Global Veterinaria 16 (4): 349-354, 2016
ISSN 1992-6197

DOI: 10.5829/idosi.gv.2016.16.04.10353

Osteomorphology of the Appendicular Skeleton of Four-Toed African Hedgehogs (*Atelerix albiventris*) Part (1): Thoracic Limb

Ibrahim Alhaji Girgiri, Ahmed Yahaya, Baba Gana Gambo, Yagana Bukar Majama and Abdulrasheed Sule

Department of Veterinary Anatomy, University of Maiduguri, Maiduguri, Nigeria

Abstract: A total of five (5) adult hedgehogs of different sexes with average body weight of 224.20±22.14 g were used to study the morphology and metrical dimensions of the bones of the forelimbs. The bone were processed by hot water maceration and ten (10) parameters were generated. The osteomorphological features of all the bones were observed and metrical dimensions were recorded. Prominent acromion, metacromion (*processus hammatus*) and suprametacromion processes (*processus suprahammatus*) were observed. There was presence of clavicle. *Tuberositas deltoidea* and *crista tuberculi majoris* were not prominent in this study. A prominent and distinct foramen in the *sulcus intertubercularis* and a large *foramen supratrochleare* were observed in the humerus. The radius and ulna bones were observed to be distinct, with only soft fibrous connection in the mid-shaft. There were seven *ossa carpi* arranged in two rows with the proximal row consist of three os carpi, and four os carpi in the distal row. The *Os carpi centrale* was absent. The manus is complete with five digits and five *ossa metacarpalia* interposed between the phalanges distally and seven *ossa carpi* proximally. There were seven *ossa carpi*. The radial and intermediate *os carpi* were fused. The manus is complete with five digits.

Key words: Four-Toed African Hedgehog · Macro-Anatomy · Thoracic Limb · Bones

INTRODUCTION

The four-toed African hedgehog (*Atelerix albiventris*) belongs to the order insectivore, family *Erinaceidae*, genus *Atelerix* [1]. They are terrestrial, placental mammals and are nocturnally active. IUCN red data list categorize hedgehog as "least-concern" [2]. A number of studies on the macro-anatomy of skeletal system of wild small mammal have been reported in literatures. This include; the mole rat [3], Wombat [4], the Rabbit [5], the Porcupine [6] and the African giant rat [7]. Ozkan [8] studied the skeletal system of European hedgehogs (*Erinaceus europaeus*). Earlier we studied the metrical dimensions of foramen magnum [9], the skull and mandible [10] of the African hedgehogs. However, basic data on the morphometry of the forelimb of this species is scarcely reported. This study is aimed at documenting a basic research data on the osteo-morphometrics of the forelimbs of hedgehog species found in Maiduguri.

MATERIALS AND METHODS

The hedgehogs (n=5) of different sexes were hand-caught using trap nets as described by Mouhoub –sayah *et al*. [11]. The study conformed to guidelines and institutional ethics of faculty of veterinary medicine (University of Maiduguri) Nigeria. The bones were processed by hot water maceration as described by Onwuama *et al*. [12] and Boyle [13]. The weights of the complete thoracic limb of each side and individual bones were determined using Metler sensitive weighing balance (model AE 163) with precision of 0.01gram (g). Metrical dimensions of the bones were measured using a digital Vernier caliper with a precision of 0.001mm and the values were recorded to the nearest 0.01millimeter (mm). Photographs of individual bone were taken in different planes, using a Panasonic digital camera (DMC-FH5) 16 mega pixel. The morphological features of the bones were grossly observed and documented. *Nomina Anatomicao*

Corresponding Author: Ibrahim Alhaji, Girgiri, Department of Veterinary Anatomy,University of Maiduguri, Maiduguri, Nigeria. Tel: +234-70-35108133.

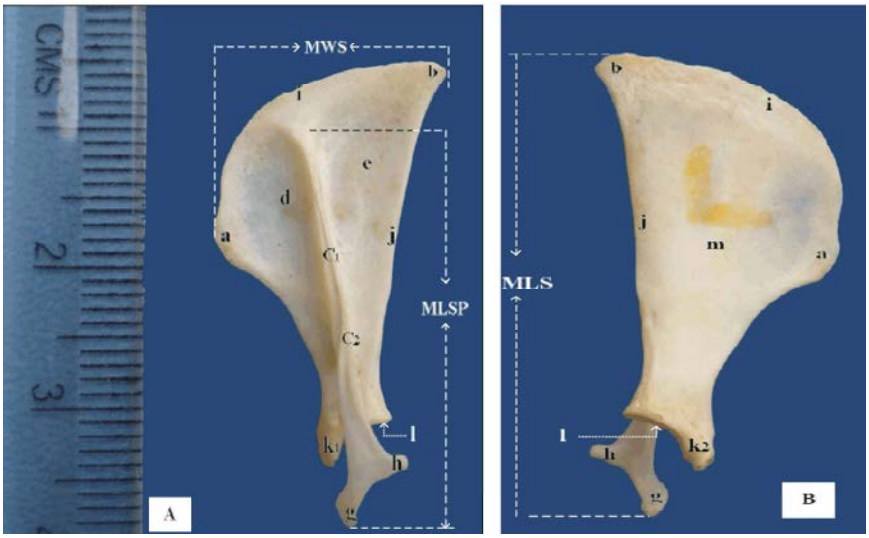

Fig. 1: Figure: 1-lateral (A), medial (B) view of scapula.a: angulus cranialis, b: angulus caudalis, c1: spina scapulae, c2: tuber spinae scapulae, d: fossa supraspinata, e: fossa infraspinata, g: processus hammatus, h: processus suprahamatus, i: margo dorsalis, j: margo caudalis, k1: tuberculum supraglenoidale, k2: processus coracoideus, l: cavitas glenoidalis

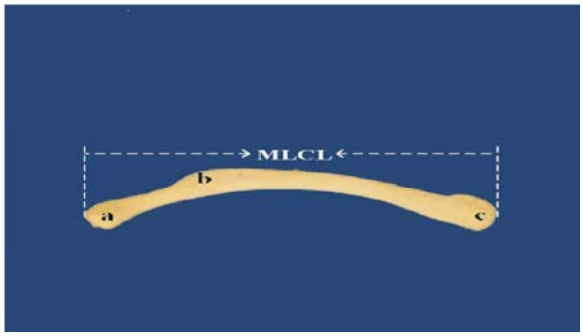

Fig. 2: The clavicle; a: sterna end, b: body of the clavicle, c: acromial end

Veterinaria (NAV) 2012 was adopted for the anatomical terms. The definition and description of the osteometrical indices are presented below;

- Maximum length of the scapula **(MLS)**: Distance measured from the tip of the dorsal border (*margo dorsalis*) to the distal end of the supraglenoid tubercle (*angulus distalis*) of the scapula (Figure 1).
- Maximum width of the scapula (**MWS**): Perpendicular distance measured between two vertically parallel lines drawn at the point of the cranial (*angulus cranialis*) and caudal angle (*angulus caudalis*) of the scapula (Figure 1).
- Maximum length of the scapula spine (**MLSP)**: Distance measured from the proximal end of the scapula spine just below the cranial border of the scapula (*margo cranialis*) to the distal end of the Hammate process (*processus hammatus*) (Figure 1A).
- Maximum length of the clavicle (**MLCL)**: Distance measured from the sterna end of the clavicle to the acromial end (Figure 2).
- Maximum length of the humerus (**MLH)**: Distance measured from the proximal end of the major tubercle (*tuberculum majus*) to the distal end of the humeral condyle (*condylus humeri*) (Figure 3).
- Maximum width of the humerus (**MWH**): Distance measured between the medial surface (*facies medialis*), and the lateral surface (*facies lateralis*) of the humerus (Figure 3).
- The maximum length of the ulna (**MLU)**: Distance measured from the olecranon tuber (*tuber olecrani*), to the distal end of the ulna (*processus styloidus lateralis*) (Figure 4).
- The maximum with of the ulna (**MWU**): Distance measured from the medial surface (*facies medialis*) to the lateral surface (*facies lateralis*) at the mid-shaft of the ulna (Figure 4).
- Maximum length of the radius (**MLR**): Distance measured from the proximal end (*extamita cranialis radii*) to the distal end of the radius (*processus styloidus medialis*) (Figure 4).
- Maximum width of the radius (**MWR)**: Distance measured from the medial surface (*facies madialis*) to the lateral surface (*facies lateralis*) at the mid shaft of the radius (Figure 4).

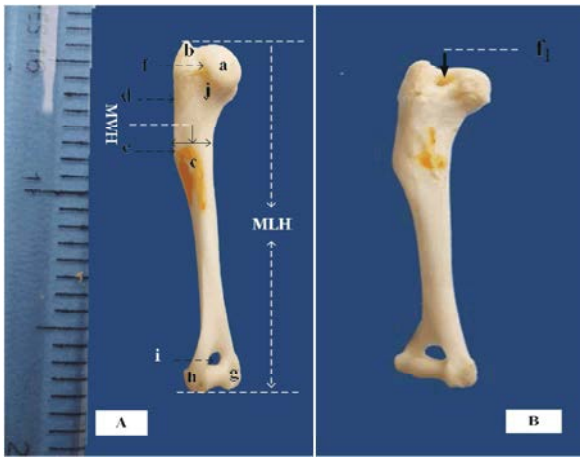

Fig. 3: Caudal view of the left humerus (A), cranial view of the right humerus (B) a: carput humeri, b: tuberculum majus, c: corpus humeri, d: crista tuberculi majoris, e: tuberositas deltoidea, f: sulcus intertubercularis, f1: foramen, g: epicondylus medialis, h: epicondylus lateralis, i: foramem supracondylare, j: collum humeri.

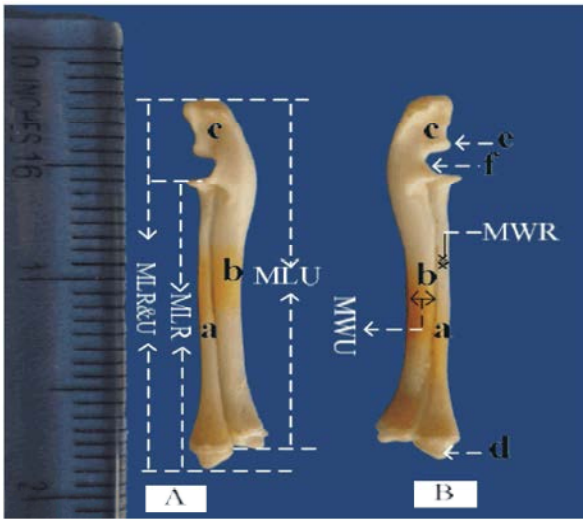

Fig. 4: The medial surface of the right radius and ulna (A), medial surface of left radius and ulna (B). a: corpus radii, b: corpus ulnae, c: olecranon, d: processus styloideus radialis, e: processus anconeus, f: inscisura trochlearis.

The data obtained were presented as mean ± standard deviation (SD) and were analyzed using statistical package data GraphPad instat R version 3.05.

RESULTS

Morphological Findings

Scapula: The scapula presented a roughly triangular outline. The *margo cranialis* was concave slanting towards the *fossa supraspinata*, displacing the *margo cranialis* slightly proximal to the mid scapula. The *margo cranialis* was concave, forming *incisura scapulae* distally. *Margo caudalis* was slightly concave and thick distally, and contributes to the formation of the *collum scapulae*. The *spina scapulae* aroused just below the *margo dorsalis* extending distally (Figure 1).

The proximal half of the *spina scapulae* terminated at the level of the *collum scapulae*. The distal half extend freely beyond the *collum scapulae,* were it flattened out and gave two (2) projections; The dorsocaudal projection (*processus suprahammatus)* and the cranioventral projection (*processus hammatus),*which projected below the *cavitas glenoidale*. The *facies lataralis* of the distal half of the *spina scapulae* was divided by a groove that faint out distally. Proximal to the *processus suprahammatus* was the tuber *spina scapulae*. The *spina scapulae* curved slightly caudal (Figure 1).

The *angulus ventralis* formed the *cavitas glenoidale* with the *tuberculum supraglenoidale* cranially and medially the *processus coracoideus*. The *fossa subscapularis* was not prominent. There were two (2) nutrient foramina; the first foramen was situated at the lateral side of the *collum scapulea* distal to the end of the proximal spine and the other at the caudal border just proximal to the *collum scapulea*.

Clavicle: The clavicle was curved caudally, and presents a flat acromial end and a bulbulous sternal end. Cranially there was a slightly raised area proximal to the sternal end. The flat acromial end was curved laterally and had a smooth medial surface and a rough lateral surface (Figure 2).

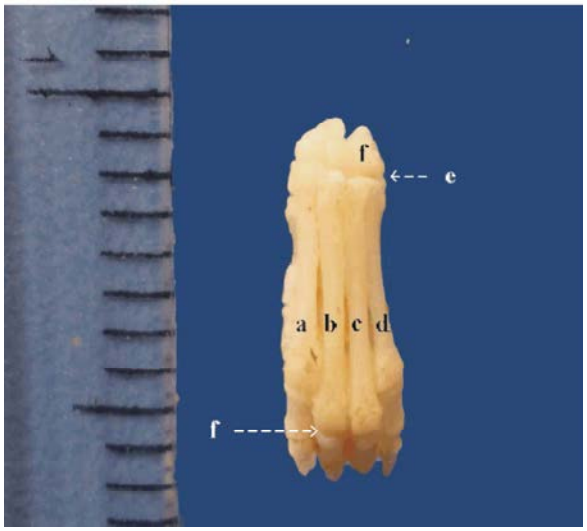

Fig. 5: The manus (dorsal view). a: osmetacarpale II, b: osmetacarpale III, c: osmetacarpale IV, d: osmetacarpale V, e: articulatio carpometacarpea, f: os carpi ulnaris, f1: articulatio metacarpophalangus.

Table 1: Average body weights and metrical dimensions of the bones of the thoracic limb

Parameters (g) (n=5)	Right (mean± SD)	Left (mean± SD)	Overall (mean± SD)
ABW	-	-	224.2±22.14
MWtS	0.16±0.03	0.16±0.03	0.16±0.03
MLS	29.43±1.50	29.41±1.74	29.42±1.62
MWS	15.81±4.52	15.87±4.78	15.84±4.65
MLSP	25.99±1.26	25.99±1.26	25.99±1.26
MWtCL	0.02±1.81	0.02±1.81	0.02±1.81
MLCL	16.93±0.76	16.92±0.67	16.93±0.72
MWtH	0.28±0.05	0.28±0.05	0.28±0.05
MLH	31.16±0.80	31.12±0.87	31.14±0.84
MWH	4.49±0.27	4.61±0.27	4.55±0.27
MWtU	0.16±0.02	0.16±0.02	0.16±0.02
MLU	35.85±1.52	35.80±1.51	35.83±1.52
MWU	2.20±0.26	2.21±0.27	2.21±0.27
MWtR	0.09±0.02	0.09±0.02	0.09±0.02
MLR	28.74±1.09	28.35±1.27	28.55±1.18
MWR	1.87±0.39	1.91±0.24	1.89±0.32

ABW- average body weight, MWtS- maximum weight of scapula, MLS- maximum length of scapula, MWS-Maximum width of scapula, MWtCL- maximum weight of clavicle, MLCL- maximum length of clavicle, MWtH- maximum weight of humerus, MLH- maximum length of humerus, MWH-Maximum width of humerus, MWtU- maximum weight of ulna, MLU- maximum length of ulna, MWU-Maximum width of ulna, MWtR- maximum weight of radius, MLR- maximum length of radius, MWTOR-Maximum width of radius

Humerus: The humerus presents two (2) extremities; the *extremitas proximalis* was thicker and presented a prominent *caput humeri*, *tuberculum major* and *tuberculum minor* separated by *sulcus intertuberculari*. A noticeable foramen was observed in the *sulcus intertuberculari* cranially. The neck was only prominent from the caudal surface. The *tuberositas deltoideus* was not prominent. The *sulcus musculi brachialis* was prominent and ended distally into the *fossa radialis* cranially. The *extramitas distalis* had the *condylus medialis, condylus lateralis* and *olecranon fossa*. *Foramen supratrochleare* was wide almost obliterated the radial and *fossa olecranon* (Figure 3).

Radius and Ulna: The radius and ulna were separate bones, which were only united by soft fibrous tissue at the mid shaft of the bones. Both bones slightly curved medially. The radius was short and wide distally, and placed craniomedial to the ulna. It had an articular surface proximally (*Circumferential articularis*) that articulate with the condyles of the humerus and end distally as a medial *processus styloideus*. The ulna was located caudolateral to the radius. The olecranon projects proximocranial beyond the radius, while the medial surface was smooth and concave obliquely. The cranial border showed a projection, the *prosessus anconeus* which was located at the dorsal limit of the *incisura trochlearis,* and ends distally in *processus styloideus lateralis*. The *styloideus medialis* was larger than *styloideus lateralis* (Figure 4).

Ossa Carpi: There were seven (7) *ossis carpi* arranged in two (2) rows. The proximal row consisted of three (3) *ossi carpi*; *os carpi radiale* and *os carpi intermeduim* were fussed forming the *os carpi intermedioradiale* medially, *os carpi ulnare* laterally and *os carpi accessorium* behind the *os carpi ulnare*. The distal row consisted of four (4) carpal bones; from medial to lateral were *os carp*i I, *os carpi* II, *os carpi* III and fused, *os carpi* IV and *os carpi* V.

Ossa Metacarpalia: The manus was complete with five (5) ossa *metacarpalia*, interposed between the *ossa carpi* and the phalanges (Figure 5). Their comparative length in mediolateral sequence were I<V<IV<II<III.

Digits (*Ossa Digitorum Manus*): There were five (5) digits, with three (3) phalanges in each digit except the second digit which had only two phalanges. Their comparative length were I<V<II<IV<III.

The values obtained for the osteometrical analysis were presented in Table 1.

DISCUSSION

In the present study, the acromion and metacromion processes were prominent. These are peculiar features of the carnivores [14, 15] which were similarly reported in the African giant rat (AGR) [16, 7], and other rodentia species [17]. Equally, *processussuprahammatus* which are uniquely found in the scapula of cat [18] and rabbits [5] were accordingly observed in this study.

The clavicle present in hedgehogs, was common to the rodentia family, AGR [7, 16], guinea pig [19], rabbits [20] and the mole rat [3]. It is one of the characteristics of burrowing animals. Its absences or rudimentary nature was attributed to the position of the thoracic limb, which was situated under the trunk [21].

A prominent *tuberositasdeltoidea* and *crista tuberculimajoris* were earlier observed in the muridae family [22] and the wombat [4]. However, these structures were less noticeable in our findings. A prominent and consistent foramen distinct at the cranial surface of the *caput humeri* at the *sulcus intertubercularis* was observed. The sulcus transmits the tendon of insertion of the bicep brachii muscle [23].

The presence of large foramen *supratrochle* are consistent in all the humerus was observed, similar to the findings in the cats [14] AGR [7, 16], wombat [4] and the rabbit [5]. These Foramenwas however not present in the *E. europaeus* [8].

The radius and ulna were distinct bones connected only by strip of soft fibrous tissue. This was similar to the findingsin European hedgehogs Ozkan [8], AGR [7] and the dog [15], but disagreed with Olawoye *et al.* [13] which reported the fusion of the two bones, except at the point of the *spatiuminterosseumantebrachiiproximale* et distal.

There are seven (7) *ossa carpi* arranged in two (2) rows. The proximal row consisted of three (3) os carpi and four (4) oscarpi in the distal row. The *ossa carpi* centrale was however absent. The same pattern was observed in *E. europaeus* by Ozkan [8]. However in *E. concolor* species of hedgehogs, Hashemi *et al*. [24] reported the presences of four (4) *ossa carpi* in the proximal row, whereas Olawoye *et al*. [13] reported the presence of nine (9) ossa carpi in AGR consisting of four (4) in the proximal row, and five (5) in the distal row. The manus is complete with five (5) digits and five (5) *ossametacarpalia* interposed between the phalanges distally and seven *ossa carpi* proximally. Similarly this has also been reported in *E. europaeus* by Ozkan [8].

REFERENCES

1. Reeve, N., 1994. Hedgehogs. London, United Kingdom: T. & A.D. Poyser limited.
2. Hutterer, R., 2005. Order Erinaccomorpha. Mammal Species of the world. A taxonomic and geographic Reference. Wilson D.E, Reeder, D.M editor; Baltimore, Maryland: John Hopkins University Press.
3. Ozkan, Z.E., 2007. Macro-anatomical investigations on the forelimb skeleton of mole-rat (Spalex lencodonnordmann). Vet. Arhiv., 77(3): 281-289.
4. Saber, A.S., 2013. Some Morphological Observation on the Thoracic Limb bones of the Hairy-Nosed Wombat (Lasiorhinus latiformis, Owen). J. Vet. Anat., 6(2): 9-109.
5. Ajayi, I.E., J.C. Shawulu, T.S. Zachariya, S. Ahmed and B.M.J. Adah, 2012. Osteomorphometry of the Bones of the Thigh, Crus, and Foot in the New Zealand White Rabbit (Oryctolagus cuniculus). Italian J Anat Embryol, 717(3): 125-133.
6. Yilmaz, S., Z.E. Ozkan and D. Ozdemir, 1998. Macro-anatomical Investigations on the Skeleton of Porcupines (Hystrix cristata). I. Ossa membri thoracici. Trop. J. Vet. Anim. Sci., 22: 389-392.
7. Olude, M.A., J.O. Olopade, A.K. Adebayo and A.M. Oluwaseu, 2010. Macro-anatomical Investigation of the Skeleton of the African giant Rats (Cricetomys gambianus water house 1840) II: Forelimb. Eur. J. Anat., 14: 19-23.
8. Ozkan, Z.E., 2004. Macro-anatomical investigations on the Hedgehog Skeleton (Erinaceus europaeus) I. Ossa membri thoracici. Turk J Vet Anim Sci., 28: 271-274.
9. Girgiri, I., J.O. Olopade and A. Yahaya, 2015a. Morphometrics of foramen magnum in African four-toed hedgehog (Atelerix albiventris). Folia Morphol., 74(2): 188-191.
10. Girgiri, I.A. Yahaya, B.G. Gambo and J.O. Olopade, 2015b. An osteometrical studies of the skull and mandible of African four-toed hedgehogs (Atelerix albiventris). Journal of Zoology and Bioscience Research, 2: 1-8.
11. Mouhoub-sayah, C., J.P. Robin, A. Malan, P. Pevet and M. Saboureau, 2008. Pattern of body temperature change in Algerian hedgehogs (Atelerix algerius) during autumn and winter. In: Lovegroove, B.G.M.

ed. Hypometabolism in animals: hibernation, topor and cryobiology. Interpack books, Pietermaritzburg, pp: 307-316.
12. Onwuama, K.T., S.O. Salami, M. Ali and J.O. Nzalak, 2012. Effect of different Methods of Bone preparation on the Skeleton of the African Giant Pouched Rat (Cricetomys gambianus). Int. J. Morphol., 30(2): 425-427.
13. Boyle, C., 2010. Maceration and Preparation of Mammal Skeletons for Long Term Curation. Archaeology and forensic laboratory. University of Indianapolis.
14. Sisson, S. and J.D. Grossman, 1975. The anatomy of the domestic animals, (vol.1), edited by R. Getty, W.S. Sunders co.
15. Dyce, K.M., W.O. Sack and C.S.G. Wensing, 2010. Veterinary Anatomy 4th ed. W.B. Saunders Company, Philadelphia.
16. Olawoye, S.S., O.K. Tobechukwu, M.M. Sunday, I. Jibril and O.S. Adeniyi, 2011. Morphological Studies of the Appendicular Skeleton of the African giant Pouched Rat (Cricetomys gambianus) Part (1) Pectoral Limb. J. Vet. Med. Anim. Health, 3(7): 82-87.
17. Hebel, R. and M. Stromberg, 1976. Anatomy of the laboratory rat. Williams and Wikens company, Baltimore, MD. pp: 106-132.
18. AL-Hussaini, A.H. and E.S. DEMIAN, 1964. Practical animal biology, vol. II, Systematic zoology, 2nd ed. Dar Al-Maaref, Cairo, Egypt.
19. Wagner, J.E. and P.J. Manning, 1976. The biology of the Guinea pig. Academic Press, New York, San Francisco, London, pp: 10-44.
20. Ucer, Y., M.M. Őcal and M. Haziroglu, 1985. Makro-anatomisch EUntersuchungen Ûber die Clavicula des einhemischen Hundes, der einheimischen Katze und des Neuzelandshasen. J, FAC Vet Med Univ Ankara, 32: 42-52.
21. Greene, C.E., 1968. The anatomy of the rat, Transactions of the American Philosophical Society. New Series vol. 27. Hafner Publishing Company, New York, London.
22. Saunders, J.T. and S.M. Manton, 1969. A manual of practical vertebrate morphology. Clarendon Press, Oxford, 4: 208-286.
23. Pasquini, C., T. Spurgeon, and S. Pasquini, 1999. Anatomy of Domestic Animals: Systemic and Regional approach. 9th ed. SUSDZ Publishing, pp: 77.
24. Hashemi, M.S. Jaradi, M. Hadian, B. Pourreza and M. Behfar, 2009. Radiological Investigation of the Hedgehog (Erinaceus concolor). Appendicular Skeleton. J. Zoo Wildlife Med., 40(1): 1-7.