

Macroanatomy of the Skeletal System of *Acomys nesiot*es Bate, 1903 (Rodentia: Mammalia)

Macroanatomía del Sistema Esquelético de *Acomys nesiot*es Bate, 1903 (Rodentia: Mammalia)

Seda Kiralp Akyuz¹ & Hatice Mutlu Eyison²

KIRALP AKYUZ, S. & MUTLU EYISON, H. Macroanatomy of the skeletal system of *Acomys nesiot*es Bate, 1903 (Rodentia: Mammalia). *Int. J. Morphol.*, 44(4):1247-1256, 2026.

SUMMARY: This study aims to describe comprehensively, for the first time, the macro-anatomical structure of the skeletal system of *Acomys nesiot*es, an endemic rodent species of Cyprus Island. A total of 105 specimens obtained from both wild-collected and laboratory-born individuals were examined. The bones of the skull, limbs, vertebral column, and other skeletal elements were analysed morphometrically, drawn, and photographed. The findings indicate that the skeletal structure of *A. nesiot*es is closely associated with locomotor adaptations, taxonomic distinctiveness, and ecological specialization. Notably, features observed in the scapula, humerus, femur, and cranial morphology suggest adaptations for agile locomotion such as climbing and quick movement. Furthermore, distinctive cranial and mandibular structures offer valuable clues for species identification and feeding behavior. The results provide a significant reference not only for systematic biology but also for paleontological and functional morphological studies.

KEY WORDS: *Acomys nesiot*es; Macro-anatomy; Skeletal system; Morphometry; Rodents.

INTRODUCTION

Due to the spiny nature of its dorsal hairs, the genus *Acomys* has attracted considerable attention. It exhibits a wide geographical distribution, including Crete, Cyprus, Anatolia, southern Iran, Palestine, the Arabian Peninsula, northwestern India, and Africa. The number of recognised species within this genus has changed substantially over time (Barome *et al.*, 2001; Steppan *et al.*, 2005; Frynta *et al.*, 2010; Fabre *et al.*, 2012; Renaud *et al.*, 2020) and this process of taxonomic revision is ongoing. According to the IUCN Red List of Threatened Species (Version 2022-1), 21 distinct *Acomys* species are currently identified worldwide (*A. airensis*, *A. cahirinus*, *A. cilicicus*, *A. cineraceus*, *A. dimidiatus*, *A. ignitus*, *A. johannis*, *A. kempi*, *A. minous*, *A. mullah*, *A. nesiot*es, *A. percivali*, *A. russatus*, *A. seurati*, *A. spinosissimus*, *A. wilsoni*, *A. louisae*, *A. subspinosus*, *A. ngurui*, *A. selousi*, *A. muzei*).

While numerous taxonomic studies have been conducted on this genus, *Acomys* has also garnered significant scientific interest in recent years in relation to diabetes (Pictet *et al.*, 1967; Creutzfeldt *et al.*, 1970; Shafrir *et al.*, 2006), physiology (Haim & Borut, 1981), biology (Haughton *et al.*, 2016) and behaviour (Fricker *et al.*, 2021).

Furthermore, due to its possession of a menstrual cycle similar to that of humans (Bellofiore *et al.*, 2017), the genus has become a valuable model in reproductive studies. In 2012, the discovery of its capacity for scar-free tissue regeneration (Seifert *et al.*, 2012) further established *Acomys* as a promising model organism in regenerative medicine, despite not being a traditional laboratory rodent.

In 1903, Bate described *Acomys nesiot*es as a new species based on rodent specimens collected from Cyprus, which exhibited morphological differences from previously recorded species. Bate primarily used osteological characteristics, particularly cranial and dental morphology, to define this taxon and emphasised its endemic status to Cyprus (Bate, 1903). The island's insular nature, restricted habitat range, and geological isolation have likely contributed to the evolutionary divergence of *A. nesiot*es. Subsequent paleozoological and zooarchaeological excavations have revealed *Acomys* fossils from the Late Holocene in Cyprus, supporting the species' long-term presence on the island (Grubb *et al.*, 1999; Gippoliti & Amori, 2002; Matthews *et al.*, 2007). Recent genetic and phylogenetic studies further

¹ Girne American University, Faculty of Health Sciences, Mersin 10, Türkiye.

² Department of Biology, Faculty of Science, Ankara University, Ankara, Türkiye.

confirm that *A. nesiotes* forms a distinct genetic lineage, differentiating it from other *Acomys* species in the Eastern Mediterranean (Macholán *et al.*, 1995; Zima *et al.*, 1999).

Within the order Rodentia, the macro-anatomy of skeletal elements has been extensively used in taxonomic and paleontological studies of various genera such as *Rattus* (Greene, 1968), *Mus* (Cook, 1965), *Hystrix* (Yılmaz *et al.*, 1999, 1998), *Sciurus* (Özdemir & Atalar, 2003), *Chinchilla* (Çevik-Demirkan *et al.*, 2007), and *Spalax* (Özkan, 2002). However, macro-anatomical studies of the genus *Acomys* have been limited mostly to the skull and baculum (Spitzenberger, 1977, 1978; Niethammer, 1978; Kivanç *et al.*, 1997), and no comprehensive examination of other skeletal structures with taxonomic significance has been conducted. Therefore, the macro-anatomy of the skeletal system of *A. nesiotes*, endemic to Cyprus, remains insufficiently documented in the scientific literature. The present study aims to address this gap and contribute new findings to the existing knowledge.

MATERIAL AND METHOD

In this study, a total of 105 specimens obtained between 2007 and 2011 were used. These comprised 11 individuals found dead and collected in the field, together with laboratory-born offspring of three live individuals captured in the field and brought to the laboratory. Because some bones were lost during the cleaning process, anatomical examinations were conducted on the best-preserved available specimens; consequently, the sample size varied among skeletal elements. The minimum sample size for any skeletal element was 16. Taxidermized skins, cranial and postcranial skeletal elements, phallic structures, and field and laboratory observation notes were utilised in the analyses.

The cranial and postcranial bones obtained from deceased individuals were cleaned of soft tissues using

the maceration technique described by Tasbas (1965). After drying, the bones were subjected to morphometric analyses, drawn under a binocular microscope, and photographed using a stereomicroscope. To prevent the loss of small bones and to visualise the integrity of the skeletal system, Selby's bone staining method (Selby, 1987) was applied.

Phallus structures were prepared according to Lidicker's methodology (Lidicker Jr., 1968). Following the drawings of their shapes, the bacula were isolated, and the necessary morphometric measurements were taken.

Several measurements of skeletal elements were performed, as detailed below and illustrated in Figure 1:

Atlas

1. Height of foramen vertebrale: the maximum vertical length of the vertebral foramen.
2. Dorsoventral length: the maximum vertical distance between the dorsal and ventral arches.

Scapula

3. Maximum length: distance between the superior and inferior limbs of the scapula.
4. Maximum width: maximum perpendicular distance between the most lateral points of the margo caudalis and margo cranialis.
5. Acromion width: the maximum vertical length of the acromion process.

Humerus

6. Craniocaudal transition length: shortest perpendicular distance between the distal point of the deltoid crest and the medial edge of the humerus.
7. Humerus length: distance between the proximal and distal ends.

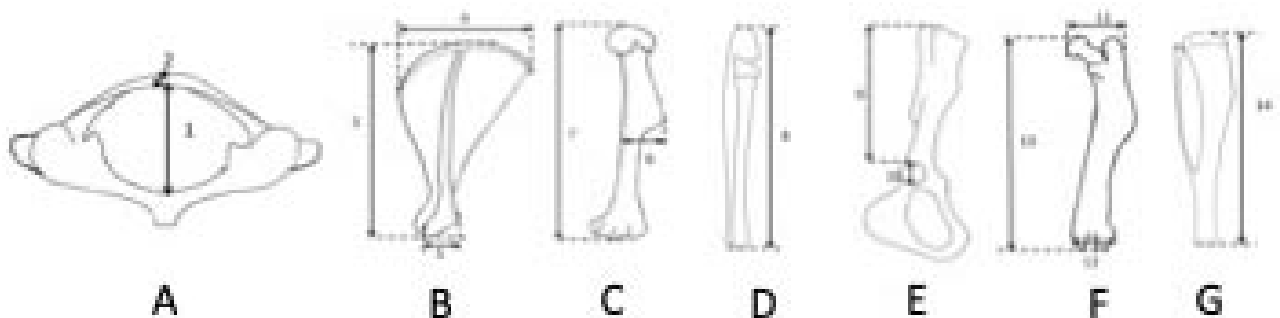


Fig. 1 Measurements taken from the atlas (A), scapula (B), humerus (C), ulna (D), coxae (E), femur (F), and tibia (G). (1. Height of foramen vertebrale; 2. Dorsoventral length; 3. Maximum length of scapula; 4. Maximum width of scapula; 5. Width of the acromion process; 6. Craniocaudal transition length of humerus; 7. Length of humerus; 8. Length of ulna; 9. Length of ilium; 10. Diameter of acetabulum; 11. Superior articular width; 12. Condylar width; 13. Length of femur; 14. Length of tibia).

Ulna

8. Ulna length: distance from the top of the tuber olecrani to the trochlea radii.

Coxae

9. Ilium length: shortest distance between the highest point of the ilium and the starting point of the acetabulum.
10. Acetabulum diameter: approximate diameter of the acetabulum.

Femur

11. Superior articular width: distance between the caput ossis femoris and the trochanter major.
12. Condylar width: distance between the outermost points of the condylus lateralis and condylus medialis.
13. Femur length: distance between the proximal and distal ends.

Tibia

14. Tibia length: distance between the proximal and distal ends of the tibia.

RESULTS AND DISCUSSION

The locomotor system in animals evolves in accordance with their lifestyle, habitat adaptations, and feeding strategies. Consequently, significant variations exist among species in skeletal structures.

Bones and muscles are the fundamental components of the locomotor system. Variations in muscle attachment patterns to bones and in bone morphology are crucial factors that enable diverse locomotor abilities across species. Modifications within the appendicular skeleton play a crucial role in facilitating behaviours such as climbing, jumping, and running. Considerable interspecific differences exist in both the number and shape of bones, making skeletal morphology a valuable tool for determining taxonomic affiliation and inferring ecological and behavioral adaptations.

Among skeletal elements, the skull (ossa cranii) is most frequently utilized in taxonomic classification and species differentiation. However, in modern systematics, bones of both the forelimbs and hindlimbs are increasingly incorporated into taxonomic and comparative anatomical studies. In paleontological research, skeletal remains serve as crucial evidence for understanding the taxonomy and evolutionary history of extinct taxa from various geological periods. Besides cranial elements, long bones

such as the femur, humerus, scapula, and coxae are commonly examined in fossil studies. The size and shape of these bones allow for comparisons with extant relatives, providing insights into body structure, weight, and locomotor patterns. Such interpretations depend on a thorough understanding of the skeletal and locomotor systems of living species, underscoring the importance of contemporary anatomical research alongside fossil data.

Although various studies have investigated the skeletal systems of several Rodentia genera, the macro-anatomical structure of the skeletal system of the genus *Acomys*, and particularly *Acomys nesiot*es, remains largely unexplored. Some taxonomic studies have provided limited information regarding the cranial morphology (ossa cranii) of the species. However, to date, no comprehensive analysis of its complete skeletal system has been conducted. This study represents the first detailed macro-anatomical investigation of the skeletal system of *A. nesiot*es, incorporating bone measurements and comparisons based on data available in the existing literature.

Cranial (Ossa cranii) characteristics

The rostrum of *Acomys nesiot*es is elongated and slender, with an average width of 4.18 mm. The nasal bone (os nasale) extends anteriorly beyond the incisive bone (os incisivum). The palatine fissures (fissurae palatinae) are long, reaching approximately the midpoint of the first molar (M1) but not extending beyond it (Fig. 2-6).

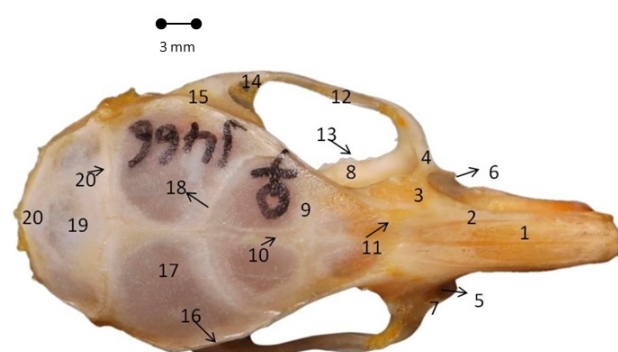


Fig. 2. Dorsal view of the skull of *Acomys nesiot*es, illustrating cranial morphology and key osteological landmarks. 1. Os nasale, 2. Os incisivum, 3. Maxilla, 4. Processus zygomaticus maxillae, 5. Canalis lacrimalis maxillaris, 6. Incisura infraorbitalis, 7. Tuber faciale, 8. Processus alveolaris maxillae, 9. Os frontale, 10. Sutura sagittalis, 11. Sutura frontomaxillaris, 12. Os zygomaticum, 13. Dentes molares, 14. Processus zygomaticus ossis temporalis, 15. Os temporale, 16. Linea temporalis, 17. Os parietale, 18. Sutura coronalis, 19. Os interparietale, 20. Os occipitale.

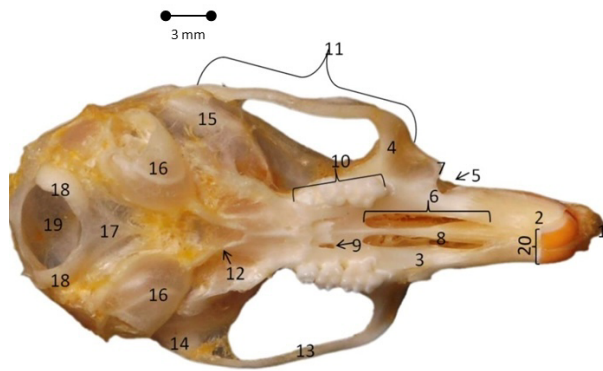


Fig. 3. Ventral view of the skull of *Acomys nesiotes*, illustrating palatal structures and cranial base morphology. 1. Os nasale, 2. Os incisivum, 3. Maxilla, 4. Processus zygomaticus maxillae, 5. Canalis lacrimalis maxillaris, 6. Fissura palatina, 7. Tuber faciale, 8. Processus palatinus, 9. Foramen palatinum majus, 10. Dentes molares, 11. Arcus zygomaticus, 12. Os pterygoideum, 13. Os zygomaticum, 14. Processus zygomaticus ossis temporalis, 15. Os temporalis, 16. Bulla tympanica, 17. Os occipitale, 18. Condylus occipitalis, 19. Foramen magnum, 20. Dentes incisivi.

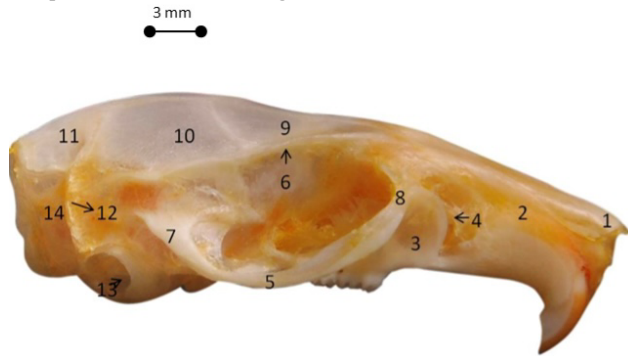


Fig. 4. Lateral view of the skull of *Acomys nesiotes*, illustrating the lateral cranial morphology and major osteological landmarks. 1. Os nasale, 2. Os incisivum, 3. Maxilla, 4. Canalis lacrimalis maxillaris, 5. Os zygomaticum, 6. Linea temporalis, 7. Processus zygomaticus ossis temporalis, 8. Processus zygomaticus maxillae, 9. Os frontale, 10. Os parietale, 11. Os interparietale, 12. Linea nuchae, 13. Porus acusticus externus, 14. Os occipitale.

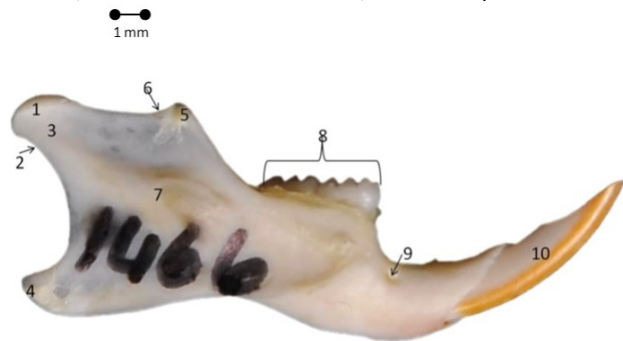


Fig. 5. Labial view of the mandible of *Acomys nesiotes*, illustrating external mandibular morphology and dental structures. 1. Caput mandibulae, 2. Collum mandibulae, 3. Processus condylaris, 4. Processus angularis, 5. Processus coronoideus, 6. Incisura mandibulae, 7. Tuberculum massetericum, 8. Dentes molares, 9. Foramen mentale, 10. Dens incisivus.

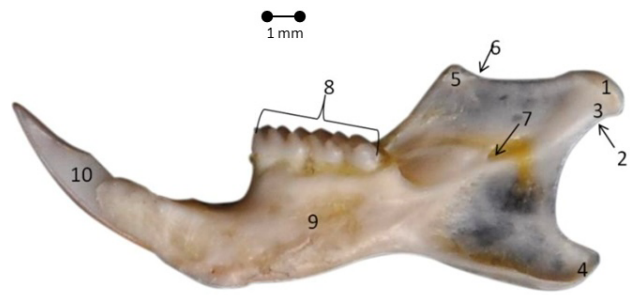


Fig. 6. Lingual view of the mandible of *Acomys nesiotes*, illustrating internal mandibular morphology and structural features. 1. Caput mandibulae, 2. Collum mandibulae, 3. Processus condylaris, 4. Processus angularis, 5. Processus coronoideus, 6. Incisura mandibulae, 7. Foramen mandibulae, 8. Dentes molares, 9. Facies lingualis, 10. Dens incisivus.

The zygomatic arches (*arcus zygomaticus*) protrude laterally in a broad and parallel configuration, with an average width of 14.4 mm. The interorbital region is broad and resembles an hourglass shape, with an average width of 5.2 mm. The temporal line (*linea temporalis*) is well defined and extends to the frontomaxillary sutures (*sutura frontomaxillaris*). The interparietal bone (*os interparietale*) is large, and the posterior portion of the skull is flattened. The maximum cranial height averages 10.1 mm.

The pterygoid processes (*processus pterygoideus*) form small triangular structures that extend to and contact the tympanic bullae (*bulla tympanica*). The tympanic bullae are moderately sized and terminate before reaching the occipital condyles (*condylus occipitalis*).

The mandibular notch (*incisura mandibulae*) is shallow, and the coronoid process (*processus coronoideus*) is low. The angular process (*processus angularis*) is blunt, while the masseteric tubercle (*tuberculum massetericum*) is prominent. The average length of the mandible is 16.1 mm.

Vertebral Column

The vertebral column of *Acomys nesiotes*, as in other mammals, is morphologically divided into five regions: cervical, thoracic, lumbar, sacral, and caudal (Fig. 7). Each region contains a specific number of vertebrae. The total number of vertebrae in the vertebral column of *A. nesiotes* ranges from 58 to 61. Specifically, the cervical region consists of 7 vertebrae ($n=22$), the thoracic region comprises 13 vertebrae ($n=22$), and the lumbar region includes 6 vertebrae ($n=22$). The sacrum is formed by the fusion of 4 vertebrae ($n=20$). The number of caudal vertebrae varies between 28 and 31.

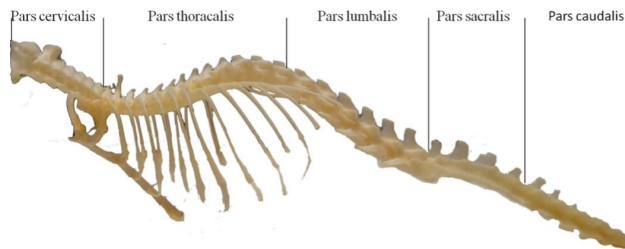


Fig. 7. Left lateral view of the vertebral column of *Acomys nesiot'es*, illustrating the morphological divisions of the spinal regions.

Atlas and Axis

In *Acomys nesiot'es*, the transverse processes (processus transversus) of the atlas are slightly curved ventrally, and the base contains a transverse foramen (foramen transversarium). The average craniocaudal length

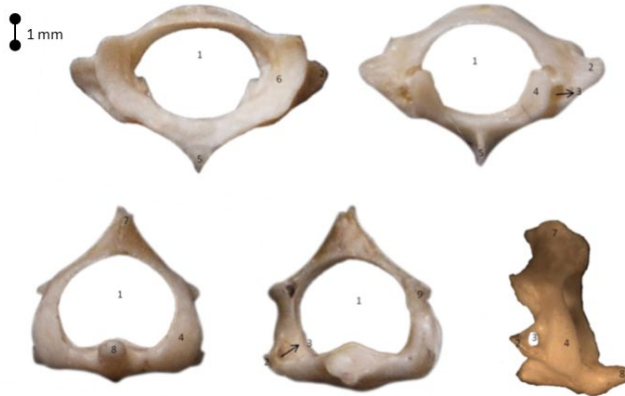


Fig. 8. Atlas and axis of *Acomys nesiot'es*, illustrating the morphological features of the first and second cervical vertebrae. 1. Foramen vertebrale, 2. Processus transversus, 3. Foramen transversarium, 4. Fovea articularis, 5. Tuberculum ventrale, 6. Fovea articularis caudalis, 7. Processus spinosus, 8. Dens axis, 9. Processus articularis caudalis.



Fig. 9. Third cervical vertebra (C3) (1), second thoracic vertebra (2) and fourth lumbar vertebra (3) of *Acomys nesiot'es*, illustrating representative vertebral morphology from different spinal regions.

of the atlas is 1.93 mm (n=16), and the height of the vertebral foramen averages 3.39 mm (n=16). The dens of the axis is prominent with a rounded tip. The transverse foramen is notably wide. The spinous process (processus spinosus) rises from anterior to posterior and terminates posteriorly in a sharp edge, with an average height of 1.96 mm (n=16). (Figs. 8-9).

In *Acomys nesiot'es*, the sacrum is composed of four fused sacral vertebrae. The pelvic surface (facies pelvina) lies parallel to the horizontal plane, and the spinous processes (processus spinosus) remain unfused and distinct. (Fig. 10).



Fig. 10. Sacrum of *Acomys nesiot'es*, demonstrating the fusion of sacral vertebrae and overall sacral morphology. A. facies dorsalis, B. facies pelvina and C. Image in left lateral view. 1. Ala sacralis, 2. Processus articularis cranialis, 3. Foramina sacralia dorsalia, 4. Foramina sacralia ventralia, 5. Linea transversae, 6. Processus spinosus.

While the first 2-3 caudal vertebrae retain typical vertebral characteristics, the subsequent vertebrae have largely lost these morphological features. (Fig. 11).



Fig. 11. Caudal vertebrae of *A. nesiot'es*.

Skeleton thoracis

The ribs consist of two parts: os costale and cartilago costalis. In *A. nesiot'es*, there are 13 pairs of ribs. The first five pairs are sternal ribs, the 6th to 11th pairs are asternal ribs, and the last two pairs are floating ribs. (Fig. 12).



Fig. 12. Os costae in *A. nesiot'es*. 1. Caput costae, 2. Collum costae, 3. Tuberculum costae, 4. Angulus costae, 5. Corpus costae, 6. Sulcus costae.

In *A. nesiot*es, the sternum consists of six sternebrae. The manubrium sterni is broad and flat. The processus xiphoideus terminates posteriorly with a large cartilago xiphoidea. (Fig. 13).

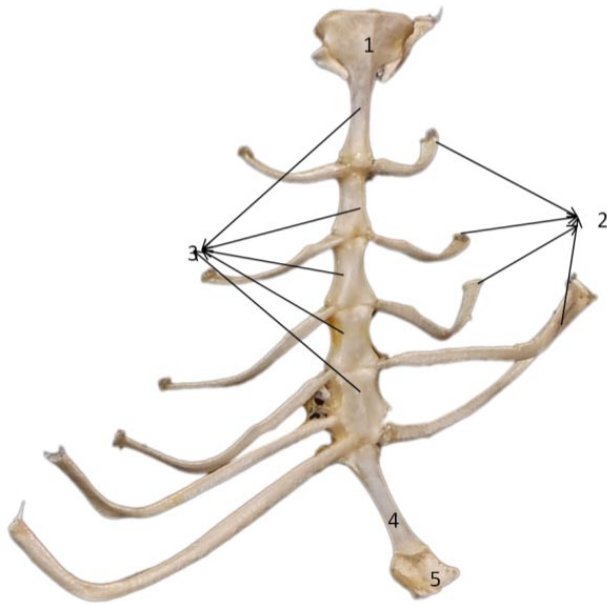


Fig. 13. Sternum in *A. nesiot*es. 1. Manubrium sterni, 2. Cartilago costalis, 3. Sternebra, 4. Processus xiphoideus, 5. Cartilago xiphoidea.

Skeleton appendiculare

It includes the limb bones and is divided into two parts: ossa membri thoracici and ossa membri pelvini.

Ossa membri thoracici (Forelimb bones)

The *ossa membri thoracici* are connected to the trunk by the *cingulum membri thoracici* (pectoral girdle). In this species, the pectoral girdle consists of the scapula and clavicle. The *os coracoideus* is present as the *processus coracoideus* on the scapula. The clavicle, which connects the sternum and the scapula, is straight with a slightly curved structure. (Fig. 14).



Fig. 14. Clavicula in *A. nesiot*es. 1. Extremitas sternalis, 2. Extremitas scapularis.

The scapula of *A. nesiot*es has a triangular appearance, with the *fossa supraspinata* being slightly narrower than the *fossa infraspinata*. *Spina scapulae* starts low and gradually rise. The lower end of the *spina scapulae* forms the *acromion*, which terminates by forming the *processus hamatus* and *processus suprahamatus*. The *processus coracoideus* is hook-shaped and well-developed. The maximum length of the scapula is 15.08 mm, the maximum width is 9.90 mm, and the acromion width is 2.57 mm. (Fig. 15).



Fig. 15. Spina scapulae in *A. nesiot*es. 1. Spina scapula, 2. Fossa supraspinata, 3. Fossa infraspinata, 4. Processus hamatus, 5. Processus suprahamatus, 6. Acromion, 7. Processus coracoideus, 8. Fossa subscapularis.

In *A. nesiot*es, the tuberculum majus of the humerus lies slightly below the level of the caput humeri. The tuberositas deltoidea is very prominent. The foramen supratrochleare is present within the fossa radialis. The total length of the humerus is 17,31 mm, and the cranio-caudal transition length is 3,01 mm. (Fig. 16).

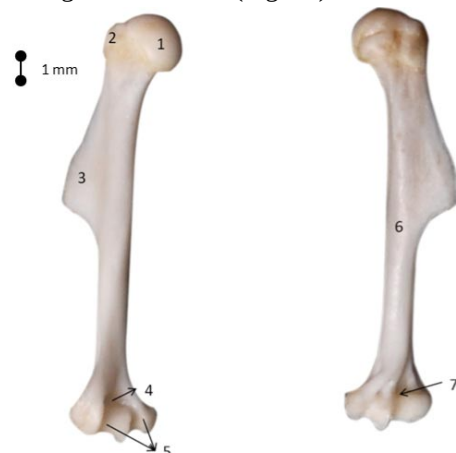


Fig. 16. Humerus in *A. nesiot*es. 1. Caput humeri, 2. Tuberculum majus, 3. Tuberositas deltoidea, 4. Foramen supratrochleare, 5. Condylus humeri, 6. Corpus humeri, 7. Fossa olecrani.

In *A. nesiot*es, the radius and ulna are two separate bones. The ulna is thicker than the radius. There are two prominences present on the tuber olecrani. The spatium interosseum antebrachii extends along the length between the proximal and distal joints. The length of the ulna is 19.07 mm. (Fig. 17).



Fig. 17. Skeleton antebrachii in *A. nesiot*es. 1. Olecranon, 2. Incisura trochlearis, 3. Processus anconeus, 4. Corpus ulnae, 5. Caput radii, 6. Collum radii, 7. Corpus radii, 8. Spatium interosseum antebrachii).

In the skeleton of the manus, a total of eight very small carpal bones were identified, with four located in the proximal row and four in the distal row. Among the five metacarpals, *os metacarpale* 3 was the longest and *os metacarpale* 1 was the shortest. In all forelimb digits, the *basis* of the *phalanx proximalis* is wider than its *caput*. Claws are present at the tip of each digit. (Fig. 18).



Fig. 18. Skeleton manus in *A. nesiot*es.

Ossa membri pelvini

In this species, the os coxae is formed by the fusion of three bones (*os ilium*, *os ischii*, and *os pubis*). The *fossa acetabuli* is deep. The diameter of the *acetabulum* is 2.73 mm, and the length of the *ilium* is 14.65 mm. The *foramen obturatum* is quite wide and oval-shaped. The *crista iliaca* is slightly convex, and the *eminentia iliopubica* is prominent. (Fig. 19).



Fig. 19. Os coxae in *A. nesiot*es. 1. Tuber coxae, 2. Ala ossis ilium, 3. Tuber sacrale, 4. Corpus ossis ilium, 5. Tuberositas iliaca, 6. Acetabulum, 7. Corpus ossis ischii, 8. Tabula ossis ischiadica, 9. Ramus cranialis ossis pubis, 10. Eminentia iliopubica, 11. Foramen obturatum).

In the femur, the *trochanter major* slightly exceeds the level of the *caput ossis femoris*. The width of the articular prominence at the upper level is 4.82 mm. The *collum ossis femoris* is prominent. The *fossa trochanterica* is quite deep. Both the *trochanter minor* and *trochanter tertius* are highly prominent. The *facies articularis sesamoidea lateralis* and *medialis* appear as depressions. The distance between the *condyli* is 3.55 mm, and the total length of the femur is 20.71 mm. (Fig. 20).



Fig. 20. Femur in *A. nesiot*es. 1. Caput femoris, 2. Trochanter major, 3. Trochanter minor, 4. Trochanter tertius, 5. Corpus ossis femoris, 6. Condylus lateralis, 7. Condylus medialis.

The patella is the largest sesamoid bone of the body and has an oval shape. (Fig. 21).



Fig. 21. Patella in *A. nesiotes*

The tibia is the longest bone in the skeletal system of the species. The *eminentia intercondylaris* is prominent. The length of the tibia is 23.02 mm. The fibula, located laterally to the tibia, has a thin corpus that thickens proximally. It is fused with the tibia at both the proximal and distal ends. (Fig. 22).



Fig. 22. Ossa cruris in *A. nesiotes*. 1. Eminentia intercondylaris, 2. Spatium interosseum, 3. Corpus tibiae, 4. Fibula.

In the skeleton of the pes, the *tuber calcanei* of the calcaneus is well-developed. There are four bones in the distal row. Five metatarsal bones are present. The basis of the *phalanx proximalis* is wider than its caput in all digits. The *phalanx distalis* of each digit bears a claw. (Fig. 23).

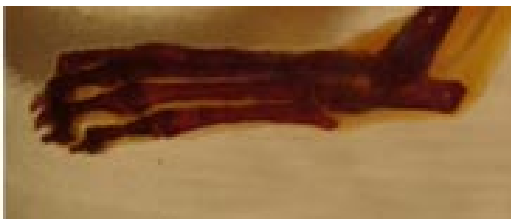


Fig. 23. Skeleton pedis in *A. nesiotes*.

This study represents the first detailed macroanatomical investigation of the skeletal system of *Acomys nesiotes* and contributes new morphometric data to the literature. In previous studies, *Acomys* species were mostly evaluated based on cranial morphology (*ossa cranii*)

and a limited number of skeletal elements (Bate, 1903; Niethammer, 1978; Kivanç *et al.*, 1997), while detailed morphological data on the axial and appendicular skeleton have not been provided.

The data obtained in this study provide important insights into the lifestyle and morphological adaptations of *A. nesiotes*. For example, the structure and proportions of bones such as the scapula, humerus, and ulna suggest that this species is adapted for climbing and agile movement. The width of the scapula and the development of the acromion processes likely support strong muscle attachments in the forelimbs, enabling agile locomotor behaviors. Similarly, the pronounced *tuberositas deltoidea* and the large *foramen supratrochleare* on the humerus may indicate robust muscle attachment areas for the forelimb musculature. These features are consistent with the bone morphologies associated with similar functional adaptations observed in other Rodentia species (Cook, 1965; Greene, 1968; Özkan, 2002).

An examination of cranial morphology reveals that the rostrum length and zygomatic arch width are distinctive features for species identification in *A. nesiotes*. In particular, the pronounced interorbital width and the highly developed *linea temporalis* are important indicators of cranial differentiation in this species. Additionally, the blunt *processus angularis* and the prominent *tuberculum massetericum* on the mandible indicate well-developed masticatory musculature. These findings are consistent with the cranial characteristics reported by Macholán *et al.* (1995) and Barome *et al.* (2001, 2000).

Another significant finding of the study concerns the vertebral count and morphological variations in the caudal vertebrae. The vertebral column of *A. nesiotes* consists of 58 to 61 vertebrae, reflecting variation in tail length and mobility, which are associated with locomotor capabilities. The progressive simplification of the caudal vertebrae towards the distal end is a typical morphological feature observed in rodents and is related to their locomotor abilities (Özdemir & Atalar, 2003).

In the *skeleton membri pelvini*, the lengths and articular surfaces of load-bearing bones such as the femur and tibia are directly related to the species' running and jumping abilities. The clear definition of the three trochanteric processes (major, minor, and tertius) on the femur indicates the presence of strong muscle attachments, which is consistent with the morphological features that support the rapid escape and climbing behaviours observed in *Acomys* species (Çevik-Demirkan *et al.*, 2007; Yılmaz *et al.*, 1998, 1999).

CONCLUSIONS

This study provides a detailed morphological description of the skeletal structures of *Acomys nesiot*es, offering qualified data that can be used for the taxonomic diagnosis of the species. In particular, the distinctive structural characteristics observed in the skull, mandible, and limb bones exhibit unique features that differentiate this species from both other *Acomys* species and closely related rodents.

These findings, supported by macroscopic measurements, are significant not only for systematic biology but also for functional morphology, evolutionary biology, and ecological adaptation studies. The anatomical clues related to locomotor ability, masticatory behavior, and environmental adaptations contribute to a better understanding of the ecological niche of *A. nesiot*es.

This study not only provides morphometric data for taxonomic identification but also offers fundamental skeletal data that can serve as a reference for paleontological, zooarchaeological, and functional morphology research. Comparative anatomical analyses with different *Acomys* species in future studies will allow for a clearer understanding of the evolutionary position and ecological adaptations of this species. The fact that this study focuses on a species that has been scarcely addressed in the literature makes the findings even more valuable.

ACKNOWLEDGMENTS. The authors would like to thank Prof. Dr. Erkut Kivanc and the Department of Anatomy, Faculty of Veterinary Medicine, Ankara University.

Author Contribution Statements. This study is part of a doctoral thesis entitled “Taxonomy, Biology, and Macro-Anatomy of The Skeletal System of *Acomys nesiot*es Bate, 1903 (Rodentia: Mammalia).”

KIRALP AKYUZ, S. & MUTLU EYISON, H. Macroanatomía del sistema esquelético de *Acomys nesiot*es Bate, 1903 (Rodentia: Mammalia). *Int. J. Morphol.*, 44(4):1247-1256, 2026.

RESUMEN: Este estudio tuvo como objetivo describir exhaustivamente, por primera vez, la macroestructura anatómica del sistema esquelético de *Acomys nesiot*es, una especie de roedor endémica de la isla de Chipre. Se examinaron un total de 105 especímenes, procedentes tanto de individuos silvestres como de individuos criados en laboratorio. Los huesos del cráneo, los miembros, la columna vertebral y otros elementos esqueléticos se analizaron morfométricamente, se dibujaron y se fotografiaron. Los resultados indican que la estructura esquelética de *A. nesiot*es está estrechamente relacionada con adaptaciones locomotoras, características taxonómicas

distintivas y especialización ecológica. Cabe destacar que las características observadas en la escápula, el húmero, el fémur y la morfología craneal sugieren adaptaciones para una locomoción ágil, como la escalada y el movimiento rápido. Además, las estructuras craneales y mandibulares distintivas ofrecen valiosos indicadores para la identificación de la especie y el estudio de su comportamiento alimentario. Los resultados constituyen una referencia significativa no solo para la biología sistemática, sino también para estudios paleontológicos y de morfología funcional.

PALABRAS CLAVE: *Acomys nesiot*es; Macroanatomía; Sistema esquelético; Morfometría; Roedores.

REFERENCES

- Barome, P. O.; Lymberakis, P.; Monnerot, M. & Gautun, J. C. Cytochrome b sequences reveal *Acomys minous* (Rodentia, Muridae) paraphyly and answer the question about the ancestral karyotype of *Acomys dimidiatus*. *Mol. Phylogenet. Evol.*, 18(1):37-46, 2001.
- Barome, P. O.; Monnerot, M. & Gautun, J. C. Phylogeny of the genus *Acomys* (Rodentia, Muridae) based on the cytochrome b mitochondrial gene: Implications on taxonomy and phylogeography. *Mammalia*, 64(4):423-38, 2000.
- Bate, D. M. A. LXXVII.—On the occurrence of *Acomys* in Cyprus. *Ann. Mag. Nat. Hist.*, 11:565-7, 1903.
- Bellofiore, N.; Ellery, S. J.; Mamrot, J.; Walker, D. W.; Temple-Smith, P. & Dickinson, H. First evidence of a menstruating rodent: The spiny mouse (*Acomys cahirinus*). *Am. J. Obstet. Gynecol.*, 216(1):40.e1-40.e11, 2017.
- Çevik-Demirkan, A.; Özdemir, V.; Türkmenoglu, I. & Demirkan, I. Anatomy of the hind limb skeleton of the chinchilla (*Chinchilla lanigera*). *Acta Vet. Brno*, 76:501-7, 2007.
- Cook, M. J. *Anatomy of the Laboratory Mouse*. San Diego, Academic Press, 1965.
- Creutzfeldt, W.; Mende, D.; Willms, B. & Söling, H. D. Vascular basement membrane thickness in muscle of spiny mice and activities of glycolysis and gluconeogenesis in the liver of animals with spontaneous and experimental diabetes and of untreated human diabetics. *Diabetologia*, 6(3):356-60, 1970.
- Fabre, P.-H.; Hautier, L.; Dimitrov, D. & Douzery, E. J. P. A glimpse on the pattern of rodent diversification: A phylogenetic approach. *BMC Evol. Biol.*, 12:88, 2012.
- Fricker, L. D.; Tashima, A. K.; Fakira, A. K.; Hochgeschwender, U.; Wetsel, W. C. & Devi, L. A. Neuropeptidomic analysis of a genetically defined cell type in mouse brain and pituitary. *Cell Chem. Biol.*, 28(1):105-112.e4, 2021.
- Frynta, D.; Palupčíková, K.; Bellinva, E.; Benda, P.; Skarlantová, H.; Schwarzová, L. & Modry, D. Phylogenetic relationships within the cahirinus-dimidiatus group of the genus *Acomys* (Rodentia: Muridae): New mitochondrial lineages from Sahara, Iran and the Arabian Peninsula. *Zootaxa*, 2660(2660):46-56, 2010.
- Gippoliti, S. & Amori, G. Anthropochorous wild mammal taxa and conservation lists. *Conserv. Biol.*, 16(4):1162-4, 2002.
- Greene, E. C. *Anatomy of the Rat*. New York, Hafner, 1968.
- Grubb, P.; Sandrock, O.; Kullmer, O.; Kaiser, T. M. & Schrenk, F. *Relationships between eastern and southern African mammal faunas*. In: Bromage, T. G. & Schrenk, F. (Eds.). *African Biogeography, Climate Change, & Human Evolution*. New York, Oxford University Press, 1999. pp.253-67.
- Haim, A. & Borut, A. Heat production and dissipation in golden spiny mice, *Acomys russatus*, from two extreme habitats. *J. Comp. Physiol. B*, 142:445-50, 1981.

- Haughton, C. L.; Gawriluk, T. R. & Seifert, A. W. The biology and husbandry of the African spiny mouse (*Acomys cahirinus*) and the research uses of a laboratory colony. *J. Am. Assoc. Lab. Anim. Sci.*, 55(1):9-17, 2016.
- Kivanç, E.; Sözen, M.; Çolak, E. & Yigit, N. Karyological and phallic aspects of the spiny mouse, *Acomys cilicicus* Spitzenberger, 1978 (Rodentia: Muridae) in Turkey. *Turk. J. Zool.*, 21:167-9, 1997.
- Lidicker Jr., W. Z. A phylogeny of New Guinea rodent genera based on phallic morphology. *J. Mammal.*, 49(4):609-43, 1968.
- Macholán, M.; Zima, J.; Cervená, A. & Cervený, J. Karyotype of *Acomys cilicicus* Spitzenberger, 1978 (Rodentia, Muridae). *Mammalia*, 59(3):397-402, 1995.
- Matthews, T.; Denys, C. & Parkington, J. E. Community evolution of Neogene micromammals from Langebaanweg 'E' Quarry and other west coast fossil sites, south-western Cape, South Africa. *Palaeogeogr. Palaeoclimatol. Palaeoecol.*, 245(3-4):332-52, 2007.
- Niethammer, J. *Einführung*. In: Niethammer, J. & Krapp, F. (Eds.). *Handbuch der Säugetiere Europas*. Wiesbaden, Akademische Verlagsgesellschaft, Bd. 1, 1978. pp.17-60.
- Özdemir, D. & Atalar, Ö. *Macro-anatomical investigations on the skeletons of squirrel (Sciurus vulgaris)*. II. Ossa membri pelvini. 2003.
- Özkan, Z. E. Macro-anatomical investigations on the hind limb skeleton of mole-rat (*Spalax leucodon* Nordmann). *Vet. Arhiv*, 72:159-66, 2002.
- Pictet, R.; Orci, L.; Gonet, A. E.; Rouiller, C. & Renold, A. E. Ultrastructural studies of the hyperplastic islets of Langerhans of spiny mice (*Acomys cahirinus*) before and during the development of hyperglycemia. *Diabetologia*, 3(2):188-211, 1967.
- Renaud, S.; Hardouin, E. A.; Chevret, P.; Papayiannis, K.; Lymberakis, P.; Matur, F.; Garcia-Rodriguez, O.; Andreou, D.; Çetintas, O.; Sözen, M.; et al. Morphometrics and genetics highlight the complex history of Eastern Mediterranean spiny mice. *Biol. J. Linn. Soc. Lond.*, 130(3):599-614, 2020.
- Seifert, A. W.; Kiama, S. G.; Seifert, M. G.; Goheen, J. R.; Palmer, T. M. & Maden, M. Skin shedding and tissue regeneration in African spiny mice (*Acomys*). *Nature*, 489(7417):561-5, 2012.
- Selby, P. B. A rapid method for preparing high quality alizarin stained skeletons of adult mice. *Stain Technol.*, 62(3):143-6, 1987.
- Shafir, E.; Ziv, E. & Kalman, R. Nutritionally induced diabetes in desert rodents as models of type 2 diabetes: *Acomys cahirinus* (spiny mice) and *Psammomys obesus* (desert gerbil). *ILAR J.*, 47(3):212-24, 2006.
- Spitzenberger, F. Die Stachelmaus von Kleinasien, *Acomys cilicicus* n. sp. (Rodentia, Muridae). *Ann. Naturhist. Mus. Wien*, 81:443-6, 1978.
- Spitzenberger, F. Die Säugetierfauna Zyperns. Teil I: Insectivora und Rodentia. *Ann. Naturhist. Mus. Wien*, 81:401-41, 1977.
- Steppan, S. J.; Adkins, R. M.; Spinks, P. Q. & Hale, C. Multigene phylogeny of the Old World mice, Murinae, reveals distinct geographic lineages and the declining utility of mitochondrial genes compared to nuclear genes. *Mol. Phylogenet. Evol.*, 37(2):370-88, 2005.
- Tasbas, M. Maserasyon tekniği üzerinde araştırmalar. *Ankara Üniv. Vet. Fak. Derg.*, 12:325-30, 1965.
- Yılmaz, S.; Dinç, G. & Aydın, A. Oklu kirpi (*Hystrix cristata*) iskelet sistemi üzerinde makro-anatomik araştırmalar. *Tr. J. Vet. Anim. Sci.*, 23:297-300, 1999.
- Yılmaz, S.; Özkan, Z. E. & Özdemir, D. Oklu kirpi (*Hystrix cristata*) iskelet sistemi üzerinde makro-anatomik araştırmalar. I. Ossa membri thoracici. *Tr. J. Vet. Anim. Sci.*, 22:389-92, 1998.
- Zima, J.; Macholán, M.; Piálek, J. & Slivková, L. Chromosomal banding pattern in the Cyprus spiny mouse. *Folia Zool.*, 48(2):149-52, 1999.

Corresponding author:
Hatice Mutlu Eyison
Department of Biology
Faculty of Science
Ankara University
Ankara
TÜRKİYE

E-mail: hmutlu@science.ankara.edu.tr

ORCID: 0000-0002-4637-5268

Seda Kiralp Akyuz
E-mail: sedakiralp@gau.edu.tr
ORCID: 0000-0002-9431-9180