

COURSE CODE:	VBA 301
COURSE TITLE:	COMPARATIVE MAMMALIAN AND AVIAN ANATOMY
NUMBER OF UNITS:	3 Units
COURSE DURATION:	Three hours per week

COURSE DETAILS:

Course Coordinator:	DR. OLUDE M.A
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Office Location:	College of Veterinary Medicine, Dept. of Veterinary Anatomy, UNAAB.
Other Lecturers:	Drs. AKINLOYE A.K., ADEBAYO A.O., and MUSTAPHA O.A

COURSE CONTENT:

Gross anatomy of the domestic chicken including osteology, myology, as well as digestive, respiratory, reproductive, circulatory and nervous systems; comparative anatomy of organs and structures of domestic animals (ox, sheep, goat, horse, pig, dog and cats) including digestive, respiratory, urinary, reproductive and circulatory system; arthrology; neuroanatomy; endocrine and sense organs.

COURSE REQUIREMENTS:

This is a compulsory course for all students in the University in view of this, students are expected to participate in all the course activities and have minimum of 75% attendance to be able to write the final examination.

READING LIST:

1. Septimus Sisson: The anatomy of the domestic animals, Fourth Edition revised.
2. Dyce, Sack and Wensing: Textbook of Veterinary Anatomy. Third Edition.
3. Konig, Liebel. Veterinary anatomy of domestic mammals: Textbook and colour atlas. Third edition.
4. Klaus-Dieter Budras, Patrick H. McCarthy, Wolfgang Fricke and Renate Richter: Anatomy of the dog. Fifth revised edition.
5. Raymond R. Ashdown and Stanley H. Done: Colour atlas of veterinary anatomy: The Horse. Volume 2.

LECTURE NOTES

COMPARATIVE OSTEOLOGY: VERTEBRAL FORMULAE

	C	T	L	S	Cy
HORSE	7	18	6	5	15-21
CATTLE	7	13	6/7	5	18-20
PIG	7	14-15	6/7	4	20
SHEEP	7	13	6	4	16-18
DOG	7	13	7	3	20
FOWL	7	7	L/S 14		6
MAN	7	12	5	5	4

	RIB PAIRS	STERNAL	ASTERNAL	STERNEBRA	
HORSE	18	8	10	7	
OX	13	8	5	7	
SHEEP	13	8	5	7	
PIG	14	7	7	6	
DOG	13	9	4	8	

RIB

- HORSE: narrow shaft, strongly curved in dorsal third
- BOVINE: wide, flat shaft, long neck
- PIG: narrow shaft, distinct angle
- DOG: cylindrical shaft

SCAPULA

- HORSE: spine fades out distally, trapezius tubercle present
- BOVINE: distinctly triangular, spine sinuous, dividing lateral surface into unequal fossae
- PIG: prominent trapezius tubercle overhanging infraspinous fossa
- DOG: spine bisect lateral surface

HUMERUS

- HORSE: bicipital groove divided by a ridge
- BOVINE: massive lateral tuberosity overhangs bicipital groove
- PIG: lateral tuberosity almost converts bicipital groove into foramen
- DOG: single lateral tuberosity. Coronoid and olecranon fossae communicate through supratrochlear foramen

ULNA

- HORSE: ulna fused 2/3rds of the way down the shaft of radius
- BOVINE: ulna complete. Projects distally beyond the the radius as the styloid process
- PIG: ulna massive. Articulates with radius and ulnar carpal
- DOG:Ulna never fused. Olecranon has trituberculate summit

- HORSE

- R I U A
(1) 2 3 4

BOVINE

R I U A
2/3 4/5

- PIG

- R I U A
1 2 3 4

DOG

R/I U A
1/2 3 4

METACARPALS AND DIGITS

- HORSE: 3rd metacarpal is functional. 2nd and 4th are vestigial (splint bones). Only 3rd digit present
- BOVINE: metacarpals 3 and 4 are weight bearing.
5th is vestigial. 4 digits present of which 3 and 4 are functional
- PIG: metacarpals 2,3,4 and 5. All metacarpals bear digits
- DOG: metacarpals 1,2,3,4 and 5. All

metacarpals bear digits. Digit 1 possesses only two phalanges

- COMPARATIVE ANATOMY OF THE DIGESTIVE SYSTEM

DENTAL FORMULA

- Horse $2(C3/3, I 1/1, P3-4/3-4, M3/3)$
- Ruminant $(0/4, 0/0, 3/3, 3/3)$
- Pig $(3/3, 1/1, 4/4, 3/3)$
- Dog $(3/3, 1/1, 4/4, 2/3)$
- Cat $(3/3, 1/1, 3/2, 1/1)$
- The fowl has no teeth

TONGUE

- Horse
 - spatula shaped
 - Two distinct vallate papillae on cauda of dorsum

- Bovine
 - Caudal half of dorsum is prominently marked and raised

- Papillae on prominence are distinct
- Filiform and conical papillae are keratinized and caudally directed
- They give a rough and prehensile surface to the tongue

- SHEEP
- Like the Bovine but prominence less raised

- PIG
- Narrow and pointed with a thin apex
- Long backward pointed papillae on the root

- DOG
- Wide, thin and mobile
- Dorsum marked by median groove
- Long backward pointing papillae on the root
- Caudal part of tip has cord of fibrous tissue-Lyssa

SOFT PALATE

- Horse
- Long and precludes oral breathing
- Tonsil is diffuse situated in the sinus, root of tongue and soft palate

HARD PALATE

- HORSE
- Divided into two equal portions by the central raphe
- Palatine ridges or rugae extend the whole length of the palate

- BOVINE
- Cranial portion forms the prominent dental pad
- The rugae extend only 2/3rds of the length of the palate
- All but the last few are serrated on their free borders

- SHEEP
- Ruggae are not serrated
- Openings of the naso palatine ducts form a prominent-V on either side of the central incisive papilla
- PIG
- Long and narrow
- Equal in width throughout
- Both rugae and median raphae are well marked

- Incisive papillae is prominent cranially
- DOG
- Widest about the 4th cheek tooth

OESOPHAGUS

- HORSE
- Voluntary as far as the base of the heart
- BOVINE
- Easily dilatable and voluntary throughout making regurgitation easy
- PIG
- Voluntary till last few inches near the cardia
- DOG
- Voluntary throughout
- Constricted ventrally at the origin by mucous glands (isthmus oesophagi).

GLANDULAR STOMACH

- HORSE
- Average capacity-3gallons
- Non glandular portion separated from the glandular by an irregular ridge (margo plicatus)
- Non glandular left extremity is called Saccus caecus

- PIG
- Average capacity 2gallons
- Left extremity has a blind pouch (diverticulum ventriculi)
- Presence of the torus pyloricus
- DOG
- Average capacity-4pints
- Pear shaped and very distensible

RUMINANT STOMACH

- Reticulum
- Rumen
- Omasum
- Abomasum
- A higher proportion of a ruminant's digestive system is stomach

Reticulum characteristics

- Located next to heart
- Honeycomb appearance
- `Catches metal and hardware
- Pathways
- `Esophagus
- `Rumen
- `Omasum
- No enzymes secreted i.e. aglandular

Rumen Characteristics

- Left side of abdomen/ median plane
- Papillae lining
- Muscular pillars
- Fermentation vat
- ` Primarily anaerobic
- ` Some aerobic microbes
- Not functional at birth
- Aglandular

Rumen Functions

- Storage
- Soaking
- Physical mixing and breakdown
- Fermentation
- `Synthesizes some vitamins
- `Synthesizes Amino Acids and protein
- `Breaks down fibrous feeds into VFAs

Rumen Development

- 48 -100 liters of liquid
- `Larger in cows on a forage diet
- `Forage-fed calves have larger rumens
- 15-21% of mature cow weight is rumen
- contents

Omasum

- “Manyplies”
- No enzymes from walls

- Function
- `Reduce particle size
- `Absorb some water

Abomasum

- “True stomach” that secretes enzymes
- from walls
- Glandular stomach like monogastric fundic
- region
- `HCL, Mucin
- `Pepsinogen, Rennin and Lipase

- HORSE
- 6inches from the pylorus
- Duodenal pouch-diverticulum duodeni
- Ventral pancreatic and hepatic ducts open in the diverticulum duodeni
- BOVINE
- Duodenum commences with a sigmoid flexure
- Bile duct opens in the ventral part of the flexure

- PIG
- Bile duct opens 2 inches from pylorus
- Single pancreatic duct opens 5 inches beyond this point
- DOG
- Bile duct and ventral pancreatic duct open 2 inches behind the pylorus
- Dorsal pancreatic duct opens 2 inches further back

- Caecum: comma shaped sac in the horse.
- Colon has right ventral, left ventral, left dorsal and right dorsal colons

- COMPARATIVE ANATOMY OF THE RESPIRATORY SYSTEM

TRACHEA

- HORSE
- Incomplete dorsally in thoracic region
- Overlap dorsally from right to left dorsally
- BOVINE
- Ends of tracheal rings are in apposition forming a dorsal ridge in thoracic region
- Incomplete dorsally in cervical region

- PIG
- Tracheal rings overlap dorsally both in thorax and neck

- DOG
- Rings are U-shaped and slender
- Ends of rings do not meet dorsally so that the trachea has a membranous dorsal wall

LUNGS

- HORSE
- Not divided into lobes by deep fissures
- Right lung has intermediate lobe

- BOVINE
- Apical lobe of right lung receives 3rd bronchus from trachea opposite 3rd rib
- Lobation very distinctly marked

- PIG
- Diaphragmatic lobe is marked off by a distinct fissure
- Cranial to this apical and cardiac lobes are separated by cardiac notch
- DOG
- Divided into 4 lobes by very deep fissures which extend to the root

AVIAN OSTEOLOGY

- Designed for lightness and strength
- Attained by fusion with concomitant deletion of some bones
- Fusion, most obvious in cranium and pelvic girdle

SPECIAL ADAPTATION

- Light, compact and strong skeleton with higher CaPO₄ content than in mammals
- Fusion of vertebrae
- Prominent sternum
- Ventrally opened pelvis
- Pneumatization of bones by air sacs through pneumatic foramina into the medullary cavities of neighbouring bones
- Absence of heavy teeth and lips replaced by a light beak

SKULL: SALIENT FEATURES

- Large orbits between bulbous cranium and pyramidal face
- Flat mandible with marginal increase in height of the skull
- Large eyes displacing and replacing the bones between the orbits in most mammalian skull to a thin median plate (interorbital septum)
- Presence of sclerotic ring
- Several cranial bones consists of two plates separated by spongy bone
- Most bones are present and typical
- Quadrate and Articular bone – homologue of mammalian middle ear ossicles (malleus and incus)
- Craniokinesis

OCCIPITAL BONE

- Encloses the foramen magnum
- Single occipital condyle articulates with atlas; forms a joint which allows for rotation of the head on the vertebral column to a much greater extent

TEMPORAL BONE

- Tympanic cavity: semi-spherical depression in lower part of lateral cranial wall
- Bounds the external acoustic meatus
- Presents cochlear and vestibular window

FACIAL BONES

- Formed principally by the nasal and premaxillary bones
- Nasal bones is dorsal in many birds
- In Psittacine: flexible connection with the frontal bone which allows the simultaneous raising of the jaw and depression of lower jaw
- Maxilla connected to the mandibular joint by long thin jugal arch (syn: zygomatic arch in domestic mammals)
- Palatine bones - caudally directed rods; connects premaxillae with pterygoid
- The osseous partition (palatine process of the premaxillae) between the nasal and oral cavities exist only rostral
- Mandible: fused rostrally, covered by the lower beak. Caudally connected to the skull between the orbit and articular bones

- Quadrate bone connected to jugal arch and by interposition of pterygoid to palatine
- Birds with craniofacial hinge, budgerigar and parrot, for example depression of the lower jaw rotates the quadrate bone which pushes the jugal arch and palatine bone rostrally thus elevating the upper jaw – CRANIOKINESIS

AXIAL SKELETON

- Strictly comprises of:
 - Vertebral column
 - Ribs and
 - Sternum
- Pelvis may be included since it is firmly attached to the synsacrum

VERTEBRAL COLUMN

- Division of the vertebral column into definite numbers of cervical, thoracic, lumbar and caudal vertebra is difficult because of extensive fusion and uncertainty in the location in the junction of the cervical and thoracic vertebrae
- Formula: C- 13(14); T- 7; L/S – 14; Ca – 6

CERVICAL VERTEBRA

- Uniformly cylindrical with prominent articular processes and rudimentary caudally directed (cervical) ribs, except for the 1st two
- Last two ribs possess vertebral ribs
- ALTA: small ring-like bone
- AXIS: dens and short cranial articular processes

THORACIC VERTEBRA

- Usually seven bearing true ribs
- Notarium: fusion of four thoracic vertebrae
- This is followed by a single free thoracic vertebra, the only mobile vertebra of the trunk. Implication?

LUMBOSACRAL BONE

- Synsacrum: fusion of thoracic (\pm), lumbar, sacral and 1st caudal vertebra
- House the kidneys
- Bones often inseparably fused laterally with the ilium

CAUDAL VERTEBRAE

- Five or six free caudal vertebrae
- Pygostyle: most caudal rudimentary fusion. Gives support to flight feathers of the tail
- Uropygial (preen gland)

STERNUM

- Large unsegmented bone with long processes
- Attachment of large flight muscles
- Prominent keel (carina)
- Manubrium: a median process on the cranial end of sternum
- Pneumatic foramen on concave dorsal surface connect with clavicular air sac
- Caudal end of sternum is cartilaginous in young; ossifies in adult – an indicator of age

RIBS

- 5 or 6 pairs connects the sternum to the thoracic vertebrae
- A complete rib consist of a dorsal (vertebral) and ventral (sternal) segment
- Remaining ribs bear caudodorsally directed uncinat process which overlaps succeeding ribs, provides anchorage for attachment of muscles and ligaments and confers rigidity to the rib cage
- First two lack the sterna segment

APPENDICULAR SKELETON

- Forelimb is modified to wing while hindlimb solely responsible for locomotion, perching and withstanding the stress of landing

FORELIMB – SCAPULA

- Flat rod, lateral and parallel to the vertebral column and extending caudally to the pelvis
- Joined to the axial skeleton by muscles and ligaments while cranially connected to the clavicle and coracoid
- The coracoids bone receives the head of the humerus
- Extends from the shoulder joint, articulates with cranial end of sternum
- Acts as brace against the up and down strokes of the wing
- Right and left clavicle fuses to form the furcula (wishbone). Borders and median ventral expansion attached to the sternum and coracoids by tough membrane
- Triosseal canal: formed by scapula, coracoid and clavicle
- Transmits the tendons of one of the flight muscle (supracoracoideus muscle)

HUMERUS

- Stout, flat at both ends
- Proximal extremity carries dorsal and ventral tubercles
- Pneumatic foramen present close to ventral tubercle

Ulna: thicker and longer than radius

- Promixal row of carpal bones reduced by fusion to two separate bones – ULNAR CARPAL and RADIAL CARPAL
- Distal row fused with metacarpal – CARPOMETACARPAL
- Number of metacarpal bones and corresponding digits are reduced to 3 (II, III & IV)

PELVIS

- Right and left hip bones and the syn(sacrum)
- Deeply concave ventrally; relatively long about half of the trunk
- Broad dorsal and lateral surface of pelvis formed by Ilium and Ischium respectively. Both forms the acetabulum
- Pubis – thin rod attached to ventral border of Ischium
- No ventral symphysis – for allowance of egg passage

Femur: head articulates with acetabulum

- Proximal end of femur has a prominent trochanter lateral to its head
- PATELLA: found in rotular groove at the distal end of the femur
- TIBIOTARSAL: longest leg bone
- FIBULA: “drum-stick”

- TARSOMETATARSAL

AVIAN MYOLOGY

MUSCLES OF THE HEAD AND NECK

Four recti and two oblique muscles move the eyeball as much as in mammals. The jaw is closed by the pseudotemporalis (formerly called the temporalis muscle), the external mandibular adductor muscle (formerly masseter) and the pterygoid muscles while the depressor mandibulae muscle opens the jaw.

Muscles of the hyobranchial apparatus (intermandibularis) elevate, protract and retract the tongue and larynx. These muscles are recognisable from their resemblance to their mammalian counterparts. Other muscles constrict the pharynx and close the larynx in swallowing.

The epaxial and hypaxial muscles of the vertebrae

- Rectus capitis
- complexus
- Spinalis cervicis and
- Intertransversarii

are mostly divided into an array of fine interlacing fascicles which makes the neck extremely mobile.

Three pairs of muscles are associated with the caudal end of the trachea: the most conspicuous is the sternolaryngeal or sternotracheal muscle

The sternohyoid muscle which inserts on the trachea and larynx probably aids the sternolaryngeal muscle in oscillating the syrinx and trachea cranio-caudally in sound production.

MUSCLES OF THE TRUNK

The musculature of the rest of the vertebral column e.g. the iliocostalis et longissimus dorsi is much reduced in the thoracic and synsacral region where the vertebrae are extensively fused.

A complex group of muscles operates the pygostyle and tail generally.

- The levator caudae

RESPIRATORY MUSCLES

The chief inspiratory muscles are the external intercostals and the triangularis sterni (costisternalis pars major) while the chief expiratory muscles are the internal intercostals and the abdominal muscles.

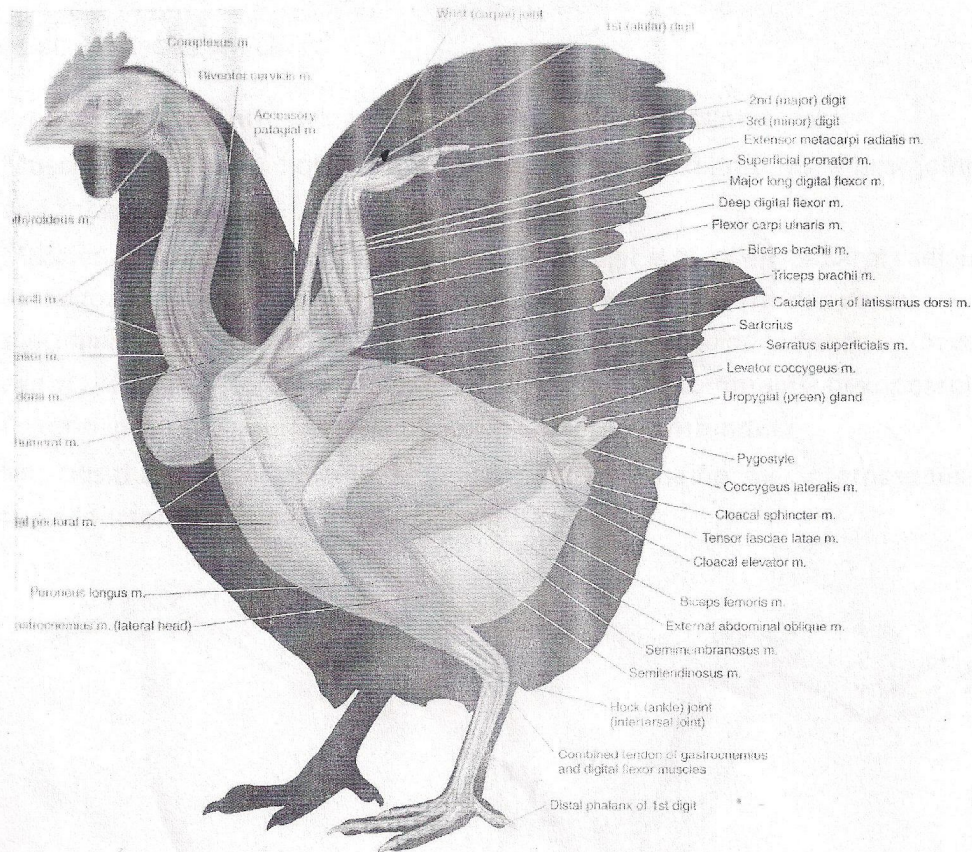


PLATE 7.6 Superficial muscles of the hen. Left lateral view. m = muscle

ABDOMINAL MUSCLES

The four abdominal muscles (rectus abdominis, transverses abdominis, internal oblique and external oblique muscles) are essentially arranged as in mammals except that in some species including fowl, the recti abdominis is represented only by a membrane.

MUSCLES OF THE WING

They move the wing and are about 20% of the body weight in some species. The main muscles of flight include:

❖ **Supracoracoideus:** smaller deep muscle

- Origin & insertion: emanates from the sternum and clavicle and its tendon is directed dorsally through the triosseal canal and then across the head of the humerus to end close to its antagonist
- Action: upward stroke of the wing

There are also muscles which:

- Protract or retract the wing e.g. rhomboideus and latissimus dorsi
- Muscles which extend or flex the shoulder joint e.g. deltoideus; elbow joint (biceps and triceps brachii)
- Muscles which extend or flex the carpus and digit e.g. extensor carpi radialis (*lies dorsal to the radius in the laterally extended wing and its short tendon passes subcutaneously over the craniodorsal surface of the carpal joint and ends on the proximal end of the carpometacarpal bone*); extensor digitorum communis; flexor carpi ulnaris; flexor digitorum superficialis and flexor digitorum profundus.
- Muscles that control the fine movements of the wing tip. E.g. interosseous muscle, the adductor and abductor muscles of the digit.

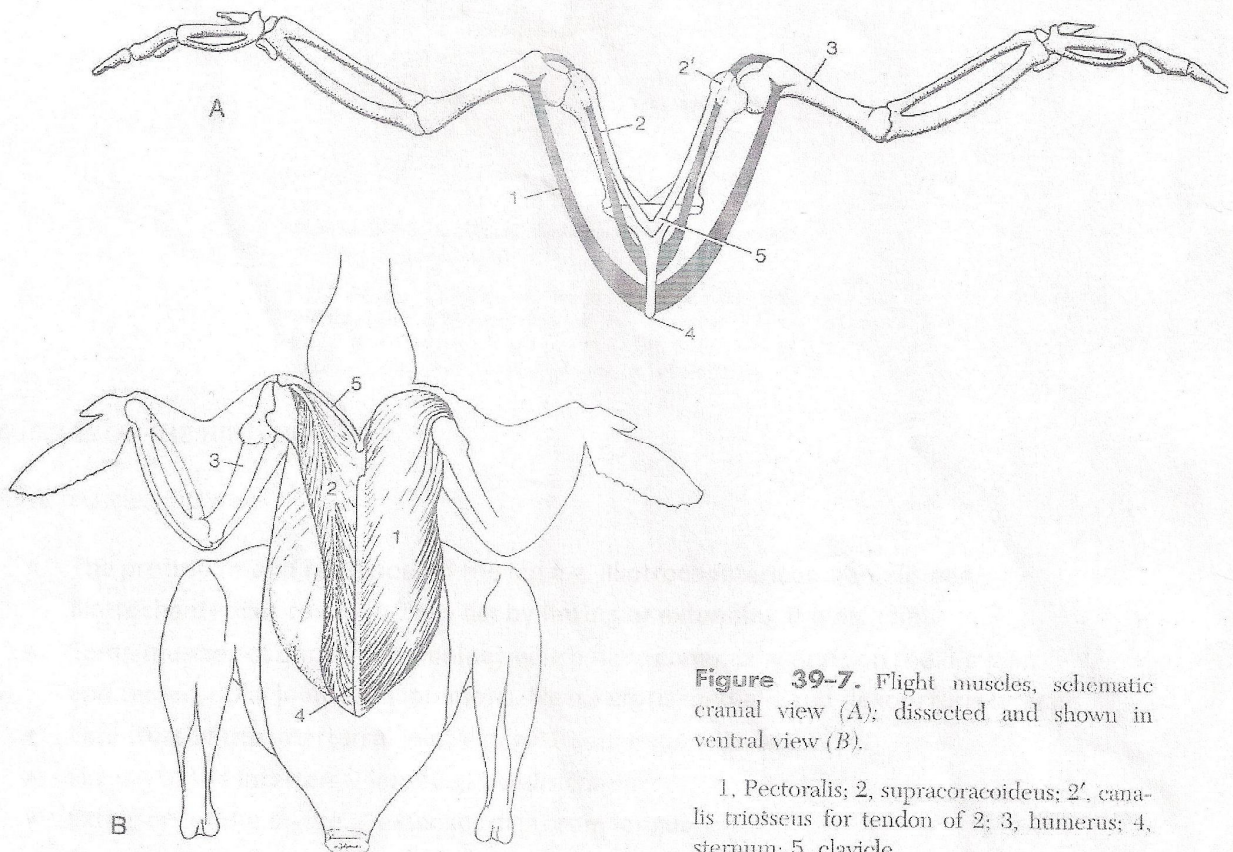


Figure 39-7. Flight muscles, schematic cranial view (A); dissected and shown in ventral view (B).

1, Pectoralis; 2, supracoracoideus; 2', canalis triosseus for tendon of 2; 3, humerus; 4, sternum; 5, clavicle.

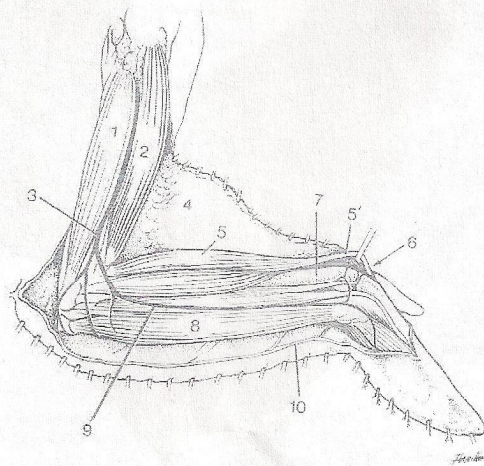
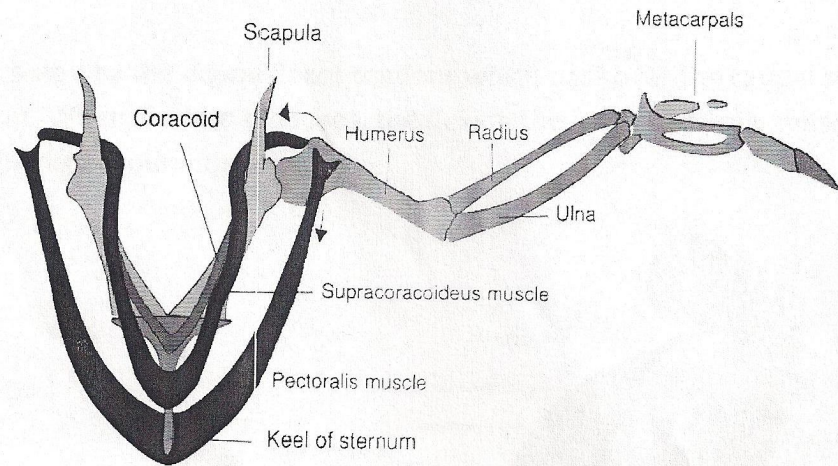


Figure 39-8. Superficial dissection of laterally extended left wing, ventral surface.

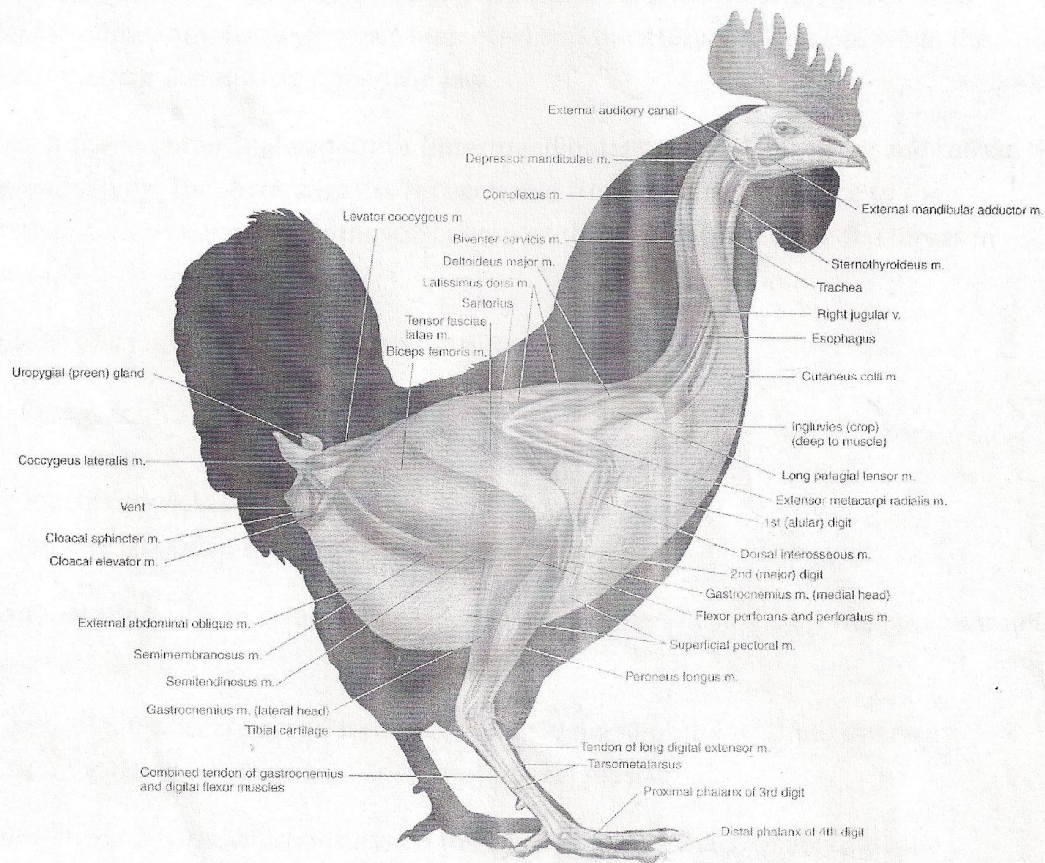
1, Triceps; 2, biceps; 3, brachial vein; 4, skin fold (propatagium); 5, extensor carpi radialis; 5', tendon of 5; 6, carpal joint; 7, subcutaneous part of radius; 8, flexor carpi ulnaris; 9, cutaneous ulnar (wing) vein; 10, reflected skin.

MUSCLES OF THE HIND LIMB

These muscles include

- The protractor and retractors of the leg e.g. iliopsoas cranialis and iliopsoas caudalis. They act by flexing or extending the hip joint.
- Some muscles of doubtful homology which have complex actions on the hip joint and femorotibial joint e.g. iliofemoralis. Flexor cruris medialis and flexor cruris lateralis
- Extensors of the intertarsal joint e.g. gastrocnemius muscle.
- Flexors of the intertarsal joint e.g. tibialis cranialis
- Extensors of the digit e.g. extensor digitorum longus

Perching is assisted by the digital flexor tendons which pass over the caudal surface of the intertarsal joint. When the bird crouches, the flexion the joints passively tenses the tendon and clamps the digit around the perch.



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PLATE 7.5 Superficial muscles of the rooster. Right lateral view, m = muscle, v = vein

RED AND WHITE MUSCLE

The red muscle fibres, RMF, contain relatively large amount of myoglobin which is responsible for its colour. Compared with the white muscles fibres(WMF), RMF tend to have other characteristics including relatively more mitochondria and a higher lipid globules and greater vascularity.

RMF uses fat rather than glycogen as a source of energy and this makes them efficient than the WMF. Because of these characteristics, RMF are better adapted for prolonged efforts while the WMF are for momentary efforts. Most avian muscles contain a mixture of RMF and WMF and the proportion depending on how prolonged the activities of the muscle.

In the pectoralis, the RMF predominates in flight birds while WMF predominates in the galliforms. The muscles of diving birds are deep red in colour indicating the presence of large amount of myoglobin for storing oxygen presumably for use during diving.

AVIAN DIGESTIVE SYSTEM

The avian digestive system comprises of:

- Oropharynx
- Esophagus

- Stomach
- Intestines
- Cloaca – also serves the urogenital system
- Others include the beak, liver and pancreas

OROPHARYNX

- From beak to esophagus – a combination of the oral cavity and pharynx
- No soft palate
- No obvious constriction separating the mouth from the pharynx
- Lips and teeth replaced by beaks and ventriculus
- Boundary: roof formed by the palate and floor by the tongue, mandible and laryngeal mound

PALATE

- Long median cleft (choana) links with nasal cavity
- Infundibular cleft, shorter and more caudal – common opening for Eustachian tubes
- Both clefts open together in the budgerigar
- Caudally directed mechanical papillae in oropharyngeal wall – scattered singly or arranged in transverse rows, aid to move the bolus to the esophagus
- Copious amounts of salivary glands opening in the oropharynx to moisten food

TONGUE

- Triangular, non-protusible
- Supported by delicate hyoid apparatus.
- The choana closes during swallowing

THE LARYNGEAL MOUND

- Caudal to base of tongue
- Presents a median slit – glottis not guarded by epiglottis
- A row of papillae delimits the boundary between the oropharynx and esophagus
- The larynx modifies the vocalization unlike in mammals but its not th actual source

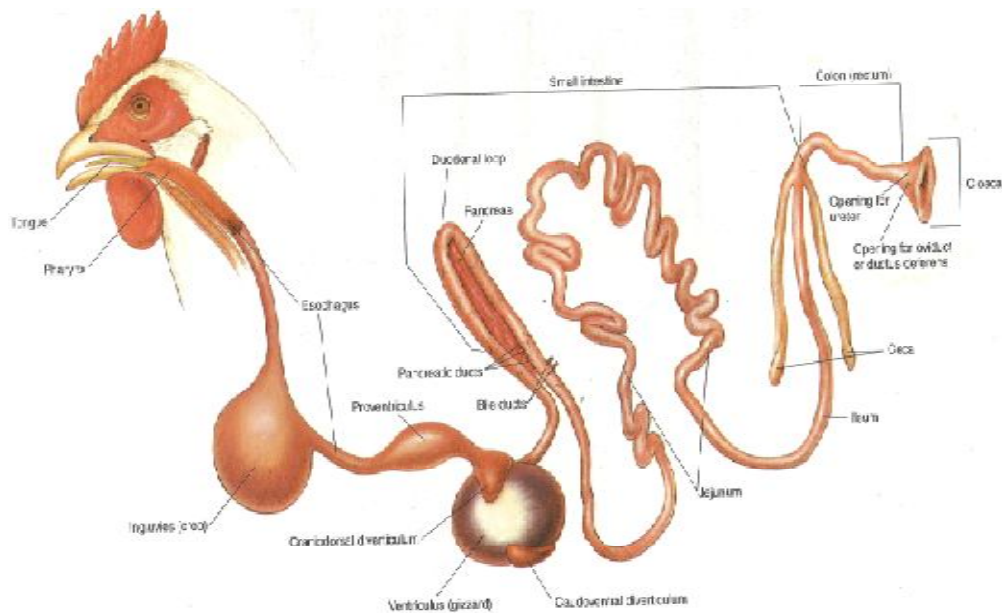


PLATE 7.9 Isolated gastrointestinal tract of the chicken.

ESOPHAGUS

- A muscular tube extending from the oropharynx to the stomach
- First lies between the trachea and the cervical muscles
- Soon deviates to the right throughout its entire course in the neck
- Ventral wall greatly expanded at the thoracic inlet forming the crop which bulges further to the right and lies against the breast muscles
- Both esophagus and crop are subcutaneous. Implication?
- Within the body cavity, it passes over the bifurcation of the trachea, below the ventral surface of the lungs, over the base of the heart and further continues as the proventriculus directly on the left of the median plane
- During brooding, the large symmetrical crop of both the male and female pigeons elaborate a crumbly material (crop milk) consisting of desquamated lipid-laden cells mixed with ingested food; regurgitated and fed to nestlings

STOMACH

- Division by a constriction:
 - Glandular proventriculus (true stomach)
 - Muscular ventriculus (gizzard)

PROVENTRICULUS

- Fusiform, about 4cm long
- Whitish mucosal columnar epithelial lining differentiates it from the more reddish lining of the esophagus

- Numerous papillae which pass the collecting duct from a thick bed of glands.
- Papillae can be mistaken for parasitic lesions
- Relations: ventrally with the left lobe of the liver

VENTRICULUS (GIZZARD)

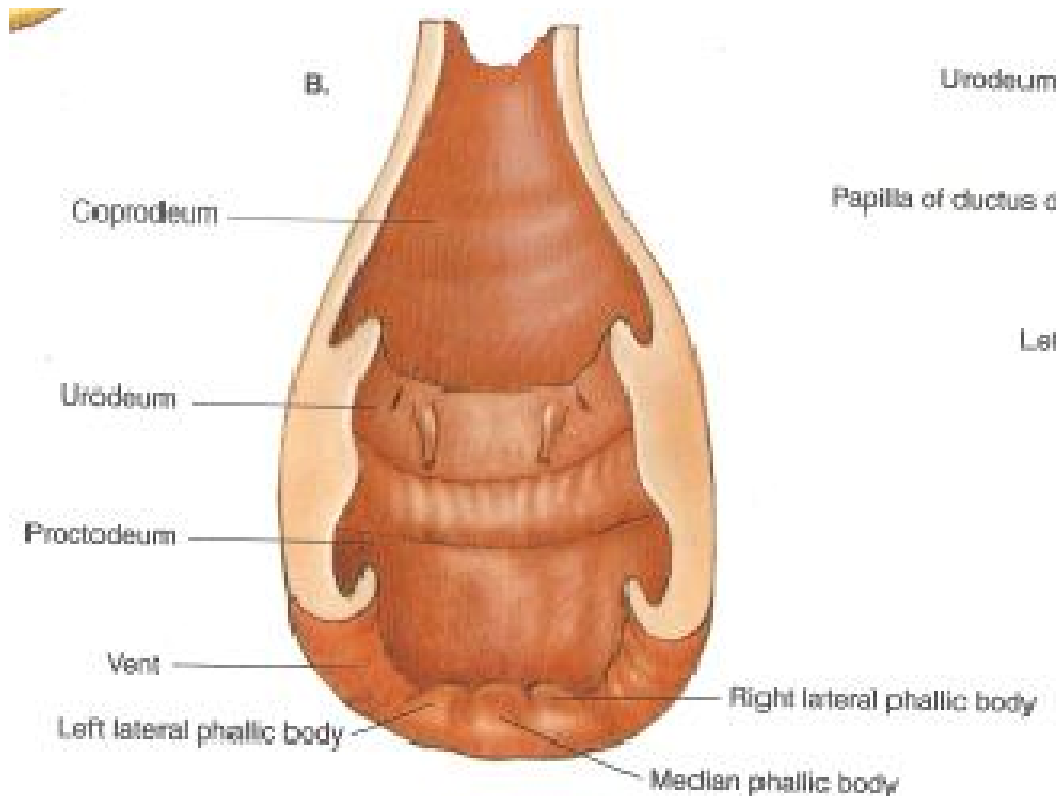
- Larger and more caudal than the proventriculus
- Lens-shaped with convex surfaces facing more or less to the right or left
- Interior is elongated and further enlarged by the cranial and caudal blind sacs
- Cranial blind sac connects with the proventriculus
- Cuticle of kaolin

INTESTINES

- Caudal part of the body cavity
- Duodenum, jejunum and ileum and a short colon that lies ventral to the synsacrum and opens to the cloaca
- Two caeca arise from the ileocolic junction and accompany the ileum in a retrograde fashion
- The duodenum secretes digestive enzymes and bicarbonate (to counter the acid from the proventriculus) from the pancreas and bile from the liver via the gall bladder. The digestive enzymes produced by the pancreas are primarily involved in protein digestion. The pancreas plays important roles in both the digestive and hormonal systems. It also secretes hormones into the blood system that are important in the regulation of blood sugar. Bile is a detergent that is important in the digestion of lipids and absorption of fat-soluble vitamins (vitamins A, D, E & K)
- Merkel's diverticulum: a finger-like projection (papillae) that marks the end of the jejunum and the start of the ileum
- Just prior to hatching, the yolk sac, which had been supplying nutrition during embryo development, is drawn into the navel cavity. The residual tiny sac is the Merkel's diverticulum. The yolk sac supplies feed and water to the newly hatched chick and is the reason that chicks can be shipped considerable distances (as in the postal services) without adverse effects

CLOACA

- Craniocaudally divided into 3 parts by 2 or more less annular folds:
 - Coprodeum
 - Urodeum
 - Proctodeum
- Serves as a common opening to the digestive and urogenital system with the colon, ureters, and deferent ducts (male) or left (oviduct) entering at different levels



COPRODEUM

- Most cranial division
- Ampuliform continuation of the colon
- Stores faeces
- Separated from the urodeum caudally by the distinct coprourodeal fold

URODEUM

- Caudal to the coprourodeal fold
- Indistinctly demarcated from the proctodeum by the uroproctodeal fold (shallow incomplete ventrally)
- Ureteric orifice (dorsolateral wall) above the papilla of the deferent duct (or slit-like opening of oviduct in female)
- Paraoccal vascular body; a caudal extension of the pudendal artery in the lateral wall of the urodeum

PROCTODEUM

- Short, most caudal of the segment
- Ends at the vent
- Cloacal bursa/bursa of Fabricius (on immunological organ similar to the thymus) opens on its dorsal wall
- Dorsal proctodeal gland caudal to the bursa

THE VENT

- Horizontal slit
- Ventral lip is of interest because it bears the copulatory organ in the male on its internal surface (non-protusible phallus) the analogue of the mammalian penis.

THE AVIAN RESPIRATORY SYSTEM

Consists of the

- Nostrils @ the base of the beak overhung by a horny flap
- Nasal cavity
- Larynx
- Trachea
- Syrinx
- Lungs
- Air sacs

THE NASAL CAVITY

- Divided by a median septum
- Communicates widely with the oropharynx through choana
- Laterally compressed and extend to the large orbits
- Rostral, middle and caudal conchae enclose recess that communicates with the nasal cavity

THE LARYNX

- Mound on the floor of the oropharynx
- Supported by the cricoids and arytenoids cartilage
- Glottis is formed by the arytenoids cartilage
- No epiglottis

THE TRACHEA

- Tightly stacked, complete and overlapping cartilaginous rings
- On the right side in the neck region
- Bifurcates into two primary bronchi dorsal to the base of the heart, which enters the ventral surface of the lungs after a short course

THE SYRINX

- Terminal part of the trachea and the beginning of the primary bronchi
- Responsible for voice production
- Tracheal cartilage of the syrinx are sturdy while the bronchial cartilages are lacking although a small vertical bar, pessulus, separates the bronchial openings
- The syrinx is the voice box. The chicken's voice is produced by air pressure on a sound valve and modified by muscle tension.
- Membranous lateral and medial walls of initial bronchial segments produce the sound when caused to flutter
- A small paired medial muscle, sternotrachealis, pulls the trachea to the syrinx, thus aids in vocalization

AIR SACS

- The air sacs are balloon-like structures at the 'ends' of the airway system
- Most birds have 9 air sacs:
 - 1 interclavicular air sac
 - 2 cervical air sacs
 - 2 cranial thoracic air sacs
 - 2 caudal thoracic air sacs
 - 2 abdominal air sacs

The air sacs act as 'bellows' to suck air in and blow it out and also to hold part of the total volume.