NIGERIAN VETERINARY JOURNAL
ISSN 0331-3026
Nig. Vet. J., March 2017 Vol 38 (1): 42-51.
ORIGINAL ARTICLE

Macro-anatomical Investigations on the Appendicular Skeleton of the Barn Owl (*Tyto alba*) Found in Nigeria

Usende, I. L.*; Oyelowo, F.; Abiyere, E.; Adikpe, A. and A. Ghaji

Faculty of Veterinary Medicinc, University of Abuja, Nigeria; *Corresponding author: Email: ifukibot.usende@uniabuja.edu.ng; Tel No:+234 8037386219

SUMMARY

Barn owls (*Tyto alba*) are crepuscular and nocturnal birds that hunts small vertebrates. They are popular for their roles in bio-controls as predators, being more effective than poison in keeping down the number of rodent pests. Gross anatomical description of the appendicular skeleton of the barn owls was undertaken to understand and document its normal features, assessing the structure-function paradigm. The present study was conducted on seven apparently healthy barn owls. The birds were euthanized and skeleton processed using cold water maceration method. Results showed bones of the forelimb consists of bones of the pectoral girdle including scapular, coracoids, clavicle, humerus, radius, ulna, ossa carpi, carpometacarpal and ossa digitorum manus (wing), while the hindlimb consists of the femur, patella, tibiotarsus, fibula, tarsometatarsus and ossa digitorum pedis. Two unique findings were consistent in all animals used: 1) A Y-shaped groove bearing a foramen at the cranial extremity of the coracoid; 2) A proximal and distal distinct foramina about mid-way of the proximal phalanx of the ossa digitorum manus. These foramina were found in both sexes. Literature and anatomical avian museum specimen search did not yield any information on these foramina on the coracoid and proximal phalanx of the forelimb of avian species. We ventured to name them proximal foramen of the coracoid and proximal phalanx digit majoris foramina respectively. In conclusion, the present study reported for the first time, the descriptive anatomy of the appendicular skeleton of the barn owl (*Tyto alba*), found in Nigeria. Our unique findings would be of benefit in understanding the adaptive features necessary for domestication of this bird and address its issue of going extinct.

Key words: *Tyto alba*, appendicular skeleton, foramina, domestication, Nigeria.

INTRODUCTION

Barn owls (*Tytoalba*) are crepuscular and nocturnal birds of prey that hunt small vertebrates. Barn owls display various adaptations to be effective under low light conditions. They are renowned for outstanding sound localization capabilities (Payne, 1971; Takahashi, 2010) and for silent flight due to a specific feather design (Bachmann *et al.*, 2007). Owls' feathers are generally larger than the average birds'

feathers, have fewer radiates, longer pennulum, and achieve smooth edges with different rachis structures (Bachmann *et al.*, 2007). The Barn Owl's flight is silent, both at frequencies audible to the human ear and ultrasonic levels (Taylor, 2004).

The unique feature of barn owl in terms of flight, feeding, hearing and preying on predators (bats, birds, lizards, rodents, amphibians and insects) and its importance to farmers being more effective than poison in keeping down rodent pests (Meyrom *et al.*, 2009) has propelled an increasing interest to establish more perfect and accurate anatomical facts about the skeleton of the bird. Here, we investigated and described in details the specific structures that constitute the appendicular skeleton of barn owl (*Tyto alba*).

MATERIALS AND METHODS

Seven (four females and three males) apparently healthy adult barn owls weighing 496-550g were used for this work. They were captured by hunters at the Faculty of Veterinary Medicine, University of Abuja, taken to the gross veterinary anatomy laboratory where they were identified by a zoologist and were immediately given lethal injection using Ketamine (100mg/kg) and xylazine (10mg/kg) combination using intraperitoneal route. The method used for processing the bones was according to the method of Tahon *et al.* (2003) with some modifications. Immediately after euthanasia, they were eviscerated and soaked in cold water solution containing soda (sodium bicarbonate) and Klin® detergent (Dimethylbenzasulfonate) for 20 days. The solution was changed every 24 hours throughout the period. The soft muscles and tissues were then easily separated from the bone using forceps, scapel blade and iron sponge leaving the joints intact. The bones were rinsed in a clean tap water and air dried under room temperature. Descriptive nomenclature used was according to Nomina Anatomica Avium (Baumel *et al.*, 1993).

RESULTS

Skeleton of the Forelimb

The skeleton of the forelimb of barn owl (*Tyto alba*) consisted of the scapular, coracoids, clavicle, humerus, radius and ulna, ossa carpi, carpometacarpal and ossa digitorum manus (Fig I-V).

Scapular

The scapular was a dorso-ventrally flattened bone and curved caudo-laterally to the vertebral column (Fig. IIA). Its cranial extremity was wider presenting three articulating facets. It articulated with the coracoids and clavicle cranially and laterally with the head of the humerus. The caudal extremity which was narrower ended as a pointed end.

Figure I: Skeleton of the forelimb of Barn owl (*Tytoalba*) found in Nigeria, West Africa

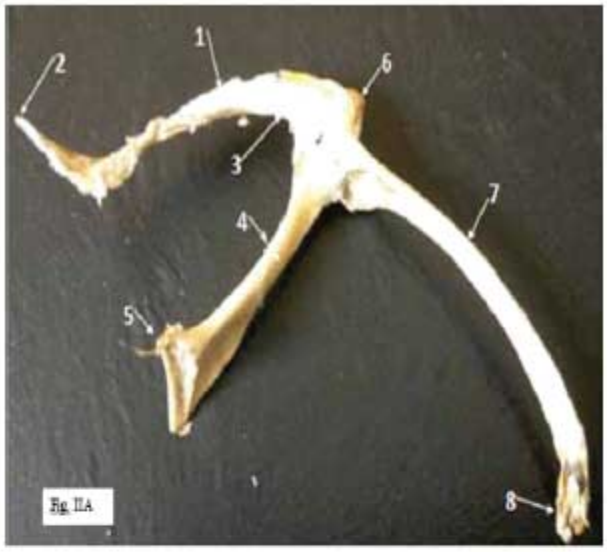
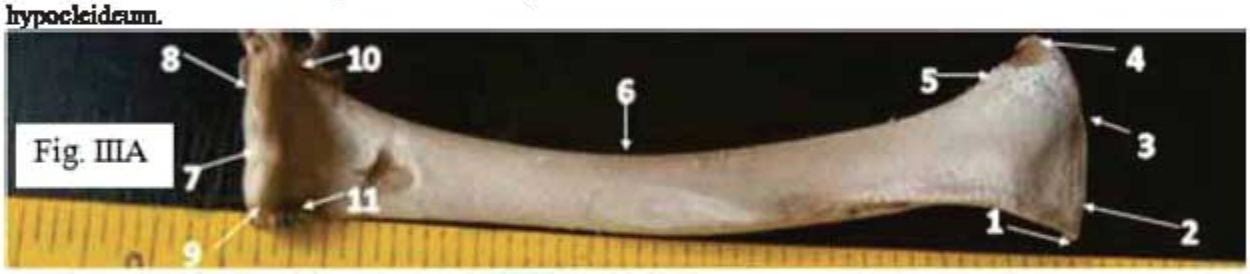


Figure IIA: Bones of the pectoral girdle of Barn owl (*Tytoalba*). Note: 1-scapula, 2-extremitas caudalis scapulae, 3- extremitascranialis scapulae, 4-coracoideum, 5-extremitas sternaliscoracoidei, 6-extremitas omaliscoracoidei, 7- clavicle, 8-hypocleideum.

Figure IIB: Oscoracoideus showing the proximal foramen of the coracoid



Coracoid

The coracoid bone has a dorso-ventrally flattened shaft (Fig. IIA). Its cranial extremity was branched in a Y-shaped groove in ventral view. The groove bears a foramen (*proximal foramen of the coracoid*) (Fig. IIB). The scapular articulated with the thin short process of the Y-shaped groove. The clavicle articulated with both processes of the groove. The long process ended as a rounded nail head.

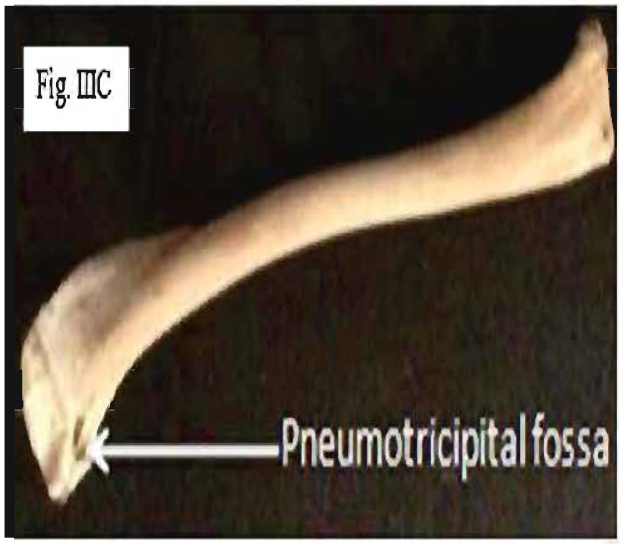
The caudal extremity of the coracoids presented a triangulo-spatular shaped end which articulated with the sternum.

Clavicle

This was a flat bone that tapered at the distal end where it fused with its second at the sternum to form a single bone called furcula (wishbone) (Fig. IIA). The fusion of the tapered end was continuous as hypocleideum (Fig. IIA). The cranial extremity articulated with the scapula and coracoids (Fig. IIA) forming the triosseous canal.

Humerus

The *Tylo alba* humerus was a long bone (Fig.IIIA, IIIB and IIIC). The medial surface presented a foramen about the middle of the distal half of the shaft (Fig. IIIB). It bears a flattened proximal extremity with a rounded head, the caput humeri (Fig. IIIA) and a dorsal tubercle close to the head (Fig. IIIA). The dorsal tubercle was continuous as a deltoid crest which was formed as a lateral



Figures IIIA, B and C: The humerus of Barn owl (*Tyto alba*). Note: 1-tuberculum ventra, 2-incisura capitishumeri, 3-caput humeri, 4-tuberculum dorsal, 5-crista deltopectoralis,6-corpus humerus,7-incisura intercondylaris,8-condylus dorsalishumeri, 9-condylus ventralishumeri, 10-epicondoylus ventralis, 11-epicondoylus dorsalis

tubercular crest. The humerus also bears a larger ventral tubercle (Fig. IIIA). Just below it, was a pneumotricipital fossa bearing a large foramen pneumaticum (Fig. IIIC).

The distal extremity of the humerus bears a large and small ulna and radial condyles respectively (Fig. IIIA). The ulna condyle articulated with ulna bone, while the radial condyle articulated with ulna and radial bones. This made up the elbow joint. Both condyles were separated by *incisura intercondylaris* (Fig. IIIA).

The caudal surface bears a *fossa olecrani* at its distal end which was wide and shallow for articulation with the olecranon of the ulna bone.

Ulna

The ulna was the thickest bone of the forearm and of almost equal length with the radius except at the projection to form the olecranon (Fig. IVA) making it a little longer in *Tylo alba*. It presented a proximal extremity, a cylindrical shaft and a distal extremity (Fig. IVA). The proximal extremity bears a 3-sided olecranon (Fig. IVA) and two articular facets for articulation with the preceding bone. The lateral surface bears a foramen about its proximal half (Fig. IVB). The slightly curved cylindrical shaft was fused with the radius bearing a wide interosseous space between them (Fig. IVA). The distal extremity articulated with the ulna carpel through a small condyle.

Radius

The radius was a thin long rod-like bone that bears *caput radii* at its proximal extremity (Fig. IVA). The slightly curved shaft was curved away from the ulna bone. The distal extremity presented a radio carpal articular facet for articulation with the radial carpal bone. It also presented the interosseous ligament which separated the radius and ulna.

Ossa carpi

Tylo alba ossa carpi was made up of the ulna and radial carpal bones (Fig. V). The *os carpi ulnare* was U-shaped and located at the caudal aspect of the carpal region. Proximally, it articulated with the ulna bone and distally with the carpometacarpal bone

(Fig. V). The triangular- shaped *oscarpi radiale* was located at the cranial aspect of the carpal region (Fig. V). Proximally, it articulated with the distal end of the radius and ulna and distally with the carpometacarpus.

Carpometacarpal bones

The carpometacarpal bones of *Tyto alba* was formed by the fusion of the distal row of carpal bones and proximal end of metacarpus (Fig. V). The proximal extremity of this compound bone presented the carpal trochlea and cranial and caudal carpal *fossae* for articulation with the proximal carpal bones. At the palmar surface of the extremity was the projected *processus pisiformis* (Fig. V).

Three carpometacarpal bones projected distally (Fig. V). The major carpometacarpus was the largest and thickest of the three (Fig. V). The alular carpometacarpus which bear the extensor process, projected as a small bone from the proximal radial end of the major carpometacarpus. The minor carpometacarpus was a thin distinctly curved bone forming a wide *interosseous* space as it fused with the major carpometacarpus (Fig. V).

Ossa digitorummanus

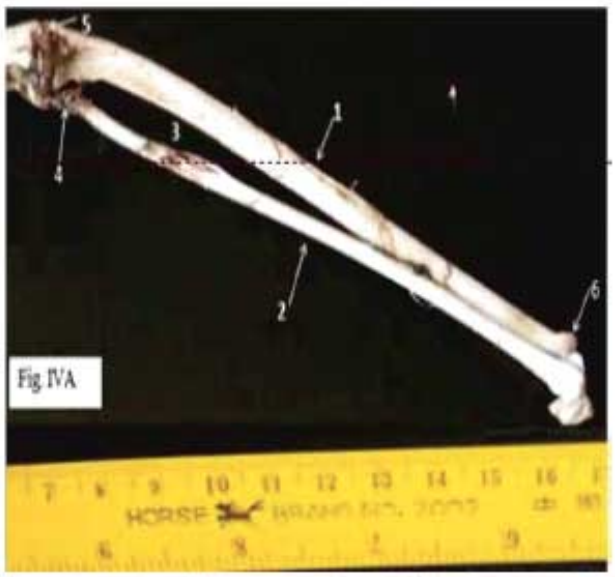
The wing comprised of three digits that articulated with the preceding carpometacarpus (Fig. V). The second digit, *phalanx digit alulae* consist of one long proximal phalanx which articulated with the alular carpometacarpus (Fig. V). Phalanx digit majoris was the longest amongst the digits (Fig. V). It consists of two phalanges. The proximal phalanx was thicker with a thick cranial border bearing a sharp curved edge and presenting two distinct foramina (proximal and distal) (*proximal phalanx digit majoris foramina)* about its middle (Fig. V). The distal phalanx was less thick without the curved edge (Fig. V).

Skeleton of the Pelvic Limb

The skeleton of the pelvic limb of the barn owl consisted of the femur, patella, tibiotarsus, fibula, tarsometatarsus and ossa digitorum pedis (Fig VI-X).

Femur

The femur was a long cylindrical bone bearing two extremities and a middle shaft (Fig. VII). The bone was fairly straight but wider distally than the proximal end. The proximal extremity bear a hemispherical *caput femoris* and a *trochanter femoris* (Fig. VII). The *facies articularis antitrochanterica* connected them together (Fig. VII). The *caput femoris* bear a depression, the *fovea ligamentum capitis* for attachment of round ligaments. It also



Figures IVA and IVB: Radius and Ulna of Barn owl (*Tytoalba*). Note 1-corpus ulnae, 2-corpus radii, 3-spatium interosi, 4-caput radii, 5-olecranon, 6-trochlea capitis

articulated with the *acetabuli* of the hip bone. The *trochanter femoris* was located on the cranial border of the femur. It bear the *crista trochanteric* (Fig. VII). The shaft presented four surfaces. It bears a foramen about its middle in between the inter-muscular lines (Fig. VII).

The distal extremity presented a trochlea bearing the lateral and medial condyles separated by *sulcus intercondylaris* (Fig. VII). The lateral condyle was bigger than the medial. Each bears an epicondyle of which the lateral was more prominent (Fig. VII). The medial condyle formed a ridge proximally on the caudal surface of the femur towards the *femoris trochanter* to form the *crista supracondyloid medialis* which passed through the *linea intermuscularis caudalis*. The medial condyle also presented a depression for muscular attachment.

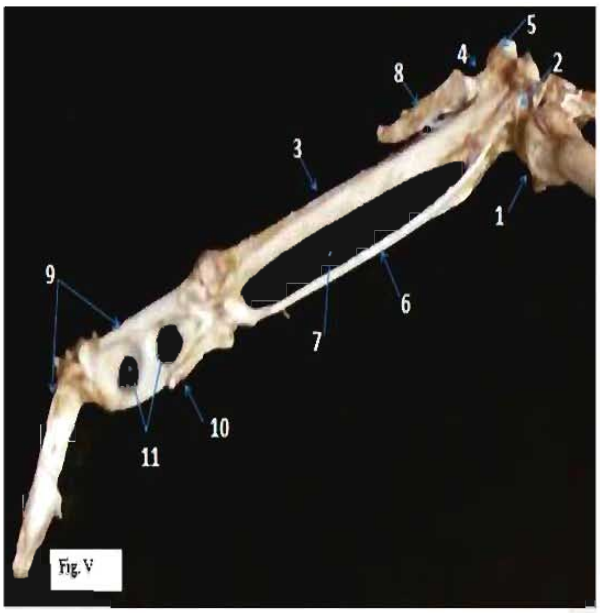


Figure V: Skeleton of the ossa carpi, carpometacarpal and ossadigitorummanus of Barn owl (*Tytoalba*) found in Nigeria, West Africa. Note: 1- os carpi radiale,2- processus pisiformis,3- osmetacarpale majus,4- osmetacarpalealulare, 5- proc. extensorius, 6- osmetacarpale minus, 7- spatiumintermetacarpal, 8- phalanx digiti alulae, 9- phalanx digitimajoris, 10- phalanx digitiminoris, 11- proximal phalanx digit majoris foramina

Patella

This was a sessamoid bone that was small presenting an oval shape. This fit into the *sulcus intercondylaris*.

Tibiotarsus

In *Tyto alba,* the tibiotarsus was a thick long bone (longer than the femur) and comprised of the fusion of the tibia bone with the proximal row of the tarsal bones (Fig. VIII). It bears both proximal and distal extremities. The proximal extremity bears both medial and lateral condyles. The tibia bears an articular facet for fibula at point distal to the lateral condyles towards the lateral surface. The proximal extremity also bears a *crista cnemialiscranialis* and a tuberous *crista cnemialislateralis* connected by shallow *sulcus intercnemialis* (Fig.VIII).

The distal extremity presented medial and lateral condyles bearing a medial and lateral epicondyle respectively. More so, the caudal surface of the extremity carried the *trochlea cartilaginis*.

Fibula

This bone was a thin bone taking 2/3 of the tibiotarsus length, and tapering to the end (Fig. VIII). It was a slightly curved bone with a flattened lateromedially wide head (Fig. VIII). It bears a proximal interosseous space just below the articulation between the two bones. The fusion was in a latero-caudal fashion. It also fused at the proximal 1/3 of the tibiotarsus forming an interosseous space about its middle (Fig. VIII).

Tarsometatarsus

This was made up of fused distal tarsal bone and metatarsal bones (Fig. IX). These metatarsal bones are the II, III, and IV. Metatarsal I was a rudimentary small bone bearing a ligamentous attachment with tarsometatarsus. The proximal extremity bears a medial and lateral *cotyla* for

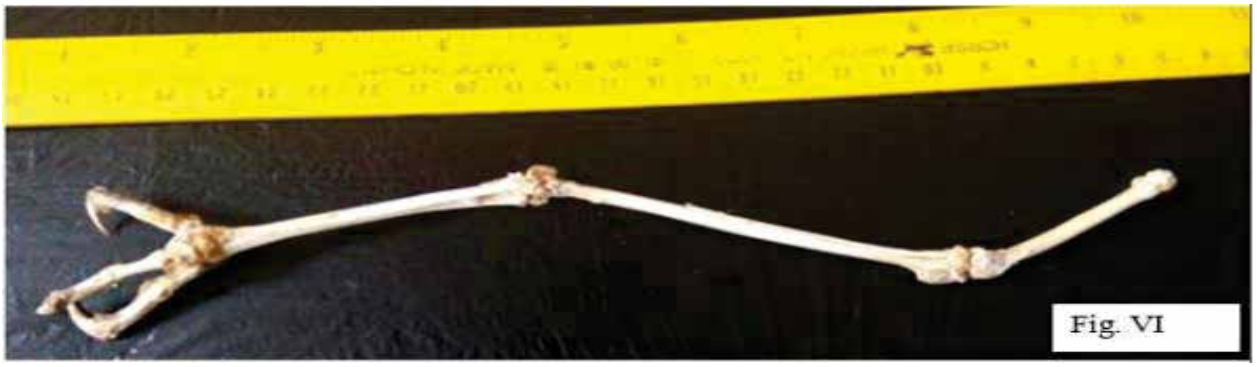


Figure VI: Skeleton of the hindlimb of Barn owl (*Tytoalba*)

articulation with the preceding bone. An eminence *intercotylaris* separates both condyles (Fig IX). The proximal extremity also bears three crests on its planter surface namely: *crista medialis hypotarsi, crista lateralis hypotarsi* and *crista intermedius hypotarsi*. The dorsal surface bears a groove, the *sulcus extensorius* at the middles of the proximal 1/2 of the shaft. After which the foramina *vasculare proximale* was located. The planter surface also presented another groove, *sulcus flexorius* which was bounded by *crista plantares medialis* and *lateralis*. The distal extremity bears three *articular trochlea matatasi* II, III and IV.

Figure VII: The femur of Barn owl (*Tytoalba*) found in Nigeria, West Africa. Note: 1-caput femoris, 1a-fovea ligamentumcapitis, 2-facies articularisantitrochanterica, 3-trochanter femoris, 4-crista trochanteris, 5-sulcus patellaris, 6-condylus lateralis, 7- condylusmedialis, 8-trochlea fibularis, 9-linea aspera,**10-**nutrient foramen

Ossa DigitorumPedis

This was made up of 4 digits (Fig. X). The first being *os digitipedis I* was medioplanterly directed and consisted of two phalanges. The second being the *os digitipedis II* was cranially directed and consisted of 3 phalanges. The *os digitipedis III* and *os digitipedis IV* consisted of four and five phalanges respectively. Each phalanx presented a proximal concave articular facets and a distal trochlea with the exception of the distal phalanges which bear a keratinized claw at its distal end.

DISCUSSION

The skeletal framework of birds contributes to the adaptation to their habitats (Ali *et al.,* 2016) hence their functional morphology. The skeleton of the forelimb of the Barn owl (*Tytoalba)* as seen in this work is similar to other avian species (Dyce *et al.,* 2002; Rezk, 2015; Ali *et al.,* 2016). The results of this showed that the scapular is dorsoventrally flattened and curved caudo-laterally to the vertebral column. This finding contrast earlier reports of Dyce *et al. (*2002) and Tahon *et al.,*(2003) in chicken and Rezk, (2015) in cattle egret.

Concerning the coracoids, the results of this study showed that its cranial extremity presents a Y-shaped groove at the ventral view. This has not been reported in other species. The *triosseal* canal reported by Rezk (2015) in cattle egret which acts as a brace against the vigorous up and down

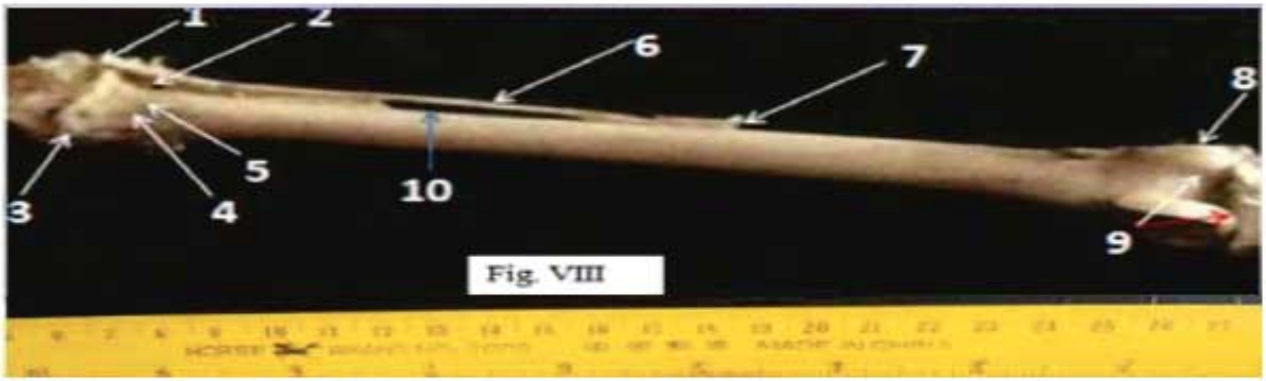


Figure VIII: The tibia and fibula of the Barn owl (*Tytoalba*) found in Nigeria, West Africa. Note: 1-caput fibulae, 2-foramen interosii, 3-crista cnemialiscranialis, 4-sulcus intercnamialis, 5-crista cnemialialateralis, 6- fibula, 7-spina fibulae, 8-epicondylus,9-trochlea cartilaginistibialis

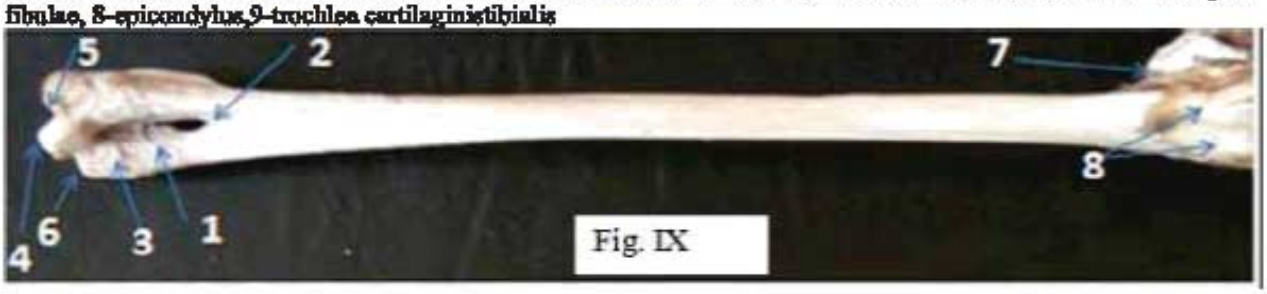


Figure IX: The tarsometatarsal of Barn owl (*Tytoalba*) found in Nigeria, West Africa. Note: 1-foramina vascularesproximale, 2-sulcus extensorius, 3-fossa infracotylarisdorsalis, 4- eminence intercotylaris, 5-cotyla medialis, 6-cotyla lateralis,7-os metatarsale, 8-incisurae intertrochleare

strokes of the wing and passage of the tendon of flight muscles (Dyce *et al.*, 2002) was present in the barn owl at the point of articulation of the scapular and coracoids. During flight, the coracoids abduct the wings from the sternum.

Dyce *et al.* (2002) presented the avian humerus to be a stout bone but we show it to be a long bone in barn owl but light weighted. This helps them to withstand the force of flight but minimize metabolic cost of flight (Ali *et al.*, 2016). The findings of this study showed the ulna and radius to be of almost equal length excepting the projection of the olecranon. This corroborates the works of Nickel *et al.* (1977) in domestic bird and Rezk (2015) in cattle egret. However, this finding is contrary to the reports of Tully *et al.* (2003); Akers and Denbow (2008) and Tahon *et al.* (2003) who observed in their

various studies that the ulna is larger and longer than the radius in chicken. The possible reasons for the differences could be attributed to species differences or accuracy

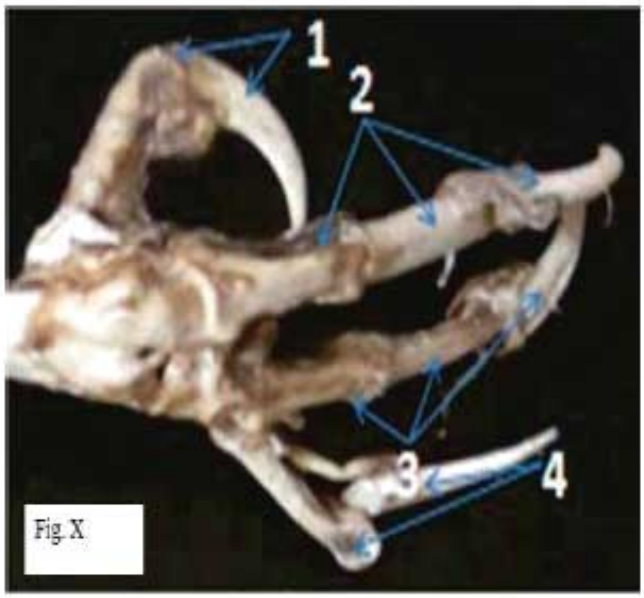


Figure X: The osadigitorumpedis of Barn owl (*Tyto alba*) found in Nigeria, West Africa 1-os digitipedisi, 2-osdigitipedis ii, 3- osdigitipedis iii, 4 -osdigitipedis iv

of the observer. We however suggest that the reason for this height difference may be due to the presence of olecranon. Similarly, the observed presence of olecranon

corroborates the recent report of Rezk (2015) who reported presence of olecranon for muscle attachment. Barnett and Lewis (1958) earlier reported the absence of olecranon in birds. The ulna shaft of the cattle egret presented small raised projections indicative of the origin of the secondary follicles of the wing feather (Rezk 2015) contrary to our observation in barn owl with smooth ulna shaft.

The findings concerning the *ossa carpi*in this study are similar to that of chicken, duck and pigeon (Ali *et al.,* 2016), cattle egret (Rezk 2015) and chicken (Tahon *et al.,* 2003). The radial carpal is rectangular in cattle egret (Rezk 2015) but triangular in barn owl. The results of the study showed that in barn owl, the carpometacarpals are as a result of fusion of the dorsal row of carpals and proximal end of the metacarpals. This observation is in corroboration with the findings of Akers and Denbow (2008) and Tahon *et al.* (2003) in chickens and Rezk (2015) in cattle egret.

Concerning the *ossa digitorum manus* of *Tyto alba*, the findings reported in this study are similar to the recent report of Rezk (2015) in cattle egret and chicken, duck and pigeon (Ali *et al.,* 2016). Interestingly, the results of this study showed that the proximal phalanx presented two distinct foramina (proximal and distal). To the best of our knowledge, this is the first report on these foramina in avian species.

The pattern of the skeleton of the pelvic limb of the *Tytoalba* followed the pattern reported by Dyce *et al.* (2002) in avian. This present report of the femur to be a long and cylindrical bone is similar to recent findings of Rezk (2015) in cattle egret. There is presence of *femoral trochanter* in *Tytoalba* contrary to the works of Ametov (1971) who observed the absence of femoral trochanter in *sittaeuropaea. Passer domesticus and parus major*.

Concerning the tibiotarsal, this present work showed that it is longer than the femur, similar to earlier report of Nickel *et al.* (1977) in chicken and recently Rezk (2015) in cattle egret. However, the results of this study showed no muscular lines and a shallow intercnemial sulcus contrary to the wider intercnemial sulcus reported in the cattle egret (Rezk 2015).

This present findings on the tarsometatarsus and pedal digits are in accordance to reports of Tully *et al.* (2003), Akers and Denbow (2008) and Tahon *et al.* (2013) in chicken and Rezk (2015) in cattle egret.

CONCLUSION

The present study reported for the first time, the descriptive anatomy of the appendicular skeleton of the barn owl (*Tytoalba*) found in Nigeria, West Africa. Importantly, the results of this study showed that the cranial extremity of the coracoids bone of *Tylo alba* is branched in a Y-shaped groove at the ventral view and this groove bears a foramen (*proximal foramen of the coracoid*) and that the proximal phalanx of the forelimb is thicker with a thick cranial border bearing a sharp curve edge and presenting two distinct foramina(*proximal phalanx digit majoris foramina)* about its middle. In the like of the fact that this Y-shape groove bearing a foramen and the proximal phanlanx presenting two distinct foramina have not been described before in literature and our search on museum specimens showed they are absent in other avian species, we ventured to name the former *proximal foramen of the coracoid* (of Oyelowo) and the later, *proximal phalanx digit majoris foramina* (of Usende). These are unique findings and will be of benefit in understanding some of the adaptive features of this bird, which may be necessary for their domestication, thereby addressing the issue of their going extinct.

ACKNOWLEDGEMENT

The authors acknowledge the leading contribution and technical support of Mr.

Tags Zachariya of the Department of Veterinary Anatomy and Dr. Alani of the Department of Veterinary Pathology, University of Abuja.

REFERENCES

AKERS R.M, and DENBOW D.M (2008)*Anatomy and Physiology of Domestic Animals*. Blackwell, Ames, Iowa.

ALI N.S, NASR M.A, and ERESHA A.M (2016) Macro and Micro Architecture of the Wing in three different Avian Habitats. *Alexandria Journal of Veterinary Sciences* 48(2):134-142

AMETOV Z, (1971) Peculiarities of the structure and function of the joints and tendon ligament apparatus of the pelvic bones and extremities of saltigrade birds. *Doclady Akad. Nauk SSSR* 200(2): 492-495.

BACHMANN T, KLAN S, BAUMGARTNER W, KLAAS M, SCHRODER W, and WAGNER H (2007) Morphometric characterisation of wing feathers of the barn owl *Tyto albapratincola* and the pigeon *Columba livia. Frontiers in Zoology,* 4: 23.

BARNETT C.H, and LEWIS O.J (1958)The evolution of some traction epiphyses in birds and mammals. *J. Anat.* (92): 593-601.

BAUMEL J. J, KING A. S, BREAZILE J.E, EVANS H. E, and VANDEN BERGE J. C, (1993) *NominaAnatomicaAvium*. Handbook of Avian Anatomy. 2nd ed., Ch. 4.Nuttall Ornithological Club, Cambridge, Massachusetts.

DYCE K.M, SACK W.O, and WENSING C.J.G (2002) Text book of Veterinary Anatomy. Saunders, Philadelphia.

MEYROM K, MOTROY, LESHEM Y, AVIEL S, IZHAKI I,ARGYLE F, and CHARTER M, (2009) Nest-box use by the Barn owl (*Tyto alba*) in a biological pest control program in the BeitShe'an Valley, Israel. *Ardea97 (4): 463–467*

NICKEL R, SCHUMMER A, and SEIFERLE E (1977) Anatomy of Domestic Birds. Verlag Paul Parey, Berlin and Hamburg.

Payne R.S (1971) Acoustic location of prey by Barn owls (*Tytoalba*). *The Journal of Experimental Biology*, 54(3): 535–573.

REZK H.M (2015) Anatomical Investigation on the appendicular skeleton of the cattle egret (*Bubulcus ibis*). *J.Exp. Clin. Anat*, 14:5-12

TAHON R.R, RAGAB S.A, ABDEL HAMID M.A, and REZK H.M,(2013)Some anatomical studies on the skeleton of chickens (doctoral thesis). Anatomy and Embryology, Faculty of Veterinary Medicine, Cairo University.

TAKAHASHI T, (2010) How the owl tracks its prey—II. *Journal of Experimental Biology*, 213(Pt 20): 3399–3408.

TAYLOR I, (2004) Barn Owls: Predator-prey Relationships and Conservation. University Press, Cambridge.

TULLY T.N, LAWTON M.P.C, and DORRESTEIN G.M. (2003). Avian medicine. Collection Forum 1999; 13(2): 51-62.