SYSTEMATIC OSTEOLOGY

Bones of the Thoracic Limb: Consists of **four chief segments**: Shoulder girdle, arm, forearm and manus.

**Shoulder Girdle:** When fully developed consists of three bones: Scapula (Shoulder blade), coracoids (In bird) and clavicle (In bird). In domesticated mammals only the scapula is well developed and small coracoids is fused with scapula as coracoids process. The clavicle is absent or rudimentary.

**Scapula/Shoulder blade**

- Flat bone
- Triangular in outline
- Linked to muscles without any articulation/joint.
- Has 3 border (Dorsal border, cranial border and caudal border), 3 angle (Cranial angle, caudal angle and ventral or glenoid angle) and 2 surface (lateral and medial surface)
- Laterally-spine of the scapula divided lateral surface into 2 part: cranially supraspinous fossa and caudally infraspinous fossa. Medial/costal surface- presents subscapular fossa
- Cranially-supraglenoid tubercle
- Caudally-glenoid cavity and glenoid notch

![Left Scapula of Dog; Lateral surface(A) and Medial Surface (B)](image-url)
Fig. Left bovine radius and ulna: lateral, cranial, and caudal views.

Fig. The left bovine scapula: medial and lateral views * Supraglenoid tubercle.

Fig. Left bovine radius and ulna: lateral, cranial, and caudal views.
Humerus (Long bone)

Divided into three basic segments/parts: 2 extremities (Proximal and distal extremity) and Shaft

- Proximal extremity- bears the head and the tubercles (Greater/lateral and lesser/medial )
- Shaft of humerus-is the middle part of the humerus. There is a broad musculo-spiral groove spiral laterally. **Bears the deltid tuberosity laterally.**
- Distal extremity- bears the humeral condyle (lateral condyle or capitulum and medial condyle is called called trochlea)
  - In dog, there is a foramen in the centre of the condyle is called the supratrochlear foramen. In cat, there is supracondylar foramen instead of supratrochlear foramen
  - Just proximal to condyle there is a fossa called the olecranon fossa (laterally) and radial fossa (medially)

Radius-ulna/Antebrachium: 2 bones fused together (fusion of radius and ulna varies among species)

**Radius:** It has three main segments/parts:
- Proximal extremity- presents head & radial articular facet.
- Shaft of the radius
- Distal extremity bears the radial trochlea.
• In the ox, the distal part of the ulna is completely fused with the radius, in the horse the distal part of the ulna is incorporated within the radius to become the lateral styloid process of ulna.

**Ulna:** The ulna consists of three main segments: proximal extremity, distal extremity and Shaft

- **Proximal extremity:**
  - Presents olecranon and olecranon process/tuber
  - Olecranon process forms point of the elbow.
  - At the base of the olecranon there is semilunar notch/trochlear notch.
  - Cranial to the trochlear notch there is a beak-shaped process which is called anconeal process.

- **Shaft of the ulna:**
  - Generally smaller than radius and fused.
  - Between the shafts of the two bones there are one or more interosseous spaces (depends on species).

- **Distal extremity—presents lateral styloid process.**

**Manus (Carpal, metacarpal, phalanges)**

**Carpal bones:** Typically 8
- Arranged in two rows. Proximal and distal row
- Proximal rows (medial to lateral): radial, intermediate, ulnar and accessory carpal
- Distal row (medial to lateral): First, second, third and fourth carpal
- In horse: 3/4; Ox: 4/2; In dog: 3/4

**Metacarpal/metatarsal bones:** Typically 5 in number.
- In dog: 5 in numbers. All are developed except McI (first). McI is smaller than others (McII-V) and it is non-weight bearing.
- In horse 3rd one (McIII) is well developed and carries the digit. **McII and McIV are called splint bones or small metacarpal bone.**
- In ox- Fused 3rd and 4th (Mc.IV and IV) are well developed. Fusion of two (3rd and 4th) metacarpal bones are well marked by a groove. The distal end is divided into two parts by a sagittal notch and each carries a digit.
Fig. Bovine left manus (carpus, metacarpals, and digits): dorsal view. The image on the left shows articulation of the large metacarpal bone with the carpus proximally, and digits III and IV distally. The image on the right shows an isolated bovine large metacarpal bone. Each digit has a proximal (P1), middle (P2), and distal phalanx (P3).

Fig. The left bovine digits: (a) palmar and (b) lateral views.
- In horse and ox, McIII also called cannon bone.
- In horse; proximal phalanx is called-long pastern, middle phalanx is called-short pastern and distal phalanx is called-coffin bone.

Sesamoid bones: generally 2 proximal sesamoid and 1 distal

**sesamoid in each digit**, 2 proximal sesamoid bones are present at the proximal end of the first phalanx (called proximal sesamoid) and one sesamoid in between 2\(^{nd}\) and 3\(^{rd}\) phalanx (called distal sesamoid).

In horse and ox, distal sesamoid bone also called navicular bone.

- Difference between metacarpal and metatarsal:
  - Body of metacarpal is flattened but metatarsal is cylindrical proximally and flattened distally.
  - Metatarsal is 1/3 longer than metacarpal

**Manus**: Carpus, metacarpus and digit are collectively called manus.

**Pes**: tarsus, metatarsus and digit are collectively called pes.

**Digit (1st+2\(^{nd}\)+3\(^{rd}\) Phalanx):**

- The digit is the collective name of the first Phalanx (Proximal), second phalanx (middle) & third phalanx (distal).
- In horse, only one digit is well developed (i.e. 3rd one).
- In ruminants, four digits are present. Among them, the 3rd and 4th are well developed while 5th are small and form *dew claws* at the back of the pastern.
- In dog there are 5 digits. Each digit has three phalanges, except digit I (which form the dew claw) has only two phalanges. The distal phalanx ends has ungual process which forms part of the claw.

**Skull** (Cranial part)

Cranium (braincase): cranium is formed by the following bones in all domestic mammals:

- Floor of the cranium is formed by-occipital and sphenoid
- Lateral wall of the cranium is formed by the--temporal bone
- Roof of the cranium is formed by-frontal, parietal and interparietal bone
- Nasal wall of the cranium is formed by- the ethmoid bone.

**Occipital bone**

- The occipital bone forms the nuchal wall of the skull
- Important features: Foramen magnum, occipital condyle, jugular process.
- Foramen magnum is the largest foramen of the skull through which the spinal cord passes.
- On either side of the foramen magnum there is a pair of bony prominences, the occipital condyles which articulate with the atlas.
- At the side of the occipital condyles there are jugular processes

**Sphenoid bone**

- The sphenoid bone forms the rostral part of the base of the cranium.
Temporal bone

Temporal bone consists of mainly 2 parts:
- **Squamous part/lateral part**-called squamous temporal
- **Petrosus part/ventral part**- called petrous temporal

Features: Tympanic bulla: It is a rounded ventral projection that forms the middle part of the ear. There is an opening in the tympanic bulla called the *external acoustic meatus* which is closed by the tympanic membrane.

Frontal bone:
- Forms the front aspect of the cranium or ‘forehead’.
- Contains an air-filled cavity called the frontal sinus which connects to the nasal chamber
- In horned ruminants, the caudal end of *the frontal bone forms the cornual process* which support the horn.

Parietal bone: The parietal forms most of the dorsolateral part of the cranial wall.

Ethmoid bone
- The ethmoid bone is form nasal wall of the cranium.
- cribriform plate of ethmoid bone forms the boundary between cranial cavity and nasal cavity.
- The cribriform plate is a sieve-like area perforated by numerous foramina through which olfactory nerve pass from the nasal mucosa to the brain.

Skull (facial part)
The facial bones of the skull form the walls of the nasal cavities and roof of the oral cavity. The floor and the lateral walls of the oral cavity are completed by the lower jaw (mandible) and supported by the hyoid bone ventrally.

**Nasal bone:** The nasal bone forms the roof of the nasal cavity and has a concave external surface.

**The lacrimal bone**
- Lacrimal bone is a small bone situated near the medial canthus of the eye
- Form parts of the orbit and the lateral wall of the face.
- The lateral surface of the lacrimal bone can be divided into an orbital part and a facial part.

**Zygomatic bone/Malar**
- The zygomatic bone lies ventrolateral to the lacrimal bone
- Forms parts of the bony orbit and the zygomatic arch.
- The zygomatic arch is formed by the union of the temporal process of the zygomatic bone and the zygomatic process of the temporal bone.

**Maxilla**
- Form the major part of the facial part of the skull;
- Form the lateral walls of the face, the nasal and oral cavities and the hard palate.
- Largest bone of the face and articulates with all of the facial bones.
- It can be divided into several portions:
  - Alveolar process
  - Palatine process
  - Frontal process and
  - Zygomatic process
- The body of the maxilla encloses an air-filled cavity (except in carnivores) which forms the maxillary sinus in horse and ox.
- The lateral wall of the maxillary body forms the external surface of the face.
  - It is characterized by a horizontal ridge, the facial crest which is especially prominent in the horse. In ruminants the facial tuber is present instead of facial crest.
  - The prominent infraorbital foramen. This is the external opening of the infraorbital canal, which passes from the maxillary foramen.

**Incisive bone/Premaxilla**
- The paired incisive bones consist of the body, nasal, palatine and alveolar processes.
- The incisive bones form the rostral portion of the facial part of the skull
- Form part of the opening to the nasal cavity and the roof of the hard palate.

**Palatine bone**
- The paired palatine bones are located between the maxilla, the sphenoid and the pterygoid bones
- Divided into a horizontal plate (forms part of the hard palate) and a perpendicular plate,

**Vomer:** Vomer is a median bone which form the ventral part of the nasal septum

**Pterygoid bone**
- Pterygoid bone is a thin bony plate surrounded by the sphenoid and palatine bone.
- It forms part of the dorsal and lateral walls of the nasopharyngeal cavity.
Its free margin forms a small hook-shaped process, hamulus of the pterygoid.

**Mandible**

Consist of 2 parts. Each half divided into:
- horizontal part: called body of the mandible
- Vertical part: called ramus of the mandible

**Body**

- The body of the mandible contains the mandibular canal, through which the mandibular artery and vein and the mandibulo-alveolar nerve pass.
- The mandibular canal form by mandibular foramen and mental foramen.
- The mental foramen: one in number in ruminants and horse; 2/3 in number in carnivores.
- Facial notch: The ventral border of the mandibular body is marked by a smooth indentation called the facial notch, where the facial vessels and the parotid duct curve around the bone. In the horse the pulse is commonly palpated at this site.

**Ramus (“Ramus” means branch)**

- The ramus of the mandible is a **vertical bone plate**.
- Its lateral surface is characterized by the **masseteric fossa**, which is the site of attachment of the masseteric muscle.
- Its medial surface is characterized by **pterygoid fossa**, which is the site of attachment of the medial pterygoideus muscle.
- The caudoventral part of the mandibular ramus forms the angle of the mandible.
- In dog/cat there is a **hook-like process called angular process**.
- The free end of the ramus consists of the **condylar process and coronoid process**. These two processes are separated by the mandibular notch.

**Hyoid bone/hyoid apparatus**

- The hyoid bones are situated between the rami of the mandible; at the root of the tongue.
- Act as a suspensory mechanism for the tongue and larynx. It is attached with the styloid process of temporal bone.
- Hyoid consists of number of fine bones and cartilages joined together looks like trapeze. It is divided into
  - Basinoid or body
  - Thyrohyoid and
  - Ceratothyoid

Fig. Lateral (A) and medial (B) views of the left half of the canine mandible. 1, Coronoid process; 2, vertical part (ramus); 3, condylar process; 4, angular process; 5, horizontal part (body); 6, mental foramina; 7, mandibular foramen; 8, sym-physial surface.
**Cervical vertebrae**

In general- cervical vertebrae are quadrangular, massive and longer than other vertebrae. The first (C1; Atlas) and second (C2: Axis) cervical vertebrae are **highly modified vertebrae**.

**Atlas (C1)**
- Named after the mythical man who held up the world (just like the atlas helps support the skull)
- **Body and spinous processes are absent.**
- It has two curve plate/wings
- The wings are wide, flattened and almost horizontal
- Wing has 2 foramina-Cranially: Alar foramen and Caudally: transverse foramen

**Axis (Longest Cervical Vertebra)**
- The cranial extremity presents dens (odontoid process).
- Arch presents elongated and expanded spinous process.

**3rd, 5th, 6th and 7th cervical vertebrae:** Typical vertebrae

**Thoracic vertebrae**

In general, all thoracic vertebrae share the following common features:
- **Costal facets are present for articulation with rib (for the rib heads and tubercles).**
- Short bodies with flattened extremities
- Short articular processes
- **Very long spinous processes**

**Lumbar vertebrae**

In general-
- The transverse processes are long, flattened and **project far laterally**.

**Sacrum**
- The sacral vertebrae are fused to form single bone called sacrum
- Ventrally it has distinct groove for median sacral artery
- The spinous processes are fused to form a median sacral crest.
Fig. Articulated bovine thorax.
Caudal vertebrae

- Gradually reduce in size from first to last.
- The cranial members of the caudal vertebrae are typical vertebrae but the caudal ones are gradually reduced to simple rods (atypical).

![Diagram of vertebral column](image)

Table 1 Foramen/openings of the skull and transmitted structures

<table>
<thead>
<tr>
<th>Name of the foramen</th>
<th>Bones involved</th>
<th>Transmitted structures/Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Foramen magnum</td>
<td>Occipital</td>
<td>Medulla oblongata, spinal cord with its coverings</td>
</tr>
<tr>
<td>2. Foramen lacerum (Jugular foramen in ruminants)</td>
<td>Basioccipital, Temporal, Basisphenoid</td>
<td>Vagus nerve, internal carotid artery, glossopharyngeal nerve, spinal accessory and ventral cerebral foramen</td>
</tr>
<tr>
<td>3. Maxillary foramen</td>
<td>Maxilla</td>
<td>Infra-orbital nerve and vessels</td>
</tr>
<tr>
<td>4. Sphenopalatine foramen</td>
<td>Maxilla</td>
<td>Sphenopalatine nerve, caudal nasal artery and vein</td>
</tr>
<tr>
<td>5. Caudal palatine foramen</td>
<td>Maxilla</td>
<td>Palatine foramen</td>
</tr>
<tr>
<td>6. Ethmoid foramen</td>
<td>Frontal</td>
<td>Ethmoid vessels and nerves</td>
</tr>
<tr>
<td>7. Optic foramen/canal</td>
<td>Presphenoid</td>
<td>Optic nerve</td>
</tr>
<tr>
<td>8. Orbito-rotundum (ruminants)</td>
<td>Presphenoid</td>
<td>Ophthalmic, maxillary, oculomotor and abducent nerve</td>
</tr>
<tr>
<td>9. Foramen rotundum</td>
<td>Presphenoid</td>
<td>Maxillary nerve</td>
</tr>
<tr>
<td>10. Hypoglossal foramen/canal</td>
<td>Occipital</td>
<td>Hypoglossal nerve</td>
</tr>
<tr>
<td>11. Supraorbital foramen</td>
<td>Frontal</td>
<td>Supraorbital artery and vein</td>
</tr>
<tr>
<td>12. Infra-orbital foramen</td>
<td>Maxilla</td>
<td>Infra-orbital artery and vein</td>
</tr>
<tr>
<td>13. Mental foramen</td>
<td>Mandible</td>
<td>Mental artery and nerve</td>
</tr>
<tr>
<td>14. Foramen incisivum/incisive canal</td>
<td>Incisive</td>
<td>Greater palatine artery</td>
</tr>
<tr>
<td>15. Alar foramen (absent in ruminants)</td>
<td>Basisphenoid</td>
<td>Deep temporal artery</td>
</tr>
<tr>
<td>16. Foramen ovale (in ruminants)</td>
<td>Basisphenoid</td>
<td>Mandibular nerve and artery</td>
</tr>
<tr>
<td>17. Stylomastoid foramen</td>
<td>Petrous and temporal part of temporal</td>
<td>Facial nerve</td>
</tr>
<tr>
<td>18. Mandibular foramen</td>
<td>Mandible</td>
<td>Mandibular vessels and nerves</td>
</tr>
<tr>
<td>19. Mastoid foramen</td>
<td>Mastoid</td>
<td>Caudal meningeal artery and vein</td>
</tr>
<tr>
<td>20. Cribriform foramina</td>
<td>Ethmoid</td>
<td>Approximately 300 in numbers in dog. They transmit olfactory nerve filaments from the nasal mucosa to the olfactory bulb of the brain</td>
</tr>
<tr>
<td>21. Major palatine foramen</td>
<td>Palatine</td>
<td>Greater palatine nerve</td>
</tr>
<tr>
<td>22. Spinous foramen</td>
<td>Basisphenoid</td>
<td>Trochlear nerve and middle meningeal artery</td>
</tr>
<tr>
<td>23. Carotid canal</td>
<td>Basisphenoid</td>
<td>Internal carotid artery and nerve</td>
</tr>
</tbody>
</table>

![Image of sacrum and cervical vertebra](image)
The jaws are separated for the sake of clearness. A, Parietal bone; B, squamous temporal bone; C, occipital bone; D, perpendicular part of palatine bone; E, maxilla; F, malar bone; G, lacrimal bone; H, premaxilla; 1, occipital condyle; 2, paramastoid process; 3, meatus acousticus externus; 4, bulla ossea; 5, zygomatic process of temporal bone; 6, 6', zygomatic and temporal processes of malar bone; 7, supraorbital process; 8, orbital part of lacrimal bone; 9, lacrimal bulla; 10, fossa saec lacrimalis; 11, facial tuberosity; 12, infraorbital foramen; 13, condyle of mandible; 14, coronoid process of mandible.
Fig. Bovine skull showing caudal parts of the occipital bone: caudal view.

Fig. The bovine skull: ventral view.
Fig. 134.—Skull of Ox, without Mandible; Ventral View.

1. Foramen magnum; 2. occipital condyle; 3. paramastoid process; 4. condyloid foramen; 5. foramen lacerum; 6. basilar part of occipital bone; 7, 7', basilar tuberces; 8. bulla ossea; 9. foramen ovale (concealed by muscular process); 10. mentus acusticus externus; 11. zygomatic process of temporal bone; 12. condyle of same; 13. external opening of temporal canal; 14. processus cornus; 15. muscular process of temporal bone; 16. pterygoid crest; 17. orbital opening of supraorbital canal; 18. choana or posterior nares; 19. hamulus of pterygoid bone; 20. crest formed by pterygoid processes of sphenoid and palatine bones; 21. horizontal part of palatine bone; 22. anterior palatine foramen; 23. lacrimal bulla; 24. maxillary tuberosity; 25. palatine process of maxilla; 26. zygomatic process of malar bone; 27. facial tuberosity; 28. body of premaxilla; 29. palatine process of same; 30. palatine fissure; 31. incisive fissure; 32. premolars; 33. molars.
Pelvic Limb/Hind limb:

Pelvic girdle:
Consists of two osa coxarum or hip bones. They are firmly attached ventrally by pelvic symphysis. Each os-coxae consists of following three bones:

Ilium
- It is the **largest and most cranial** pelvic bones. 2 parts: (Wing and body)
  - 2 surfaces: gluteal and pelvic surface
  - irregularly triangular in shape
  - the **medial angle** is called **tuber sacrale** which is close to sacro-iliac joint
  - the lateral angle is called **tuber coxae** and form the point of the hip (known as hookbone)
  - The area between tuber coxae and tuber sacrale is called wing of of the ilium and **dorsal margin is called iliac crest**.

Ischium
- projects backward from the acetabulum
- Has large roughened caudal projection called ischial tuber (commonly called pin bone in cattle).

Pubis
- smallest pelvic bone
- L-shaped
- form cranial part of the floor of the pelvic cavity
**Table 1 Sexual differences of the pelvic girdle**

<table>
<thead>
<tr>
<th>POINTS</th>
<th>STALLION</th>
<th>MARE</th>
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</thead>
<tbody>
<tr>
<td>1. Conjugated diameter (sacro-pubic)</td>
<td>Smaller 18.75 cm</td>
<td>Larger 24 cm</td>
</tr>
<tr>
<td>2. Pelvic inlet &amp; outlet</td>
<td>Comparatively smaller</td>
<td>Comparatively larger</td>
</tr>
<tr>
<td>3. Ischial arch</td>
<td>Comparatively less wider</td>
<td>About 1/3 wider than horse</td>
</tr>
<tr>
<td>4. Pubic floor</td>
<td>Pubic floor is thick and convex</td>
<td>Comparatively thin and concave</td>
</tr>
<tr>
<td>5. Obturator foramen</td>
<td>Comparatively smaller</td>
<td>Comparatively larger</td>
</tr>
<tr>
<td>6. Pelvic cavity</td>
<td>Less roomy than mare</td>
<td>More roomy</td>
</tr>
</tbody>
</table>

**Femur (Thigh bone)**
- Largest long bones.
- It presents
  - Shaft
  - Two extremities-proximal and distal.
  - The shaft/body-cylindrical in shape

Proximal extremity-
- Presents the head
- head articulate with the acetabulum
• Head presents a notch called fovea capitis.
• Fovea capitis is the site of attachment of intracapsular ligament.
• Head is separated from the body by neck.
• Lateral to head—there is a large process called greater trochanter.
• The greater trochanter and the neck of the femur are separated by the trochanteric fossa: divided into cranial and caudal part.
• Lesser trochanter is present on the medial side.
• In the horse, additional process third trochanter/trochanter tertius, is located laterally.

Distal extremity carries—
  – Medial and lateral condyles caudally and a trochlea cranially.
  – Intercondylar fossa (A deep fossa between the medial and lateral condyle)
Kneecap (patella)
- Largest sesamoid bone
- Located in the tendon of the quadriceps muscle of the thigh.
- Its articular surface faces caudally towards the femur;
- Free surface faces cranially
- Palpable under the skin.

Tibia-Fibula: Fused together and form the true leg or crus

Tibia
- The tibia can be divided into three segments:
  - proximal extremity- presents the articular surface of the femorotibial joint,
  - shaft and
  - distal extremity-presents cochlea for the articulation with the talus
- Proximal extremity
  - three-sided and carries two condyles (Lateral and medial)
  - The spine or intercondyloid eminence central prominence. It consists of a high medial part and a lower lateral part
  - Intercondyloid fossa or groove in which cranial cruciate ligament and the menisci are attached
  - Condyles are separated caudally by the popliteal notch
- Distal extremity carries the cochlea
- Cochlea consists of two grooves separated by an intermediate ridge.
- The medial side of the cochlea presents the medial malleolus and the lateral side of the cochlea presents lateral malleous (formed by the fusion of the distal end of the fibula to the tibia)

Fibula
- Highly variable among species.
- Developed in horse, dog and pig.
- Rudimentary in ruminants and fused with tibia.
- divided into body and 2 extremities
  - Proximal extremity- presents head and neck and a distal extremity presents lateral malleolus.
  - In ruminants: no shaft and proximal extremity presents a small prominence below the lateral condyle of the tibia.
  - Distal extremity presents lateral malleolus (formed by the fusion of the distal end of the fibula to the tibia)
The fibula is separated from the tibia by interosseous space.

**Tarsus (forms the tarsal or hock region)**

- Consists of tarsal bones.
- Tarsal bones are arranged in three rows: the proximal, middle and distal.
- Proximal or crural row (in mediolateral sequence):
  - **Tibial tarsal bone or talus**-large bone
  - **Fibular tarsal bone or calcaneus**- large bone
  - middle or intertarsal row and
  - central tarsal bone (os tarsi centrale) and
- Distal or metatarsal row (in mediolateral sequence):
  - first tarsal bone (os tarsale primum),
  - second tarsal bone (os tarsale secundum),
  - third tarsal bone (os tarsale tertium) and
  - fourth tarsal bone (os tarsale quartum)
  - In carnivores and pigs-seven tarsal bones
  - In ruminants-five tarsal bones.
  - In horse- six tarsal bones.

**Talus**
- Tibial tarsal
- Medial large bone of the proximal row of the tarsus.
- divided into body, trochlea and a cylindrical head

**Calcaneus**
- Fibular tarsal bone
- Lies lateral and plantar to the talus
- Form point of the hock.
- Presents the calcaneal tuberosity/tuber.