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The mammalian temporo-pterygoid ligament

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(With 12 figures in the text)

An account is given of a generally unrecognized fascial ligament (lig. temporo-pterygoideum) found to occur in eutherian mammals. This structure is a functional specialization of the salpingo-palatal fascia, developed in response to the activity of the palatal tensor and levator musculature. The ligament is attached superiorly to the Eustachian process of the temporal bone and inferiorly to the hamular process of the medial pterygoid lamina. It is responsible for the development of both these processes, which, in the macerated cranium, testify to the original presence of this ligament.

Contents

Introduction

Mammalian ligaments are separable into three constitutional categories, viz. (1) fibrous or fibrocartilaginous elements directly associated with the articulations, (2) the fibrous relics of structures functional during foetal life, (3) local condensations of the indifferentiated mesoderm (deep fascia) of the body.

This third category of ligaments is developed in accordance with a general anatomical principle—namely, that continuous or intermittent movement within the body necessitates a correspondent augmentation and thickening of the relevant deep fascia. It includes therefore such canonical structures as the carotid sheath, the flexor and extensor retinacula and the costo-coracoid, stylo-mandibular and pelvic visceral ligaments. It includes also a ligament resulting from the activity of the palato-pharyngeal musculature, which though apparently widespread throughout the mammalia, lacks formal recognition in comparative myology. This is the structure described herein as the temporo-pterygoid ligament.

The mammalian soft palate, as the roof of the pharynx proper (Wood Jones, 1940) is a muscular apparatus interposed between superjacent airway and subjacent food-channel and obliged therefore to respond to the virtually continuous demands of respiration, deglutition and phonation. The considerable activity thereby imposed upon its levator and tensor musculature induces a condensation of their associated deep fascia in the form

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of a short fibrous sheet—the salpingo-palatal fascia or fascia of Weber-Liel—and the thickened caudal margin of this sheet forms the temporo-pterygoid ligament of present notice.

The salpingo-palatal fascia, though recognized for man (Jonnesco, 1901) and incidentally noted in the Indian elephant (Miall & Greenwood, 1878) escapes attention in general myological literature, wherein the palatal musculature receives a relatively scant consideration, possibly from the difficulty of prosectorial access and the necessity of cranial mutilation for its complete exposure. Individual palatal muscles are thus rather more frequently nominated than described: they are adequately described for man and the commoner domestic mammals, less so for the higher primates (Duckworth, 1915: Sonntag, 1924: Raven, 1950) and in varying detail for such exotic forms as the hippopotamus (Gratiolet, 1867), elephant (Miall & Greenwood, 1878), tree shrew (Clark, 1926), tarsier (Woollard, 1925), marmoset (Beattie, 1927), colobus (Polak, 1908), macaque (Geist, 1933) and Giant panda (Davis, 1964).

The mammalian levator and tensor palati muscles arise contiguously (sometimes in common) from the caudo-lateral aspect of the cartilaginous portion of the Eustachian tube and adjacent undersurface of the cranial base—the medially situate levator muscle from the petrosal, the laterally situate and somewhat tendinous tensor muscle from the pterygoid process with occasional extension on to the petrosal. The muscle bellies are invested by the salpingo-palatal fascia which blends with their epimysium and at the caudal border of the tensor muscle thickens into a ligamentous band—the temporo-pterygoid ligament. This band is attached superiorly to a special projection (Eustachian process) from the undersurface of the petrous temporal bone and inferiorly to the apex of the pterygoid hamulus—bony processes occupied exclusively by its fibres and readily identifiable in the macerated cranium. The band shows to best advantage in formalin-injected material, wherein fibrous tissue is both bleached and hardened, but it may prove remarkably obtrusive in unfixed material as in the *Delphinus* specimen noticed below.

The temporo-pterygoid ligament originally engaged the author's attention (1941: 6) as an unexpected dissection finding in the young gorilla and subsequently in the adult dolphin (1954: 10) and in the mature orang (1955: 7) wherein its similarity of constitution and topography compelled its recognition as an anatomical entity. The "new" ligament was later exposed by dissection in the young African Black rhinoceros (1960: 9), in the adult African White rhinoceros (1964: 9) and again in the adult orang (1968: 7). Partial evidence of its occurrence was also encountered in the adult baboon and in the Californian sea-lion.

The ligament's bony attachment sites—the superior (Eustachian process) in particular—were found to be recognizable in the generality of eutherian crania, thus engendering the opinion that such a structure is canonical in mammalian anatomy. In support of this opinion the following prosectorial and oesteological evidence is submitted.

Materials and methods

The temporo-pterygoid ligament was exposed by dissection in the various unrelated mammalian forms listed below. Its attachment sites were scrutinized in mammal crania representing most orders preserved in the British Museum (Natural History), the Royal College of Surgeons Museum and the Colyer Collection (now incorporated into the Odontological Series of the College Museum).

Observations

General

The salpingo-palatal fascia (fascia of Weber-Liel, lateral aponenrosis of Jonnesco) is the major of two fascial formations reflecting palato-pharyngeal muscle activity—the minor being the petro-salpingo-pharyngeal ligament—and is a constituent of the wall of the sinus of Morgagni. It is a short but substantial sheet of white fibrous tissue attached to the lateral lamina of the cartilaginous Eustachian tube and to the caudal aspect of the petrous temporal bone. Thence it descends over the superficial aspect of the mm. tensor et levator palati and blends with their epimysium. Alongside the caudal margin of the tensor muscle it terminates in a thickened hem, the temporo-pterygoid ligament.

The Eustachian process is a discrete anterior projection from the apical region of the petrous temporal bone continuous with the inferior margin of the ostium of the osseous Eustachian tube. It underlies, non-supportively, the tympanic extremity of the cartilaginous portion of that tube and is wholly and exclusively occupied by the superior attachment of the temporo-pterygoid ligament. It is most frequently situate infero-lateral to the tympanic extremity of the cartilaginous Eustachian tube, but it may lie directly inferior or even (more rarely) infero-medial thereto. Its free extremity may be bifid, the effective process being then the lateral of two prominences. It may assume the form of a lateral bony flange, as in forms wherein two such flanges (a medial and a lateral) embrace the tympanic extremity of the cartilaginous Eustachian tube (Figs 8, 9, 10). In the elephant it constitutes the descriptive anterior tympanic process and in equids may be represented by the muscular or the hyoid process of the petrous temporal.

The pterygoid hamulus is merely the posteriorly recurved free angle of the medial pterygoid lamina, commonly, but not invariably, of uncinate configuration (Figs 11, 12). It were best considered to be that portion of the pterygoid lamina lying postero-superior to the groove for the tensor palati tendon which indents the inferior border of the lamina for in the absence of such a groove pterygoid hamulus and pterygoid lamina are mutually indistinguishable. It gives attachment medially to the pterygo-mandibular ligament, apically to the temporo-pterygoid ligament. In shape the hamular region varies from that of a mere tuberosity to that of a spiculate or spatulate process or to an obtrusively recurved hook-like projection. Its prolongation posteriorly tends to increase with increased width of the medial pterygoid lamina and when maximal brings the hamulus apex into close proximity with the temporal bone.

The temporo-pterygoid ligament being merely the thickened caudal margin of the salpingo-palatal fascia lacks the precision of outline characteristic of an articular ligament. Somewhat rounded and gently concave superiorly, it is continuous deeply with the tensor palati epimysium. Superiorly it has attachment to the Eustachian process, inferiorly to the apex of the pterygoid hamulus, occupying each of these processes entirely and exclusively, and by a minor degree of terminal ossification capable of increasing the length of either. The ligament lies deep to such major structures as the mandibular nerve, the spheno-mandibular ligament and the temporo-mandibular joint.

Prosectorial

Gorilla (***Gorilla g. berengei***)

The dissection (1941) of the deep cervical structures of a young Mountain gorilla disclosed two unexpected findings—(1) the attachment of the spheno-mandibular ligament

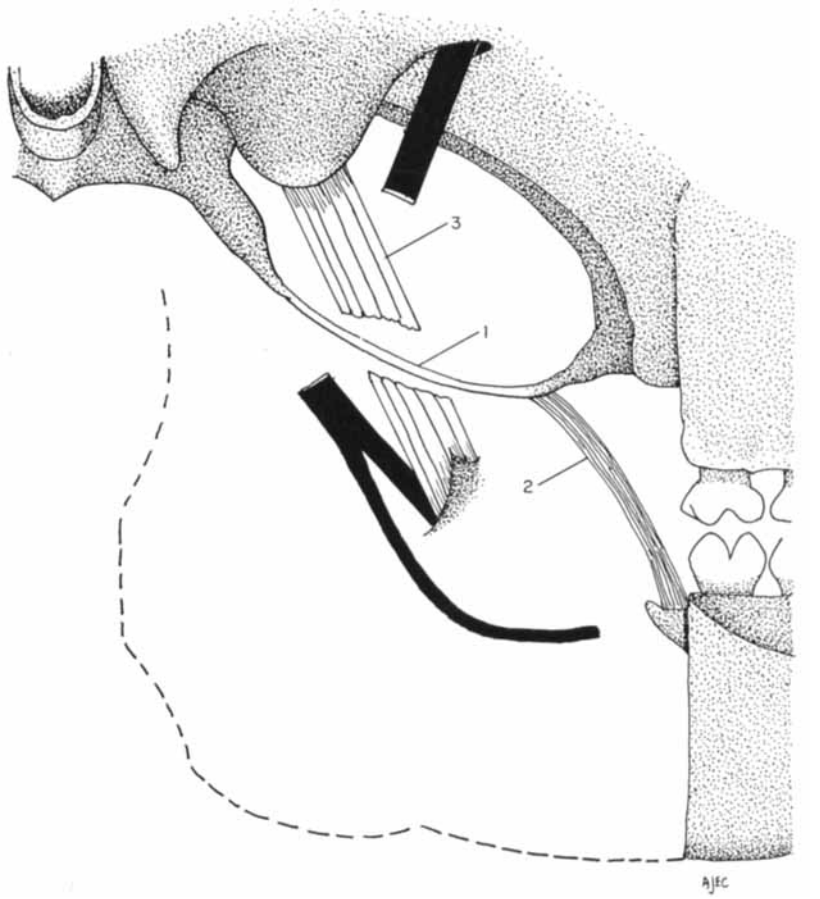

FIG. 1. Gorilla (*Gorilla g. berengei*) ♂ juv. Showing mutual relationships of (1) temporo-pterygoid (2) pterygo-mandibular and (3) divided spheno-mandibular ligaments. Mandibular ramus removed: mandibular, lingual and inferior dental nerves black.

to the temporal, not the sphenoid, bone and (2) an unfamiliar ligamentous band connecting the petrous temporal bone to the pterygoid hamulus (Fig. 1).

The broad, well-developed spheno-mandibular ligament was attached superiorly to the summit of a large (endoglenoid) tubercle projecting ventrally from the squamous temporal medial to the glenoid fossa; thence its fibres ran downwards and forwards to the mandibular lingula. The pterygo-mandibular ligament (raphé) was a 30 mm long lax band connecting medial aspect of the pterygoid hamulus to the posterior end of the mylohyoid ridge.

An obtrusive salpingo-palatal fascia descended from the lateral aspect of the cartilaginous Eustachian tube and the basis cranii, covering the tensor palati muscle and blending with its epimysium. At the muscle's caudal border this fascia thickened into a rounded ligamentous band, some 17 mm long, substantial enough to withstand dissection disturbance and manipulation. This band was attached superiorly to a relatively large and prong-like Eustachian process and inferiorly to the spiculate apex of a well-formed

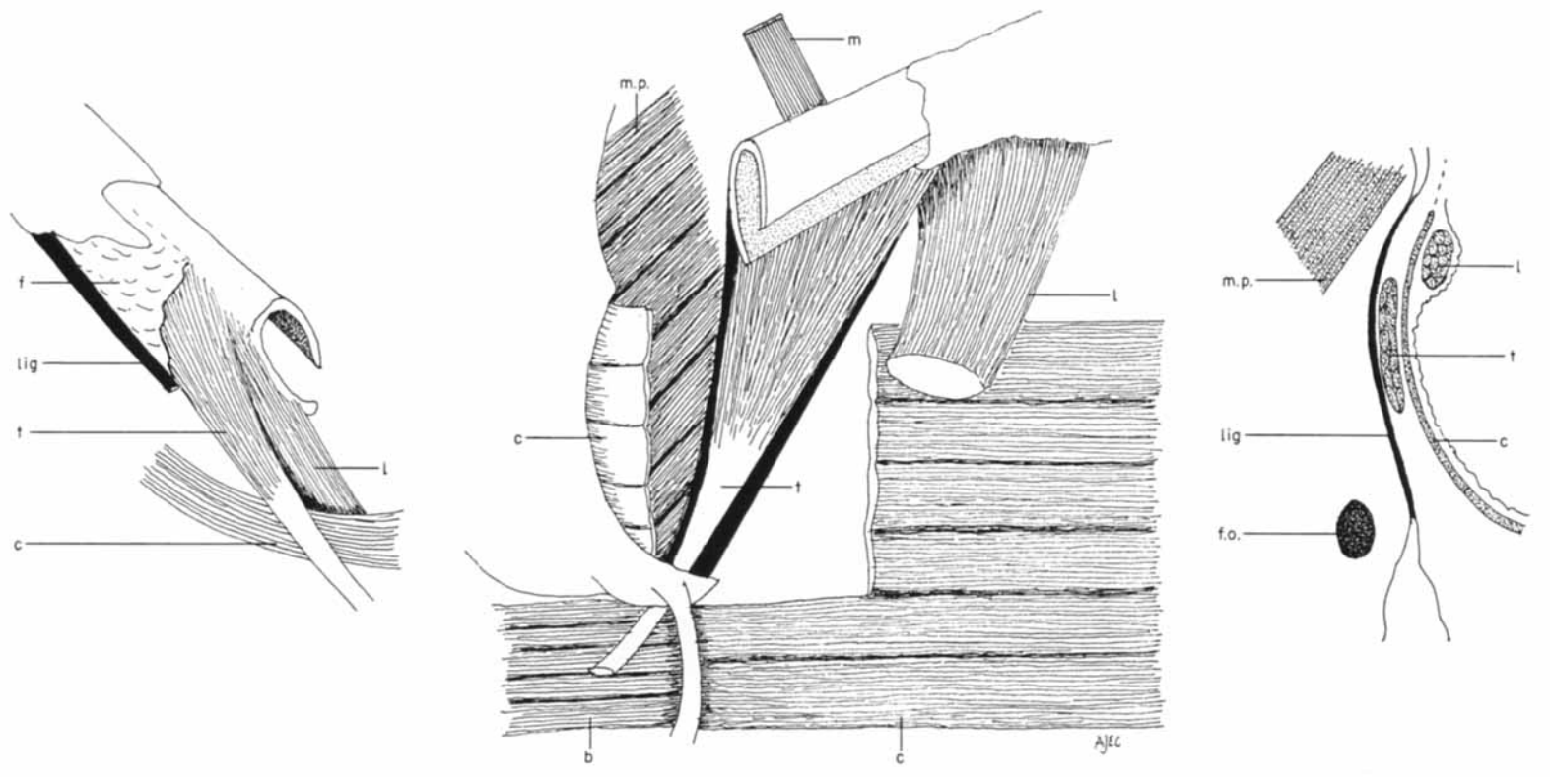

FIG. 2. Chimpanzee (*Pan satyrus*) ♀ ad. Showing (a) mm. tensor et levator palati in relation to (dissected) superior constrictor muscle, salpingo-palatal fascia (black) and Eustachian tube: (b) common origin of palatal muscles, salpingo-palatal fascia (white), temporo-pterygoid ligament (black) and superior constrictor: (c) relations of constrictor, palatal muscles and temporo-pterygoid ligament (black) in horizontal section. b = buccinator muscle: c = superior constrictor muscle: f = salpingo-palatal fascia: fo = foramen ovale: l = levator palati muscle: lig = ligamentum temporo-pterygoideum: m = mandibular nerve: pm = medial pterygoid muscle: t = tensor palati muscle.

pterygoid hamulus. It had every appearance of constituting an anatomical entity and was therefore provisionally designated the temporo-pterygoid ligament.

Chimpanzee (***Pan satyrus***)

A temporo-pterygoid ligament was encountered during the dissection (1966) of an adult female chimpanzee.

The spheno-mandibular and pterygo-mandibular ligaments were canonical in disposition. The mm. tensor et levator palati took common origin from the petrous temporal undersurface and from the lateral lamina of the cartilaginous portion of the Eustachian tube (Fig. 2). From this same region descended a tough salpingo-palatal fascia which invested the palatal muscles so closely as to require piece-meal removal for their complete exposure. Alongside the caudal border of the tensor palati muscle this fascia thickened notably to form a stout band (temporo-pterygoid ligament), attached superiorly to a prominent spinous Eustachian process and inferiorly to the apex of a recurved pterygoid hamulus.

Orang (***Pongo pygmaeus***)

A temporo-pterygoid ligament was disclosed by dissection in two adult orangs, viz. a 30-years-old female (1955) and a 15-years-old male (1968), anatomical arrangements being essentially identical in both specimens.

In the female animal (Fig. 3) the cartilaginous portion of the Eustachian tube was some 12 mm long, with tympanic extremity underlain by a prominent spinous Eustachian process: the pterygoid hamulus was well demarcated and the salpingo-palatal fascia well-developed. The rounded, fleshy m. levator palati arose from a ridge-bordered, shallow concavity on the petrous temporal undersurface, medial to the tympanic extremity of the

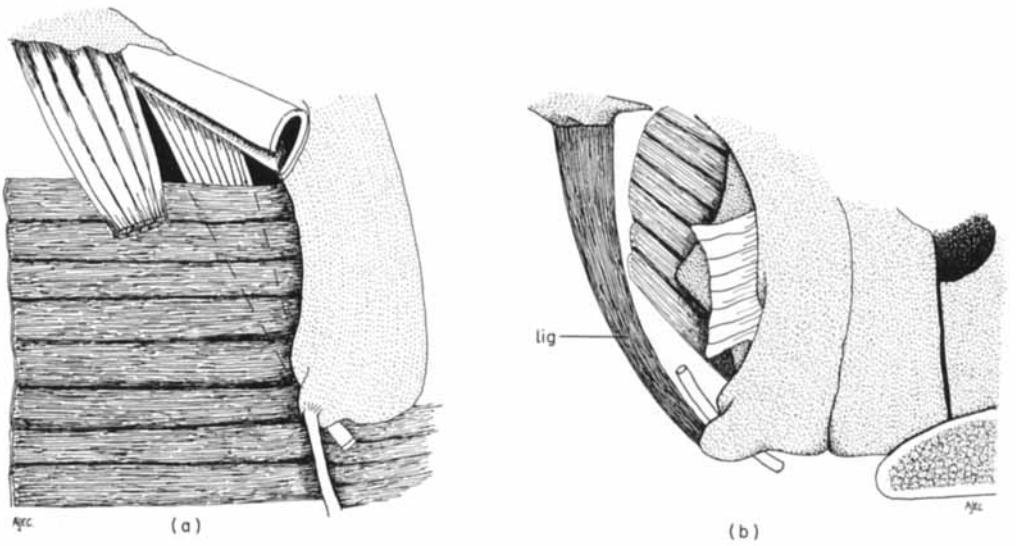

FIG. 3. Orang (*Pongo pygmaeus*) ♀ ad. Showing (a) relations of Eustachian tube, palatal tensor and levator muscles, salpingo-palatal fascia (black), medial pterygoid lamina and superior constrictor muscle: (b) temporo-pterygoid ligament (lig.) after removal of constrictor and palatal musculature.

cartilaginous Eustachian tube: the flatter m. tensor palati arose from this same undersurface lateral to the cartilaginous tube and from the pterygoid process of the sphenoid bone: both muscles took additional origin from the cartilaginous portion of the Eustachian tube.

The salpingo-palatal fascia was a whitish sheet of fibrous tissue attached superiorly to the petrous temporal bone and the lateral lamina of the Eustachian tube. It adhered to the palatal muscles and at the caudal margin of the tensor muscle was developed into a distinct band (temporo-pterygoid ligament) connecting the Eustachian process to the pterygoid hamulus.

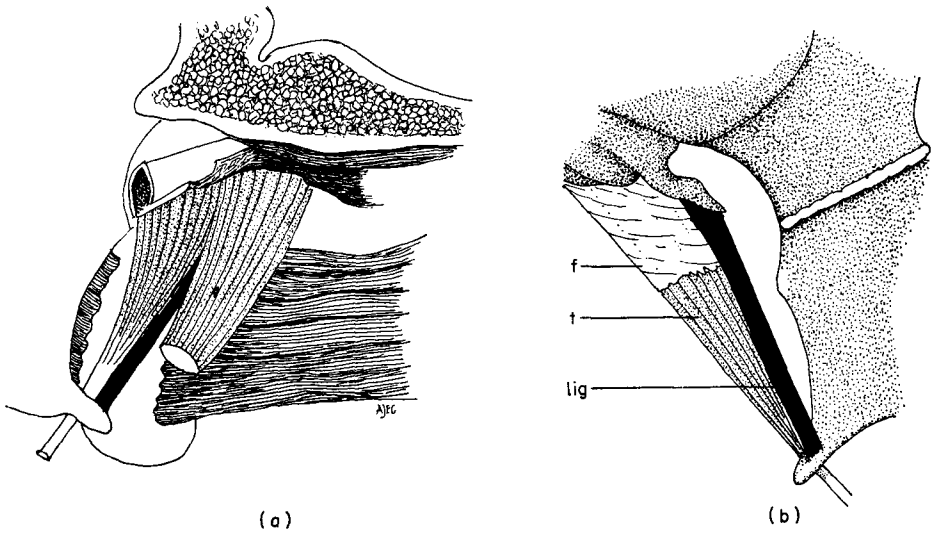

FIG. 4. Orang (*Pongo pygmaeus*) ♂ ad. Dissection sketches showing (a) dextral temporo-pterygoid ligament (black) in relation to m. tensor palati and pterygoid hamulus: (b) sinistral temporo-pterygoid ligament (lig) in relation to Eustachian process, salpingo-palatal fascia (f), m. tensor palati (t) and pterygoid hamulus.

In the male animal (Fig. 4) the cartilaginous portion of the Eustachian tube was 12 mm long and its tympanic extremity was underlain by a substantial Eustachian process: the pterygoid hamulus was triangular and prominent. The spheno-mandibular and pterygo-mandibular ligaments were canonical in disposition. The fleshy m. levator palati and the semitendinous m. tensor palati arose from the lateral lamina of the cartilaginous Eustachian tube and from the petrosal undersurface, the tensor muscle extending thence on to the pterygoid process of the sphenoid.

A strong salpingo-palatal fascia arose from the petrous temporal bone, the pterygoid process and the lateral aspect of the cartilaginous Eustachian tube. It closely invested the palatal muscles and below the tensor muscle was thickened band-wise to form a temporo-pterygoid ligament attached superiorly to the Eustachian process, and inferiorly to the apex of the pterygoid hamulus.

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

A temporo-pterygoid ligament was dissected out (1960) in a young female African Black rhinoceros.

The tympanic extremity of the 70 mm long cartilaginous Eustachian tube was embraced by lateral and medial bony flanges projecting anteriorly from the ostium of the osseous portion of the tube (Fig. 5). A sulcus on the inferior border of the medial pterygoid lamina demarcated a rugose pterygoid hamulus from the remainder of that plate. The mm. levator et tensor palati took common origin from the lateral lamina of the cartilaginous Eustachian tube and from the petrous temporal undersurface. The more laterally situate tensor muscle, long, fusiform and almost horizontally disposed, terminated in a relatively long, flat tendon which traversed the sulcus on the pterygoid lamina. Superficially this muscle was clothed by a whitish salpingo-palatal fascia, traceable superiorly to the cartilaginous portion of the Eustachian tube and to the apex of the petrous temporal bone. Caudad of the tensor muscle this fascia condensed to form a temporo-pterygoid ligamentous band, attached superiorly to the lateral petrosal flange and inferiorly to the rugosity representing the pterygoid hamulus.

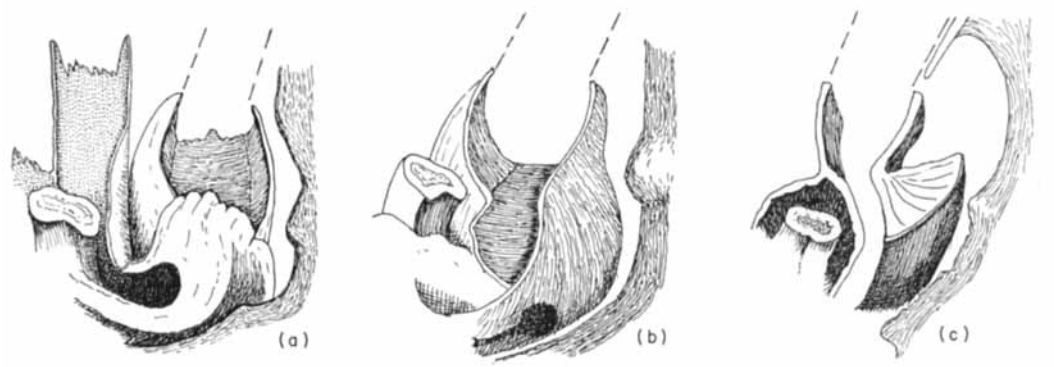

FIG. 5. Eustachian process of flange-like configuration in (a) *Diceros*, (b) *Rhinoceros*, (c) *Ceratotherium*. Position of cartilaginous Eustachian tube indicated in broken line.

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

A well-developed temporo-pterygoid ligament was disclosed by dissection (1964) in a subadult female African White rhinoceros.

The cartilaginous portion of the Eustachian tube was 135 mm long: its tympanic extremity was received between lateral and medial bony flanges projecting anteriorly from the petrous temporal apex (Fig. 5): the inferior border of the medial pterygoid lamina was sulcated for the tendon of m. tensor palati, the sulcus demarcating a robust hamulus from the remainder of the lamina. The mm. levator et tensor palati took an apparently common origin from the lateral lamina of the cartilaginous Eustachian tube and from the petrosal region (at least) of the basis cranii. The long, flattish tensor muscle was covered superficially by a strong, adherent salpingo-palatal fascia. This fascia was traceable superiorly to the Eustachian tube lateral lamina and the petrosal undersurface. At the caudal border of the tensor muscle it thickened into an obtrusive ligamentous band (temporo-pterygoid ligament) attached superiorly to the lateral petrosal flange and inferiorly to the well developed pterygoid hamulus (Fig. 6).

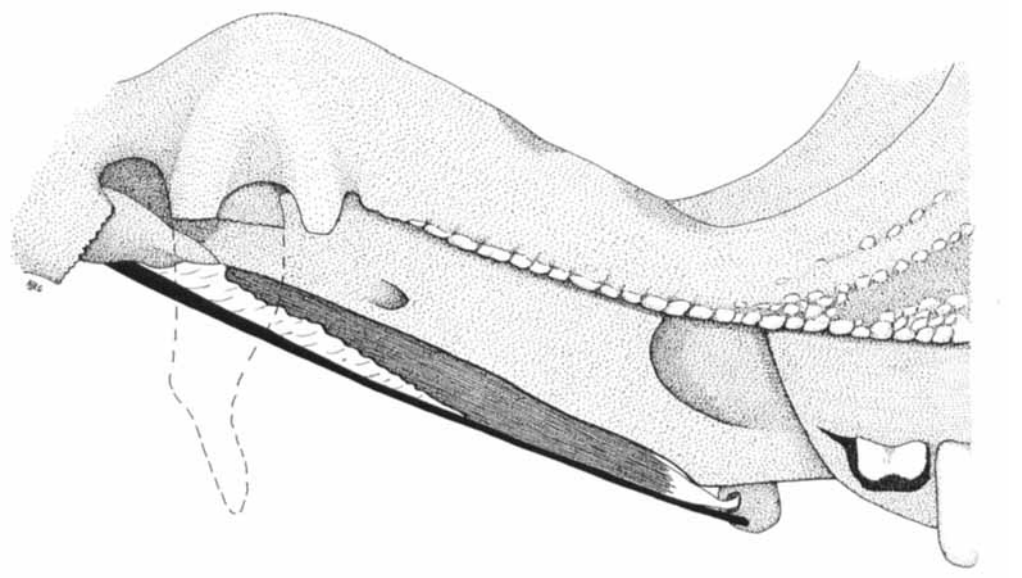

FIG. 6. African White rhinoceros (*Ceratotherium simum*) ♀ ad. Dextral m. tensor palati in relation to remaining salpingo-palatal fascia (white) and temporo-pterygoid ligament (black).

Common dolphin (***Delphinus delphis***)

An obtrusive temporo-pterygoid ligament was exposed during the partial dissection (1954) of the fresh head of an adult common dolphin. A contemporary dissection sketch of the topography of this structure (reproduced herein as Fig. 7) shows the palatal levator and tensor muscle bellies as cleared of investing fascia and partly separated and the former muscle as cut short.

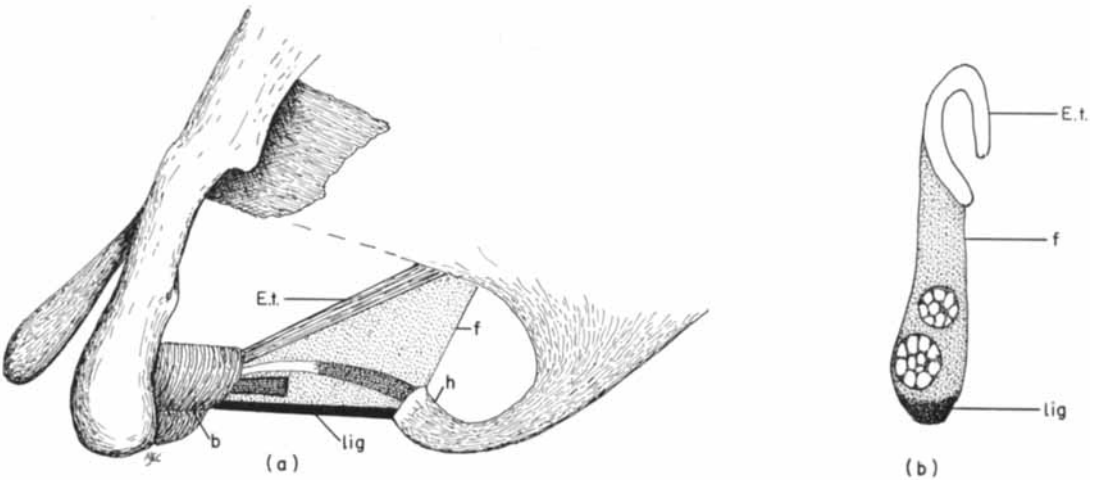

FIG. 7. Common dolphin (*Delphinus delphis*) ad. Dissection sketches showing (a) palatal muscles in relation to Eustachian tube (E.t.), salpingo-palatal fascia (f), temporo-pterygoid ligament (lig), auditory bulla (b) and pterygoid hamulus (h): (b) relationships of tube, fascia, muscles and ligament in vertical section.

The notably yellow cartilaginous portion of the Eustachian tube was of typically mammalian tympano-epipharyngeal disposition and terminated inferiorly behind the concave posterior border of an alariform medial pterygoid lamina. The lamina hamular region, markedly falcate, terminated in a hamular process with somewhat expanded apex. The white salpingo-palatal fascia contrasted sharply with the yellow elastic tissue of the Eustachian tube. It formed a thick, firm sheet stretched tautly between Eustachian tube and auditory bulla medially and the pterygoid hamular region laterally. It enveloped the palatal levator and tensor muscle bellies and immediately caudad thereof thickened abruptly into a ligamentous band (temporo-pterygoid ligament) extending between the tympanic bulla and the pterygoid hamulus.

The bulla received the cartilaginous portion of the Eustachian tube and supported the caudal portion of the salpingo-palatal fascia: from its apical region the cordiform m. tensor palati arose by a short, gracile tendon and from a small fovea thereon arose the cylindrical and more fleshy m. levator palati.

Osteological

Dissection establishes that, whilst the pterygoid hamulus affords attachment to the pterygo-mandibular raphé and the pterygopharyngeal fibres of the superior constrictor muscle, its apex is reserved for the attachment of the temporo-pterygoid ligament. Dissection also demonstrates the exclusive association of the Eustachian process with the superior attachment of this ligament. The presence of these two bony processes in the macerated cranium is valid evidence therefore of the former presence of a temporo-pterygoid ligament, and the examination of mammal crania representing most eutherian orders shows a Eustachian process of one form or another to be a constant feature of the basis cranii and to be directly aligned with the pterygoid hamulus. In some forms indeed the two processes are so closely approximated that their mutual connexion by ligament is virtually self-evident. Thus all available oesteological evidence, though indirect in nature, serves to confirm the inference from prosectorial study that a temporo-pterygoid ligament is canonical in mammals generally.

The Eustachian process is manifestly a traction apophysis developed exclusively in connexion with the temporo-pterygoid ligament and is well-formed even in the immature cranium. Its configuration (Figs 8, 9, 10) differs among the different mammalian genera and is determined by functional, not taxonomic, considerations, since no single type of process is confined to any particular generic form. The shape of the individual process is correlated with that of the temporal bone itself, and notably with the development of a tympanic bulla. Its length is influenced by the degree of posterior extension of the pterygoid hamular region and by the variability due to sex and age. (Thus its length in the adult male gorilla ranges from 9 to 13 mm, in the adult female gorilla from 8 to 10 mm).

Most commonly presenting as a single bony projection the Eustachian process may display an apical bifidity (as in *Orycteropus*, *Galictidis*, *Hyaena*) and though usually situate infero-lateral to the tympanic extremity of the cartilagenous Eustachian tube, may lie directly inferior (*Odobaenus*, *Enhydra*, *Hylobates*) or even medial (*Elephas*) thereto.

It may assume the form of a blunt tubercle (as in *Daubentonia*, *Elephantulus*, *Bradypus*, *Ateles*), of a blunt or sharp spicule (as in *Lemur*, *Rattus*, *Tamandua*, *Manis*), of a longer conical, pyramidal or digitiform projection (as in *Gorilla*, *Hydrochoerus*, *Elephas*) or even of a vertical bony flange (as in *Rhinoceros*, *Ceratotherium*, *Diceros*).

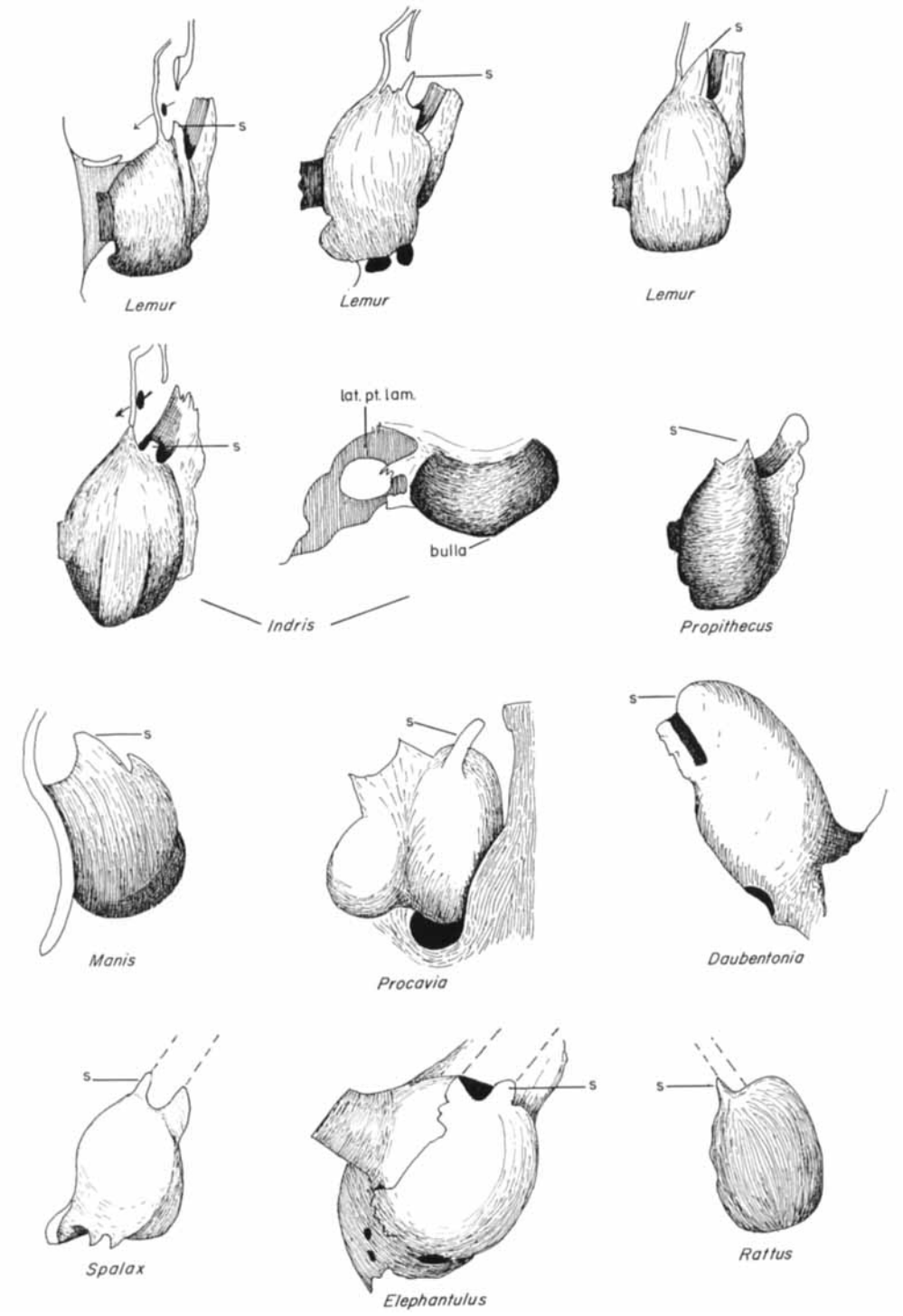

FIG. 8. The Eustachian process (s) in various mammalian genera. (Cartilaginous Eustachian tube in broken line. Not to scale).

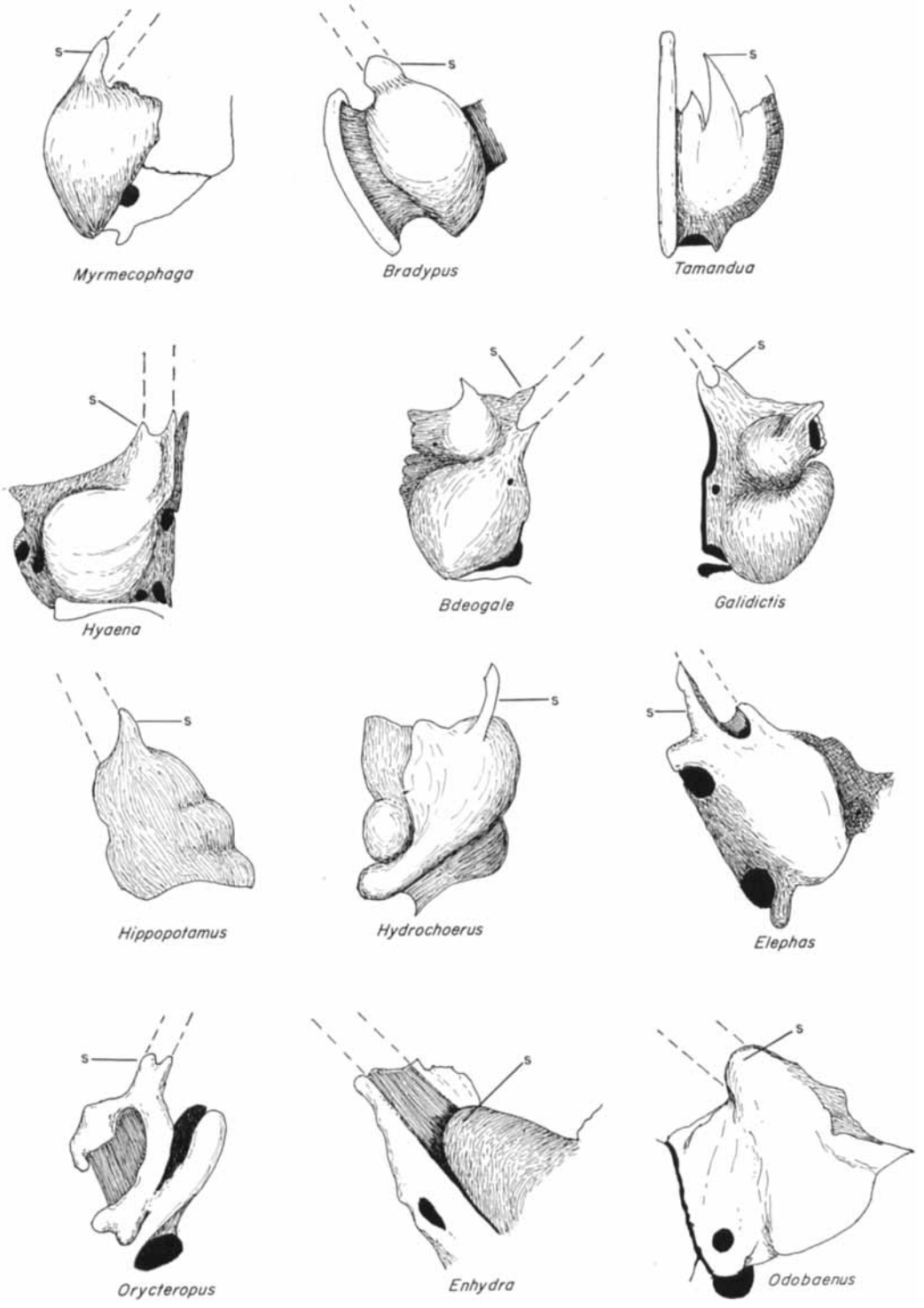

FIG. 9. The Eustachian process (s) in various mammalian genera. (Cartilaginous Eustachian tube in broken line. Not to scale).

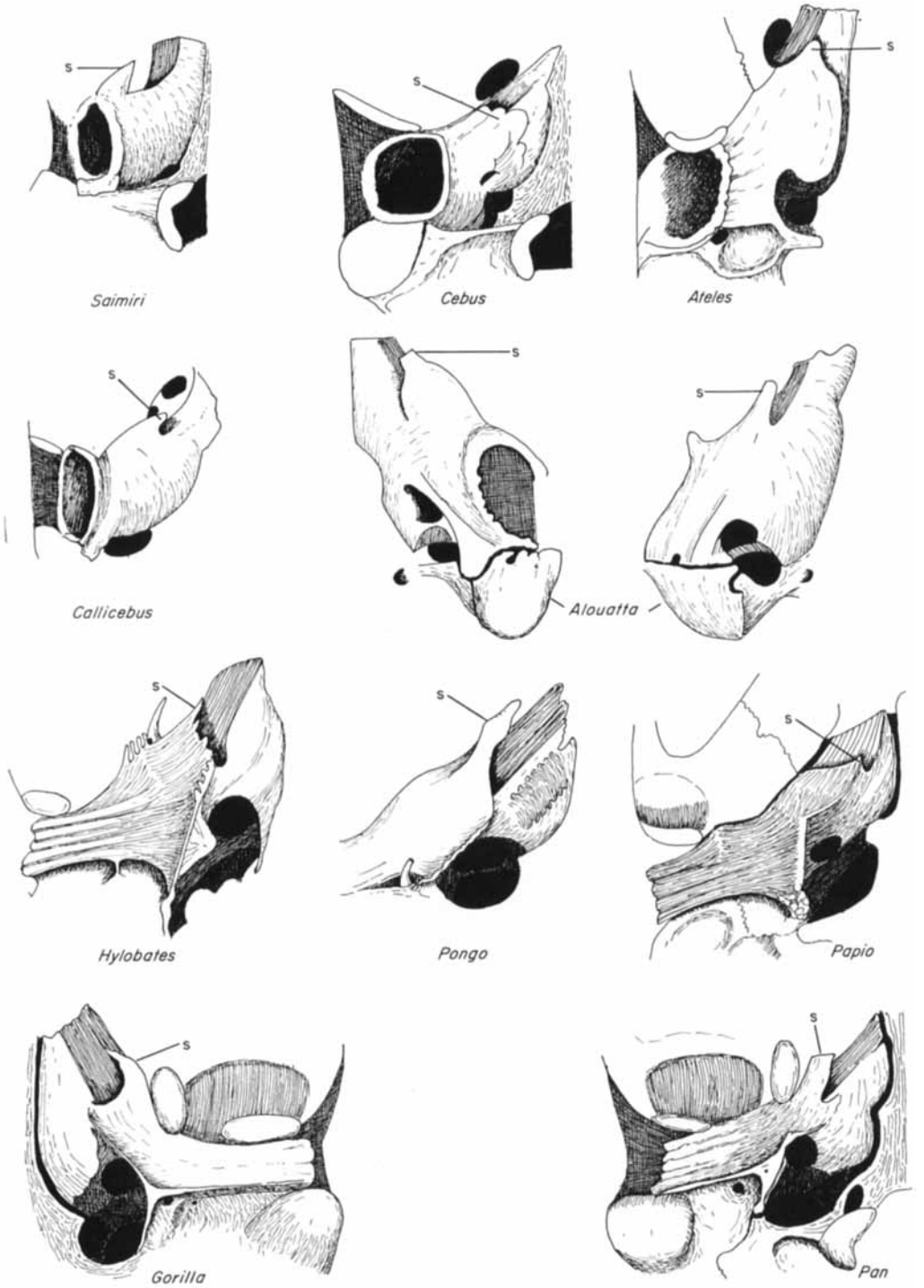

Fig. 10. The Eustachian process (s) in various Primate genera. (Not to scale).

The pterygoid hamulus likewise manifests considerable variation in size, shape and degree of prolongation posteriorly (Figs 11, 12), and a comparable form of hamulus occurs in widely disparate genera. Despite its canonical designation the process is not invariably hamate in configuration, being in some genera (e.g. *Elephas*, *Dugong*, *Trichechus*) a mere rugose tuberosity. In outline it may be spiculate (as in *Talpa*, *Phoca*, *Bos*), spatulate (as in *Giraffa*, *Cryptoprocta*, *Phascolarctos*), uncinate (as in *Erinaceus*, *Glis*, *Procyon*) or falciform (as in *Coenolestes*, *Poiana*, *Anomalurus*). It may be a small acuminate projection from the main mass of the medial pterygoid lamina or a recurved process extending posteriorly almost to the auditory region. It shows the variation due to sex and age and in some forms (e.g. *Rhinoceros*) an infantile tuberous type of hamulus may be preserved, in certain individuals, unchanged into adulthood.

The degree of hamulus posterior extension affects the size of the medial pterygoid lamina and the mutually relative sizes of the medial and lateral pterygoid laminae. In this latter

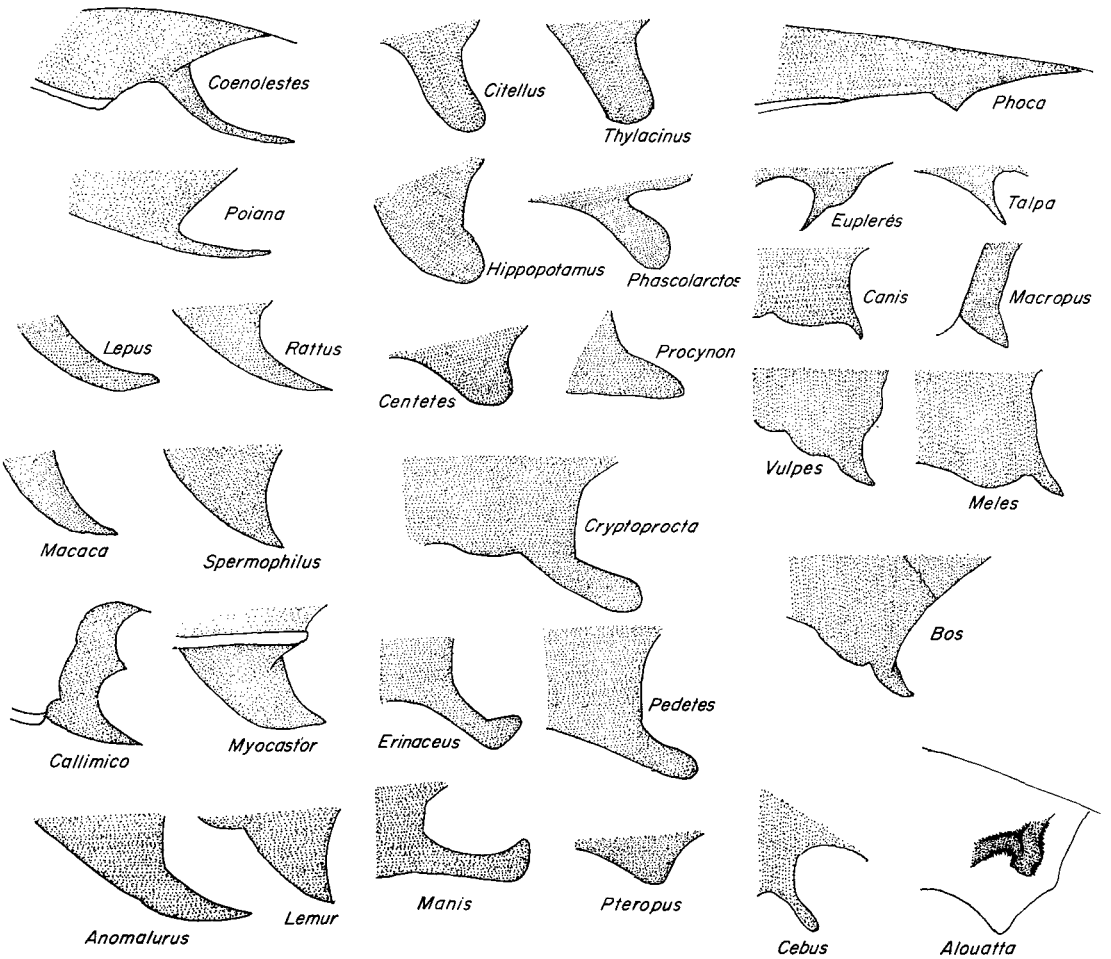

FIG. 11. Configuration of hamular region of medial pterygoid lamina (stippled) in various mammalian genera. (No to scale).

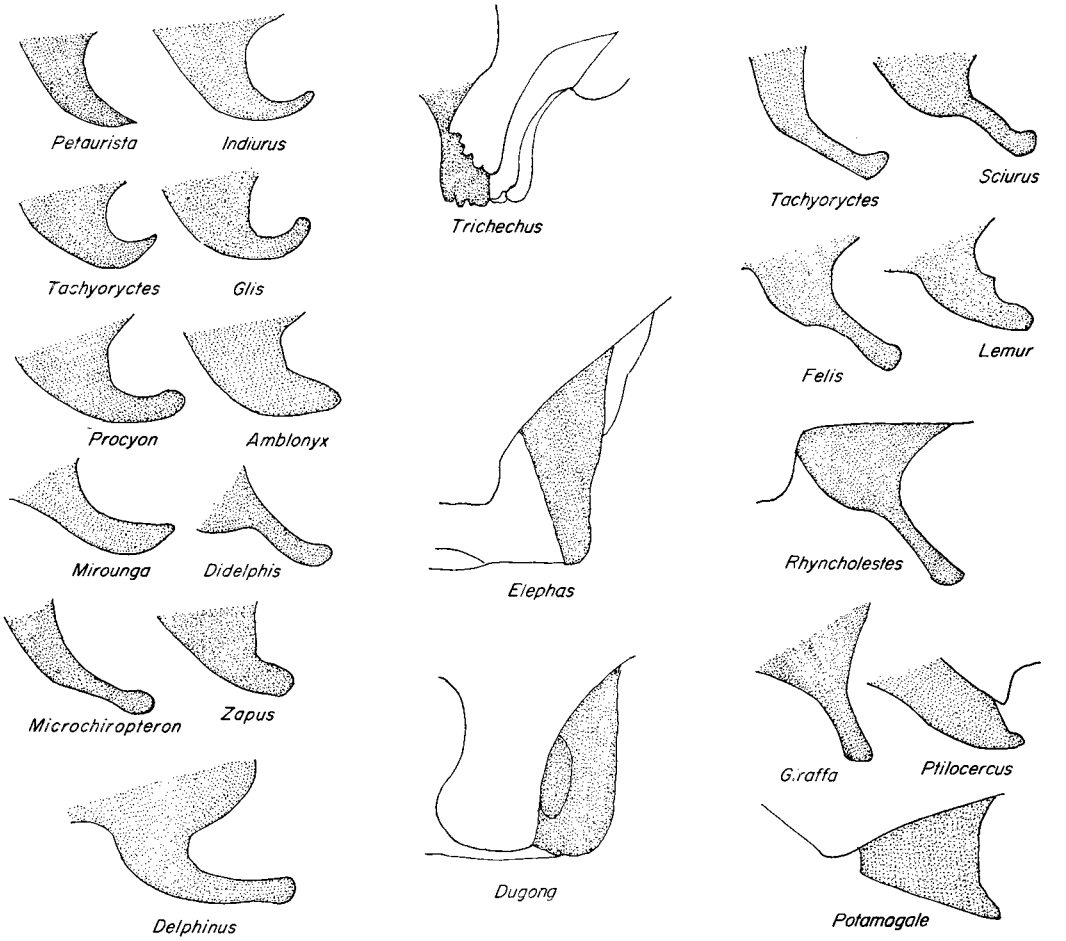

FIG. 12. Configuration of hamular region of medial pterygoid lamina (stippled) in various mammalian genera. (Not to scale).

connexion great variability is encountered, the lateral lamina remaining small but the medial extending almost to the auditory bulla in some forms (e.g. *Rattus*) whilst in others (e.g. *Propithecus*, *Lagostomus*, *Dasyprocta*) the lateral lamina is prolonged posteriorly into direct contact with the bulla. Such anatomical differences of lamina proportion are manifestly of functional, not taxonomic, significance. The two pterygoid laminae subserve the attachment of muscles concerned with mastication and deglutition and their absolute and relative sizes are determined by the particular mass of such musculature. Lamina size and proportion is therefore indicative not of taxonomic relationship but of physiological differences in dietary and in modes of feeding.

Commentary

To date the salpingo-palatal fascia has been accorded formal recognition for but a single mammalian form—man, still the most thoroughly anatomized member of his class.

Nevertheless the presence of this fascia in the non-human mammal is clearly expectable inasmuch as all mammals share a basically uniform disposition of the palato-pharyngeal musculature, and an associated fascial structure known to be present in any one mammalian form is unlikely to be wanting in others.

The formation from the salpingo-palatal fascia of a temporo-pterygoid ligament has been presently established by dissection in various taxonomically unrelated mammals and the ligament shown to have attachment to the Eustachian process of the temporal bone and to the apex of the pterygoid hamulus. These two attachment processes are invariably recognizable in skeletal material wherein they testify to the *in vivo* presence of a temporo-pterygoid ligament. The Eustachian process is the more dependable criterion of such presence because developed solely in connexion with this ligament and occupied exclusively by its fibres and in one shape or another has been found to be a constant feature of the mammalian basis cranii.

The prosectorial evidence submitted is limited in systematic range but is significant as indicating the taxonomic diversity of forms manifesting a temporo-pterygoid ligament. Such direct, if limited, evidence is fortified by the indirect evidence of cranial osteology, so that the total anatomical evidence available would appear to justify the inference that a temporo-pterygoid ligament is a canonical, if minor, feature of mammalian morphology.

Summary

A description is given of a formally unrecognized mammalian structure, the temporo-pterygoid ligament. This ligament is a specialization of the salpingo-palatal fascia. The ligament is attached to a specially developed (Eustachian) process of the petrous temporal bone and to the apex of the pterygoid hamulus.

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