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Anatomy of the Spine of an Elaphe Daguet (*Cervus Elaphus*)

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Abstract

The growth of the branch in male elaphe deer (*cervus elaphus*) is a seasonal phenomenon resulting in a significant variation in the weight of the deer head of up to 14 kg. Comparative anatomy studies to identify which biomechanical structures are being implemented to adapt and cope with such predictable variations have been undertaken. The study of the angle of the spruce serouts of the tourniquet allowing a pulley return and a force vector was not conclusive; the complete dissection of the spine of a young male deer was undertaken. The results unequivocally demonstrated the obvious correlation between the weight of future antlers and the size of the diameter of the nuchal ligament in the daguet. Such results open the door to new questions about the correlation that might exist between the weight of the adornment, the presence of neuropeptide Y in the nuchal ligament and calcium production.

Keywords: Dissection • Elaphe deer • Nuchal ligaments • NPY • Calcitonin

Introduction

The study of the spine of a daguet (young deer) elaphe has made it possible to highlight the importance of the nuchal ligament and the peri spinal muscular system associated with it. The anatomical and comparative description of the tissues gave rise to a description of the cerebrospinal axis allowing a biomechanical understanding of the deer's head for the wearing of antlers.

The choice of the species Cervus elaphus was guided by the seasonal appearance of its adornment, in direct relation to the

variability of the weight of its head. Each year, a new branch develops in males in the spring, reaches its peak in the fall during sling and mating, and then falls in winter. The anatomical characteristics of the woods and their obsolete character made it possible to lay down the basic hypotheses of this study, in tense, anatomical and clinical coherence.

The description according to Haigh and Hudson and the nomenclature of the branches allowed their classification according to species and subspecies (Figure 1) [1].





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Unlike animal horns that are made up of keratin, deer antlers are made of bone, whose density is the lightest of all those measured in other bone tissues of various animal species (Figure 2) [2].



Figure 2. Density of different bone tissues and ratio of organic matter content to mineral content [2].

However, the weight of each wood can reach 3 to 7 kg, making them adornments of up to 14 kg, ranging in size from 0.8 m to 1.2 m in amplitudes. Taking into account the development in height and width, as well as the calculation of the moment of forces for each of the woods, this represents a force torque of several tens of kilograms exerted on the frontal pivots (Figure 3).



Figure 3. Elaphe Deer in the wild (photos by Carol Pianel).

The antlers develop from the pivots, located on the frontal bone, which appear as early as the 3rd month in the young deer (Figure 4).



Figure 4. Position of pivots on the frontal bone in Elaphe Deer.

The first shoot, which occurs in the first year, forms two daggers, which is why the young deer is called "daguet" (Figure 5).



Figure 5. Paruregrowth Cycle in Elaphe Deer [1].

In the years that followed, the trimming strained became more and more imposing. The woods do not, however, express the age of the animal but its vitality and sexual maturity: between 8 and 10 years, the branch reaches its peak and the number of formed antlers can reach ten to twelve horns per wood, then around 12 to 15 years, the woods regress in size and in number of antlers and splets, until the death of the deer, which occurs around 20 years in the natural environment.

The growth of the woods is also under the control of the diet and the ability to fix calcium [3]. Charles De Reinach's observations corroborate this hypothesis since in times of famine deer develop only small plumes [4].

The search for the biomechanical understanding of the deer's head by the preliminary study of the angles of the withers allowing a pulley return, and therefore a force vector, having been inconclusive, the research has turned to complete dissection of the spine of an elaphe daguet. The observations revealed that the wearing of antlers in these large deer involved factors other than bone factors. The musculoskeletal approach of the spine provides a better understanding of the evolutionary and biomechanical processes in this species.

The biochemical interest of the ligament hypothesis in relation to calcitonin and neuropeptide Y is also advanced.

Materials and Methods

The specimen studied was an elaphe daguet aged 7 to 9 months, banded and identified by the FICIF (Intercommunal Federation of Big Game Hunters of Ile-de-France), of Rambouillet in France. The daguet was killed during a hunt in rambouillet forest on November 15, 2018. The remains were preserved by freezing and wrapped in cellophane film, to facilitate its transport.

The first step was to X-ray the daguet, still frozen, on November 19, 2018, at the EIFFELVET Paris XVe treatment centre, using a scanner. The collection was created on Advantage Workstation 4.6 (AW4.6 ext 04) as an indication of the IHE Portable Data for imaging application profile, Copyright 2010, GE Medical Systems (Figure 6).



Figure 6. Daguet Scanner.

Then, in a second phase, after thawing in the dissection room by skinned the daguet and found that the latter's occiput had been very damaged by the impact of hunting projectiles. The Radio Scanner had also demonstrated this breach.

The study of the anatomy of the spine was carried out using manual dissection with a spinal prevalence to clear the nuchal ligament and its supra-thorny extension. Of the parts described, only the right part of the muscular system was analyzed.

The whole of this dissection was orchestrated based on comparative anatomy studies from several books cited in reference [5,6]. On an 18-hour space-time in the dissection room, all measurements of weight, lengths and angles of pennation were performed for the spinal muscles and the results were reported.

Dissection was done in Paris at MNHN.

Results

The sternozygomatic muscle

The sternal fibers are inserted into the ventral and central part of the sternal manubrium to anastomoser in their caudal and lateral insertions to the sternal insertions of the sternocephalic, which appears more ventral (Figure 7).



Figure 7. Representation of the sternozygomatic muscle (in red).

The sternozygomatic muscle blends into its sternal insertion with its symmetrical, medially. The zygomatic tendon becomes anastomosis at the nasal insertions of the massage muscle, in a sliding sheath, on the two-thirds cranial tendon. The sternozygomatic muscle has, in its cranial and tendon head downstream of the zygomatic insertion, a passage in a fibrous and sliding sheath, coming from the massage muscle. This tendon will thus be dorsalized cranially and backwards, achieving a concave curvature forward and bottom in relation to its insertion point on the zygomatic bone. Unlike anatomical descriptions of sheep and cornate cattle, the fibrous returning sheath, similar to a force-distribution pulley, is absent or inconsistent in these other ruminants.

The sternozygomatic is associated in its tendon and cranial part with a sheath of 8 cm ligamento-tendinous, perpendicular to the muscle fibers of the muscle massage. In its rear part, the latter has longitudinal fibers that follow the physiological angle of the muscular body. A chef dorsies over 25 cm to anastomoser the brachio-cephalic at his caudal third, to gain the caudal and nasal part of the mastoid. Its zygomatic insertion is done on the non-articular rear and lower side of the malar bone, by a 10 cm rostro-ventral tendon to the massage. It is noted that the sterno-cephalic of the horse is anastomosis to the masseter, by a sub-parotid fascia, thus behind said masséter, which also anastomosis even further back to the brachio-cephalic, in its subcranial part (Figure 8).



Figure 8. Zygomatic and occipital insertion of sterno-zygomatic muscle without mastarian pulley.

Ear muscle

The ear muscle is part of a set of nine associated or accessory muscles. The superficial and posterior ear muscles are parotid with an Atloid insertion into their deep parts. Muscle fibres have a penenddicular angle at their base. The mobile complex of the ear being made of more than nine main muscles, associated with some accessories, we will mention only the occipito-atloid muscle.

Brachio-cephalic muscle

It exists identically in equines and bovids. Brachicephalic is an important muscle on the ventral side of the neck. It fits on the frontolateral crest of the cranial part of the humeral diaphysis. It has, at the cranial level, some fibers that become mastoid - most of which are Atloid - and a fascia that becomes occipito-ligamentary on the cranial part of the nuchal ligament.

The muscle maseter

The maseter muscle is mandibular. It extends from the horizontal branch at its rear third to the rising branch, and then gains the suborbital part of the ventral part of the incisive bone in its fifth cranial towards malo-frontal insertion. It presents, in its nasal part, the sheath of the cranial tendon of the sternozygomatic. The elaphe deer, which is part of the ruminant family, has a sternozygomatic muscle, absent in equines, but present in Bos Taurus beef. This is nevertheless essentially mandibular and rarely zygomatic in its cranial part. This specificity would be related to the weight of the woods, the direct position of the zygomatic allowing the maintenance of the head when the woods go backwards, especially during the slab.

The trapeze

The trapeze is divided into a cervical head and a thoracic head with opposite and divergent angles of pennation. It's a very aponeurosic muscle. The cervical part is occipital, which is not the case in rabbits and equines, where it remains half-cervical in a caudal manner. The thoracic part overflows heavily from the withers in beef, rabbit and humans, while it remains much localized in equine and other carnivores. The trapeze has a caudal insertion on the cartilaginous and dorsal edge of the scapula, lateraling on its fibrous side in its dorsal part, forward for the cervical head and back to the chest head. It ends on the nuchal ligament in front and on the suprathorny ligament back.

The rhomboid

The rhomboid, which is not atloid as in pigs, or cervical as in carnivores, is a union muscle that is defined between the upper edge of the scapula, in its dorso-caudal cartilage that extends the bone back, and the thoracic vertebrae in their transverses, from T1 to T7, as in most ruminants. The angles of pennation are increasingly angular towards the first thoracic, while in T5/T6, the muscle fibers are perpendicular to the longitudinal axis of the spine.

Head and neck splenius

The splenius of the head and neck are highly identified on the transverses of C3 and especially of C5, which is not the case of beef, and moreover, unlike equines, they merge with the small complexus of the atlas at the level of the atloid fibers and the large complexus, or semi-thorny of the head. They are more developed than in bovids and equines, certainly because of the development of their future plume. The splenius are essentially spinal muscles, which decompose into splenius of the head and splenius of the neck, itself divided into C3 and C5 splenius. The splenius, with a high head in plume on a caudo-cranial axis, have a dorsal insertion on the nuchal ligament and back on its superficial aponevrose. They merge even further back with the insertion of the serrated in its dorso-cranial part, then they gain caudalandment and ventrally the ribs of the 5th to the 9th ribs. For the splenius of the head, a mastoid and occipital insertion will be described in its very lateral part. The neck splenius, usually not developed in the ruminant, was found to be present in this deer. Deeper than the above, it has two main twigs, one more in C2/C3 and the other in C5 as in equine, which is rarely described in beef, although ruminant. These twigs merge in a cranial way with the Atloid fibers of the small atlas complexus. The distinction is made between the more ventraliated caudal rhomboid and the more ventrcanal-like head and neck splenius.

The small complexus of the head or longissimus of the head

The small complexus of the head, or longissimus of the head, is identical in equines. The complexus are currently named semi-thorny head, longissimus of the head and longissimus of the atlas. The longissimus of the head fits into its ventro-cranial part on the temporo-parotid area, then takes its caudal insertion on the transverse processes of the 3rd and 4th cervical, and not up to the first chests as in equines and bovids. Fusiform, the complexus has muscle fibers that coil in a dorso-ventral way, in the senestral sense, especially in their cranial part and mainly for the large complexus, or semi-thorny of the head, and this on the right side of the animal. The caudal pennation angles are perpendicular to the main axis of the muscle in its caudo-dorsal part. It is necessary to differentiate the semi-spiny head into large occipital complexus and small complexus of the head. It then becomes the longissimus of the head, in temporoparotid insertion. The small complexus of the atlas or longissimus of the neck is the deepest of the three.

The small complexus of the atlas or longissimus of the neck

The small complexus of the atlas or longissimus of the neck is identical to all the descriptions of the equines, more ventral on this dissection. This muscle is auxiliary to the splenius, we can describe only one tendon of lateral insertion on the occiput, and not two as in carnivores or pigs. The splenius complex, semi-tendent and longissimus, or complexus, are more developed in deer than in other ruminants and equines, probably because of the weight of their future seasonal plume.

Scalènes

Scalenes are a complex of three muscles in the lower part of the cervicaloverflowon the 1st rib for ventroral or supra-costal scales, and deeper for the middle scalene. The dorsal scalen earlier than the other two is part of the cranial part of the transverses of the 4th, 5th and 6th cervical, as in all ruminants and in humans. It is described from the 2nd to the 6th vertebra in the cat. Their ventral face extends to the cranial side of the 1st coast, and a fascia remains contiguous until the 3rd coast. This fascia is present in humans inconsistently until the 2nd coast, and rarely until the 3rd. The supra-costal or ventral scales fit like the back, on the transverses of the 4th to the 6th cervical for their ventral face, and extend on the cranial face of the 1st side. The middle scalelen ecannce is found on a whole side of the transverse of the 6th cervical and then caudally, it overflows on the cranio-external side of this 1st rib, dorsing in relation to it (Figure 9).



Figure 9. Left ventrleal scalene.

The oblique of the head

The oblique of the head inserts itself dorsally over the entire caudo-cranial axis of the spiny axis, ending laterally, cranially on the lateral part of the atlas wing.

Along the neck and head

Along the neck and head, sometimes named large right of the head, is anastomosed in C3. It fits caudally on the transverses of the 6th to the 3rd cervical, and cranially on the lateral part of the occiput, overflowing on the large wing of the sphenoid. Contrary to what is observed in equines, there is no guttural pocket separating it from the deep plane.

The cross-neck

The transverse of the neck is anastomosis with the thoracic part of the neck. It is fickle in equines, non-existent in humans, but constant in ruminants. Caudalement, it inserts itself on the transverse of the 5th cervical and ends up crannatingly on the very lateral part of the wing of the atlas. Deep, it anastomosis with the ventral intertransversaires and along the neck, medially and ventrally. Since it comes out of the biomechanics of the cervical tendon that is the setting for this study, its description here is partial. The thoracic part of the neck, laterally anastomosed in depth with the caudal part of the transverse, at the level of C5, will extend caudally towards the 1st and up to the 3rd thoracic in their vertebral body ventrally.

The semi-thorny neck

The semi-spiny neck, very low in humans, but much more consequential in ruminants and equines, spreads crânially on the spines of the last five cervicals, as in other ruminants, and ends caudally on transverses of the first three chests. Strong anastomosis are observed with the thoracic spine that extends on each chest to the spinal ectuator's fascia at the first lumbar level. The description of the large cranial oblique of the head, which extends the large caudal right of the head, towards the latero-medial zone of the occiput, is incomplete because it was very damaged by the entry of the hunting

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projectile. It fits dorsally over the entire caudo-cranial axis of the axis spin, ending laterally and cranially on the lateral part of the atlas wing.

Cervical cross-transverses

It is a succession of small transtransversary and thorny fleshy beams stretching from the space between C1 and C2 cranially, and caudalement towards the 6th and 7th cervical spaces to extend towards the 1st chest by what is akin to a fascia, anastomosed with the intertransversaries of the neck specific to each space. Very weak in humans and much more consequential in ruminants and equines, it spreads heavily on the spines of the last five cervicals on our dissection, and as in other ruminants, it ends caudally on transverses of the first three chests. Strong anastomosis is to be described with the thoracic spine that extends on each chest to the spinal ectuator's fascia at the first lumbar level.

The multifide of the neck and semi-thorny of the neck

It is represented by a succession of small, fleshy, intertransverse and thorny beams that spread from the space between C1 and C2, and caudally towards the 6th and 7th cervical spaces to extend towards the 1st chest by what is akin to a Fascia. His anastomosis with the intertransversaries of the neck specific to each of the spaces that are described succinctly.

Discussion

The nuchal ligament and its anatomical continuity, the supra-spinal ligament, having the same embryological origin as the desmodontal ligament leads to the idea that there is a biological, clinical and chemical coherence between these three elements, and that their programming function would take precedence over their structure function [7,8].

The links of embryological congruences between these three anatomical pieces, combined with the results of work on calcitonin, itself linked to the presence of neuropeptide Y (NPY) open the way for new research oriented on these ligament axes.

Discovered and sequenced in 1982 by Tatemoto, the NPY is a peptide neurotransmitter of 36 amino acids, of very preserved sequence in the animal kingdom [9]. Thus, the sequence of NPY in the alligator is identical to that of humans that of the hen is distinguished by only one amino acid and that of the sheep by two amino acids. NPY belongs to the family of eponymous peptide neurotransmitters that also includes polypeptide Y (PPY) and pancreatic polypeptide (PP). Secreted by the hypocampus, it is found in the central and peripheral nervous system, in the sympathetic and parasympathetic system, and on the periphery of many organs. Its versatile role has already been reported in the literature: appetite stimulator, thermoregulator, vasoconstrictor, anxiolytic. Its action on the calcium chain has also been highlighted [10].

The bio-library study of Trypsin-digested NPY blasts demonstrated sequence similarities for three positions - except in rats where the position is different: the SSPETLISDLLMR group in position 68-80, the HYINLITR group in position 54-61 and YYSALR in position 48-53. The first two sequences, SSPETLISDLLMR and HYINLITR, are

blasted 100% in all mammals listed, and 92% in some white bats, hamsters, and mice. These results serve as preliminaries for subsequent spectrographic analyses at the Monod Institute with Dr. Thibaut Léger on various ligament samples.

The hypothesis of the presence of NPY at the ligament level was advanced as early as 1999 by Yew and Chan and then taken over in 2012 by Sengul and Watson [11,12]. They stress the relevance of NPY at the high ridges until the 12th week of gestation in humans, to propagate laterally and secondaryly cranio-caudalement to the sacred region, gaining future pudendal ganglia, to balance the innervation of the streaked muscles of the sphincter area of the molimen. It is only at the end of this caudal migration, after the 15th week and during the end of the post-chorddale neurulation, that the NPY will be found on its hippocampal axis [11]. This analysis corroborates the hypothesis of the presence of NPY at the ligament level of the supra spiny in the area of the tourniquet, as previously envisaged by the embryological data. Moreover, in their work on the spine, Aspden and Porter show that this ligament relevance would be verifiable on the entire supra-thorny ligament up to the lumbar vertebrae [13].

It is first within the dental joint and especially the desmodontal ligament that Dr. Bouchard's work has demonstrated the presence of NPY [8]. Then it was on the pituitary and hypothalamic level that brain concentrations were found [14]. The purpose of this preresearch, through a look at anatomy and embryology, is now to consider the presence of NPY on a ligament plane.

Work on calcitonin and NPY since 1986 has, among other things, helped to understand the brain's cholinergic interactions with NPY in Alzheimer's disease and its influence on depression and memory stability, which has been confirmed recently by the work of Dr Gérard Karsenty [15,16]. The links discovered between NPY and calcitonin, identified through the same gene CGRP 90, are in this ensemble an axis of complementation and coherence to this research [17].

Thus, the relationship between wood weight, tourniquet, wood calcium and NPY, would be a source of understanding of calcium interactions for these bone structures that are wood. It is this set that drives us to consider chemical analyses on the nuchal ligament. The evidence of the presence of neuropeptide Y on the nuchal ligament of several elaphe deer specimens would support the hypothesis that the weight of the wood stimulates calcium production. The search for NPY could initially be carried out by immunofluorescence on various ligament tissues from a female - naturally devoid of wood - and a mature male with developed woods. The various anatomical sites studied would be the nuchal ligament, the supra-spinal ligament, the desmodontal ligament, the ball suspense and the hamstring. The collection protocol for the Elaphe deer would be made on anatomical material from animals identified by bracelets, numbered and certified by FICIF (Figures 10-12).



Figure 10. Ligament nuchal.



Figure 11. Ligament nuchal represented in its entirety.



Figure 12. Anterior part of the nuchal ligament.

Conclusion

Comparative anatomy analyses of all these parts revealed that the diameter of the nuchal ligament in elaphe deer is greater than in other bovids and in equines. It anastomosis to the over-thorny ligament up to the sacro-coccygian zone, without a continuity solution, creating an overall biomechanics and strengthening the cephalic maintenance of the woods. Increasing towards its cranial

part, it measures in the specimen analyzed more than 42.7 mm in diameter on average, which makes it possible to understand its cerebrospinal biomechanical coherence.

The result of this dissection thus highlighted the more than obvious importance of the nuchal ligament and therefore the existence of a biomechanical coherence, in relation to the weight of the woods. The anatomical comparison with this same ligament in the doe, which has no branch and therefore no seasonal overweight at the head, would corroborate, or if necessary deny, the link between the large diameter of the nuchal ligament observed in deer (the daguet) and the wearing of antlers.

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