process of the second cervical vertebra is in the form of a crescent hollow above, instead of being a conical tuberosity as in *Tragulina* and *Suina*.

5. The auditory bulla is simple and hollow within, instead of being filled with cancellated tissue as in *Tragulina*, *Tylopoda*, and *Suina*.

6. The outer metacarpal and metatarsal bones are rudimentary, and do not extend the entire length of the middle metacarpal and metatarsals.

7. The distal extremity of the fibula is represented by a distinct malleolar bone of peculiar shape, articulating with the outer surface of the lower end of the tibia‡.

8. The molar and premolar teeth of *Moschus* are truly Cervine, though more compressed throughout the series than in most Deer. In consequence of this, the first upper premolar has the inner crescentic lobe but little developed; but its presence can be distinctly seen in specimens that are not much worn, and there is no tendency to that great disparity of breadth between the two anterior premolars and the true molars seen in the *Tragulina*, whose teeth retain much of the old *Xiphodon* type§.

It is scarcely necessary for the present purpose to enumerate numerous minor osteological characters (many of which are pointed

* For a description of the placenta of *Moschus*, we are indebted to Pallas (*loc. cit.*).

† The only recorded exception to the ordinary origin of the left brachial artery in the *Pecora* is in the Giraffe, where Prof. Owen found that the arch of the aorta, after distributing the vessels to the heart itself, gives off first a large innominate, which subdivides into the right vertebral artery, the right brachial artery, and the common trunk of the two carotids, secondly the left brachial artery, thirdly the left vertebral artery (Trans. Zool. Soc. vol. ii. p. 229). But Joly and Lavocat describe, in the Giraffe dissected by them, a common innominate trunk (or anterior aorta) as in the Ruminants generally, giving off both brachials and carotids ("Recherches sur la Giraffe," Mém. Soc. d'Hist. Nat. de Strasbourg, t. iii. 1845, p. 103); and Prof. A. H. Garrod informs me that the same distribution of the great vessels occurred in two specimens which he had examined.

‡ In *Tragulus* the upper part of the fibula is present as a long slender style, but the lower end ankyloses at an early age with the tibia. The latter is the case with *Hyomoschus crassus* and *H. aquaticus*, according to A. Milne-Edwards; but in a perfectly adult specimen of the last-named animal in the Museum of the Royal College of Surgeons, the malleolar bone is still free, though not of the very characteristic form it possesses in all true Ruminants.

§ In all Deer the first upper premolar has three roots, and the crown is formed by an inner and outer crescent. In *Tragulus* this tooth has but two roots, and a simple compressed crown. In *Hyomoschus*, though the crown resembles that of *Tragulus*, the additional inner root is present. In this respect, as in the condition of the fibula, *Hyomoschus* comes nearer to the Deer than does *Tragulus*,

out in Milne-Edwards's monograph) by which the *Tragulina* differ from the *Pecora*, including *Moschus*; but perhaps the absence of a distinct ridge on the lower end of the metapodium and the form of the lower jaw may be mentioned as examples—the coronoid process being much less elevated, not rising prominently above the zygoma, and the posterior and inferior surfaces presenting an even curve, without a distinct projection at the angle. It may, in fact, be taken for granted that, when animals of the same original type have been so far modified as to differ in so many important characters as have been shown above, the closer the scrutiny of their structure, the more differences in details will be revealed*.

The question of the near affinity of *Moschus* to the *Tragulina* being thus eliminated, I will next proceed to consider its position in the group of which it is really a member.

The *Pecora* or true Ruminants form, as has often been remarked, an extremely homogeneous group, one of the best-defined and closely united of any of the Mammalia. But though the original or common type has never been departed from in essentials, variation has been very active among them within certain limits; and the great difficulty of subdividing them into natural groups (the "despair of zoologists," as Pucheran calls it) arises from the fact that the changes in different organs (feet, skull, frontal appendages, teeth, cutaneous glands, &c.) have proceeded with such apparent irregularity and absence of correlation that the different modifications of these parts are most variously combined in different members of the group. In questions of this kind the absolute certainty of zoological classification referred to above no longer holds, at least in the present state of knowledge, and opinion may be allowed to have sway, and results must be stated with some feeling of doubt and diffidence. It appears, however, extremely probable that the *Pecora* very soon branched into two main types, the *Cervidæ* and the *Bovidæ* (otherwise the antlered and the horned Ruminants), the Giraffe being perhaps an early and since much modified offset of the former—though whether this be the case or whether it be regarded as a third distinct type may be left out of present consideration.

Although by the general consent of all naturalists the two main groups thus indicated are held to be distinct, and although there is no difficulty in separating them by the character of their frontal appendages, it is by no means easy to find further characters universally applicable by which they can be distinguished, and which are necessary in the cases in which such appendages are not developed, as in the animal now under discussion.

It may be said generally that the *Bovidæ* are distinguished from

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while in the form and greater freedom of the inner metacarpal and metatarsal bones it is further removed from them. In both genera the true molars are much less deeply indented by the enamel inflections, and the characteristic "Ruminant" crescent less distinctly defined than in the Deer.

* Dr. J. Chatin has recently described the muscles of the limbs of *Hyomoschus*, and finds, as might have been anticipated, that they differ much from those of the *Pecora* and rather resemble those of the *Suina* ("Observations sur la Myologie de l'*Hyomoschus*," Annales des Sciences Naturelles, 5e série, t. xv. 1872, p. 1).

the *Cervidæ* by the absence of canine teeth, by the absence of distinct metacarpals and phalanges to the outer (second and fifth) digits, by the presence of a gall-bladder, by the single lachrymal canal placed within the margin of the orbit, and by the presence of Cowper's glands. But yet, as will be shown presently, it is doubtful if any one of these characters is exclusively characteristic—that is, may not be found in some member of the other groups.

There is still another character of some importance, derived from the form of the molar teeth. Although there is nothing in the general mode of arrangement of the enamel-folds or in the accessory columns absolutely distinctive between the two groups, existing species can generally be distinguished, inasmuch as the Deer are what may be termed "brachyodont," and the *Bovidæ* "hypsodont"*: *i. e.* the teeth of the former have comparatively short crowns, which, as in most mammals, take their place at once with the neck (or point where the crown and root join) on a level with or a little above the alveolar border, and remain in this position throughout the animal's life; whereas in the other form (the crown being lengthened and the root small) the neck does not come up to the alveolar level until a considerable part of the surface has worn away, and the crown of the tooth thus appears for the greater part of the animal's life partially buried in the socket, and no part of the root is visible. In this form of tooth (which is always most developed in the posterior molars of the permanent series) the constituent columns of the crown are necessarily nearly parallel, whereas in the other they diverge from the neck towards the free or grinding surface of the tooth. In the more completely hypsodont forms, the interstices of the lengthened columnar folds of enamel and dentine are filled up with cementum, which gives stability to the whole organ, and which is entirely or nearly wanting in the short crowned teeth.

The same modifications from low to high crowns without essential alteration of pattern is seen in an even still more marked manner in some of the Perissodactyle Ungulates, where the tooth of a horse bears to that of *Anchitherium* the same relation that that of an ox does to the early Selenodont Artiodactyles.

As the hypsodont tooth is essentially a modification of, and, as it were, an improvement upon, or specialization of, the other, it is but natural to expect that all intermediate forms may be met with; and it is not always easy to decide, especially in old and much-worn teeth, in which group any given example should be classed. Even among the Deer themselves, as Lartet has observed†, the most ancient have very short molars, and the depressions on the grinding-surface are so shallow that the bottom is always visible, while in the *Cervidæ* of the more recent Tertiary periods, and especially the Pleistocene and living species, these same cavities are so deep that, whatever be the state of the dentition, the bottom cannot be seen‡.

* Terms first used, I believe, by Mr. Boyd Dawkins.

† Comptes Rendus, 1868, t. lxvi. p. 1119.

‡ Some existing Deer, as the Axis, are far more hypsodont than the majority of the family; and, on the other hand, many of the Antelopes are far more brachyodont than the more typical *Bovidæ*—Goats, Sheep, and Oxen.

There is, however, little practical difficulty in deciding, by an examination of the molar teeth of any of the existing Ruminants, to which section it belongs; and, judged by this test, *Moschus* is decidedly brachyodont, and thereby resembles the Cervine members of the group, though in some details, as has already been mentioned, it has slight peculiarities of its own.

The best method, however, of testing the claims of *Moschus* to a definite position will be to take *seriatim* all the principal characters in which it shows variation from the average Pecorine type, and consider in which direction they severally tend.

I. The absence of frontal appendages. This is a well-marked external character, but one the significance of which has been much altered by Mr. Swinhoe's discovery of *Hydropotes*, which, although its anatomy is not yet fully known, I think may he safely assumed to be a true Deer. It is certainly less aberrant than *Moschus**.

Even before the existence of other Deer without antlers was known, it might have been suspected that such appendages were really only of secondary importance in a natural system of classification, as they occur among existing Deer in such infinite variety of form and size without correlation with other structural modifications; and as, moreover, palæontology teaches us that Deer (*i. e.* animals having all the osteological and dental characters of the group, as *Dremotherium*) abounded before the antlered forms came into being, it is by no means unreasonable to suppose that some of the recent members of the family might retain this primitive character†.

As one or more species of true Deer are without antlers in either sex, as all (*Tarandus* excepted) have none in the female sex, and as, on the other hand, no *Bovidæ* are known without frontal appendages in the male and nearly all have them in both sexes, it follows that a ruminant, like *Moschus*, wanting these parts is so far more likely to belong to the Cervine than to the Bovine section. The absence of antlers is no indication of special relationship to the *Tragulina* any more than it is to the Camels, Pigs, or any of the early forms of the order.

II. Dentition. The brachyodont character of the molar teeth, as lately mentioned, is some evidence in favour of *Moschus* belonging to the Cervine section, but not by itself conclusive; for even if we knew of no existing Bovine animal in this case, it would be quite possible to conceive of some member of the group retaining a character once common to all.

* The still more recently discovered *Lophotragus michianus*, Swinhoe (P. Z. S. 1874, p. 452), appears to be another Deer without antlers; but very little is yet known of its structure.

† *Dremotherium* is sometimes placed among the *Tragulidæ*, or rather the artificial group in which those animals as well as *Moschus* were included; but in the majority of its dental and cranial characters it was a true Deer, of course somewhat generalized and in so far approaching the *Tragulina*. *Gelocus* was an older form, and retained the four premolars of the more primitive types. They both appear to belong to the stock from which the *Pecora* are descended after the ancestors of the *Tragulina* had branched off from it. The latter, as will be seen in the tabular view of the classification of the group (p. 189), are the lowest and least-modified of all the existing selenodont Artiodactyles.

The incisors are of rather peculiar form, the central being straight and awl-shaped instead of expanded and diverging, as not only in most Deer and Antelopes, but also, in a still more marked degree, in the *Tragulina*. But the Reindeer, as Sir Victor Brooke lately pointed out*, has incisors not unlike those of the Musk; and the same or a closely similar form is not uncommon among the *Bovidæ*. This is rather an absence of specialization than a mark of affinity.

The great development of the upper canine teeth of the male is a remarkable characteristic of *Moschus*, and one on which much stress was formerly laid in separating it from the Deer. Most of the latter, however, have canines; and their great size in the Muntjaks forms a considerable approximation to the condition in *Moschus*. But *Hydropotes* offers a crucial test of the value of this character. This singular genus agrees with *Moschus* in the great size of the canines as well as the absence of antlers (in these cases apparently correlated phenomena). If *Moschus* is to be separated from the *Cervidæ* on the strength of these two most striking external characters, *Hydropotes* must go with it, and the family *Moschidæ* will consist of the two genera *Moschus* and *Hydropotes*†—an arrangement which may satisfy some zoologists; but, as shown by Sir Victor Brooke in his description of the skull of *Hydropotes*, these animals differ greatly in many important respects; in fact, in the form of the base of the cranium, they are as widely removed from each other as are any of the true Deer,—*Moschus*, with its small rugged auditory bulla, resembling the Muntjak and the Roe; while *Hydropotes* has the same part smooth and inflated even in a greater degree than the Axis and Hog-Deer, and more resembling some of the Antelopes. The question of the affinity of these two forms will receive further elucidation when the visceral anatomy of *Hydropotes* is known; but there is at present but little reason for supposing them nearly related.

As it is a very characteristic feature in the *Bovidæ* to have entirely lost the upper canine teeth (very few indeed possessing any, and these always very rudimentary), their presence on such a large scale in *Moschus* is further corroboration to the evidence derived from the molars that it is not intimately allied to that family.

On the other hand, little weight can be attached to this character as showing any very near affinity to the *Tragulina*. The excessive growth of a particular tooth is an instance of specialization, and occurs so often in forms so remotely allied to each other as *Machairodus*, *Trichechus*, &c., that it can only be taken as evidence of relationship between animals otherwise very nearly akin. In the present case it is probably adaptive, and follows the general tendency among all Artiodactyles, Suine as well as Ruminant, to possess either tusk-like canines or frontal appendages, these being, with some notable exceptions, complementary to each other in development. All the early Artiodactyles had canines, at first of moderate proportions; but it was not long before the tusks became immensely developed in the

* "On *Hydropotes inermis* and its Cranial Characters as compared with those of *Moschus moschiferus*," P. Z. S. 1872, p. 522.

† As in Dr. Gray's 'Hand-list of Ruminants in the British Museum,' 1872.

males of many species, as *Amphitragulus* and *Dremotherium*. These, after a time, became generally superseded by horns or antlers; but they have either continued from those times or have been independently developed by the agency of similar causes in *Hydropotes* and in *Moschus*, and to a less extent in *Cervulus*, *Tragulus*, and *Hyomoschus*. The latter supposition seems more likely, as when closely examined the canines of *Moschus* and *Tragulus* will be seen to differ much in form and direction. The former are rounded and the latter concave on the external surface; the former tend to approach each other as they grow downwards, the latter to diverge and turn backwards *. The canines of the Musk seem at first sight to differ from those of other Deer in having persistent pulps; but this is only a question of degree. In old Musks, as in old Muntjaks and *Hydropotes*, the base of the tooth becomes closed, as specimens in the Museum of the College of Surgeons show; but this takes place at a relatively later age.

III. The special characters of the feet are:—(1) the navicular and cuboid united together, (2) the ectocuneiform free, (3) the outer metatarsals entirely absent, (4) the lower extremity of the outer metacarpals fairly developed, (5) well-developed phalanges to the outer toes on all extremities.

The first is common to all the *Pecora* and *Tragulina*, but separates them from the *Tylopoda* and *Suina*. The second is found in all *Pecora* except the Muntjaks and the Pudu, which, in the union of these bones, exhibit a nearer approach to the Chevrotains than does *Moschus*. The third character is common to all the *Pecora*†, and separates them from the *Tragulina*. The fourth *Moschus* shares in common with *Alces*, *Rangifer*, *Hydropotes*, *Capreolus*, *Coassus*, *Cariacus*, and *Pudu*, but not with the other Deer or any of the remaining *Pecora*‡. The fifth is found in all the *Cervidæ* except *Cervulus*, but not (or only in a comparatively rudimentary condition) in any of the other *Pecora*.

The evidence from the feet, then, is decidedly in favour of the affinity of *Moschus* with the *Cervidæ*; for in that group alone is their exact counterpart to be found.

IV. A very constant distinction in the skeletons of the *Bovidæ* and the *Cervidæ* (excluding *Moschus*) is to be found in the orifice of the lachrymal canal. In nearly all the former this is single and situated just within the anterior margin of the orbit; in the latter there are two openings, one above the other (the upper one situated just upon, and the lower one rather anterior to, the margin of the orbit), and there is generally a bony tubercle between them; the two canals very soon join together. Professor A. Milne-Edwards, to whose excellent observations on this group of animals I am indebted for my first knowledge of this useful character§, mentions certain exceptions; but on a closer examination of these, I find

* Milne-Edwards, *op. cit.* p. 50.

† If ever present, they are excessively rudimentary.

‡ See Sir Victor Brooke, P.Z.S. 1874, p. 36.

§ Though pointed out in Cuvier's 'Leçons d'Anatomie Comparée,' t. ii. (1837).

that his rule is even more absolute than he himself supposed it to be*.

Hydropotes exactly follows the other Deer in this respect, while *Moschus* entirely differs from them and agrees with the *Bovidæ*. But it is not only the *Bovidæ* but also the *Tragulina*, the *Tylopoda*, and probably all the primitive Artiodactyles † that *Moschus* resembles in this character; wherefore it is only evidence of generalization or the retention of an original character, not of special affinity to either one of the other groups which possess it. It is a very singular circumstance, and not easily explained, that the conformation of the lachrymal canals, which has just been mentioned as a special character of the typical *Cervidæ*, also appears in the modern Pigs.

V. The presence of a gall-bladder. This, like the last, is obviously the retention of a general character, as the presence of this organ is the rule in all Artiodactyles excepting the Deer, the Giraffe (where it has occasionally been found), the Camels, and the Peccaries. More accurate and extended observations, however, are required as to its presence or absence; for, at least in those orders (as the Artiodactyles and the Rodents) in which it may or may not be present in nearly allied forms, it seems to be a somewhat variable character even in the same species‡.

The presence of a pedunculated Spigelian lobule to the liver must

* Speaking of *Moschus*, Milne-Edwards says:—"Le trou lacrymal est unique, situé à la partie inférieure de l'os du même nom en dedans du bord orbitaire, disposition qui ne se voit qu'exceptionnellement chez les Cerfs, mais qui existe d'ordinaire dans le groupe des Antilopes," adding in a note "Chez le Cerf Duvaucel, on ne compte également qu'un seul trou lacrymal, mais chez presque toutes les autres espèces du même genre, il en existe deux, l'un au-dessus de l'autre sur le bord même de l'orbite ou plutôt en dehors. Chez le Muntjac, on trouve trois trous lacrymaux. Le Gnou et le Guib [as mentioned in the 'Leçons d'Anatomie Comparée,' 2nd edit. t. ii. p. 495] sont des exceptions à cette règle, leurs trous lacrymaux sont au nombre de deux de chaque côté." (*Op. cit.* p. 17.)

With reference to the first exception, in a series of skulls of *Cervus duvaucelli* in the British Museum I find the lachrymal canal double and conforming in every way to the ordinary Cervine type. In the Muntjak the third or lowest foramen on the anterior margin of the orbit is not an opening into the lachrymal canal but an antero-posterior perforation of the wall of the orbit, passing from the orbit into the antorbital fossa, and probably for the passage of a vessel or nerve. The true lachrymal orifices are like those of other Deer. In the Gnu the second or lower foramen, as the lowest in the Muntjak, has nothing to do with the lachrymal canal, but is only a perforation of the prominent anterior edge of the orbit, represented by a notch in many other allied forms. The Guib (*Tragelaphus scriptus*) and its immediate allies *T. decula* and *T. sylvaticus*, and the Eland (*Oreas canna*), however, are real exceptions; and there is another in the curiously aberrant Prongbuck (*Antilocapra*), which possesses the Cervine character of a double orifice to the lachrymal canal (though not placed quite so externally as in the Deer), in addition to others pointed out by Dr. Murie (P. Z. S. 1870, p. 334); yet this animal has most strongly marked hypsodont molars.

† This is certainly the case with *Cænotherium*, *Xiphodon*, *Hyopotamus*, and all the Eocene Artiodactyles which I have examined.

‡ As is well known, Dr. Crisp (P. Z. S. 1862, p. 136) has recorded the presence of a gall-bladder in three specimens of the Axis and in one of the American Deer (*Cervus superciliaris*) and its absence in eight species of the *Bovidæ* examined by him.

also be noticed, and perhaps accounted for in the same manner; but until the livers of all other species of Deer have been examined, its significance cannot be properly estimated.

VI. In the same category may be placed the presence of Cowper's glands, organs generally absent in the Deer and present in all the other Artiodactyla. But although the examination into this question has not yet been very searching, exceptions have already been found. Their presence in the Pudu has been noted above; and their absence in the Prongbuck (*Antilocapra*), an animal which though aberrant I cannot but place among the Bovine section of the group, has been recorded by Dr. Murie in his valuable description of the anatomy of that animal*.

Together with the absence of Cowper's glands, the Deer have a form of penis unknown in other Artiodactyles, and to which *Moschus* does not quite conform; but closer investigations are required before the value of this character can be ascertained.

VII. The cutaneous glands. Some importance as a taxonomic character has been attached by zoologists to the abdominal odoriferous gland for which the Musk-Deer is so well known. This has been given, for instance, as one of the family characters by which *Moschus* has been separated from the Deer on the one hand and the Chevrotains on the other. But its importance has been overrated, from the supposition that it was a structure *sui generis* instead of only one of the numerous modifications of specialized patches of involuted integument found so universally throughout the vertebrate animals, probably always for a similar purpose at present not perfectly understood, but evidently connected with the discovery and recognition of the presence of individuals of the same species in the neighbourhood. Such glandular patches, either of the skin extended in its usual manner over the surface, or more or less involuted so as to produce a pouch in which the secretion may be retained for a time and its effect thus intensified, are abundantly developed and most variously located in the Artiodactyla—as below the lower jaw in the Chevrotains, on the forehead in the Muntjaks, behind the ear in the Chamois, below the ear in the Prongbuck, in front of the eye (the crumen) in a vast number of species, on the middle of the back in the Peccaries, beneath the tail in Goats, within the edge of the prepuce in the Pigs, some Antelopes, and *Moschus*, in the inguinal region in many Antelopes, on the outside of the metatarsus in most Deer, between the toes in so many species; and their presence or absence, though extremely interesting to observe in each species, especially with a hope to discover more of their function, is not so constantly correlated with other characters as to enable us to make use of them in classification otherwise than in distinguishing very minor groups. There are, in fact, few parts of the organization so variable and readily modified†.

* P. Z. S. 1870, p. 334.

† Although the first commencement of the modifications of portions of the external covering for the formation of special secretions may be at present difficult to understand, the principal of natural selection will readily

The absence of antorbital glands (generally indicated in the skeleton by the flatness of the facial surface of the lachrymal bone) is a general character of the older members of the order, retained in some few Deer, many of the *Bovidæ*, the Giraffe, and all *Tragulina*, *Tylopoda*, and *Suina*. The same is probably the case with the interdigital glands, while the great development of the preputial gland is a specialization of the genus *Moschus*.

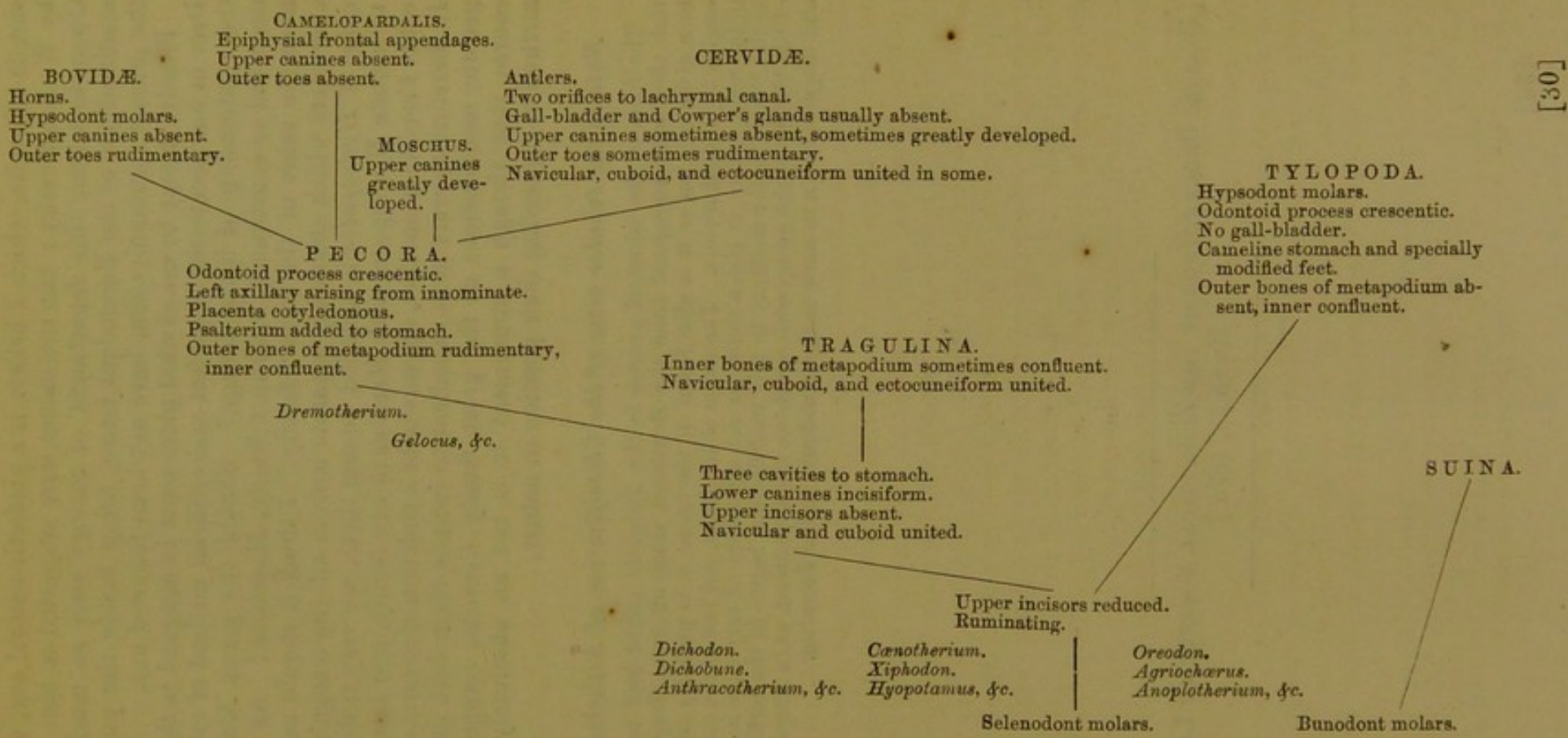
VIII. The brain of the Musk, in its smallness, simplicity of surface-markings, and narrowness of the anterior part, indicates a low type of the group. It is inferior in these respects to the existing Deer, and still more to the Antelopes of corresponding size.

IX. The peculiar construction of the psalterium probably also indicates a simple or low type of the group.

X. I am not quite sure whether it is safe to put any reliance upon the character of the hair of the Musk, which is rather an exaggeration of that found in most Deer. But Antelopes such as *Antilocapra*, and especially *Oreotragus saltatrix*, show a very similar structure in their external covering. The fact of the young Musks being spotted (a character so nearly universal in the Deer, and not known in any of the other groups) may be some indication of Cervine affinity.

To sum up the position of *Moschus*, it appears to me to be an animal belonging to the stock which remained of the selenodont (or crescentic-toothed) Artiodactyles after the *Tylopoda* and the *Tragulina* had been thrown off, and which, by continued modifications of the placenta, of the stomach, and other parts, produced the *Pecora*. Of this stock it is a low and little-specialized form, not having the characteristic peculiarities of either the *Bovidæ*, the *Giraffidæ*, or the *Cervidæ*, being probably descended from the stock before either of those forms was well established, and having undergone comparatively little modification, though on the whole its affinities are nearest to the last-named group. I look upon it as, in the totality of its organization, an undeveloped Deer—an animal which in most points has ceased to progress with the rest of the group, while in some few it has taken a special line of advance of its own. Its position will perhaps be better understood by reference to the annexed table, in which I have endeavoured to show, only of course in a provisional manner, the order in which the principal modifications of the primitive Artiodactyle type have been brought about. The names of some of the best-known extinct forms are inserted to indicate their position only approximately; in the absence of knowledge of their visceral anatomy and unfortunately of much of their osteology, greater certainty cannot be attained. The primary division of the order into Selenodonts, or those having a crescentic arrangement of the projections on their molar teeth, and Bunodonts, or those with only

explain how such organs can become fixed and gradually increase in development in any species. If the function suggested above be the correct one, such individuals as by the intensity and peculiarity of their scent had greater power of attracting the opposite sex would certainly be those most likely to leave descendants to inherit and in their turn propagate the modification.



Primitive ARTIODACTYLA, having the typical number (44) of incisor, canine, and molar teeth, brachyodont molars, odontoid process conical, four distinct toes on each foot, with metapodium and all the tarsal bones discrete, a single orifice to the lachrymal canal, left brachial artery arising separately from aorta, placenta diffuse, a gall-bladder, Cowper's glands, and no frontal appendages.

simple tubercles, which I believe is a perfectly natural one, was made by W. Kowalevsky; but the names were suggested to him by Prof. Owen, to whom this department of zoology owes so much. The modifications of the Buonodont forms, being beside the purpose of the present communication, have not been followed out.

Finally, it may be asked what place must be assigned to the Musk-Deer in our necessarily imperfect and artificial method of expressing the relationship of living beings? Should the genus *Moschus* be described as constituting a distinct family, *Moschidæ*? As I apprehend the value of the term "family," I think it should not. The characters which absolutely separate it from all the recognized *Cervidæ*, if *Hydropotes* is included among them, are very trifling; and to include *Hydropotes* with *Moschus* in one family, and leave all the other *Cervidæ* in another, appears to be a violation of natural affinities. It therefore appears most expedient to include them both as distinct generic modifications of the great family *Cervidæ*, recognizing of course that though a convenient it is not an absolutely perfect method of expressing their position in nature.

Note to the tabular view of the Classification of Artiodactyla.

The form of the odontoid process in the *Tylopoda* might lead to the idea that they were segregated from the Ruminant stock after the *Tragulina* had been given off; but as it is also found in the horse, it is probably adaptive, as are the hypsodont molars. The union of the inner, and loss of the outer, bones of the metapodium is also a character not significant of very close relationship to the *Pecora*, as the tendency to this modification begins in the earliest period of the history of the group with which we are acquainted, as in *Anoplotherium*, and crops out even in some of the bunodonts, as the Peccaries.

[*From the* Proceedings of the Zoological Society of London, March 16, 1875.]
