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TOPIC:

Contribution to the study of the Anatomy and ethology and Pathologies of the lion (panthera leo) at the Berabtia zoological park in El Kala (Algria)

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Abstract

This thesis aims to explore the anatomical and behavioral characteristics of the lion (*Panthera leo*) in a semi-natural environment at the Berabtia Zoological Park in El Kala, Algeria. The first part focuses on external and internal anatomical analysis based on comparative and observational methods, covering regions such as the head, limbs, tail, and coat. The applied part consists of a seven-month ethological observation including feeding, resting, reproductive, aggressive, and stereotypic behaviors, along with a parasitological laboratory study for detecting gastrointestinal parasites. The findings suggest that the lions exhibit behaviors closely resembling their wild counterparts, with some captivity-related deviations, emphasizing the need for improved enrichment and veterinary care in zoological settings.

Résumé

Ce mémoire vise à étudier les aspects anatomiques et éthologiques du lion (*Panthera leo*) dans un cadre semi-naturel au Parc zoologique de Brabtia à El Kala, Algérie. La première partie est consacrée à une description anatomique externe et interne à travers des observations directes et comparatives, portant sur la tête, les membres, la queue et le pelage. La seconde partie, pratique, comprend une étude comportementale basée sur sept mois d'observation continue (alimentation, repos, reproduction, agressivité, stéréotypies) ainsi qu'une étude parasitologique en laboratoire visant à détecter les parasites gastro-intestinaux. Les résultats montrent que les lions manifestent des comportements similaires à ceux en milieu naturel, bien que certains écarts soient dus à la captivité, soulignant ainsi l'importance de l'enrichissement et des soins en captivité.

ملخص

تهدف هذه الرسالة إلى دراسة الجوانب التشريحية والسلوكية للأسد (Panthera leo) في بيئة شبه طبيعية بحديقة حيوانات برابطيا في القالة، الجزائر. يُخصص الجزء الأول لوصف تشريحي خارجي وداخلي من خلال ملاحظات مباشرة ومقارنة للرأس والأطراف والذيل والفراء. أما الجزء الثاني، وهو عملي، فيتضمن دراسة سلوكية مبنية على سبعة أشهر من المراقبة المستمرة (التغذية، الراحة، التكاثر، العدوانية، الصور النمطية)، بالإضافة إلى دراسة طفيليات معوية مختبرية تهدف إلى الكشف عن طفيليات الجهاز الهضمي. تُظهر النتائج أن الأسود تُظهر سلوكيات مشابهة لتلك الموجودة في البرية، على الرغم من أن بعض الانحرافات ناتجة عن الأسر، مما يُبرز أهمية الإثراء والرعاية في الأسر.

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Above all, I thank God Almighty for granting me the strength, patience, and perseverance to complete this work. Without His guidance and blessings, none of this would have been possible.

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I would also like to thank Mr. Saudi Hani and the staff of the Scientific Research Laboratory at Chadli Bendjedid University – El Taref for their support and expertise during the parasitological examination.

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Introduction

The conservation of wildlife is essential for maintaining biodiversity and thus preserving ecosystems as best as possible. The lion is a threatened species, and some subspecies are at risk of extinction. The current global population of wild lions is estimated to be 30,000 in Africa and less than 300 in India. Over the past twenty years, the lion population has decreased by 30 to 50%.

The main cause of this massive extinction is human activity, including hunting, the increase in human population, and intensified agriculture leading to the reduction of their traditional habitat and the scarcity of prey. The fragmentation of areas where lions live also result in a loss of genetic diversity. Environmental factors also contribute to the extinction of these species, as global climate change causes natural disasters, including droughts or, conversely, floods, which disrupt ecosystems.

The aim of this study is to understand the ethological and anatomical aspects of lions, as well as the pathological aspects, in order to propose a health management strategy to conserve this animal species.

The first part will focus on describing this animal species, including taxonomy and phylogeny, anatomical and physiological characteristics, ethology, and finally geographic and eco-climatic distribution. In the second part, we will discuss our work at the zoo, particularly presenting the anatomy of the lion and the common pathologies observed in the Brabtia Zoo of El Kala.

Chapter I: General Description of the Species

Chapter I: General Description of the Species

The lion (*Panthera leo*) belongs to the Felidae family, subfamily Pantherinae, and genus *Panthera*, which includes the tiger (*P. tigris*), leopard (*P. pardus*), jaguar (*P. onca*), and snow leopard (*P. uncia*). It is the only social species among big cats, living in organized groups called prides. Taxonomically, lions are divided into several subspecies, but recent genetic studies support the classification of two major clades: the African lion (*Panthera leo leo*) and the Asiatic lion (*Panthera leo persica*) (Bertola et al., 2016).

Phylogenetic analysis using molecular data suggests that the genus *Panthera* diverged from other felids during the Pliocene, approximately 2 to 3 million years ago. Among *Panthera* species, the lion is most closely related to the tiger, as confirmed by mitochondrial DNA and nuclear genome sequencing (Johnson et al., 2006). These evolutionary relationships reflect ecological adaptations, particularly to predation strategies and environmental pressures.

The historical distribution of lions once extended across Africa, southern Europe, the Middle East, and southwest Asia. Today, their natural range is severely restricted, with wild populations primarily found in sub-Saharan Africa, while a single, critically endangered population of Asiatic lions persists in the Gir Forest in India (Nowell & Jackson, 1996; IUCN, 2021).

From an ecological standpoint, lions are best suited to tropical and subtropical ecosystems, thriving in habitats that offer open terrain for hunting and shelter for resting and reproduction. They inhabit savannahs, grasslands, dry woodlands, and some semi-arid regions but tend to avoid dense tropical forests and deserts (Sunquist & Sunquist, 2002). Their survival is closely linked to the availability of large herbivores and well-balanced trophic dynamics.

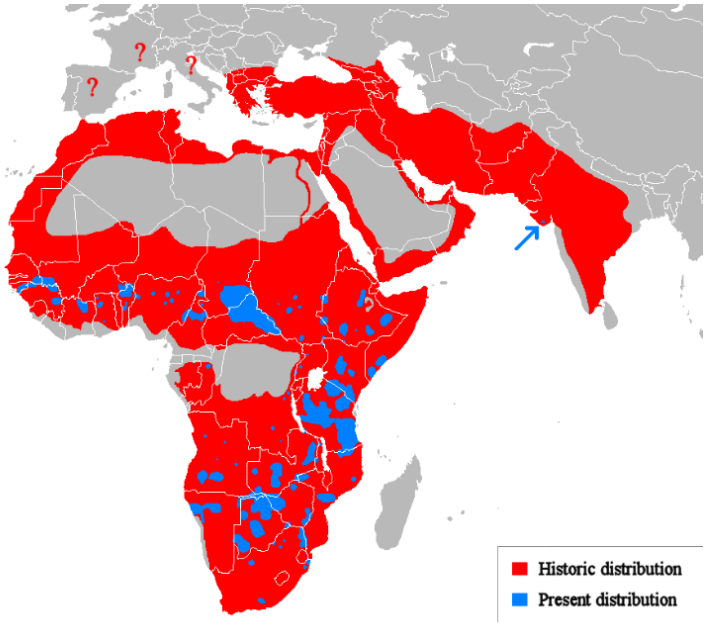


Figure 1: This map shows lions historical broad distribution across Africa, Europe, and Asia (in red), contrasted with current isolated populations (in blue).

CHAPTER II: ANATOMY OF PANTHERA LEO

CHAPTER II: ANATOMY OF PANTHERA LEO

Géneralities

The lion is part of the genus Panthera along with the leopard; it is the largest of the African carnivores. It is an animal with a robust, muscular, and elongated body, equipped with fairly large legs. The size of individuals varies greatly depending on the regions (climate, environment, abundance of food). For example, they are larger in Southern Africa. Females are 20 to 50% smaller than males. (mammiferes Africans.org).

I.1. Conformation

On average, an adult male lion weighs about 200 kg and stands 125 cm at the shoulder (compared to 130 kg and 105 cm for females). Despite large variations in size and weight, the overall body plan of felines has remained particularly stable for the last 20 million years (Anatomy of male lion).

Regarding the lion, the head is wide and globular but has a fairly elongated muzzle. Highly prominent zygomatic arches can be seen extending far from the skull. The ears are short and rounded (Anatomy of male lion), and have a black spot on the back face (african mammals.org).

The vast majority of lions with lesions on their ears (wounds, tears, etc.) show these lesions only on the left ear. Since these injuries are mostly due to fights with peers, it seems that most lions are right-handed. Indeed, during a fight, lions primarily use their right forelimb, and in doing so, they preferentially make contact with the left ear of their opponent. These injuries are an integral part of the morphological identity of the lion, as they allow different individuals to recognize each other (Anatomy of male lion).

In addition to ear injuries, alopecia patches (mainly around the tail tuft), one-eyed lions, or various visible scars on the face are frequently observed. The forelimb is particularly well-developed in terms of muscle, with a very short neck. The torso is elongated and robust with a marked waist, supported by relatively short but powerful thoracic limbs. The pelvic limbs, on the other hand, appear slenderer (SUNQUIST and SUNQUIST 2002).

I.2. The Posture

The lion is digitigrade, that's mean he walks on its toes, without the metapod touching the ground (GRASSE, Treatise on Zoology, Volume XVI First Fascicle: Mammals, Integument, Skeleton 1967).

This posture allows for an increase in the physiological length of the limb compared to plantigrade species, which enhances the length of strides. The first toes of the forelimbs do not touch the ground, and those of the hind limbs are vestigial. The gait is fluid (ANATOMIE OF MALE LION).

Male lions adopt a specific, characteristic posture that serves not only to impress potential intruders but also to attract females: they stand with their limbs extended, with a ruffled mane and their tail held high (SUNQUIST and SUNQUIST 2002).

I.3. The fur

The color of the fur is tawny, more or less dark, with the belly and the inner face of the limbs lighter than the body cream to almost white (african mammals.org).

The young are tawny with rosette-shaped spots. Their fur becomes uniform as they grow, however, these spots sometimes persist in older individuals, especially in East Africa and mainly in females (african mammals.org).

This hue perfectly matches that of the dry grasses of the savanna, which makes the predator invisible to the eyes of herbivorous prey that see in black and white (BERTRAM 1978).

The lion is a stealthy hunter: it approaches its prey as closely as possible without revealing itself before pouncing. The coat therefore provides a strategic advantage, allowing the predator to camouflage itself through two main methods:

The coloration that generally resembles the dominant shades of the habitat (a major adaptation for hunters in open terrain).

The patterns and lighter areas of the coat that enable forest and savanna hunters to conceal themselves optimally through the interplay of light among tall grasses and woodland vegetation (ANATOMIE OF MALE LION).

I.4. The mane

Only males have a mane that appears around the age of 2 to 3 years. Its size (length and thickness) and color are highly variable depending on the regions, climate, age, and individual

specimens. The shade can range from blonde to black, including hues of ochre or reddish-brown (african mammals.org).

The color of the mane is part of the genetic heritage and tends to darken with age. The abundance of the mane is also linked to this heritage but also to testosterone production. Some lions do not have a mane, or have very little. Castrated lions lose their mane (african mammals.org).

The mane extends from the cheeks to the shoulders, above the nape of the neck, under the neck to the belly, and even to the back of the front legs. It may sometimes continue as a fringe under the belly (african mammals.org).

The exact role of the mane is not known for certain, but it is believed to provide protection for the head and neck during fights and to symbolize strength. According to experiments with plush toys or models, it seems that females prefer males with a dark mane. Males with thick, dark manes are more feared by their rivals. The mane becomes abundant around the age of 4 to 5 years and continues to darken with age until around 9-10 years (african mammals.org).

Lions are the only felines to exhibit such sexual dimorphism. However, there are instances of females with manes. Between 2014 and 2016, in the Okavango Delta in Botswana, 5 maned lionesses were studied by scientists. This abundant mane is due to a hormonal disorder that leads to an abnormally high level of testosterone (african mammals.org).

Researchers have questioned the low proportion of black-maned lions, while studies have shown that this trait provides a real social advantage (better chances of being accepted and lasting in a group...). It seems that the downside of this attribute is a significant thermal handicap: indeed, the longer and darker the mane, the less it allows heat to dissipate. However, lions are very sensitive to heat, as they have a low surface-to-volume ratio and do not sweat. Thus, they release excess heat by panting at the slightest effort and through thermal radiation from their skin (WEST 2005).

Figure 2: Lion mane by lions tigers and bears.

Case of vibrissae (LOVERDGE and MACDONALD 2010) (ANTON and TURNER 1997):
Although the composition is generally similar to that of other hairs, the implantation is deeper and the bulb is very richly innervated, notably by branches of the trigeminal nerve, which allows the lion to detect movements in the nearby environment, thus providing the predator with a "vision through touch." They appear early in embryonic development, before the "classic" hairs, and play a crucial role in protecting the eyes while collecting environmental information (very important for hunting and senescence, when vision begins to fail) (www.vetopsy.fr/sens/systeme□somatosensoriel/toucher/vibrisses.php n.d.).

In carnivores, there are 4 main groups of vibrissae on the face:

The buccal group at the level of the snout and lips; the snout of lions has 4 or 5diameter that allow individuals to be differentiated from each other.

The supra-orbital group in the ocular region

The zygomatic group at the level of the cheeks

The sub-mental group

Study by region

1.The head

1.1. The eyes

A lion's vision is arguably its most essential sense. With a keen sense of smell and remarkable hearing, these top predators possess a significant edge over the majority of their prey. Their vision, while no better than ours in daylight, is significantly enhanced at night; it's claimed that lions can see eight times more effectively than we can in the dark.

Lions primarily perceive blue and green hues and possess excellent night vision. This doesn’t imply they can see in the dark; in total darkness, a lion would also be blind. The structure of a lion's eye enables them to detect and enhance extremely dim light like that which comes from the stars and the moon.
Their eyes can amplify this dim light via various techniques.

1.1.1. Within the eye:

In the retina of the eye, rod cells outnumber cone cells. These are photoreceptor cells that are sensitive to light; cone cells are responsive to color, while rod cells are sensitive to light. Lions possess a greater density of light-sensitive cells concentrated in the fovea (the retina’s most sensitive region), which allows them to see with just 1/6th of the light required by humans. Lions possess a Tapetum lucidum, which is a reflective cell layer located behind the retina. This indicates that light entering the eye gets absorbed by either rod or cone cells ; the light that goes through the retina and photoreceptor cells is reflected back by the Tapetum lucidum, giving the light-sensitive cells another opportunity to absorb the light waves, effectively enhancing their night vision’s efficiency. This reflective surface causes the spooky ‘eye shine’ observed when directing a light at animals during the night. Most animals possess this layer to different extents (Safari guide online).

1.1.2. Outside the Vision

It may seem odd, but the external features of a lion’s face improve their ability to see at night. The white strips beneath their eyes bounce subtle light into the eyes, enhancing the volume of light that enters the eye. This trait strongly suggests that this creature is active at

night, whereas examining cheetah eyes reveals the contrary. Cheetahs possess black tear markings that minimize glare while they hunt during the day. Similar to how an American football player applies black face paint beneath their eyes. In conclusion, human senses differ significantly from those of animals, primarily depending on our larger brain to navigate life. Our vision and hearing are quite good, whereas our sense of smell is much weaker in comparison to that of most animals. As humans, our understanding of the surrounding world is quite limited, making it challenging for us to envision anything beyond what we can perceive and observe. For example, numerous snakes possess heat-sensitive receptors on their heads, allowing them to perceive a thermal representation of their environment. Numerous birds have the ability to perceive Ultra-Violet lightwaves, but that is an entirely different topic (Safari guide online).

Figure 3: lion eye by ISTOCKE

1.2. Tongue and dentition

1.2.1. Tongue

The lion’s tongue measures around thirty centimeters and is adorned on its dorsal surface with keratinized papillae, approximately 5 mm long, curled backwards. These do not have a gustatory role but facilitate the extraction of muscles attached to bones during a meal (MORIN-GARRAUD 2001). They also help to clean the blood from the fur and remove external parasites, which is essential for the fur to maintain its protective role against heat and sunlight (FRISCIA and GOSWAMI 2010). Moreover, they protect the tongue from injuries that can be caused by sharp foods, such as bones. Foliate papillae are poorly developed in lions. (Anatomy of male lion).

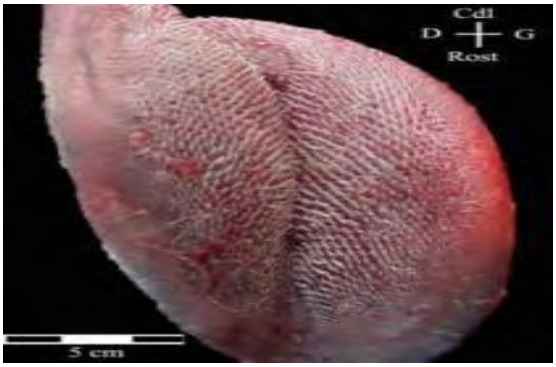


Figure 4: Cornified papillae of the tongue. Photo by J. Magrans, ©ACO.

1.2.2. Dentitin

The deciduous dentition develops from 3 weeks of age, and the milk canines only develop around 15 weeks. As for the permanent dentition, it is fully established by 15 months. Due to the shortening of the jaw in lions, as in all felines, the number of teeth is reduced compared to other carnivores.

I3/3; 1/1; PM; 3/2; M 1/1 30 teeth (GRASSE, Treatise on Zoology, Volume XVII First fascicle; Mammals the orders: Anatomy, Ethology, Systematics 1955)

The teeth of the lion have specialized to suit its particular strict carnivore diet

- The long and sharp canines do not actually participate in food intake but are the preferred weapon during hunting. They fit between the vertebrae and allow the breaking of the spine of smaller prey. In this regard, Leyhausen suggests that the rich innervation of the canines helps locate the space between the vertebrae of prey. For larger prey, male lions use the technique known as the "kiss of death": they bite the victim's snout in such a way as to crush the nostrils together, which suffocates it (The anatomy of male lion 2015) .
- The incisors are small and arranged in a straight line, not in an arc as is the case with canids, for example. They not only allow tearing muscle from bones but also gently extracting internal organs from the carcass to share with the rest of the group.
- The first upper premolar and the molar are vestigial. The last maxillary premolar and the mandibular molar, known as carnassials, act like a true pair of scissors, allowing the lion to cut the meat into smaller pieces that it can swallow. Indeed, there is no true chewing behavior in this species, and the jaws are also incapable of lateral movements (the anatomy of male lion).

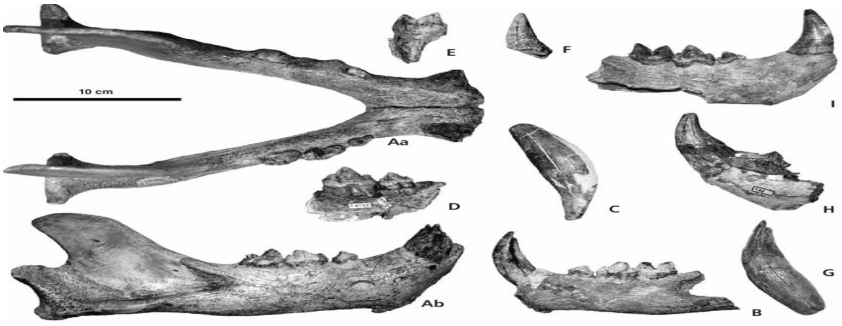


Figure 5: Mandible remains of Panthera leo spelaea (Goldfuss, 1810) from open air loess sites in Central Bohemia and other sites in the Czech Republic. • A-lower jaw of an adult male individual, a-dorsal, b-right mandible lateral. • B-left mandible of an adult

2. The Members

The average walking speed of a lion is about 4 km/h. Its limbs, even though they are strong and allow it to jump up to 12 meters long, are not highly specialized compared to those of other felids, except for the leopards and Acinonyx jubatus (Schreber, 1775). It can be concluded that: Short limbs provide greater strength for jumps as well as excellent acceleration over short distances. Long limbs ensure increased speed over long distances. In lions, there is a compromise between these two adaptations, with a slight prevalence for the first, which aligns with their hunting method. However, it is noteworthy that the humero-radial index of the lion is 98.3%, making it closer to that of the cheetah (100%) compared to that of the leopard (87%) (LOVERIDGE and MACDONALD 2010). The lion is therefore an excellent runner, capable of reaching speed bursts of up to 60 km/h over distances of around a hundred meters. However, most of the pursued herbivores are faster, resulting in a specific hunting method: hunters get as close as possible to the animal to envelop it (in teams of about 4 people). Then, one team member charges (the anatomy of male lion).

It is fascinating to note that the anatomy of the limbs alone cannot justify the speed that a lion is capable of achieving and maintaining over considerable distances. Other adjustments come into play here: The flexibility of the spine allows for significant flexion/extension movements, increasing the length of strides. The significant lateral flexibility of the intervertebral joints in the spine provides the ability to negotiate very tight turns at high speed. The clavicle is reduced to a vestige, allowing the shoulder joint to be freed, which offers a better range of motion in the forelimbs. The specific arrangement of muscles on the scapula provides a great amplitude of movement.

2.1. claws

The claws are keratinized appendages formed from cells embedded in the ungual groove of each distal phalanx of each finger. They consist of a cornified sheath derived from the epidermis of a wall made up of a cornified plate wrapped on each side, which thins out on the sides. The claw of digit I of the thoracic limbs does not reach the ground and is only used to grasp prey. It is generally longer than the other claws (approximately 110% of the claw of digit II, Londei 2000) and has a greater curvature. Furthermore, the sheath of the claw bears an ossified collar, the ungual crest, which holds the proximal part of the claw at the bottom of the ungual groove of the distal phalanx, ensuring better tolerance to stress.

The lion shares with other felines the ability to retract its claws. This retractability consists of the opening/closing of the 2-3 phalangeal angle:

2.1.1. Retraction, a passive phenomenon: it is first noted that the distal end of the second phalanx has a particular shape that creates a slight offset of the interphalangeal joint. This offset allows the medial side of the third phalanx to position against the lateral side of the second on the same finger. This observation applies to all fingers except for the thumb. It is the dorsal elastic ligaments that allow the third phalanx to return to the lateral interdigital space without any muscular intervention. Thus, most of the time the claws are "retracted," which protects them from the external environment and keeps them always sharp, especially since they are covered by a skin fold that completely conceals them "in the retracted position (PERRAULT 1977).

2.1.2. Protraction, an active phenomenon: it occurs through the contraction of certain muscles that insert on the last two phalanges (PERRAULT 1977).

2.1.3. For the anterior member

- The extension of the proximal interphalangeal joint caused by:
- the contraction of the common and lateral extensor muscles of the fingers
- the action of the inter-flexor muscles which drive a forward push of the second and third phalanges.
- The contraction of the deep flexor muscle of the fingers allows the opening of the 2-3 phalangeal angle (the anatomy of male lion).

2.1.4. For the posterior member

The extension of the toe, along with the clawing, is enabled by the contraction of the long extensor muscles of the toes, the short extensor muscles of the toes, and the deep flexor of the toes (flexion of the distal interphalangeal joint) (the anatomy of male lion).

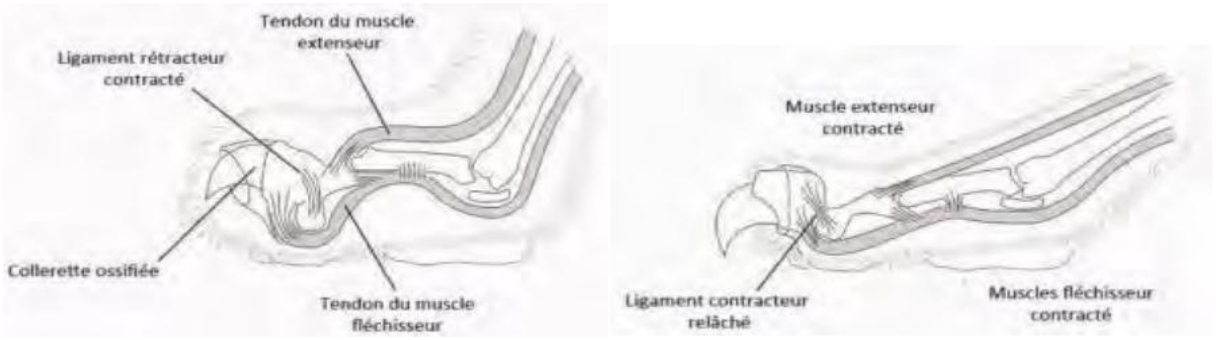


Figure 6: Schematic representation of the mechanism of protrusion of the retractable claws of felines. After (SUNQUIST and SUNQUIST 2002)

2.2. The torus

These are skin appendages located on the hands and feet. They consist of tubercles through which the limb makes contact with the ground (PERRAULT 1977):

2.2.1. Digital torus

Numbering five, they protrude beneath the last interphalangeal joint. The one on the thumb persists only as a vestige. Oval in shape, the apex is oriented towards the corresponding claw.

2.2.2. Metacarpal and metatarsal torus

Roughly triangular in shape with a rounded peak, it is larger than the previous ones. It inserts between the digital tubercles of fingers II, III, and IV. In lions, the supporting fibers form a thick, very resistant fibrous bundle.

2.2.3. Carpal torus

Pear-shaped, it is the smallest of the tubercles. It is particularly prominent on the palm side.

They are supported by fibrous bundles derived from the tendon of the perforating muscle. During hunting, these bundles contract and the pads, which are very prominent at rest, flatten to facilitate running (PEEL, Lion Anatomy - Paws 2011).

The skin covering the pads is particularly thick and hard. It is black and hairless. Beneath, there is a core of elastic, fibro-adipose tissue. This tissue is rich in sweat glands (which are responsible for marking), blood vessels, and sensory nerve endings that confer great tactile sensitivity to these tubercles.

They help redistribute body weight, thereby ensuring not only secure ground contact (LOVERIDGE and MACDONALD 2010) but also smooth and quiet movements. The presence of hair between the toes also helps to muffle sounds (PEEL, Lion Anatomy - Paws 2011). They thus constitute an essential adaptation for hunting.

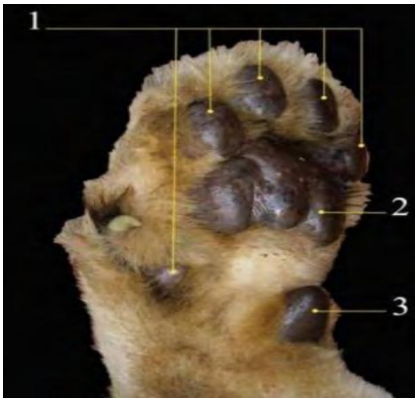


Figure 7: Location of the toruses on the left thoracic limb. Photo by J. Magrans, ©ACO.

3. The tail

Shorter than that of climbing species, it still represents 40% of the total body length (SUNQUIST and SUNQUIST 2002). Acting as a rudder, it allows the lion to make tight turns quickly while running.

Figure 8: lion tail. photo by Dutchbaby. 2010

Osteology

1. The axial skeleton in lions

1.1. The skull

-Skull is narrower and longer than in cats, pronounced masticatory muscle development, requiring widened insertion areas (occipital and sagittal crests).

-Wide orbits, very flared zygomatic arch.

-Large tympanic bulla, with a bony septum typical of felids.

-The skull, defined according to NAV nomenclature as the bony box surrounding the brain, is divided into two parts:

-**Neurocranium (caudal part): protects the brain.**

-**Splanchnocranium (rostral part): forms the face.**

1.1.1. Neurocranium

Occipital bone: unpaired, triangular, occupies the most caudal region. It features a prominent external occipital protuberance and wide condyles framing a foramen magnum that is wider than it is high. Insertion of muscles by the nuchal crest and external sagittal crest.

Sphenoid bone: floor of the skull, composed of the presphenoid (rostral) and basisphenoid (caudal), the latter bearing a marked pterygoid process (pterygoid hook).

Parietal bones: paired and symmetrical, less extensive than in cats, with little relief.

Temporal bone: laterally partitions the neurocranium; composed of squamous, petrous, and tympanic parts. Presence of an endotympanic bone in a large tympanic bulla.

Frontal bone: paired, forms the dorsal limit of the orbits, with a sharp zygomatic process.

1.1.2. Splanchnocranium

Nasal bone: long and narrow, without a rostral process.

Zygomatic bone: forms the lateral-ventral edge of the orbit, articulates with the temporal bone (zygomatic arch).

Lacrimal bone: limited to the orbit in lions.

Maxilla and incisive bone: form the upper jaw, housing the upper teeth.

Vomer, pterygoid, and palatine bones: contribute to the nasopharyngeal meatus and bony palate.

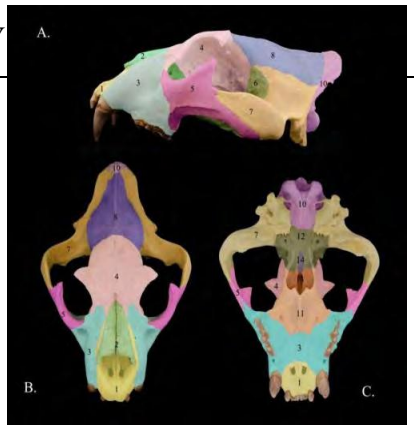


Figure 9: Bones of the face and skull, lateral view (A), dorsal view (B), and ventral view (C). Photo by J. Magrans, ©ACO.

1. Incisive bone; 2. Nasal bone; 3. Maxillary bone; 4. Frontal bone; 5. Zygomatic bone; 6. Lacrimal bone; 7. Temporal bone; 8. Parietal bone; 10. Occipital bone; 11. Palatine bone; 12. Basisphenoid bone; 13. Vomer; 14. Presphenoid bone.

1.1.3. The mandible

The mandible is paired, asymmetrical, and represents the lower jaw. It consists of:

A body (horizontal part) that holds the teeth.

A branch (vertical part) for muscle attachment.

Articulation with the skull via the mandibular fossa of the temporal bone.

Ventral mandibular symphysis uniting the two branches.

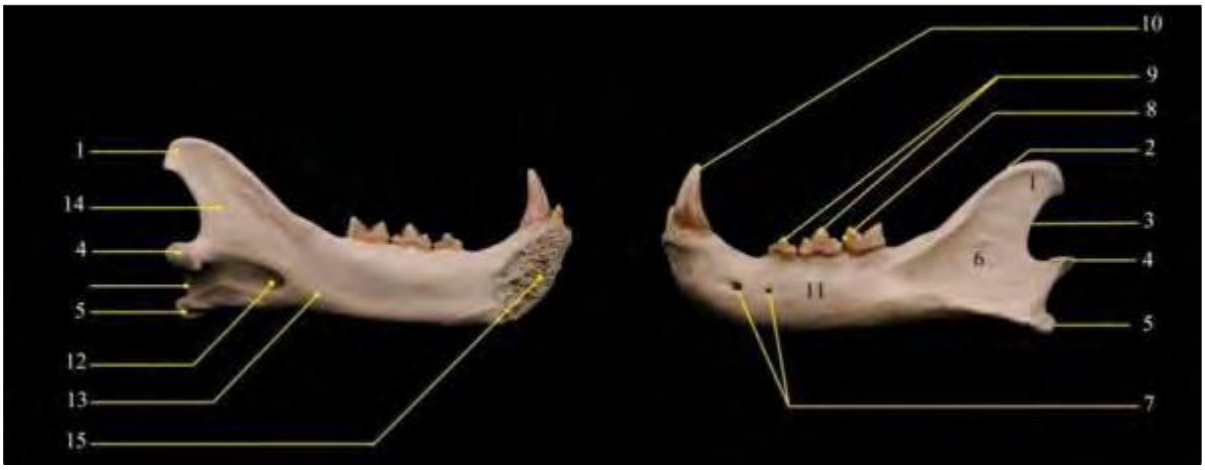


Figure 10: Lateral (A.) and medial (B.) views of the left mandible. Photo by J. Magrans, ©ACO.

1. Coronoid process; 2. Coronoid crest; 3. Mandibular notch; 4. Condylar process; 5. Angular process; 6. Masseteric fossa; 7. Mental foramen; 8. Molar tooth; 9. Premolar teeth; 10. Canine tooth; 11. Body of the mandible; 12. Mandibular foramen; 13. Mylohyoid line; 14. Ramus of the mandible; 15. Articular surface for the opposing mandible.

1.1.4. The hyoid

A structure derived from the branchial arches, connecting the base of the tongue to the larynx. In lions, it includes:

-**Stylohyoid:** connected by ligament to the epihyoid.

-**Epihyoid:** primarily ligamentous in lions, with a bony remnant. This configuration would facilitate roaring through the vibration of the larynx.

-**Tympanohyoid:** syndesmosis articulation with the skull; mobile rostrocaudally, with angular differences compared to cats.

-**Cerathohyoid:** a small elongated bone, with a synovial articulation at the caudal end.

-**Basihyoid:** transverse, located at the level of C5 (more caudal than in cats).

-**Thyrohyoid:** mixed (bony/cartilaginous), sometimes prolonged by an elastic ligament toward the thyroid cartilage.

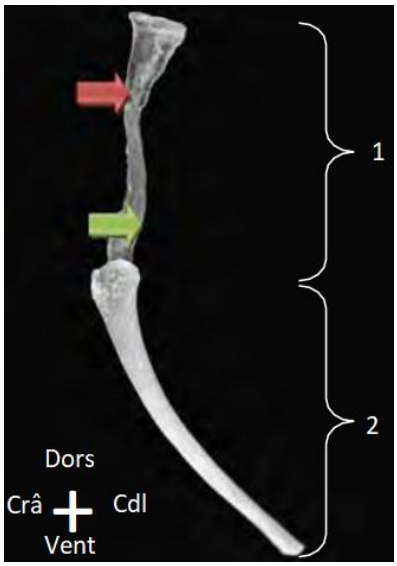


Figure 11: Lateral view of the tympanohyoid (1) and stylohyoid (2) of the lion. After (FITCH, et al. 2002) The arrows indicate the beginning (red) and the end (green) of the rotating part of the tympanohyoid bone.

1.2. The spine

The spine of the lion exhibits a series of morphological features that reflect its functional adaptations as a large carnivore.

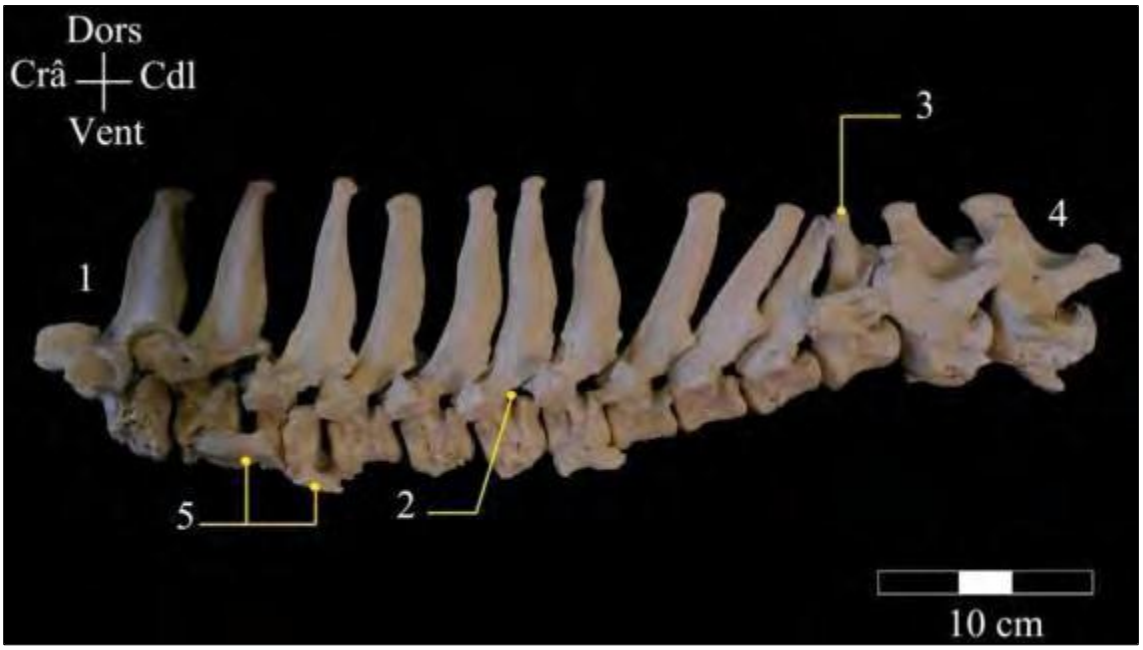


Figure 12: Side view of the articulated thoracic spine of the lion.

1. 1st thoracic vertebra; 2. Intervertebral foramen; 3. 11th thoracic vertebra: anaclinal vertebra; 4. 13th thoracic vertebra; 5. Spondylosis.

Table 1: The vertebral formula of the lion

Type of Vertebrae	Number	Description
Cervical	7	Neck vertebrae
Thoracic	13	Chest vertebrae
Lumbar	7	Lower back vertebrae
Sacral	3	Fused in the sacrum
Coccygeal (Caudal)	18 to 23	Tail vertebrae - number may vary

1.2.1. The cervical vertebrae

1.2.1.1. The atlas

the first cervical vertebra, does not have a true vertebral body but consists of a ventral arch and a dorsal arch. Its transverse processes are well-developed and take the shape of wings. The ventral tubercle is slightly prominent and the allantoid fossa is more excavated than in the cat.

1.2.1.2. The axis

the second cervical vertebra, is characterized by the presence of the odontoid process (tooth), which plays a pivotal role in the rotation of the atlas and the head. As in the cat, the cranial notch remains open.

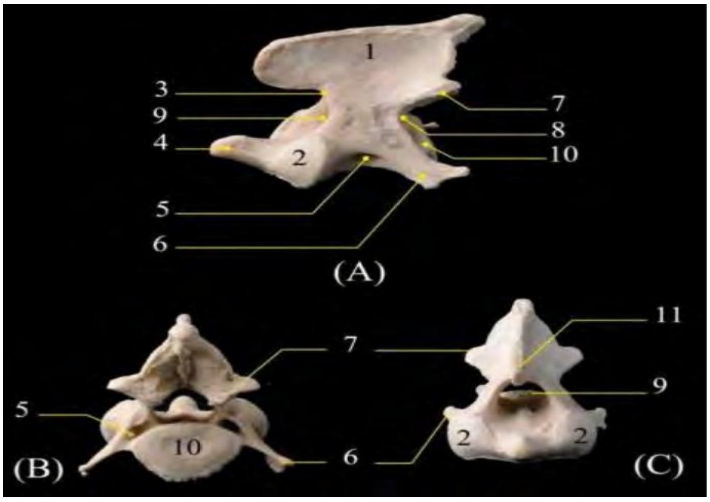


Figure 13: Left lateral view (A), caudal view (B), and cranial view (C) of the Axis. Photo by J. Magrans, ©ACO.

1.2.1.3. The other cervical vertebrae:

are distinguished by particularly wide transverse processes, indicating significant development of the cervical musculature.

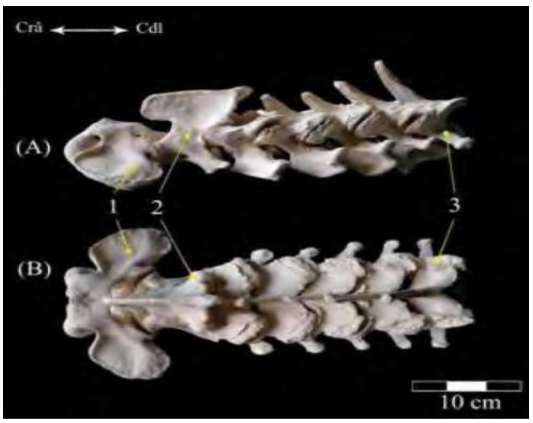


Figure 14: Left lateral view (A) and dorsal view (B) of the articulated cervical spine. Photo by J. Magrans, ©ACO.

1. Atlas; 2. Axis; 3. Seventh cervical vertebra.

1.2.2. The thoracic vertebrae

The thoracic region, heavily muscled, is marked by elongated spinous processes and short but wide transverse processes. A caudal orientation is observed in the first ten spinous processes, while those of the last thoracic vertebrae and lumbar vertebrae orient cranially, illustrating the phenomenon of the anticlinal vertebra. The eleventh thoracic vertebra, known as the anticlinal vertebra, has a perpendicular process, serving as a transition point between the opposite orientations of the adjacent vertebrae.

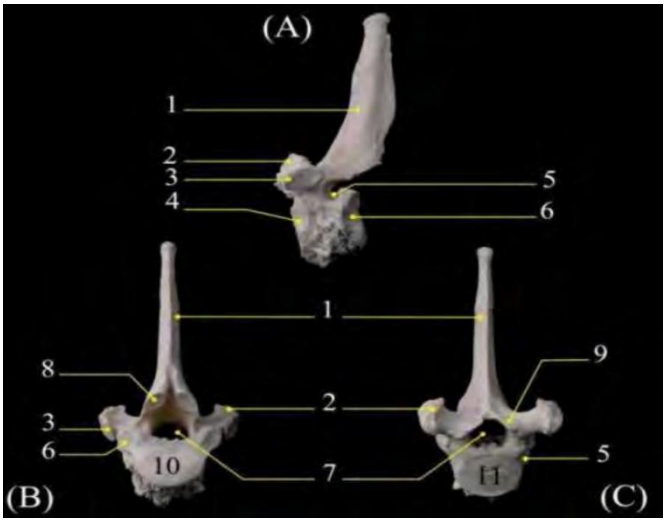


Figure 15: Left lateral view (A), caudal view (B), and cranial view (C) of the 7th thoracic vertebra. Photo by J. Magrans, ©ACO.

1. Spinous process; 2. Transverse process; 3. Costal facet of the transverse process; 4. Articular facet for the 7th rib; 5. Caudal vertebral notch; 6. Articular facet for the 8th rib; 7. Vertebral canal; 8. Caudal articular process; 9. Cranial articular process; 10. Vertebral fossa; 11. Head of the vertebra.

1.2.3. The lumbar vertebrae

Wider than the previous ones, the lumbar vertebrae of the lion are also less elongated and have a more cuboidal shape than in the cat, reflecting an adaptation for weight-bearing and stability of the hindquarters.

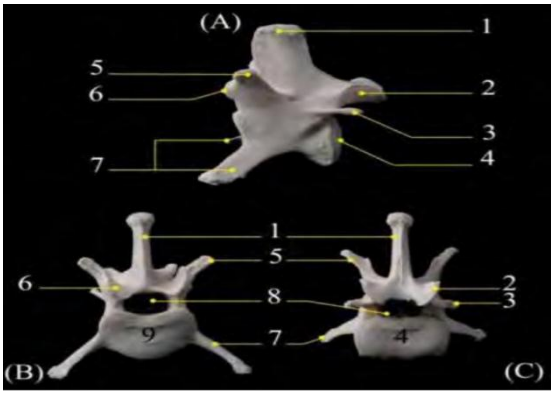


Figure 16: Left lateral view (A), cranial view (B), and caudal view (C) of the second lumbar vertebra. Photo by J. Magrans, ©ACO.

1. Spinous process; 2. Caudal articular surface; 3. Accessory process; 4. Vertebral fossa; 5. Mammillary process; 6. Cranial articular surface; 7. Transverse process; 8. Vertebral foramen; 9. Vertebra head.

1.2.4. SACRAL

In number three, small in size, they form a short and wide sacrum, ensuring stability and flexibility of the hindquarters.

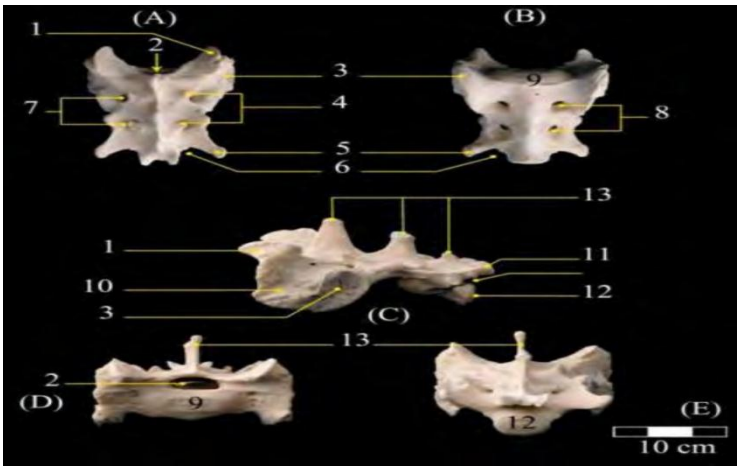


Figure 17: Dorsal view (A), ventral view (B), left lateral view (C), cranial view (D), and caudal view (E) of the lion's sacrum. Photo by J. Magrans, ©ACO.

1. Cranial articular process; 2. Sacral canal; 3. Auricular surface; 4. Remnants of mammillary processes; 5. Transverse process of the last sacral vertebra; 6. Caudal vertebral notch; 7. Dorsal sacral foramina; 8. Pelvic sacral foramina; 9. Head of the first sacral vertebra; 10. Wing of the sacrum; 11. Caudal articular process; 12. Fossa of the last sacral vertebra; 13. Spinous process.

1.2.5. The coccygeal vertebrae:

The caudal vertebrae gradually lose their characteristic elements (neural arch and processes) from the proximal region to the distal region, until they become simple tubular structures. The hemal process is underdeveloped in the lion. Some authors mention the presence of a terminal claw-shaped keratinous spur on the last caudal vertebra, hidden under the caudal tuft. However, this feature has not been observed in any of the specimens studied.

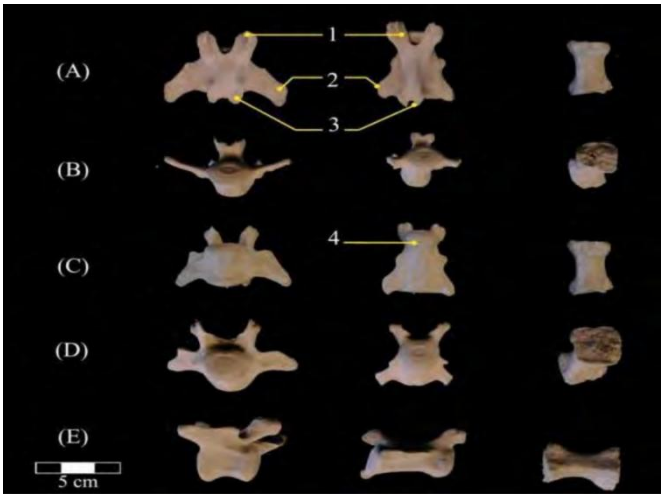


Figure 18: Dorsal view (A), cranial view (B), ventral view (C), caudal view (D), and right lateral view (E) of the 2nd (I), 7th (II), and 10th (III) coccygeal vertebrae. Photo by J. Magrans, ©ACO.

1. Cranial articular process; 2. Transverse process; 3. Caudal articular process; 4. Hemal process.

1.3. The Ribs

The thoracic skeleton of the lion consists of 13 pairs of ribs, long bones that are slightly flattened and curved, measuring between 25 and 30 cm. This configuration actively participates in protecting the thoracic cavity and in respiratory mechanics.

The first nine pairs are called sternal ribs: they articulate directly with the sternum via a cartilaginous segment known as costal cartilage. The 10th, 11th, and 12th pairs are referred to as false ribs, as they connect indirectly to the sternum by joining the costal cartilage of the preceding rib, thus forming the costal arch. Finally, the 13th pair is generally floating, not articulating with any ventral structure.

Osteologically, each rib articulates dorsally with a thoracic vertebra through two reliefs: the costal head and the costal tuberosity. These structures gradually decrease from the first to the thirteenth rib, such that the last ribs become monocephalous.

The costal head of a given rib (n+1) has two articular facets: a cranial facet, articulating with the caudal costal facet of vertebra n, and a caudal facet, in contact with the cranial costal facet of vertebra n+1, at the level of the parapophysis (GRASSÉ, Treatise of Zoology, Volume XVI, Fascicle I: Mammals, Integument, Skeleton, 1967).

Between these facets lies the capitular ridge, a rough surface facing the intervertebral disc and receiving the attachment of the intercapital ligament. The costal tuberosity, on the other hand, articulates with the transverse process of vertebra n+1 and serves as the anchoring point for the intertransverse ligaments.

Thus, each thoracic segment formed by a pair of ribs, a thoracic vertebra, and the sternum plays an essential functional role in protecting the thoracic viscera and in respiratory mobility.

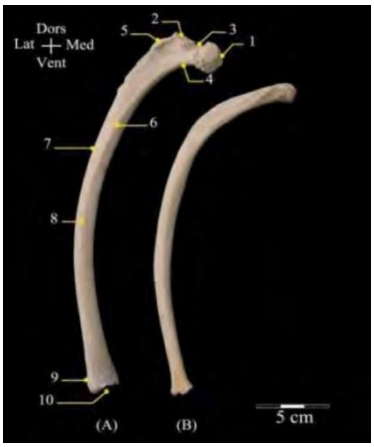


Figure 19: Cranial view of the 3rd and 13th right ribs. Photo by J. Magrans, ©ACO

1. Head; 2. Tubercle; 3. Neck; 4. Angle of the rib; 5. Tuberosity of the iliocostalis muscle; 6. Groove of the external surface; 7. External surface; 8. Cranial border; 9. Ventral end; 10. Location of the costochondral joint.

1.4. The sternum

It is a set of bony pieces forming an elongated and median bone, within which three parts can be identified:

- **Cranial part:** the manubrium, very elongated, largely exceeds the costal notch in the lion. It thus constitutes a true rostrum that is ossified.
- **Middle part:** the body of the sternum.
- **Caudal part:** the xiphoid process.

2.The appendicular skeleton:

2.1. The thoracic limb:

The thoracic limb of the lion exhibits notable morphological characteristics, reflecting its functional specialization as a large predator. It consists of bony structures comparable to those of other felids but adapted to the specific biomechanical constraints of the species.

2.1.1. The clavicle:

Although not articulating with any other bone, the clavicle, nearly 10 cm long, is completely encompassed within the brachiocephalic muscle. It is an elongated and flattened bone along the cranio-caudal axis, with a lateral end that is widened and curved backward. Compared to the domestic cat, it is proportionally smaller.

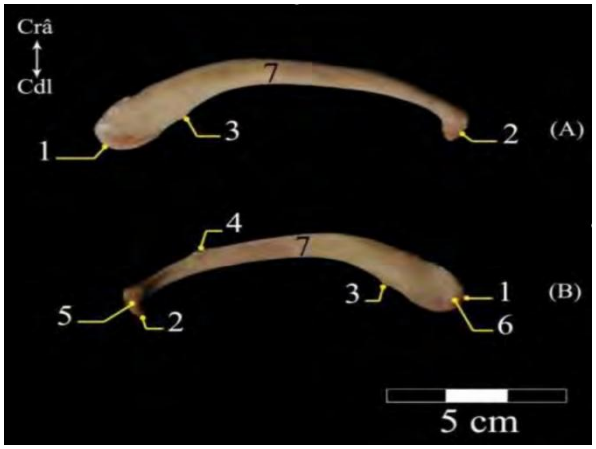


Figure 20: Dorsal (A) and ventral (B) views of the left clavicle of the lion. Photo by J. Magrans, ©ACO.

1. Acromial end; 2. Sternal end; 3. Conoid tubercle; 4. Impression of the costoclavicular ligament; 5. Sternoclavicular articular facet; 6. Acromial articular facet; 7. Body of the clavicle.

2.1.2. The scapula:

The scapula is a flat bone, elongated in a triangular shape, marked by a prominent spine on its lateral surface. In comparison to the domestic cat, it appears thinner cranio-caudally and is more elongated proximo-distally. This trend increases with the age of the lion (Du Plessis, Kirberger, and Turner, 2005). The acromion, highly prominent, is oriented cranio-distally. The infra- and supra-glenoid tubercles are present but minimally developed.

Figure 21: Lateral view (A) and medial view (B) of the right scapula. Photo by J. Magrans, ©ACO.

1. Cranial angle; 2. Dorsal border; 3. Caudal angle; 4. Infraspinous fossa; 5. Caudal border; 6. Scapular spine; Acromion: 7. Supraglenoid process, 8. Hamate process; 9. Ventral angle; 10. Supraglenoid tubercle; 11. Scapular notch; 12. Cranial border; 13. Supraspinous fossa; 14. Serrated surface; 15. Subscapular fossa; 16. Coracoid process; 17. Glenoid cavity.

2.1.3. The humerus:

The humerus has a poorly developed greater tubercle, similar to that of the cat. The supratrochlear foramen is absent, replaced by trabecular bone, unlike in dogs. Conversely, a large supracondylar foramen is present, as in cats.

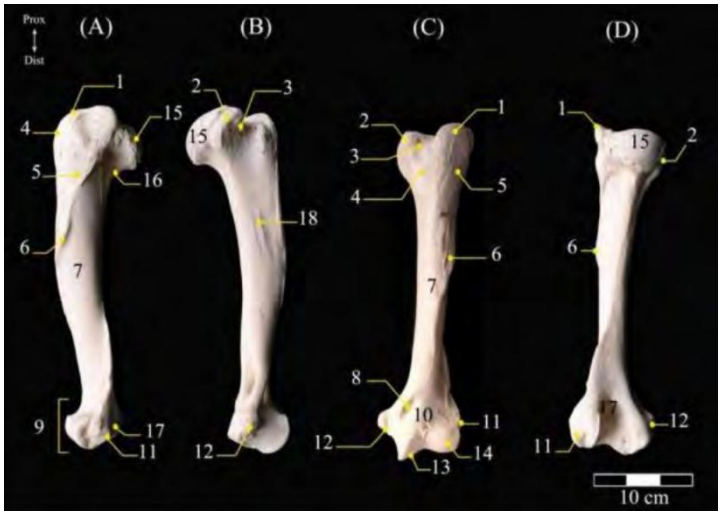


Figure 22: Lateral (A), medial (B), cranial (C), and caudal (D) views of the left humerus of a lion. Photo by J. Magrans, ©ACO.

1. Greater tubercle; 2. Lesser tubercle; 3. Intertubercular sulcus; 4. Greater tubercle ridge; 5. Tricipital line; 6. Deltoid tuberosity; 7. Body of the humerus; 8. Supracondylar foramen; 9. Condyle;
10. Radial fossa; 11. Lateral epicondyle; 12. Medial epicondyle; 13. Trochlea; 14. Capitulum; 15. Head;
16. Neck; 17. Olecranon fossa.

2.1.4. The radius and ulna:

In the lion, the elbow joint does not include a sesamoid bone.

2.1.4.1. The radius:

has a well-defined head with a marked neck and a prominent lateral tuberosity. The diaphysis is rough on the caudal side, tapering at the insertion of the interosseous ligament (a configuration similar to that of dogs). The distal part is laterally widened. The nutrient foramen is oriented cranio-proximally over approximately 3 cm.

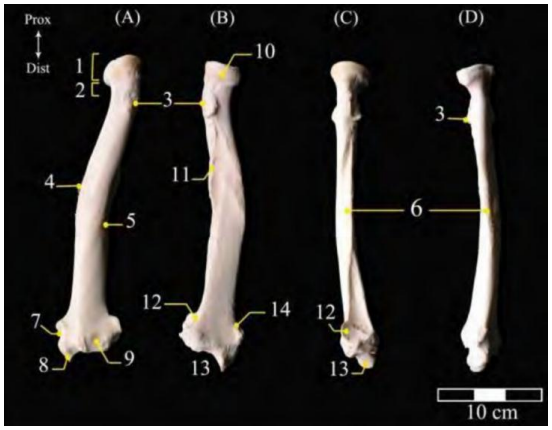


Figure 23: Cranial view (A), caudal view (B), lateral view (C), and medial view (D) of the left radius. Photo by J. Magrans, ©ACO.

1. Head; 2. Neck; 3. Lateral tuberosity of the proximal end of the radius; 4. Medial border; 5. Lateral border; 6. Shaft; 7. Groove of the abductor pollicis longus muscle; 8. Styloid process; 9. Groove of the radial extensor carpi muscle; 10. Articular circumference; 11. Nutrient foramen; 12. Ulnar notch; 13. Articular surface for the carpus; 14. Groove of the common extensor of the fingers.

2.1.4.2. The ulna:

is characterized by a wide and blunt anconeal process and a larger medial coronoid process compared to that of the cat. The distal styloid process articulates with the lateral face of the accessory carpal bone. The nutrient foramen opens cranio-medially, in close proximity to that of the radius, and extends cranially for 4 cm)

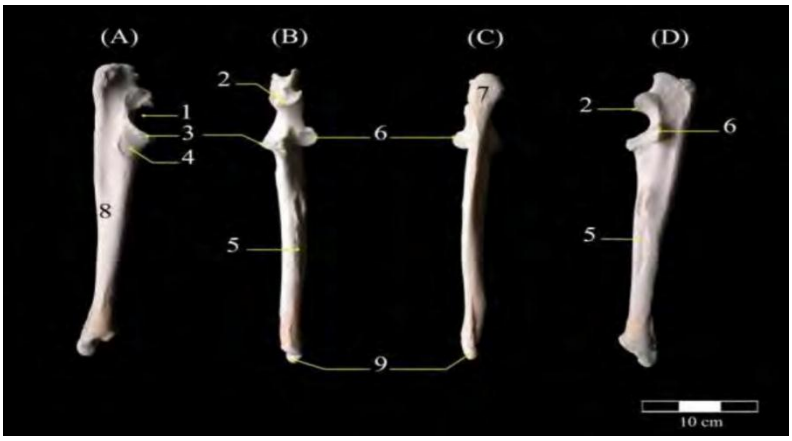


Figure 24: Medial (A), cranial (B), caudal (C), and lateral (D) views of the left ulna of the lion. Photo by J. Magrans, ©ACO.

1. Trochlear notch; 2. Anconeus process; 3. Medial coronoid process; 4. Medial tuberosity of the proximal end of the ulna shaft; 5. Interosseous border; 6. Lateral coronoid process; 7. Olecranon; 8. Ulna body; 9. Styloid process.

2.1.5. The carpus:

The carpus has a morphology similar to that of the dog. The intermedioradial bone shows an impressive tuberosity, which articulates with the widened base of the sesamoid bone of the long abductor muscle of digit I, which is well-developed. There is an interosseous space between carpals III and IV. The proximal articular surface of carpal III is more convex than that of the cat, adapting to a concave distal surface of the intermedioradial bone.f)

2.1.6. The metacarpals and phalanges

The lion has five metacarpal bones aligned parallel to each other. Metacarpal I, very short and robust, is associated with two phalanges and two palmar sesamoid bones. Metacarpal II has a thinned cortex and a slight axial concavity. Metacarpals II to V are short, stocky, with

prominent condyles, and exhibit visible dorsal curvature in lateral and medial views. The phalanges are generally similar to those of the cat but show fine adaptations. The middle phalanx of digit III laterally expands into an articular head, while the distal phalanges are thick dorsopalmarly and equipped with a well-developed ungual crest. The claws consist of two distinct parts: a juxtaphalangeal part, surrounding the apex of the phalanx, an extraphalangeal part, in the shape of a hook (Bryant & Russell, 1996).

Unlike other carnivores, the distal articular surface of the middle phalanx does not have a dorsolateral groove, which increases the medio-lateral mobility of the distal phalanx, especially at the digits.

Finally, the phalanges of finger III are the longest and strongest, followed by those of fingers IV, II, and then V. This hierarchy is common to both thoracic and pelvic limbs.

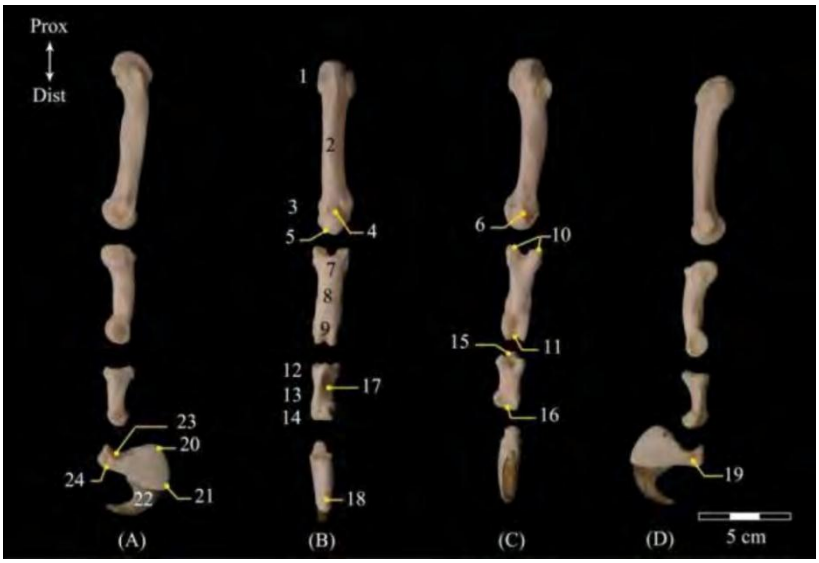


Figure 25: Medial (A), dorsal (B), palmar (C), and lateral views of the third metacarpal bone and the bones of the third digit of the left thoracic limb of the lion. Photo by J. Magrans, ©ACO.

Metacarpal bone: 1. Base, 2. Body, 3. Head; 4. Fossa of the sesamoid bone; 5. Trochlea; 6. Sesamoid crest; Proximal phalanx: 7. Base, 8. Body, 9. Head; 10. "Cochlea"; 11. Trochlea; Middle phalanx: 12. Base, 13. Body, 14. Head; 15. Cochlea; 16. Trochlea; 17. Fossa allowing passive retraction of the claw; Distal phalanx: 18. Base, 19. Body; 20. Tubercle of the common extensor muscle of the digits; 21. Ungual crest; 22. Claw; 23. Articular surface; 24. Insertion of the deep flexor muscle of the digits.

3. The pelvic limb

The pelvic limb of the lion reveals a skeletal morphology adapted for propulsion, postural stability, and muscular strength, essential for its locomotor and hunting capabilities.

3.1. The bony pelvis

The lion's pelvis is distinguished by a particularly elongated ischium, acting as a lever arm for the femoral extensor muscles. This configuration optimizes jumping power, a key ability in this large predator (Grasse, Treatise on Zoology, 1967).

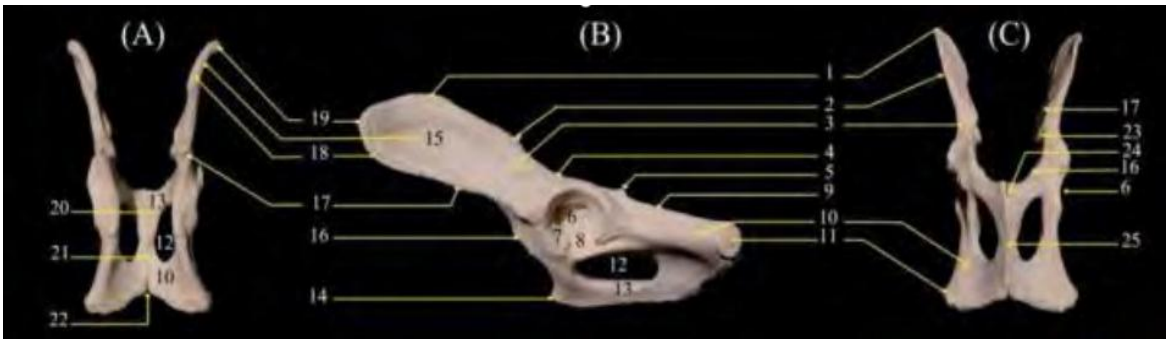


Figure 26: Dorsal (A), lateral (B), and ventral (C) views of the right and left coxae. Photo by J. Magrans, ©ACO.

1. Cranio-dorsal iliac spine; 2. Dorsocaudal iliac spine; 3. Body of the ilium; 4. Greater sciatic notch; 5. Ischial spine; 6. Acetabular fossa; 7. Lunar surface of the acetabulum; 8. Acetabular notch; 9. Lesser sciatic notch; 10. Body of the ischium; 11. Ischial tuberosity; 12. Obturator foramen; 13. Pubis; 14. Ventral tubercle of the pubis; 15. Wing of the ilium; 16. Iliopubic eminence; 17. Ventrocaudal iliac spine; 18. Ventrocranial iliac spine; 19.Iliac crest; 20. Pubic symphysis; 21. Ischiatic symphysis; 22. Ischial arch; 23. Auricular surface; 24. Pubic tubercle; 25. Pelvic symphysis.

3.2. The femur:

The femur features a lateral supracondylar tuberosity; a bony prominence located on the caudo-distal face of the diaphysis. It serves as an insertion site for the gastrocnemius muscle. This structure, absent in young individuals, gradually develops with age (Du Plessis, Kirberger & Turner, 2005).

The femoral condyles are very prominent, while the trochlear groove, although wide, remains shallow. The stifle includes a sesamoid bone of the gastrocnemius muscle that articulates with the lateral femoral condyle, while the medial condyle does not present one.

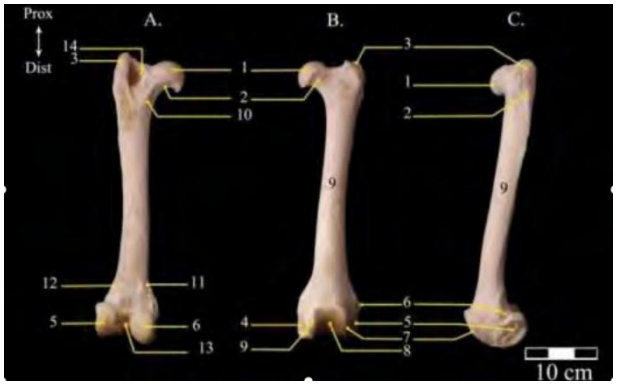


Figure 27: Caudal (A), cranial (B), and lateral (C) views of the left femur. Photo by J. Magrans, ©ACO.

1. Femoral head; 2. Neck of the femur; 3. Greater trochanter; 4. Medial epicondyle; 5. Lateral condyle; 6. Lateral condyle; Trochlea: 7. Lateral lip, 8. Groove, 9. Medial lip; 10. Lesser trochanter; 11. Medial supracondylar tuberosity; 12. Lateral supracondylar tuberosity; 13. Intercondylar fossa; 14. Trochanteric fossa.

3.3. The patella:

In the lion, the patella has an elongated cranial apex, with a wide and flattened base. It is about two times wider than it is high, a shape similar to that observed in domestic cats, but more pronounced in adult individuals.

Figure 28: Cranial view (A) and caudal view (B) of the patella. Photo by J. Magrans, ©ACO.

1. Base; 2. Cranial surface; 3. Articular surface; 4. Apex.

3.4. The tibia and fibula:

The fibula is 2.5 times wider at its ends than at mid-shaft. The groove for the tibial extensor is deep, correlating with the significant development of the long digital extensor muscle. The tibial plateau is the site of insertion for the sesamoid bone of the popliteus muscle, visible on its caudo-lateral face. Between the medial femoral condyle and the tibial plateau, the medial meniscus is identified, located cranio-medially to the intercondylar eminence.

Figure 29: Lateral view (A) and cranial view (B) of the left fibula, caudal view (C) and medial view (D) of the right fibula. Photo by J. Magrans, ©ACO.

1. Head of the fibula; 2. Body of the fibula; 3. Lateral malleolus; 4. Distal articular facet for the tibia; 5. Proximal articular facet for the tibia.

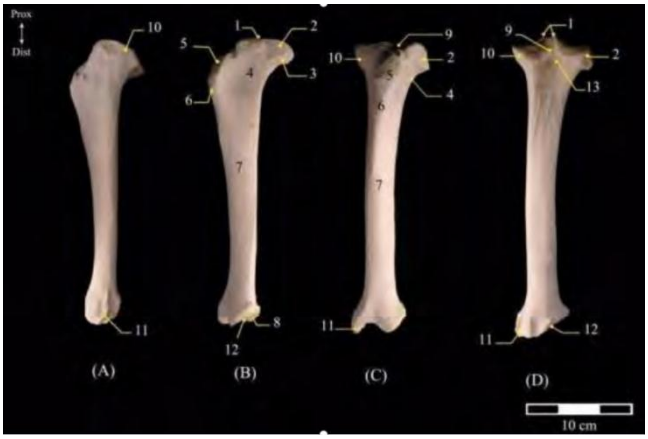


Figure 30: Medial view (A) and caudal view (D) of the right tibia, and lateral view (B) and cranial view (C) of the left tibia of the lion. Photo by J. Magrans, ©ACO.

1. Intercondylar eminence; 2. Lateral condyle; 3. Proximal articular facet for the fibula; 4. Tibial fossa;
5. Tibial tuberosity; 6. Tibial crest; 7. Body of the tibia; 8. Distal articular facet for the fibula;
9. Intercondylar area; 10. Medial condyle; 11. Medial malleolus; 12. Distal articular surface; 13. Popliteal notch.

3.5. The tarsus:

The calcaneal tuberosity has a marked caudal angulation. Its medial process is more prominent than the lateral one. The joint with the medial malleolus leaves a wide joint space, widening distally. The central tarsal bone shows a caudo-medial curvature. A vestige of the first tarsal bone, which is rectangular in shape, can also be distinguished.

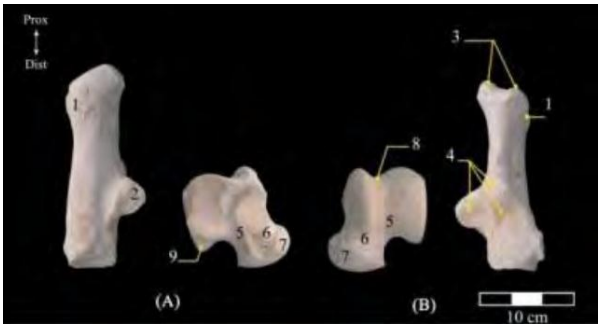


Figure 31: Plantar (A) and dorsal (B) views of the calcaneus and talus of the lion. Photo by J. Magrans, ©ACO.

Calcaneus

1. Calcaneal tuberosity; 2. Sustentaculum tali; 3. Lateral and medial processes of the calcaneal tuberosity; 4. Articular surfaces for the talus.

Talus

5. Body; 6. Neck; 7. Head; 8. Trochlea; 9. Lateral process.

3.6. The metatarsus and the phalanges:

The first toe is significantly reduced, with metatarsal I often being vestigial, sometimes having a rudiment of the first phalanx (Du Plessis, Kirberger & Turner, 2005). The other metatarsals are longer than the metacarpals (about +5 cm), narrow, parallel, with prominent condyles and a slight dorsal curvature. The dorsal sesamoid bones are absent, while the plantar sesamoids of digits III and IV are elongated, as are the axial plantar sesamoids of digits II and V. The phalanges are similar to those of the forelimb, but with a less pronounced curvature. The hind claws, less hooked, have the appearance of flattened blades rather than sharp hooks (Bryant, Russell et al., 1996).

Figure 32: Medial (A), dorsal (B), plantar (C), and lateral views of the bones of digit III of the left pelvic limb of the lion. Photo by J. Magrans, ©ACO.

Metatarsal bone: 1. Base, 2. Body, 3. Head; 4. Fossa of the sesamoid bone; 5. Plantar tubercle; 6. Sagittal crest; 7.

Trochlea; Proximal phalanx: 8. Base, 9. Body, 10. Head; 11. Cochlea; 12. Trochlea; Middle phalanx: 13. Base, 14. Body, 15. Head; 16. Cochlea; 17. Trochlea; 18. Fossa allowing passive retracting of the claw; Distal phalanx: 19. Base, 20. Body; 21. Ungual crest; 22. Claw; 23. Articular surface; 24. Insertion of the deep digital flexor muscle.

Figure 33: Lateral view contours of the distal phalanx of digit III of the hand (A) and foot (B) of the domestic cat and superposition of these two contours (C). After (BRYANT, RUSSELL, et al. 1996)

Myologie :

1. The myology of the head and neck

1.1. Muscles of the head

The muscles of the lion's head, particularly **the masticatory muscles**, are well developed, illustrating their crucial role in predation. Among them:

Temporal muscle: large, it attaches to the temporal fossa and contributes to the powerful closure of the jaw.

Masseter muscle: very rounded, it attaches to the ventral edge of the mandible and is particularly thick, providing great biting force.

Digastric muscle: it shows remarkable development and assists in lowering the mandible.

Pterygoid muscle: participates in the lateral movements of the mandible.

Other facial muscles include: the platysma, buccinator, orbicularis oculi, and levator labii superioris, playing a role in facial expression and grasping.

Figure 34: Lateral view of the head after removal of superficial elements. Photo by J. Magrans, ©ACO.

1. Parotid salivary gland; 2. Mandibular salivary gland; 3. Facial nerve (dorsal buccal branch); 4. Digastric muscle; 5. Temporal muscle; 6. Masseter muscle; 7. Platysma muscle; 8. Levator of the upper lip muscle; 9. Buccinator muscle; 10. Orbicularis oculi muscle.

1.2. Muscles of the neck

The lion's neck is powerful, supporting a massive head and serving to immobilize prey. It exhibits a muscular organization in several planes:

1.2.1. Cutaneous plane

Cervical platysma: involved in facial expression and in raising the mane, particularly during dominance behaviors. It also contributes to the piloerection of the skin.

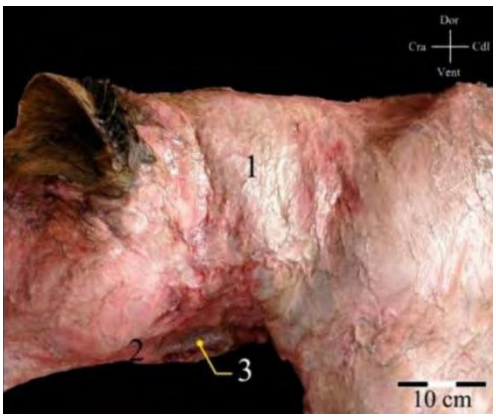


Figure 35: Left lateral view of the cutaneous muscles of the neck. Photo by J. Magrans, ©ACO

1. Platysma; 2. Neck sphincter muscle; 3. Left external jugular vein.

1.2.2. Middle plane

Cleidocephalic muscle: particularly developed in lions, it consists of the following parts:

Cleidomastoid, attaching to the mastoid process of the occipital bone.

Cleidocervical, which ends in an aponeurosis on the curved line of the occiput.This muscle covers most of the other cervical muscles and unites with the brachial muscle at the proximal ulna.

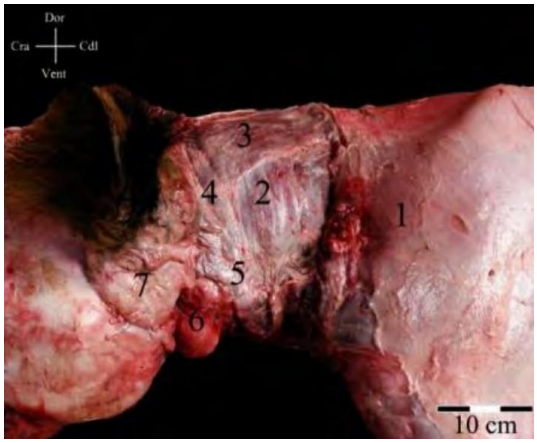


Figure 36: Left side view of the neck: medium shot. Photo by J. Magrans, ©ACO.

1. Cervical part of the cleidocephalic muscle (under the skin muscles); 2. Splenius muscle; 3. Rhomboid muscle of the head; 4. Small dorsal rectus muscle of the head; 5. Cranial oblique muscle of the head; 6. Mandibular salivary gland; 7. Parotid salivary gland.

1.2.3. Deep plane

Among the deep muscles, we find:

Cervical and head rhomboid muscle: contributes to scapular stabilization.

Splenius of the head muscle: involved in the extension and rotation of the head.

Complexus and semispinalis muscle: stabilize the cervical region.

Longus capitis and longus colli muscles: participate in the ventral flexion of the neck.

Cranial and caudal oblique muscles of the head, dorsal rectus major, dorsal rectus minor: these muscles control the fine movements of the atlas and the axis.

Omotransverse muscle: contributes to scapulocervical mobility.

Serratus ventralis muscle of the neck: participates in the suspension of the thorax.

Sternocephalic and sternohyoid muscles: form the deep ventral plane and are involved in head movements and swallowing.

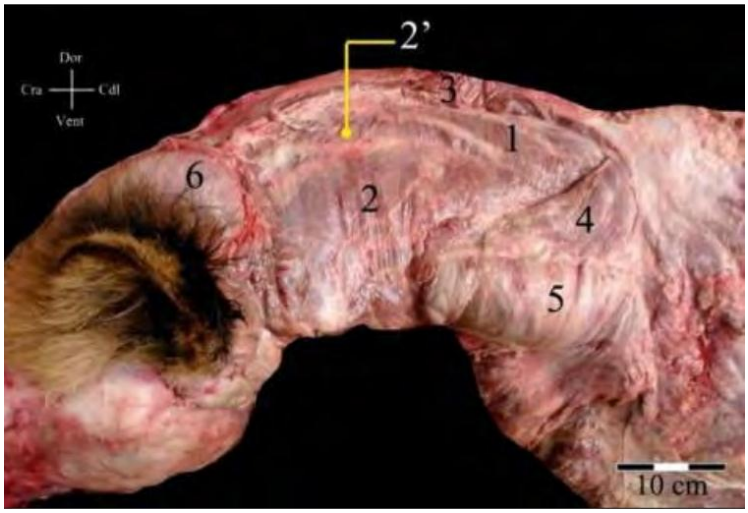


Figure 37: Left lateral view of the neck: deep plan. Photo by J. Magrans, ©ACO.

1. Cervical rhomboid muscle; 2. Semispinalis capitis muscle; 2'. Digastric muscle of the neck; 3. Rhomboid muscle of the head (sectioned); 4. Ventral serratus muscle of the neck; 5. Omotransversarius muscle (sectioned); 6. Temporal muscle.

2. Musculature of the thoracic limb of the lion

2.1. Extrinsic Muscles (or muscles of the epaxial group)

The extrinsic muscles connect the thoracic limb to the trunk and are divided into two layers:

Superficial layer (attached to the scapular spine)

- Trapezius muscle
- Omotransversarius muscle

Deep layer

- Latissimus dorsi muscle
- Rhomboid muscle (grouped into a single muscle layer beneath the trapezius in the lion, without distinction between the heads: GRASSÉ, 1971)
- Serratus anterior muscle

The reduction of the clavicles promotes a functional fusion between the deltoid muscle (clavicular head), trapezius, and sternocleidomastoid, thus forming the brachiocephalicus muscle, facilitating a linear movement of the limb – an adaptation for running.

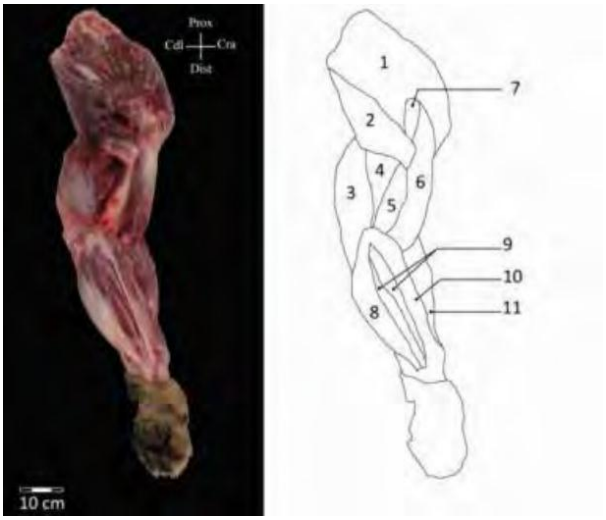


Figure 38: Medial view of the left thoracic limb of the lion after the removal of the extrinsic shoulder muscles. Photo and drawing by J. Magrans, ©ACO.

1. Subscapular muscle; 2. Teres major muscle; 3. Tensor of the antebrachial fascia; Brachial triceps: 4. Long head, 5. Medial head; 6. Biceps brachii; 7. Coracobrachialis; 8. Superficial digital flexor; 9. Deep digital flexor; 10. Radial flexor of the carpus; 11. Radial extensor of the carpus.

2.2. Intrinsic Muscles

2.2.1. Shoulder and arm muscles

Muscles connecting the shoulder girdle to the arm:

- Deltoid (without a distinct clavicular head, well-developed acromial head)-

Teres minor, teres major, subscapularis (multipennate), supraspinatus, infraspinatus (less developed),

coracobrachialisMuscles connecting the arm to the forearm:

- Brachial biceps (one head: absence of the coracoid head)

-Triceps brachii (four heads: long, lateral, medial, accessory)

- Brachialis muscle

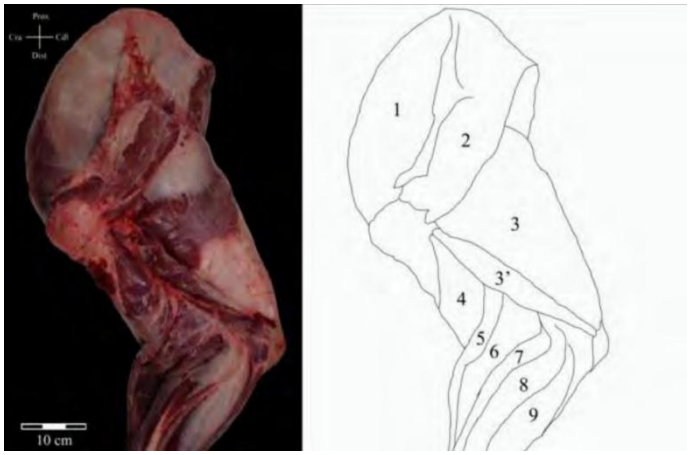


Figure 39: Lateral view of the proximal part of the left thoracic limb after removal of the deltoid muscle. Photo and drawing by J. Magrans, ©ACO.

1. Supraspinatus muscle; 2. Infraspinatus muscle; Triceps brachii: 3. Long head, 3'. Accessory head; 4. Brachial muscle; 5. Brachioradialis muscle; 6. Radial extensor of the carpus; 7. Common extensor of the fingers; 8. Lateral extensor of the fingers; 9. Ulnar extensor of the carpus.

2.2.2. Forearm and hand muscles

IV.2.2.2.1. From the arm to the forearm

- Brachioradialis, supinator, anconeus, pronator teres

IV.2.2.2.2. Connecting the radius and ulna:

- Pronator quadratus

IV.2.2.2.3. From the arm to the carpals/metacarpals:

- Radial and ulnar carpal extensors, long abductor of the thumb, radial and ulnar carpal flexors.

Figure 40: Lateral (A) and medial (B) views of the left forearm of the lion after removal of the fascia. Photo by J. Magrans, ©ACO.

1. Ulnar flexor of the carpus; 2. Ulnar extensor of the carpus; 3. Lateral extensor of the digits; 4. Common extensor of the digits; 5. Radial extensor of the carpus; 6. Long abductor of digit I; 7. Carpal torus; 8. Triceps brachii; 9. Brachioradialis; 10. Brachialis; 11. Superficial flexor of the digits.

IV.2.2.2.4. Towards the phalanges:

- Long extensor of the phalanges, lateral extensor of the phalanges, superficial and deep flexors of the phalanges in the lion, certain muscles exhibit particular development (PERRAULT, 1977):

- Extensor of the thumb and index phalange: very powerful lateral tendinous branch.

- Lateral extensor of the phalanges: very well-developed fleshy muscle, distinct lateral tendinous insertion and connection with the interosseous.

- Ulnar flexor of the wrist: additional tendinous branch towards the metacarpal IV.

- Flexor muscle of digit V: large and well-defined.

-Index adductor: additional muscle located between the interosseous muscles II and III.

Figure 41: Dorsolateral view of the distal end of the left thoracic limb. Photo by J. Magrans, ©ACO.

1. Dorsal ligament of the carpus; 2. Tendon of the ulnar flexor muscle of the carpus; 3. Tendon of the ulnar extensor muscle of the carpus; 4. Tendon of the lateral extensor muscle of the fingers; 5. Tendon of the common extensor of the fingers.

IV.2.3. Ligaments

The ligaments of the carpus and fingers are robust. In the lion, we observe:

Deep transverse ligament of the carpus (connects the digital sheaths via the large sesamoids of fingers II and V),

-Medial and lateral elastic ligaments of finger II,

-Capsular ligament 2-3 phalangeal (with marked fibrous trabeculae),

-Medial dorsal elastic ligament (at the level of the forefoot).

IV.2.4. Innervation

Innervation is provided by the collateral and terminal branches of the brachial plexus. Details of the nerves and their territories are provided in the appendix.

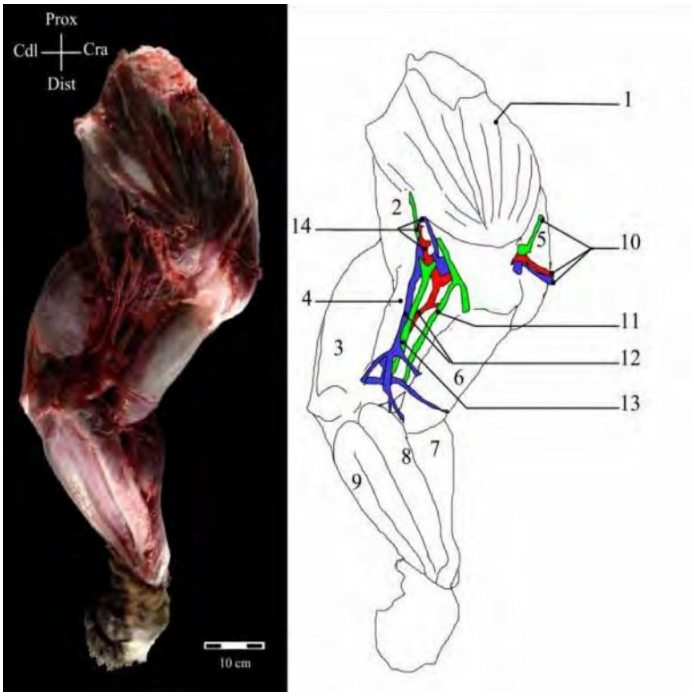


Figure 42: Medial view of the left thoracic limb and the brachial plexus (red: artery, blue: vein, green: nerve). Photo by J. Magrans, ©ACO.

1. Subscapular muscle; 2. Teres major muscle; 3. Tensor of the antebrachial fascia; 4. Triceps brachii muscle; 5. Supraspinatus muscle; 6. Biceps brachii muscle; 7. Radial extensor of the carpus muscle; 8. Radial flexor of the carpus muscle; 9. Superficial digital flexor muscle; 10. A., v., and n. suprascapular; 11. Musculocutaneous nerve; 12. A. and v. brachial; 13. Ulnar and median nerves; 14. A., v., and n. thoracodorsal.

IV.3. Musculature of the pelvic limb of the lion

IV.3.1. Muscles of the hip and thigh

The hip and thigh muscles of the lion form a vast and well-defined muscle complex. This group is divided into several functional sub-groups that connect the spine, pelvis, and thigh, as well as the leg.

IV.3.1.1. Muscles connecting the spine

-At the thigh: Psoas major and gluteofemoral.

-At the leg: Dorsal head of the semitendinosus muscle.

IV.3.1.2. Muscles connecting the pelvis

-At the thigh level: Pectineus muscle, External and internal obturator muscles, Adductor of the thigh, Gluteal muscles, Piriformis, Quadriceps femoris (including the rectus femoris), Semimembranosus.

-At the leg level: Sartorius, Gracilis, Semimembranosus, Biceps femoris (long head), Semitendinosus (ventral head).

IV.3.1.3. Morphological particularities

Fusion of the psoas major and iliacus:

The psoas major and iliacus muscles fuse into a single tendon, forming the iliopsoas muscle, which is distally inserted on the lesser trochanter of the femur. This fusion is frequently described as a single bicipital muscle, a common feature among carnivores (GRASSÉ, 1971).

Specific characteristics of the lion (panther leo):

Sartorius muscle: In the lion, this muscle has only one part, but its distal attachment divides into two inserts: tibial and patellar.

Pectineus muscle: The insertion of the pectineus extends over the proximal third of the linea aspera of the femur in the lion, compared to the distal half in the domestic cat.

Intermediate vastus muscle: This muscle is poorly defined and seems to merge with the medial vastus muscle, creating a deep layer.

Gracilis muscle: Despite its name, the gracilis has a relatively thick fleshy body in the lion and constitutes the most superficial element of the internal thigh face.

Thigh adductor muscle: The adductor complex, typically consisting of several muscles in other species, is almost entirely fused in the lion to form a single unitary muscle, the thigh adductor.

Gastrocnemius muscles: Like the adductors, the gastrocnemius muscles (or obturator

muscles) are poorly differentiated and appear as a unified muscle mass.

Biceps femoris: The tendon of the biceps femoris merges with that of the gastrocnemius to attach to the lateral malleolus, a more distal insertion than in other carnivores.

Semitendinosus muscle: This muscle loses its original digastric structure and appears in a simplified form in the lion.

Semimembranosus muscle: Unlike the semitendinosus, the semimembranosus retains a clear subdivision into two heads.

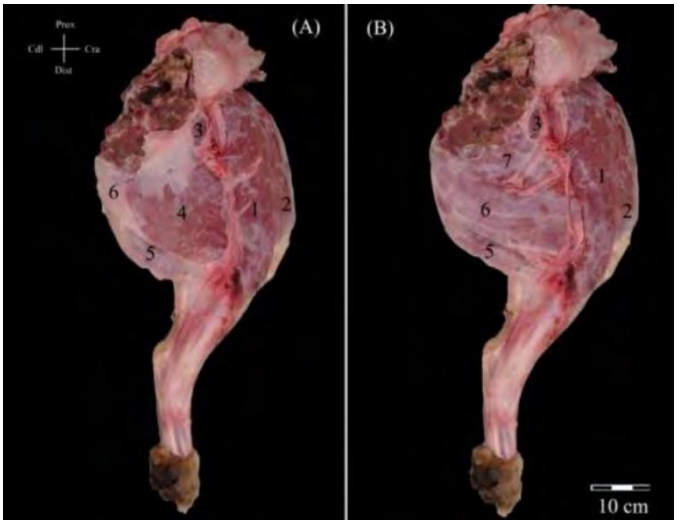


Figure 43: Medial views of the left pelvic limb of the lion before (A) and after (B) removal of the gracilis muscle. Photo by J. Magrans, ©ACO.

1. M. vastus medialis; 2. M. rectus femoris; 3. M. iliopsoas; 4. M. gracilis; 5. M. semitendinosus; 6. M. semimembranosus; 7. M. adductor of the thigh.

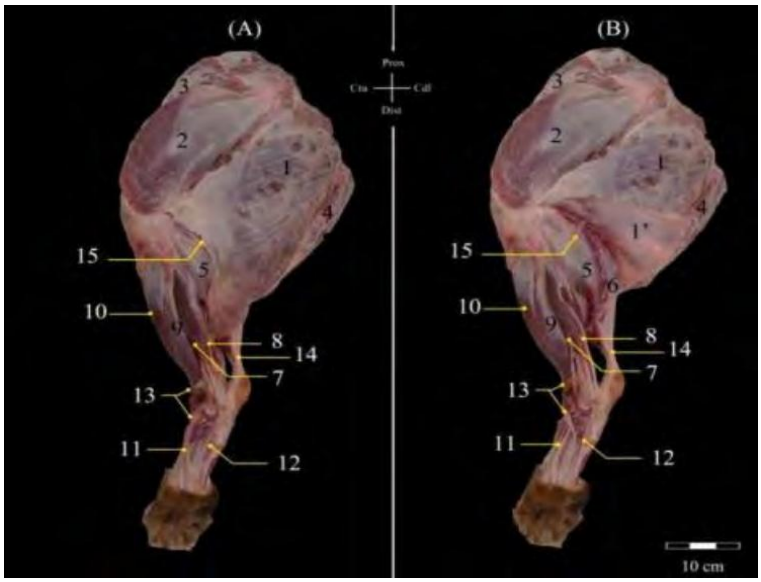


Figure 44: Lateral views of the superficial muscles of the left pelvic limb after removal of the fascia lata, with the biceps femoris in place (A) and reclined (B). Photo by J. Magrans, ©ACO.

1. M. biceps femoris; 1'. M. biceps femoris reclined; 2. M. vastus lateralis; 3. M. tensor fasciae latae; 4. M. semitendinosus; 5. M. soleus; 6. M. gastrocnemius; 7. M. fibularis longus; 8. M. fibularis tertius and brevis; 9. M. long extensor of the toes; 10. M. cranial tibialis; 11. Tendons of M. long extensor of the toes; 12. Tendon of M. fibularis tertius; 13. Transverse ligaments; 14. Common calcaneal tendon; 15. Common fibular nerve.

V.3.2. Musculature of the leg and foot of the lion

V.3.2.1. Muscles of the leg and foot

The muscles of the lion's leg and foot comprise several important functional groups that enable efficient and powerful movement of the hind limb. These muscles are divided based on their actions on the thigh, ankle, and phalanges.

Muscles connecting the thigh and the leg

- Popliteal muscle: An important muscle connecting the thigh to the leg, playing a key role in knee flexion.

Muscles connecting the thigh and the leg to the ankle

- Gastrocnemius muscles (calf twins), Cranial tibial muscle, Long and short fibular muscles, Soleus muscle, Caudal tibial muscle.

Muscles connecting the thigh, the leg, and the phalanges

- Long extensor of the toes, long extensor of the thumb, Superficial and deep flexors of the toes.

Intrinsic muscles of the foot:

- Short extensor of the toes, Short extensor of the thumb, Interosseous muscles.

Morphological particularities of the lion:

- Short fibular muscle: In the lion, the short fibular muscle is particularly developed, its fleshy body being almost as large as that of the long fibular muscle.
- Divergence of the tendons of the common extensor of the toes: As in cats, the four tendons of the common extensor of the toes diverge very proximally, at the same level, and move towards their respective attachment points on the phalanges.
- Lateral extensor muscle of the toes: The fleshy body of the lateral extensor muscle of the toes is relatively thin and primarily consists of a long tendon.

  -Short extensor muscle of the phalanges:

- The intermediate and lateral tendons insert into the tendon of the long extensor of the phalenges.
- The medial fleshy body is split.
- An additional fleshy body, thin and short, is also present. Its tendon reaches the medial edge of the branch of the common extensor muscle for toe II, inserting on the proximal phalanx of toe II.
- Superficial flexor muscle of the fingers: This muscle is proportionally much larger than in the cat. It has muscle bundles that intertwine, including remnants of the short flexor muscle of the fingers.
- Fusion of the adductor and abductor muscles of the fingers: in the lion, the adductor muscles of fingers II and V, as well as the abductor muscle of finger II, merge into a single muscular plane. This plane is located between the perforating tendon and the interosseous muscles, facilitating fine and coordinated movements of the fingers.()

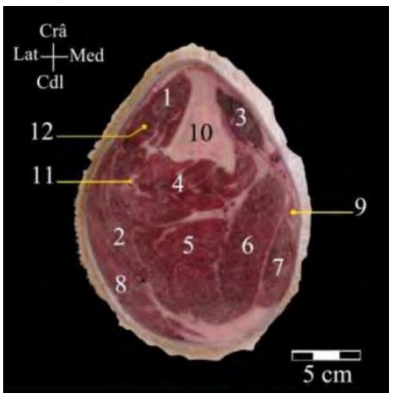


Figure 45: Cross-section of the proximal third of the left leg of the lion. Photo by J. Magrans, ©ACO.

1. Cranial tibial muscle; 2. Gastrocnemius muscle (lateral head); 3. Sartorius muscle; 4. Deep digital flexor muscle; 5. Superficial digital flexor muscle; 6. Gastrocnemius muscle (medial head); 7. Semitendinosus muscle; 8. Biceps femoris muscle; 9. Semimembranosus muscle; 10. Tibia; 11. Fibula; 12. Long extensor muscle of the toes.

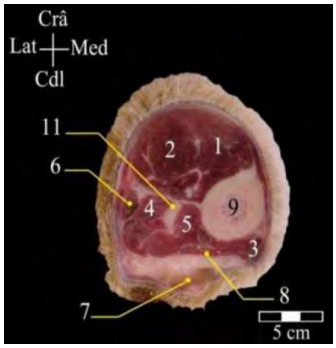


Figure 46: Cross-section of the distal third of the left leg of the lion. Photo by J. Magrans, ©ACO.

Cranial tibial muscle; 2. Long digital extensor muscle; 3. Deep digital flexor muscle (medial digital flexor muscle); 4. Short and long fibular muscles; 5. Deep digital flexor muscle (lateral digital flexor muscle); 6. Lateral digital extensor muscle; 7. Common calcaneal tendon; 8. Superficial digital flexor muscle; 9. Tibia; 10. Fibula.

CHAPTER III:

ETHOLOGY OF THE LION

CHAPTER III: ETHOLOGY OF THE LION

I. INTRODUCTION

The lion (Panthera leo), a member of the genus Panthera, is the only feline to adopt a developed social behavior, living in groups called prides. This communal lifestyle strongly influences its anatomy and behaviors. Descending from saber-toothed cats like the Smilodon, the lion has developed unique characteristics that merit in-depth study to understand how evolution has shaped its morphological and social traits.

Figure 47: Lion kingdom. National geographic.by terra matter factual studio

II. Social Organization

Lions live in prides that can number up to 40 individuals, although the average is around 15. These groups consist of males, females, and young. Each lion has a place within the social structure. Relationships are generally peaceful, reinforced by affiliative behaviors such as facial greetings and mutual grooming.

Males are often not well integrated, although they play a fundamental role in defending the territory and the cubs. They patrol and mark their domain, ensuring reproduction with the females. The latter, being slimmer and without manes, are the primary hunters and educators of the cubs. They often remain in their natal group for their entire lives.

Cubs are raised collectively. Education occurs through play, and maternal solidarity allows for the nursing of orphans by other lionesses. However, infant mortality is high, sometimes reaching 80%, notably due to predators, diseases, or famine.

Communication among members is varied: visual (facial expressions and postures), olfactory (smells and markings), auditory (roars), and tactile (licking and rubbing). This reinforces group cohesion and allows for effective collective organization.

Figure 48: A family unites. planet wild

Territory

Historically present from Europe to India, lions are now primarily confined to sub-Saharan Africa and the Gir Forest in India. Their territory is divided into hunting zones, resting zones, and breeding zones. It can reach up to 400 km², especially in dry regions.

The territory is actively defended by males. Marking occurs through urine, feces, roars, and scratches. These signals allow other lions to recognize an occupied area and avoid direct conflicts. Females may also defend certain areas, particularly in the absence of males.

Sedentary troops stay in the same territory, while nomads, often young expelled males, roam in search of a group or territory. The latter have a shorter lifespan and a lower reproduction rate.

Figure 49: Tree climbing lions. Wild. by National geographic

IV. Diet

Lions are strict carnivores, their diet relies on prey such as zebras, wildebeests, and buffalo. Females, in groups, organize coordinated hunts using encirclement tactics. Males, although less active in hunting, eat first during meals.

Hunting is a physically demanding activity. The lion has adapted musculature, powerful legs, a robust jaw, and retractable claws. The killing is generally done by strangulation or a bite to the neck. The simple digestive tract allows for quick digestion of animal proteins.

Consumption follows a hierarchical order: dominant males, females, then young. This hierarchy is not rigid among females, but it is respected in the presence of males. During periods of scarcity, cubs suffer first. Furthermore, lions do not hesitate to steal prey from other carnivores.

Figure 50: lions eat a cape of bufallo. Tsavotrust

Reproduction

Reproduction in lions is heavily influenced by hierarchy and changes in males. When a new male takes power, he often kills the cubs to accelerate the females' return to estrus. This maximizes his chances of passing on his genes during his often short reign (2-3 years).

The estrous cycle lasts from 4 to 7 days and the lioness can mate several times per hour. Mating is brief but repeated. Gestation lasts about 110 days. The lioness gives birth to 1 to 4 cubs in a secluded den. She hides them for several weeks before introducing them to the group.

Maternal care includes nursing, protection, and learning through play. Mortality remains high, but collective caregiving behaviors increase survival chances. Learning through imitation is essential in acquiring social and hunting behaviors.

Figure 51: African lion mating. Science photo library.by Simon booth

VI. CONCLUSION

The lion, with its anatomy and unique social lifestyle among felines, presents an exceptional evolutionary model. Its behavioral adaptation in groups is reflected in its morphology, reproduction, hunting, and communication systems. Understanding this species sheds light on the close connections between anatomy, ecology, and social dynamics in carnivores.

Part III: The major pathologies of the lion

i. INTRODUCTION

Le lion (*Panthera leo*), en tant que grand prédateur emblématique, occupe une place essentielle dans l'équilibre écologique de son habitat. Toutefois, en captivité comme en milieu naturel, cette espèce est confrontée à diverses affections qui peuvent compromettre sa santé, sa reproduction et sa survie. La connaissance approfondie de ces maladies revêt une importance capitale, tant pour la conservation des populations sauvages que pour le bien-être des individus hébergés en parcs zoologiques.

Les lions sont sensibles à de nombreuses pathologies, qu'elles soient infectieuses, parasitaires, métaboliques ou dégénératives. Certaines affections, comme la maladie de Carré ou la tuberculose, ont déjà provoqué des épidémies dévastatrices au sein de groupes entiers,

notamment en Afrique. Par ailleurs, la captivité expose les lions à des maladies spécifiques liées à la promiscuité, au stress ou à une alimentation inadaptée.

L'étude des maladies du lion s'inscrit donc dans une démarche à la fois vétérinaire, éthologique et conservatoire. Elle vise à identifier les principales affections, à comprendre leurs mécanismes physiopathologiques, à évaluer les risques zoonotiques, et à proposer des mesures de prévention et de gestion adaptées aux différents contextes.

II. diseases, injuries, and natural rivals of lions: (The Challenges of Survival in Lions: Animal Instinct)

Despite their status as apex super predators in the food chain, African lions face several natural challenges that threaten their survival, including diseases, injuries, and competition with other predators.

1. Diseases in lions

Felines, like all wild animals, are susceptible to various diseases that can significantly impact their health and survival.

1.1. Infectious diseases

Lions are vulnerable to several infectious diseases. Among these is tuberculosis, which can be contracted by consuming infected prey, and feline infectious peritonitis, a viral disease that can spread within prides.

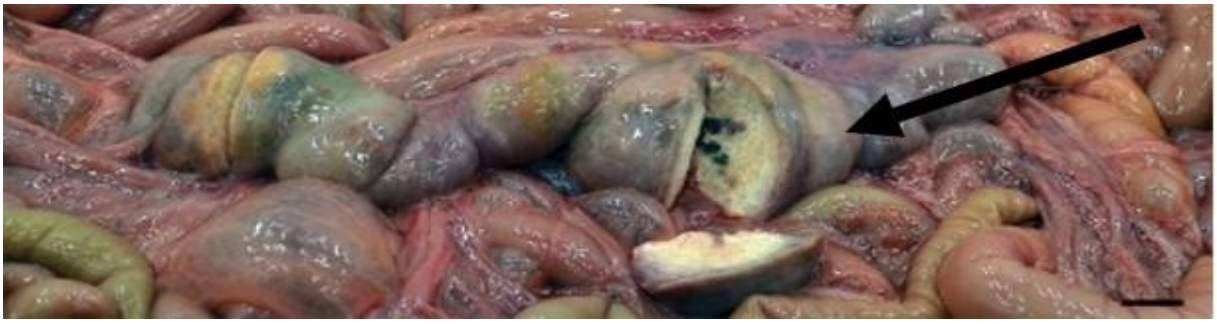


Figure 52: Enlarged lymph node (arrow) in the abdomen of a free-ranging Australian sea lion. In this case, there was no apparent involvement of the lungs which is the more typical location for tuberculosis in seals and sea lions.by the university of sydney

1.2. Parasitism

Internal and external parasites, such as worms and ticks, are common among felines. These parasites can weaken felines by depriving them of essential nutrients or transmitting diseases.

1.3. Diseases transmitted by prey

By consuming sick prey, felines can contract diseases like anthrax or brucellosis. These diseases can lead to outbreaks within prides, especially if their diet is concentrated on a small number of prey sources.

1.4. Transmission and impact on prides

Close living conditions within prides can facilitate the rapid transmission of diseases among members. An outbreak can affect several lions at the same time, threatening the stability and survival of the group.

1.5. Consequences for lion populations

Disease outbreaks can have serious consequences for local lion populations, reducing their numbers and affecting their genetic structure. This is particularly concerning in areas where lion populations are already declining due to other threats.

The vulnerability of lions to diseases is an important aspect of their ecology and conservation management. Disease monitoring and management are essential for maintaining healthy and viable lion populations. Understanding the disease risks and ways to mitigate them is crucial for lion conservation efforts across Africa.

2. Injuries in Lions

Lions, as large predators, are exposed to various injury risks throughout their lives. These injuries can come from several sources and have various impacts on their health and ability to survive in the wild environment.

2.1. Injuries during hunting

Hunting is one of the riskiest activities for lions, especially when they target large prey like buffalo, giraffes, or elephants. These animals can defend themselves vigorously and inflict serious injuries on lions, such as fractures, lacerations, or internal trauma.

2.2. Intraspecific conflicts

Conflicts among lions are another common source of injuries. These confrontations can occur for territorial or dominance reasons, particularly among males. Brawls for dominance within a pride or for access to females can lead to serious injuries.

II.2.3. Accidental injuries

Accidents can occur while moving through difficult terrain, falling trees or rocks, or crossing areas with natural obstacles.

2.4. Consequences of injuries

Injuries can limit a lion's ability to hunt and defend itself, thus affecting its survival. Severely injured felines may become less able to participate in hunting or defend their pride, which can lead to a decline in their status within the group.

Injuries are a constant reality in the lives of lions, resulting from their hunting behavior, social conflicts, and interactions with other species. The ability of lions to heal and adapt to these injuries is essential for their survival. Understanding the risks and consequences of injuries is important for conservation efforts,particularly to assess the health and viability of lion populations in the wild.

III.Parasitism

1. Toxascaris leonina

Toxascaris leonina is a prevalent parasitic roundworm present in dogs, cats, foxes, and similar host species. T. leonina is an ascarid nematode, a widely spread helminth parasite that belongs to a class of eukaryotic parasites which, in contrast to external parasites like lice and fleas, inhabit the host's interior (Maizels RM, Yazdanbakhsh M (2003),Immune regulation by helminth parasites: cellular and molecular mechanisms).

The definitive hosts of T. leonina comprise canids (dogs, foxes, etc.) and felids (cats), while the typical intermediate hosts are rodents, including mice or rats. Infection takes place in the definitive host when the animal consumes an infected rodent. Though T. leonina can be found in both dogs and cats, it is much more common in cats.(Roundworms in pets, Vet PetStop, UK)

1.1. Life cycle

The life cycle of T. leonina is quite straightforward. Eggs are consumed and develop in the small intestine. The juveniles subsequently invade the mucosal layer of the small intestine. Following growth and shedding, they reenter the intestinal lumen and develop. The mature female worm produces eggs that are excreted in the animal's feces. The eggs become infectious within 3–6 days when in the environment (wekipedia *Toxascaris leonina*).

Cats can get infected by consuming either the eggs or rodents that carry the larvae. Typically, rodents serve as the intermediate hosts for T. leonina. The rodent consumes the eggs, and when the eggs hatch, the larvae move through the rodent's tissues. The definitive host becomes infected with this parasite after consuming an infected rodent (wekipedia *Toxascaris leonina*).

The T. leonina egg is typically more oval-shaped than round. The prepatent duration for T. leonina ranges from two to three months. The mature worms typically measure 3-4 inches in length and may be observed in the animal's feces and vomit (Wekipedia, *Toxascaris leonina*).

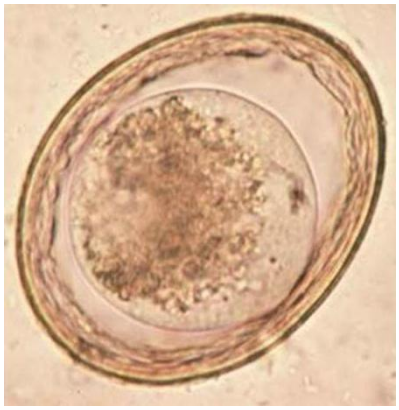


Figure 53: Toxocaris leonina egg.capcvet.org

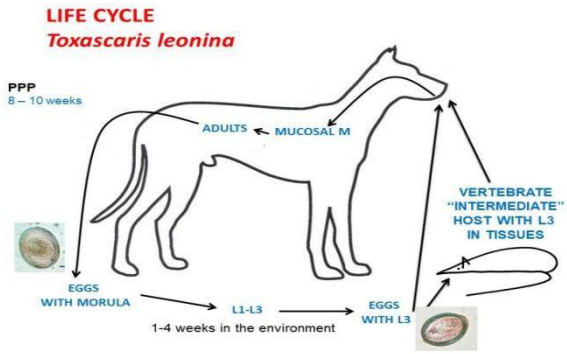


Figure 54: toxocaris leonina life cycle by western college of veterinary medecine, university of saskkatchewan

1.2. Symptoms

Roundworms take in the nutrients from the host, which may disrupt digestion and potentially harm the intestinal lining. Animals might exhibit no visible signs of roundworms, but in some more severe cases, they could suffer from diarrhea, vomiting, decreased appetite, and may have thinning, dull coats; additionally, puppies or kittens might develop swollen bellies or a "pot-belly" look. (Brooks, Wendy Roundworms in Dogs and Puppies)

Symptoms of infection resemble those caused by other Toxocara species (T. canis, T. cati). It is a frequent reason for diarrhea in young animals and may also lead to vomiting. Occasionally, the worms are expelled from the body, which can be startling since they can grow quite large, with females measuring up to seven inches in length.

The worms feed on the host's nutrients and can result in sluggishness and a typical pot-bellied look. In contrast to T. canis and T. cati, T. leonina does not migrate and its life cycle impacts solely one organ (Brooks, Wendy. "Roundworms in Dogs and Puppies).

1.3. Prevention and treatment

It is advised to deworm all puppies and kittens at 6 weeks of age and to repeat the treatment 2–4 weeks following the initial treatment. Infections caused by T. leonina roundworms are managed using the same treatment regimen as those for T. canis or T. cati roundworm infections (refer to Toxocariasis). Consequently, when eggs are observed in a fecal flotation test or fecal swab, identifying the species present is not required. Roundworm infections are managed with drugs known as "de-wormers," which encompass medications like fenbendazole, pyrantel, milbemycin oxime, and piperazine.

To avoid reinfection of parasitic roundworms, it is advised that all items the animal has touched should be completely cleaned or substituted, including bedding and kennels. It is highly advised that areas outside where defecation might happen be cleaned, along with the daily removal of feces from outdoor pet runs, crates, and the garden (Brooks, Wendy Roundworms in Dogs and Puppies).

1.4. Danger to people

Typically, humans are not hosts for T. leonina; nonetheless, this parasite has been discovered in humans on rare occasions and can lead to visceral larva migrans in children, although it is less often associated than Toxocara canis, the most prevalent roundworm parasite in dogs (Wekipedia, *Toxascaris leonina*).

Part II: Practical Study: Assessing the Effects of Captivity on Lion Health and Behavior at Brabtia Zoo, El Kala

1. Introduction to the Observation Site

The practical study was conducted at the Brabtia Zoological Park, located approximately 20 kilometers east of El Kala, in the El Tarf Province of Algeria. Spanning over 200 hectares, this zoological facility serves as a significant hub for the conservation and exhibition of both native and exotic species. The park's infrastructure includes naturalistic enclosures designed to mimic the animals' native habitats, alongside advanced veterinary facilities to support animal welfare. The site is situated in a region characterized by a Mediterranean climate, which influences the management practices for the resident species, including the lion (*Panthera leo*).

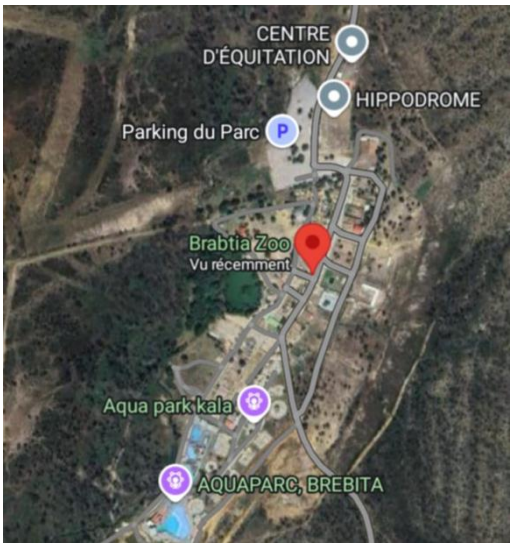


Figure 55: Zoo berabtia el kala. google map

II. Methods Employed:

The study utilized a multi-faceted methodological approach to comprehensively investigate the anatomy, behavior, and health of lions in captivity. The following methods were employed:

1. Direct Observation:

1.1. Behavioral Observation:

Systematic observations were conducted over multiple sessions to document the lions' behavior. Observations were performed during peak activity periods (early morning and late afternoon) to capture natural behaviors such as social interactions, vocalizations (roars, grunts, growls), feeding patterns, and territorial marking. A standardized ethogram was used to categorize behaviors, ensuring consistency in data collection.

1.2. Anatomical Observation:

External morphological characteristics, such as body size, mane development in males, and sexual dimorphism, were recorded through visual inspections. Observations focused on qualitative aspects, such as the texture and coloration of the mane, fur condition, and physical symmetry, as well as quantitative measurements using photographic references and calibrated scales where applicable.

2. Data Analysis

Qualitative Analysis: Behavioral data were analyzed qualitatively to describe social dynamics, vocalization patterns, and stress-related behaviors. Notes from direct observations were coded and categorized to identify recurring themes.

Quantitative Analysis: pathology prevalence were quantified where possible. For instance, the frequency of specific diseases was calculated based on veterinary questionaire

Comparative Approach: Findings from the Brabtia Zoo lions were compared with literature on wild and captive lions to contextualize the effects of captivity on health and behavior.

III. Lion Census at El Kala Zoo

As part of the practical component of this study, a field census was conducted at El Kala Zoo, focusing on the lion population. A total of 22 adult lions were officially recorded, consisting of 13 females and 10 males. In addition, three new cubs were born in 2025, bringing the total population to 26 individuals.

The zoo applies a management policy that ensures the segregation of African lions (*Panthera leo leo*) and white lions (*Panthera leo krugeri*). This housing separation helps maintain animal welfare, facilitates reproductive monitoring, and supports appropriate veterinary care.

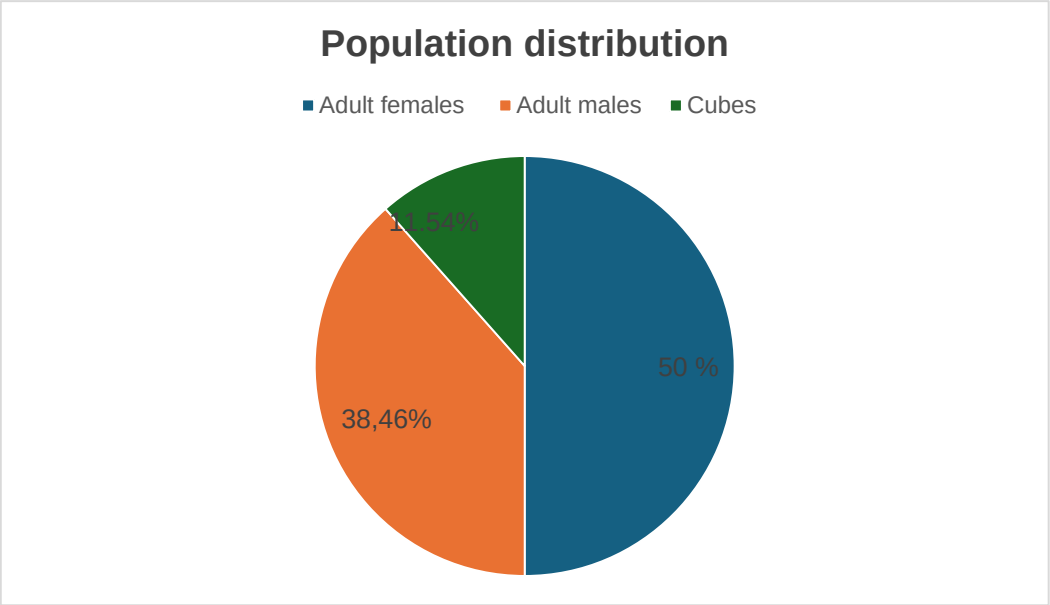
Figure 56: African lions

Breeding and Recent Developments:

The birth of 3 new cubs is a notable achievement, reflecting the effectiveness of the zoo's breeding programs. These cubs, likely a mix of African and potentially white lions, enhance the population's genetic diversity. The success in breeding, especially for white lions, underscores the zoo's role in preventing the decline of this rare morph, which faces challenges in the wild due to habitat loss and human conflict.

Figure 57: Cube lion in kala zoo

Figure 1 below presents a pie chart illustrating the population distribution by gender and age class (adult males, adult females, and cubs).



The lion population at the El Kala Zoological Park consists of a total of 22 individuals, including hybrid and pure African lions, as well as a rare white lion. Among them, the majority (72.73%) are hybrid African lions, while 22.73% are pure African lions. Notably, the park is home to a single pure white lion, representing 4.55% of the total population. This distribution reflects the genetic diversity of the captive lion population within the park and highlights the presence of a unique white phenotype, which is of particular interest for both educational and conservation purposes.

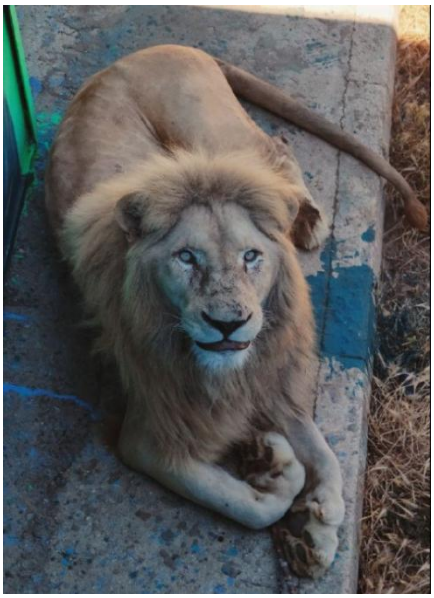
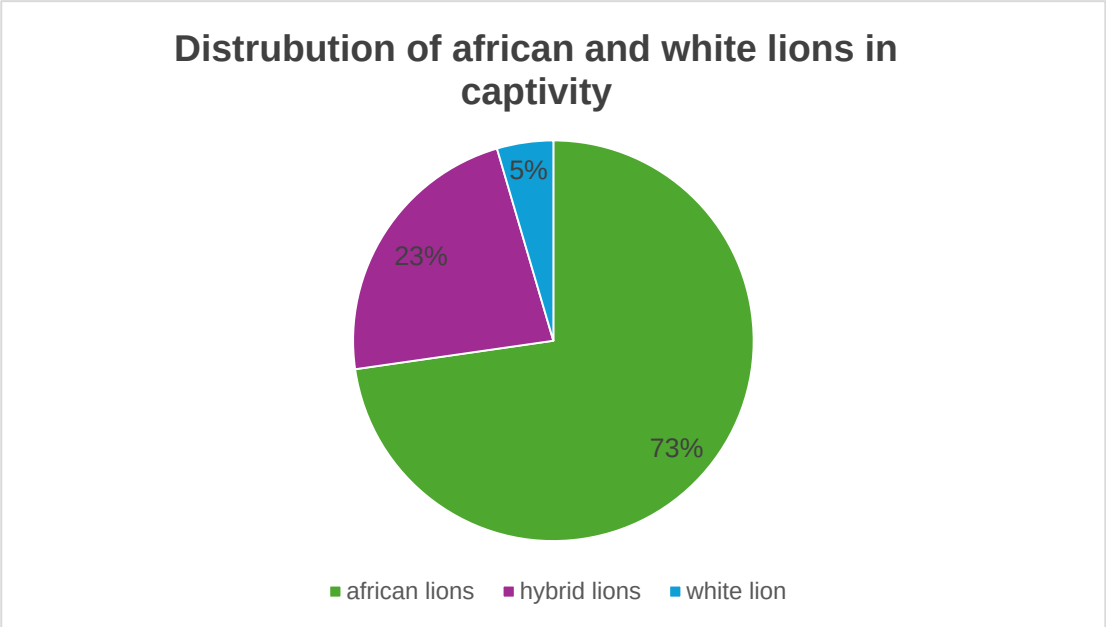


Figure 58: White lion (Bikham) in kala zoo



III. Anatomical Observations

Direct observations confirmed several anatomical features documented in existing literature. Male lions are distinguished by their imposing size, with an average body length of 2.5–3.3 meters (including tail) and a weight ranging from 150–250 kg. Females are comparatively smaller, typically weighing 120–180 kg. The mane of the male, varying from light brown to black, serves as a secondary sexual characteristic and an indicator of health and genetic fitness. Qualitative assessments revealed variations in mane texture and density, with healthier individuals displaying fuller, more lustrous manes. Fur condition was generally smooth, . Physical symmetry and posture indicated robust overall health, with no significant developmental anomalies observed in the sampled population.

1. Head Region

The head of the lion (*Panthera leo*) is anatomically specialized to serve its dual role as a powerful weapon in predation and a sensory hub for environmental perception and communication. Its structure reflects evolutionary adaptation for dominance, efficiency in hunting, and social signaling.

1.1. Cranium

Cranium The skull is broad and robust, with a prominent forehead and distinct facial features. The muzzle is wide, supporting powerful jaws, and the nasal openings are large, enhancing olfactory capabilities. In males, the mane extends over the cranium, varying in color from light brown to black, serving as a visual indicator of health and genetic fitness.

1.2. Face

The face is wide and muscular, with a compact snout and prominent whisker pads. The nasal region is broad, with large, rounded nostrils visible externally, facilitating enhanced scent detection. The fur around the face, particularly in males, integrates with the mane, varying in color from light brown to black, signaling health and vitality.

Figure 59: Lion head region

1.3. Eyes

Lions have large, frontally positioned eyes, which provide excellent binocular vision and depth perception. Their eyes are adapted for low-light conditions, with a high density of rod cells in the retina and the presence of a tapetum lucidum—a reflective layer that enhances night vision by reflecting light back through the retina. This adaptation supports their crepuscular and nocturnal hunting behaviors. Eye color ranges from amber to gold, and the pupils are circular, unlike the slit pupils seen in smaller felids.

Figure 60: lion eyes in kala zoo

1.4. Ears

The ears are rounded, erect, and highly mobile, capable of rotating independently to triangulate sound sources. Externally, they are covered in short, dense fur, while the rear side typically bears a dark black spot—a feature that may aid in visual signaling during coordinated group movements. Lions possess acute hearing, able to detect prey movements from several hundred meters.

Figure 61: Black spot in the ears

1.5. Whiskers (Vibrissae)

Vibrissae, or tactile whiskers, are **specialized mechanosensory hairs** present on specific regions of the lion's head. These structures play a vital role in environmental sensing, social interaction, and hunting, particularly under low-light conditions. In lions (*Panthera leo*), vibrissae are highly developed and regionally distributed, each group adapted for distinct functions.

1.5.1. Mystacial Vibrissae (Upper Lip Region)

Location: Arranged in organized horizontal rows on the upper lip, forming the mystacial pad.

Structure: These are the longest and most prominent vibrissae, often extending beyond the width of the lion's face.

Arrangement: Typically, 4–6 horizontal rows, each containing 5–8 whiskers. These rows follow a quasi-grid pattern that is highly symmetrical on both sides of the face.

Function:
Primary tactile interface for the environment.
Detects the position and texture of objects near the mouth.
During feeding, they help guide precise jaw movements.
Important in close-contact predation and determining the position of prey in total darkness.

Unique Trait: The pattern of follicle placement in the mystacial pad is unique to each individual, making it a potential tool for identification in research or conservation tracking.

1.5.2. Genal Vibrissae (Cheek Region)

Location: Situated on the **lateral aspects of the cheeks**, posterior and slightly dorsal to the mystacial vibrissae.

Function:

Provide **spatial awareness** of the head's lateral boundaries.

Aid in detecting obstacles during movement in dense vegetation or tight spaces.

May also contribute to social interactions—detecting proximity during grooming or face-to-face communication.

1.5. 3. Supraorbital Vibrissae (Above the Eyes)

Location: Positioned just above the **orbital ridge** (eyebrows), typically 1–3 per side.

Function:

Act as **protective sensors**, triggering the blink reflex if touched—protecting the eyes from debris or branches.

Provide vertical spatial information, especially when the head is lowered.

1.5.4. Infraorbital Vibrissae (Below the Eyes)

Location: Found just beneath the lower eyelid, anterior to the cheeks.

Function:

Sensitive to subtle movements near the midface.

May assist in coordinating **facial movement** and orientation during prey engagement or grooming.

III.1.5 .5. Mandibular Vibrissae (Chin and Lower Jaw Region)

Location: Emerge from the **lower jaw** and the **mental region** (chin).

Function:

Detect the ground or surface beneath the jaw.

Useful in feeding when the lion is in a crouched position.

Likely help in sensing the alignment of prey beneath the head.

Functional and Neurological Features:

- Each vibrissa is anchored in a **follicle-sinus complex** rich in **mechanoreceptors**, including:
- Merkel cells

- Lanceolate endings
- Free nerve endings
- Blood sinus system that amplifies mechanical displacement
- Signals from vibrissae are transmitted via the trigeminal nerve (cranial nerve V) to the somatosensory cortex, enabling real-time tactile mapping of the environment.
- Vibrissae movements are both passive (from external contact) and active (via subtle muscular contractions in the muscle sling system around the follicle).

Behavioral Role:

Used during hunting to detect the precise position of prey, especially when making a killing bite to the throat or muzzle.

In social interactions, they contribute to physical contact communication such as allogrooming or maternal behavior with cubs.

Also assist in facial exploration, e.g., sniffing and brushing against conspecifics or objects.

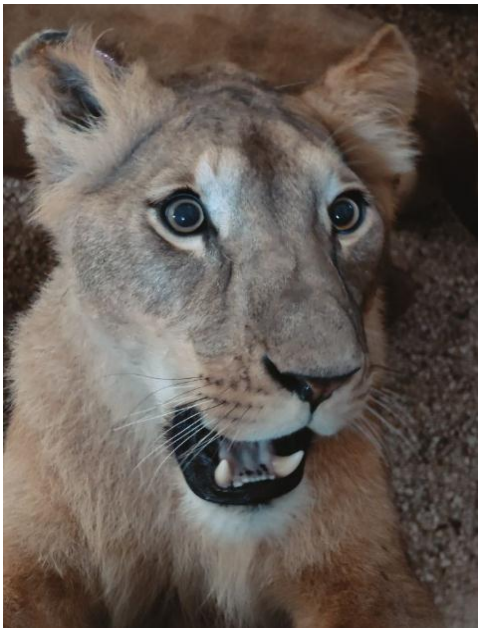


Figure 62: Lion vibrissae in kala zoo

1.6. Muzzle & Nose (External Anatomy):

The muzzle of the lion is relatively short, broad, and robust, adapted to its carnivorous diet and role as a top predator. It houses strong facial musculature that supports a powerful bite and facilitates complex facial expressions, essential in communication and social signaling.

1.6.1. Nose:

The **nose** is large and rounded, with **broad nares (nostrils)** that enhance olfactory capabilities. This adaptation is critical for detecting prey scent trails, marking territory, and social communication via pheromonal cues.

The **nostrils** are capable of dilating during intense activity (e.g., hunting, roaring), increasing airflow.

Pigmentation: Typically, black or dark brown. The color can lighten or become spotted with age, especially in older lions, and is sometimes used as an age indicator in field studies.

The **nasal planum** (the hairles, moist surface of the nose) is textured with a unique pattern of ridges and grooves—**as individual as a human fingerprint**—which can be used for identification.

The **philtrum**, the vertical groove running from the nose to the upper lip, helps direct moisture and scent particles toward the nares, aiding in olfactory function.

Figure 63: Lion muzzel and nose in kala zoo

1.6.2. Vibrissae (Whiskers) Around the Muzzle:

Long, thick vibrissae are embedded in the mystacial pad on either side of the muzzle.

Each vibrissa is rooted in a follicle-sinus complex richly supplied with nerves and blood, acting as a mechanoreceptor.

These whiskers are crucial for tactile sensing, especially during low-light hunting or when navigating in dense vegetation or tight spaces.

Arrangement: Vibrissae are organized in distinct, horizontal rows and vary in length and thickness. The pattern is species-specific and can be used to identify individuals.

1.6.3. Lips and Surrounding Tissues

The **upper lip** is highly mobile and contributes to vocalization and expression.

The **lower lip** is typically less mobile but forms a tight seal to prevent blood loss when feeding on prey.

Around the lips and muzzle, **sebaceous glands** are present, contributing to scent marking and fur maintenance.

1.7. Teeth:

Lions possess **30 permanent teeth**, adapted to a hypercarnivorous diet. The dental formula is: **Incisors (I) 3/3, Canines (C) 1/1, Premolars (P) 3/2, Molars (M) 1/1.**

Canines: These are long, conical (~6–7 cm in adults), and extremely strong, designed for piercing and gripping prey.

Carnassials: The fourth upper premolar and first lower molar form the **carnassial pair**, which act like shears to slice flesh and tendons.

Incisors: Used for scraping meat off bones and delicate grooming.

Molars: Unlike in herbivores, lion molars are reduced and non-grinding.

The tongue is highly muscular and covered in keratinized filiform papillae, giving it a rough, sandpaper-like texture. These structures assist in grooming, cleaning wounds, and rasping meat from bones efficiently.

Figure 64: Lion teeth

2. Neck Region (Cervical Region) – External Anatomy

The neck of the lion is a prominent and powerful structure that plays vital roles in locomotion, feeding, hunting, combat, and social display.

2.1. External Features

2.1.1. Size & Proportions

The neck is thick and cylindrical, especially in adult males, reflecting the underlying muscular development. It appears broader and more compact in mature individuals due to the accumulation of muscle and, in males, the presence of the mane.

2.1.2. Skin and Fur

The skin of the cervical region is thick and flexible, which provides additional protection during fights with conspecifics or while handling struggling prey.

Covered with short, dense fur in females and immature males. In adult males, the fur is modified into a long, coarse mane.

2.2. Mane (in Males)

2.2.1. Development

Begins to develop around 18 to 24 months of age, with full mane development by 4 to 5 years, depending on genetics, hormone levels (particularly testosterone), and environmental conditions.

2.2.2. Color & Texture

Can vary in color from blonde to dark brown or black.

Darker manes are often linked to higher testosterone levels and are considered more attractive to females and intimidating to rivals.

III.2.2.3. Coverage:

The mane typically encircles the neck, extends to the chest, shoulders, and sometimes the lower throat and upper back.

2.2.4. Function:

Physical Protection: Provides a cushion during fights, shielding vital areas like the throat and carotid arteries.

Sexual Selection: A visual indicator of health, strength, and genetic fitness, playing a key role in mating success.

Social Signaling: A full, dark mane can act as a visual deterrent to rival males and may reduce the likelihood of physical confrontation.

2.3. Contour and Shape:

The external contour of the neck appears arched and elevated due to underlying trapezius and splenius muscles.

The neck's robust base merges smoothly into the shoulder girdle, giving the lion a low, prowling profile when stalking prey.

III.2.4. Movement and Functionality (External View):

The range of motion of the head and neck is evident during behaviors like roaring, scanning the horizon, grooming, feeding, and dragging prey.

Head posture is typically elevated and alert, particularly in dominant individuals, which also serves a visual communication function in group dynamics.

3. Thoracic Region (Chest)

Thoracic Cage: Wide and deep, housing large lungs and heart. The ribs are strong and curved, allowing flexibility during respiration.

Scapula: Lies against the thoracic wall, not directly connected to the skeleton, providing flexibility in forelimb movement.

Pectoral Muscles: Thick and powerful, involved in limb propulsion and prey manipulation.

Skin/Fur in this Region: Thicker in males due to the mane, and shorter in females.

4. External Abdominal Region

This region, located between the thorax and pelvis, presents distinct external features:

Abdominal Wall: Covered with a firm but elastic layer of skin and superficial fascia. Visible abdominal muscles include the external obliques and rectus abdominis, giving the belly a tight contour in healthy adults.

Teats: Females possess 4 pairs of mammary glands, visible along the midline; males have rudimentary nipples.

Umbilical Region: Usually not visible in adults, but slight scarring may be present in cubs.

Pelvic Slope: The abdomen narrows towards the pelvic girdle, especially in males, highlighting the powerful hindquarters.

5. Forelimbs – External Anatomy

The forelimbs of the lion are powerful and highly specialized structures that serve multiple roles, including locomotion, hunting, climbing, digging, grooming, and social interaction. Externally, they are robust and muscular, reflecting the lion's predatory lifestyle.

General Structure:

Proportions:

The forelimbs are relatively short but thick, providing a low center of gravity and maximizing leverage and strength during attacks or when pinning down prey.

Muscle Contour:

Externally, the limbs display prominent musculature, particularly at the shoulder and upper forelimb, where the deltoid, biceps brachii, and triceps brachii give the limb a visibly bulky and athletic appearance.

Joints (External Functionality):

The shoulder joint is covered externally by well-developed muscles and has a wide range of motion, enabling swiping, stretching, and forward propulsion.

The elbow joint appears as a prominent angle along the forelimb and allows strong flexion and extension, critical for striking or lifting heavy loads (e.g., dragging prey).

The wrist (carpal) joint provides flexibility and contributes to fine paw positioning during movement or manipulation of objects.

Paws and Digits:

Size:

The forepaws are large and round, well-padded to distribute weight and reduce noise during

movement.

Adult males often have slightly larger paws than females.

Digits:

Each paw has five digits (including a dewclaw higher up the limb), with four functional weight-bearing toes.

Claws:

Each digit terminates in a large, curved, and sharp retractable claw.

Claws are usually retracted at rest and during walking, staying sharp and concealed in protective sheaths.

During attack or defense, they are protracted using muscular contraction in the distal phalanx and associated tendons.

Dewclaw (First Digit):

Positioned higher on the medial aspect of the forelimb and not used in walking. It assists in gripping and holding prey, especially when the lion delivers a killing bite.

Pads:

Digital Pads:

Located under each toe, they are thick and textured, providing traction and cushioning.

Metacarpal Pad:

The largest pad under the center of the paw, which acts as a shock absorber and supports the lion’s weight during running or pouncing.

Carpal Pad:

Found higher up on the backside of the wrist, aiding in grip and braking, especially during climbing or rapid stops.

Fur and Skin:

Covered in short, dense fur, with slightly rougher or thicker hair over joints and the back of the paw.

The ventral side (underside) of the forelimb may appear lighter in color compared to the dorsal side, especially in older individuals.

6. Hindlimbs – External Anatomy

The hindlimbs of the lion are built for powerful propulsion, enabling the animal to sprint, leap, and deliver strong blows during predation. Externally, they are muscular and streamlined, contributing to both speed and stealth in movement.

General Structure:

Appearance & Proportions:

The hindlimbs are longer than the forelimbs, giving the lion a slightly sloping back from the rump to the shoulders. This conformation enhances acceleration and jumping ability.

The upper portion (thigh region) appears thick and rounded, showcasing the lion's well-developed gluteal and hamstring muscles.

Pelvis & Hip Region (External View):

The pelvic region is broad and sturdy, supporting the massive musculature required for bursts of speed.

Externally, the hip joints are obscured by dense musculature, but their placement contributes to the wide stance and strong hindquarters typical of lions.

Joints (External Functionality):

The hip joint allows for extensive forward thrust and lateral motion during stalking or turning mid-pursuit.

The stifle (knee) joint, visible along the upper hindlimb, facilitates powerful flexion and extension.

The hock (ankle) joint, positioned mid-limb, gives the lion its characteristic crouched posture and contributes significantly to leaping force.

Paws and Digits:

Hindpaws are slightly smaller and narrower than forepaws but equally robust.

Each paw has four digits, each equipped with sharp, retractable claws.

Claws are usually hidden within sheaths when not in use, remaining razor-sharp for gripping and raking.

They are unsheathed during combat, climbing, or sprinting for enhanced traction.

Pads:

Digital Pads: Located beneath each toe, help in grip and shock absorption.

Plantar Pad (Heel Pad):

Large and oval-shaped, positioned at the rear of the hindpaw.

Functions as a primary shock absorber and provides traction during sprinting and silent movement.

Texture:
All pads are thick, leathery, and finely textured, allowing silent stalking by muffling sound against hard or dry ground.

Stance and Locomotion:

Posture:

When walking slowly or resting, lions adopt a plantigrade stance, where the heel pad touches the ground, giving stability.

During faster movement (trotting, sprinting, or pouncing), they shift to a digitigrade stance, rising on their toes to enhance speed and agility.

The hindlimbs provide the major thrust during running or leaping, with muscular contractions propelling the lion forward.

Skin and Fur:

The fur covering the hindlimbs is short and dense, with a texture similar to the forelimbs.

The inner thigh and groin region often have lighter coloration, which may aid in heat dissipation or species recognition.

7. Tail

Length & Structure:

The tail is muscular and typically measures around one-third of the body length. It is composed of caudal vertebrae, covered in flexible skin and fur.

Function: Assists in balance during movement and acts as a communication tool. The tuft at the end is used in social signaling, particularly between mothers and cubs or during group hunts.

8. Skin and Fur (Integumentary System)

Texture:

The fur is coarse but short, providing protection without overheating. Skin beneath is thick and pigmented.

Coloration:

Ranges from light tawny to reddish-brown. The ventral side is paler. White lions lack pigment due to a genetic mutation (leucism), not albinism.

Mane:

In males, hair is longer and coarser, offering thermoregulatory challenges but compensating via increased reproductive success.

Markings:

Cubs have faint rosettes or spots that fade with age—believed to aid in camouflage during infancy.

Chapter IV: Ethology of Lions at El Kala Zoo – Observations over Seven Months

Chapter IV: Ethology of Lions at El Kala Zoo – Observations over Seven Months

I. Introduction

Ethology, or the study of animal behavior, is a key discipline in veterinary and behavioral sciences, especially when it comes to wild animals kept in captivity such as African lions (Panthera leo). In this study, behavioral observations were conducted on a group of African and white lions housed at the El Kala Zoological Park (Algeria) over a period of seven months. The objective was to analyze their behavior in a controlled environment and identify how captivity, social structure, and environmental factors influence their ethological patterns.

II. Field Setup and Methodology

The study was carried out at El Kala Zoo, which hosts a genetically diverse group of lions, including hybrid African lions and a rare white lion. The enclosure was semi-natural, comprising shaded zones, rocks, artificial vegetation, a water pond, and wooden platforms for resting. Daily observation sessions were conducted for 3 hours, distributed across morning, midday, and evening periods. Behaviors were categorized into feeding, social, exploratory, aggressive, and resting types.

III. Feeding Behavior

Lions displayed natural feeding responses despite being in captivity. Upon food distribution, lions would quickly approach the feeding area, with visible competition among males or between males and females. Dominant individuals typically ate first. Growling, swiping, and vocal displays were recorded as signs of food-related aggression. Instinctive behavior such as dragging meat to shaded or private areas was also observed, mimicking wild tendencies.

Figure 65: Feeding behavior

IV. Social Behavior

Social interactions among the lions were well-structured. Allogrooming (mutual grooming) was commonly seen among females or between mothers and cubs, reinforcing social bonds. Greeting behaviors involving head or mouth contact were noted, indicating submission or acceptance. A dominance hierarchy was apparent, especially among males. The dominant male often occupied elevated or shaded resting zones and received deference from others.

V. Resting and Inactivity

Lions spent the majority of their day in a state of rest or low activity, particularly during hot hours. On average, they were inactive for 16–18 hours daily. Preferred resting sites included shaded spots, rocks, or near the water pond. Resting positions varied from lateral recumbency to alert head-up postures, with occasional shifts to more comfortable locations.

VI. Aggression and Territoriality

Male-male aggression was more frequent during the mating season (January–March). It involved prolonged growling, back arching, and slow stalking behaviors. Defensive aggression was also observed when humans approached the enclosure or during cleaning. Males demonstrated territorial behaviors through scent-marking, roaring, and posturing.

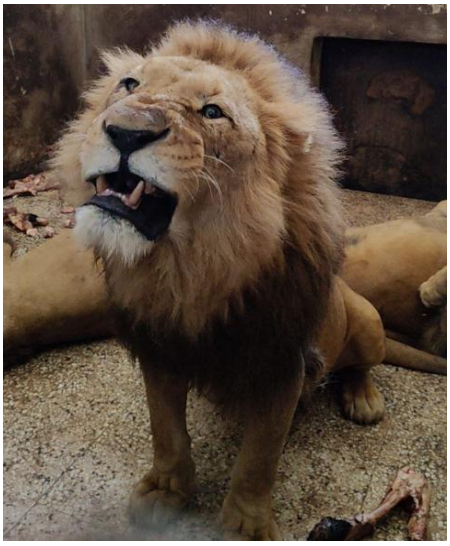


Figure 66: Lion roaring during cleaning

VII. Reproductive Behavior

Courtship behaviors were clearly displayed during the breeding season. These included head rubbing, following, and attempted mounting. Receptive females would show acceptance by raising the tail and lying down. Not all females were receptive, and some displayed avoidance behavior. Observations suggest reproductive cycles influenced social dynamics temporarily.

VIII. Stereotypic Behavior

A few instances of stereotypic behavior, such as pacing along enclosure borders and bar licking, were observed. These were typically more frequent in the evening or during periods of low enrichment. However, the frequency was relatively low, indicating that environmental enrichment at the zoo was partially effective.

9. Conclusion

The long-term behavioral observation revealed that lions at El Kala Zoo display complex social structures, natural feeding and resting behaviors, and signs of reproductive and territorial instincts. While some captivity-induced behaviors were noted, their low occurrence suggests that the current environmental conditions are relatively suitable. However, further improvements in enclosure enrichment and spatial complexity are recommended to enhance animal welfare.

Chapter V: Parasitical Study of African and White Lions

Chapter V: Parasitical Study of African and White Lions

1. Introduction

During the behavioral and health monitoring of the lions, episodes of diarrhea were frequently observed in several individuals. In order to understand the potential causes behind this clinical sign, I prepared a set of targeted questions and consulted with the attending veterinarians and zoo personnel. According to their responses, the most commonly suspected and confirmed cause was parasitic infections, particularly those affecting the gastrointestinal tract. No other significant pathological conditions were reported at that time, which further supported the decision to proceed with a coproscopic (fecal) examination to detect the presence of internal parasites.

This chapter details the coproscopic procedures conducted on a group of African lions and white lions housed at the El Kala Zoological Park. The examinations were carried out at the Scientific Research Laboratory of Chadli Bendjedid University – El Taref, under the supervision of thesis advisor Dr. Maatallah Faouzi, and directed by laboratory head Mr. Saudi Hani.

2. Definition of Coproscopic Examination

A **veterinary coproscopic examination** (also known as fecal examination or coprological analysis) is a diagnostic technique used to detect the presence of gastrointestinal parasites in animals. This test can identify both **helminths** (e.g., nematodes, cestodes, trematodes) and **protozoa** (e.g., *Giardia*, *Coccidia*, *Cryptosporidium*) by observing parasitic elements in fecal samples.

3. Methodology

3.1 Sample Collection

Fecal samples were collected for the first time from the African lions on **March 19th, 2025**. Collection was performed promptly after defecation to ensure sample integrity and minimize the hatching or degradation of parasitic stages.

Materials used:

Sterile containers for sample storage

Disposable gloves (for zoonosis prevention)

Labeling tools (for recording animal ID, date, and time)

Collection Guidelines:

Samples were collected within 2 hours post-defecation.

Care was taken to avoid contamination with urine, soil, or litter.

Each sample was stored in a **refrigerator at 4°C** if not analyzed immediately.

Approximately **5 grams** of fecal material was collected per individual.

3.2 Macroscopic Examination

Prior to laboratory processing, samples were examined macroscopically for:

Consistency (formed, soft, or diarrheic)

Presence of blood, mucus, or visible parasites

3.3 Sample Preparation

3.3.1 Weighing the Fecal Sample

Instruments used:

Kern PFB precision balance

Sterile Petri dishes

Disposable spatula

Gloves and disinfectant (70% ethanol)

Procedure:

The balance was calibrated and tared with an empty Petri dish.

Using a sterile spatula, 5.00 g of feces were transferred into the dish.

After measurement, the weighing pan was disinfected with ethanol.

Figure 67: Weighing the fecal sample

3.3.2 Grinding and Homogenization

Purpose:

To ensure even distribution of parasitic elements within the sample for accurate microscopic evaluation.

Materials:

Sterile porcelain mortar and pestle

Sterile saline solution

Beaker and pipette

70% ethanol or 10% bleach for sterilization

Procedure:

The mortar and pestle were sterilized before use.

5 g of feces were placed in the mortar and crushed into a uniform paste with 1–2 mL of saline.

70 mL of saline solution was gradually added to dilute the sample.

The homogenized sample was filtered into a clean beaker.

3.4 Sample Mounting and Microscopic Observation

The filtered mixture was transferred into test tubes.

Tubes were filled until a convex meniscus was formed at the top.

A coverslip was carefully placed on top and allowed to sit for 15–20 minutes.

The coverslip was then mounted on a glass slide for microscopic examination.

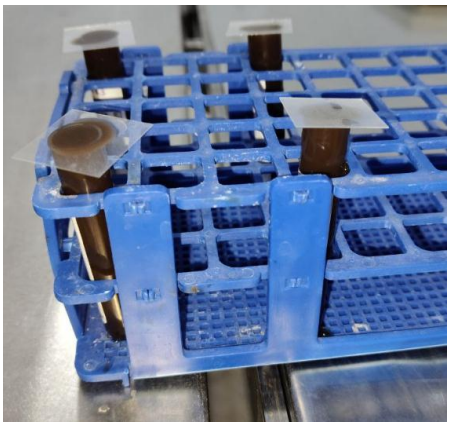


Figure 68: Tubes with coverslip

Microscopy:

Observations were conducted under **10x and 40x** magnifications.

The presence of **parasite eggs, cysts, or oocysts** was noted and documented.

4. Observations on African Lions

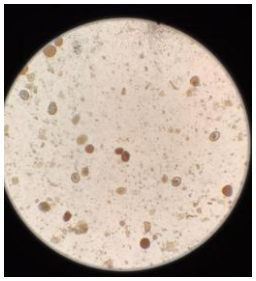


Figure 69: microscopical observation of Toxocaris leonina

The macroscopic examination revealed varying fecal consistencies, with some samples from both African and white lions showing signs of diarrhea, while others were formed; no blood was observed in any samples. Microscopic analysis identified a significant presence of *Toxocara leonina* eggs in both African and white lion samples, indicating a high prevalence of this gastrointestinal parasite across the tested population. The housing separation between African and white lions at the park may help manage the spread of the parasite, though the presence of *Toxocara leonina* in both groups suggests a common environmental or management-related source of infection.

Table 2: Results Summary

Sample Type	**Date Collected**	**Date Analyzed**	**Samples Weight**	**Parasite Detected**	**Observations**
African Lions	March 19, 2025- Mai 19, 2025	March 19, 2025- Mai 19, 2025	5 grams	*Toxocara leonina*	High prevalence of eggs; varying fecal consistency (diarrhea to formed)
White Lions	March 19, 2025- Mai 19, 2025	March 19, 2025- Mai 19, 2025	5 grams	*Toxocara leonina*	High prevalence of eggs; varying fecal consistency (diarrhea to formed)

Discussion

The study of lion anatomy, ethology, and pathology—particularly in a zoological park—is essential for the health and conservation of this animal species. Understanding the lion's physical structure (anatomy) and the diseases to which it is susceptible (pathology) helps ensure its well-being in captivity and contributes to its protection in the wild (Nowell & Jackson, 1996).

The lion's anatomy, with its powerful jaws and retractable claws, is perfectly adapted for hunting. By understanding these adaptations, caretakers can better meet the dietary and behavioral needs of lions in captivity (Sunquist & Sunquist, 2002).

In-depth knowledge of internal anatomy (skeletal and muscular systems, etc.) allows for more accurate diagnosis of diseases and the implementation of effective treatments (Fowler & Miller, 2008).

Reproductive anatomy, including gestation period and average litter size, is essential for managing captive populations and species conservation (Asa & Porton, 2005).

The study of lion anatomy, including fossil specimens, can provide valuable insights into feline evolution and adaptation to various environments (Turner & Antón, 1997).

Identifying common diseases in lions (infections, parasitoses, metabolic disorders, etc.) and their symptoms is crucial for rapid and effective diagnosis and treatment (Miller et al., 2013).

Understanding risk factors for disease helps implement preventive measures to limit their occurrence and spread in both captivity and the wild (Munson, 1993).

Lion pathology is closely linked to species conservation. Infectious diseases can decimate entire populations, especially in high-density areas or where lions face environmental challenges (Packer et al., 1999).

Proper health management of captive lions requires a solid understanding of ethology, anatomy, and pathology to ensure their welfare and minimize suffering (AZA Lion Care Manual, 2012).

Conclusion

In conclusion, the study of lion anatomy and pathology is a critical tool for managing lion populations in zoological parks and conserving this symbolic species.

Better understanding of these aspects improves well-being, facilitates disease diagnosis and treatment, and enables effective conservation measures .

Our monitoring of the lion population highlights the importance of scientific research in improving knowledge for the proper management, control, and preservation of lions living in captivity at the Brabtia Zoo in El Kala .

Recommendations

Enhance Environmental Enrichment Programs

It is recommended to introduce more frequent and varied environmental enrichment tools (e.g., feeding puzzles, climbing platforms, hidden scents, interactive objects) to reduce stereotypic behaviors and stimulate natural hunting and exploratory instincts in captive lions.

Increase Space and Spatial Complexity

The enclosure should be expanded or restructured to include more shaded areas, elevation levels, and isolated corners, allowing lions to express territoriality, privacy, and hierarchy-based distancing, as observed in wild populations.

Implement Behavioral Monitoring Protocols

Regular ethological observation schedules should be institutionalized to monitor behavior changes, identify stress patterns, and assess animal welfare in a standardized way.

Improve Nutritional Variety

Although basic feeding was observed, a more diverse and naturalistic diet—including bones, feathered prey, or varied textures—may encourage natural feeding behavior and dental health.

Establish a Routine Parasitological Screening Program

Based on the results of the coproscopic examination, routine parasitological assessments should be conducted every 3–4 months to monitor gastrointestinal health and prevent internal parasite infestations.

Staff Training in Animal Behavior and Handling

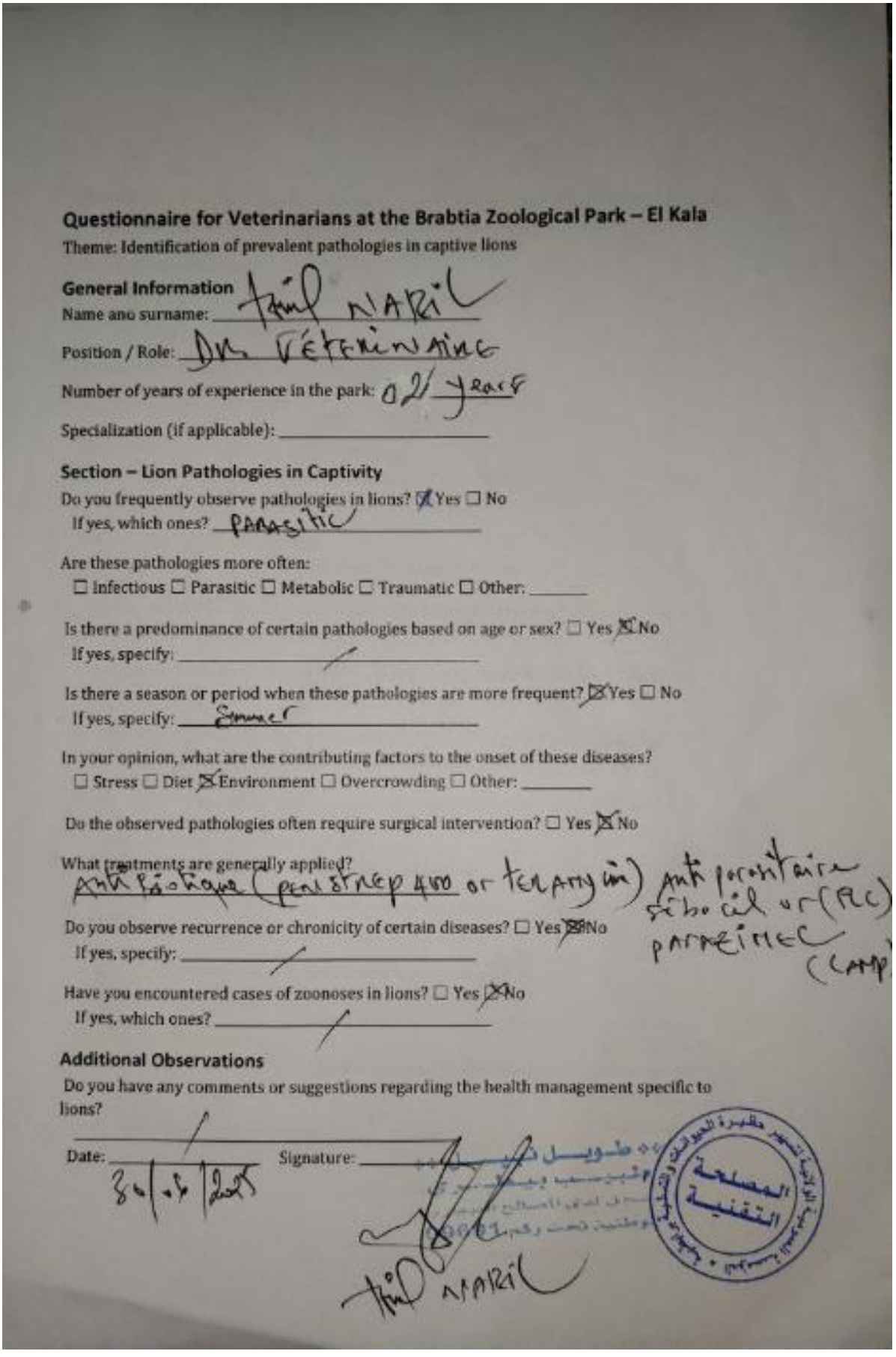
Keepers and handlers should receive ongoing training on lion behavior and signs of discomfort or aggression to ensure safety and improve human-animal interaction within the enclosure.

Enhance Public Education on Lion Conservation

Display panels or guided tours should integrate scientific facts from this study to raise awareness among zoo visitors about the anatomy, behavior, and conservation status of lions, both in captivity and in the wild.

Encourage Collaboration with Veterinary Faculties

Partnerships with universities—like the one with El Taref—should be reinforced to allow continued research, student training, and health monitoring of zoo animals.



Questionnaire for Veterinarians at the Brabtia Zoological Park – El Kala

Theme: Identification of prevalent pathologies in captive lions

General Information

Name and surname: Jamil MARIL

Position / Role: Dr. Vétérinaire

Number of years of experience in the park: 02 years

Specialization (if applicable): _____

Section – Lion Pathologies in Captivity

Do you frequently observe pathologies in lions? ☒ Yes ☐ No

If yes, which ones? Parasitic

Are these pathologies more often:

☐ Infectious ☐ Parasitic ☐ Metabolic ☐ Traumatic ☐ Other: _____

Is there a predominance of certain pathologies based on age or sex? ☐ Yes ☒ No

If yes, specify: _____

Is there a season or period when these pathologies are more frequent? ☒ Yes ☐ No

If yes, specify: Summer

In your opinion, what are the contributing factors to the onset of these diseases?

☐ Stress ☐ Diet ☒ Environment ☐ Overcrowding ☐ Other: _____

Do the observed pathologies often require surgical intervention? ☐ Yes ☒ No

What treatments are generally applied?

Anti Biotique (peni STREP 400 or TERRAMYCIN) Anti parasitaire Fébocil vr (PLC) PARASITEC (CAMP

Do you observe recurrence or chronicity of certain diseases? ☐ Yes ☒ No

If yes, specify: _____

Have you encountered cases of zoonoses in lions? ☐ Yes ☒ No

If yes, which ones? _____

Additional Observations

Do you have any comments or suggestions regarding the health management specific to lions?

_____

Date: 30/05/2025 Signature: Jamil MARIL

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