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Phylogenetic Significance of the Postcranial Skeletons of the Hipparions from Maragheh (Late Miocene), Northwest Iran

By

Mahito WATABE* and Hideo NAKAYA**

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Abstract

The postcranial samples of *Hipparion* (Equidae, Perissodactyla) collected by the Paleontological Expedition of Kyoto University in 1973 from Maragheh, northwest Iran were compared with other materials stored in other institutes in Europe. Three morphotypes could be distinguished in the third metapodials by their size and proportions. They are: 1) medium to large robust morphotype; 2) large and slender morphotype; and 3) small and slender morphotype. The first morphotype corresponds to *H. prostylum,* the second to *H. urmiense,* and the third to *H. moldavicum* recognized in the same locality by cranial materials.

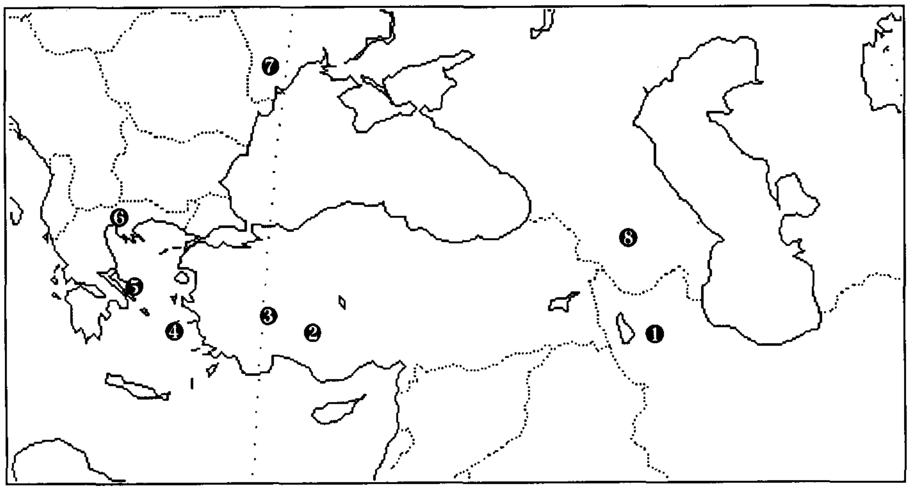
It is crucial procedure for taxonomy and phylogenetic analysis of extensively deversified Late Miocene *Hipparion* in Eurasia to make clear association in a single taxon between cranial and postcranial morphotypes from a fossil locality, resulting the increase of morphological characters and data on the functional tie between facial and locomotory features. **Key words**: *Hipparion,* Perissodactyla, Maragheh, Turolian, postcranial, late Miocene, Iran, taxonomy, phylogeny.

1. Introduction

Maragheh has been since long known as one of the major localities of Miocene fossil mammals (see a review of classic excavations and studies by BERNOR, 1985), but its fauna is not as well studied as the contemporaneous Greek localities, Samos and Pikermi. An example of the few studies on the Maragheh fauna are those by MECQUENEM (1908, 1911, 1924–25). Maragheh is important because of its diversified faunal composition, geological and geographical location close to both western and eastern Old World's fossil localities (Fig. 1).

Integrative geological and paleontological investigations on the Maragheh fauna have been made recently by ERDBRINK et al. (1976), KAMEI et al. (1977) and CAMPBELL et al. (1980). They discussed the faunal composition, geological age and correlation with other mammalian fossil localities.

* The PaleoWorld, Inc., Kusaka-cho 3-1-5-421, Higashi-Osaka 579, Japan.
** Department of Earth Sciences, Faculty of Education, Kagawa University, Takamatsu 760, Japan.



❶: Maragheh (Turolian)
❷: Kayadibi, Turkey (Turolian)
❸: Esme-Akcakoy (Vallesian), Garkin & Kinik (Turolian), Turkey
❹: Samos, Greece (Turolian)
❺: Pikermi, Greece (Turolian)
❻: Saloniki, Greece (Turolian)
❼: Cimislia, Novo-Elizavetovka, Taraklia, Tudorovo, Grebeniki et al. in the northern shore of the Black Sea region (Meotian = Turolian)
❽: Bazalethi (Turolian) & Eldar (Vallesian), Caucasus

Fig. 1. Relationship of Maragheh (northwest Iran) to the main fossil localities in the Sub-Paratethys and USSR regions.

BERNOR (1985, 1986) summarized the geological and paleontological data obtained by those modern excavations.

This is a report on the hipparionine materials collected by the Japanese-Iranian excavation in Maragheh held in 1973. In order to clarify the phylogenetic status of the Maragheh hipparions, we examined further materials from the locality stored in some European museums and attempted to correlate skull materials and postcranials.

We propose that the postcranial elements, which have been thought little of, are as important as skull materials in hipparionine systematics, especially third metapodials and tarsal elements.

2. Methods and Materials

Biometric methods were applied in this study. We measured postcranials: MC III, MT III, astragalus, calcaneus, proximal phalange III, medial phalange III, and pelvis from Maragheh. Other postcranial elements were measured, however, they were excluded from this study, because these elements are limited in number their intra- and inter-locality comparison is rather difficult. Those elements are abundant and have been paid attentions to by many authors from the view points of both biology and biostratigraphy.

To compare those data we used 1) bivariate scatter plots; 2) Dice diagram (JONES, 1988); and 3) ratio diagram (SIMPSON, 1941).

The bivariate scatter plots show allometric relationships between two variables, if plotted in logarithmic scale. The box plots are useful for uni-variate comparison, showing range, means, standard deviation, and standard error of mean. The ratio diagram can compare overall size and proportions of specimens at the same time.

The discriminant function analysis were performed for the proximal phalanges III from Maragheh. The method was explained by Sneath and Sokal (1973) in detail.

The 95% equi-probability ellipsoids were drawn for the measurements on the MT III from Maragheh, following the method by DEFRIESE-GUSSENHOVEN (1955).

The studied materials of hipparions, stored in Kyoto University, mainly came from Maragheh (upper Maragheh horizon by BERNOR et al., 1980). In order to compare the data on these materials and to establish correspondence between skulls and postcranials we studied hipparionine materials from other localities of Eurasia and Africa. Our materials on the Maragheh hipparions consist of the collections stored in the Department of Geology and Mineralogy, Faculty of Science, Kyoto University, the KNHM of Vienna, and the MNHN of Paris. The materials deposited in the BMNH of London and other institutions were not examined. The measured data on the collections by University of California expedition were obtained from BERNOR (1985).

Abbreviations

POF: Preorbital fossa.

POB: Preorbital bar, the space between the posterior rim of POF and anterior rim of the orbit, also meaning its measurements.

MC III: The third metacarpal.

MT III: The third metatarsal.

Ma: Megaanna, millions of years ago in the radioisotopic time scale.

KUAC: Specimens in Department of Geology and Mineralogy, Kyoto University.

MNHN: Muséum National d'Histoire Naturelle, Paris.

MAR: Maragheh specimens in MNHN.

KNHM: Naturhistorische Museum, Wien.

BMNH: British Museum of Natural History, London.

UC: University of California.

All measurements are in millimeters.

Anatomical terms used in this paper are based on GETTY (1975) and EISENMANN et al. (1988).

3. History of Investigation on Maragheh Hipparions

MECQUENEM (1908, 1911, 1924–25) described vertebrate taxa from Maragheh, including hipparion forms. He described the hipparion forms as "*Hipparion gracile*"

GABUNIA (1959) reexamined U.S.S.R. hipparions, once studied by GROMOVA (1952), and examined new materials discovered since Gromova's comprehensive work. GABUNIA (op. cit.) mentioned hipparions from Urmia of Azerbaizhan, near Maragheh, and possibly from the same formation, and established a new species, *Hipparion urmiense.* This form was characterized by the possession of a shallow POF dorsally located on face and a narrow skull.

FORSTÉN (1968), in her revision of Palearctic hipparions by biometrical methods, proposed the existence of two major hipparionine forms in the Palearctic region: *H. mediterraneum* with slender metapodials and *H. primigenium* with robust metapodials. She stressed the importance of postcranial characters in hipparionine taxonomy.

FORSTÉN (1983) summarized her data on POF morphology and showed that a POB/P2-Orbit distance scatter diagram was useful for species discrimination in the Eurasian *Hipparion.* She presented results for the discrimination and sorting out of Maragheh hipparions, together with those from other Turolian localities such as Pikermi, Saloniki, and Samos.

WOODBURNE and BERNOR (1980), presenting four supra-specific groups of Eurasian hipparions, noted hipparionine assemblages in Maragheh. They recognized all four groups in the locality, suggesting a well diversified assemblage of hipparions.

BERNOR (1985) described Maragheh hipparions and discussed their phylogenetic relationships with those of other localities. He established two new species of hipparion: *Hipparion gettyi* from Kopran, lower horizon of the Maragheh Formation, and *Hipparion campbelli* from the upper horizon of the formation. The former is based on the materials preserved in Wien, Austria and the latter on those excavated by the American researchers in the period from 1974 to 76. BERNOR (1986) carried out a detailed stratigraphic corrrelation of the results of several excavation teams: the Dutch-German group in 1973, the Japanese-Iranian group in 1973, and the American group from 1974 to 1976. He believed that a 9.5–7 my interval represents the best estimate for the age range of the Maragheh fauna (see also, CAMPBELL et al., 1980).

In the above mentioned studies the results by different authors do not agree with one another. Debatable points are: 1) how many species of *Hipparion* were present at Maragheh? 2) how many hipparion forms can be discriminated on the basis of postcranial elements? 3) how do skull morphotypes and postcranials correspond to each other?

The answers to the first question ranges from two (FORSTÉN, 1968) to five (BERNOR, 1986). Only FORSTÉN (1968) attempted to answer the second question. The answer to the third question was given by FORSTÉN (1968), in an insufficient manner.

The above three questions should be answered to the studied fossil localities which yield several different forms of *Hipparion*.

For the analysis, we must understand the number of morphotypes recognizable on the postcranial elements, referring the skull morphotypes from Maragheh. The next step will be to correlate postcranial and cranial elements which include upper and lower cheek teeth.

4. Geology

Excavation in 1973

The excavation was carried out in Dareh-e Gorg, near Mordagh, in the autumn of 1973, under the collaboration scheme between the Geological Survey of Iran and Kyoto University. Dareh-e Gorg is on the route from Mordagh to Kerjaveh in the Maragheh area, south of Mt. Sahand. During the excavations, efforts for precise age determination were made simultaneously with fossil collecting (KAMEI et al. 1977).

The works carried out at the Maragheh locality were: 1) Paleomagnetic study of the Maragheh Formation; 2) Fission-track age determination on volcaniclastics in the formation; 3) Excavation at four sites, Site-I, II, III, and IV.

Sites

Site-I: Fossil bones were found only in the lowest level of the section; the excavations proceeded in a horizontal direction, transversely to the slope.

Site-II: Fossil bones were unearthed from horizons D and E. For small vertebrate fossils the mudstone was sampled about one ton each from each horizon.

Site-III: Much excavation work was done at this site. Mudstone of about one ton was sampled for small vertebrate fossils.

Site-IV: Many fossil bones were found in the trench.

Most of fossil materials were collected from the sites II and III. Their horizon is about 20 m below the Upper Pumice ('Loose Chips' pumice bed by CAMPBELL et al., 1980), being correlated with the upper Maragheh of CAMPBELL et al. (1980).

In Site III, two clusters of bone accumulation can be distinguished: northern part (Section VI and V) and southern part (Section IV and III). The former bone accumulation is elongated in northwest—southeast direction, and the latter in east—west direction. The sections VI and V (more precisely near their boundary) yielded rich fossil materials in the levels (Horizons) of b'-2, 5 and 6. And other sections IV and III (mainly IV) did in the levels of b'-4, 5 and 6. In all sections the levels b'-1 and 3 were scarce in fossils (Figs. 2, 3).

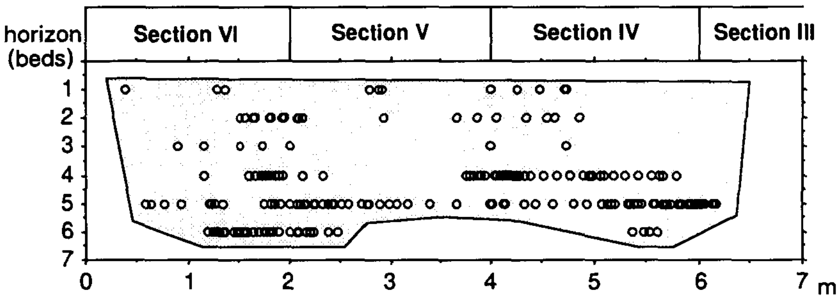


Fig. 2. Fossil occurrences projected on the east wall as Site III in Maragheh (N. W. Iran) surveyed by Kyoto University Expedition team. Compiled from the data by KAMEI et al. (1977). This is a section perpendicular to the elongation axis of fossiliferous portion, showing channel topography of fossil bone accumulations.

Open circles indicate the center of each fossil bones. Heavy concentration of fossil bones in the left and right channel fills. The lithology of the fossiliferous portion is of mainly gray sandy silt. The other is of pinkish white clay and pinkish gray clay, indicating overbank deposits. After WATABE (1990).

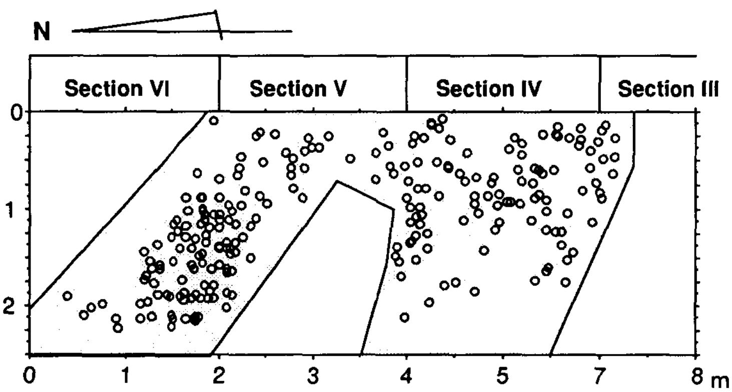


Fig. 3. Composite horizontal plane of the layers from b'-1 (upper horizon) to b'-6 (lower horizon) in Maragheh, showing the elongation of fossiliferous portions. The orientation of the elongation is west to east. The orientation of long bones and other detailed information were indicated in KAMEI et al. (1977; p. 9–10).

Fossil Occurrence

1) Southern cluster of bone accumulation: Section IV, Horizon b'-5 and Section IV, Horizon b'-4

The pelvis are large-sized (KUAC 95018, KUAC 95303, KUAC 95014 from Horizon b'-4, and; KUAC 95313 and 95311 from Horizon b'-5) and small-sized (KUAC 95305 from Horizon b'-5).

The astragali are small-sized (KUAC 95320) and large-sized (KUAC 95301) from Horizon b'-5. The calcaneus is small-sized (KUAC 95306) from Horizon b'-5.

The MC IIIs from Horizon b'-5 (KUAC 95315 and 95322) are of large and slender group.

The adult skull KUAC 95331 from Horizon b'-5 is of *Hipparion prostylum*. A juvenile skull KUAC 95335 from Horizon b'-5 can not be assigned to any skull group.

2) Northern cluster of bone accumulation: Section VI and V, Horizon b'-4, 5, and 6

The MT IIIs are small and slender form (KUAC 95318 and 95319) from Section VI, Horizon b'-6.

The skulls are of *H. prostylum* (KUAC 96046 and 95089) and of *H. moldavicum* large (KUAC 95330) and small (KUAC 95329) from Section VI, Horizon b'-6.

The pelvis from Section VI, b'-5, KUAC 95310 is small-sized. On the other hand, the pelvis from Section V, b'-4, KUAC 95017 is large-sized. The astragalus from Section VI, b'-5, KUAC 95055 is middle to large-sized.

The postcranial bones and skulls come from a same bone accumulation body and they were deposited simultaneously. *Hipparion* with different limb proportions and facial morphology had lived close each other synchronously.

Fossil preservation

The preservation of the fossil bones was rather good. In each cluster of bones, the fossils seem to have a definite orientation, and fossil bones seem to form concentrated piles in some sections and layers.

Although articulated limb bones of hipparion were discovered in situ, no complete, articulated whole skeletons were found. The bones had been transported by a stream before burial, but not for a long distance. On the surface of the bones there are trace of several kinds of carnivorous damage. The weathering condition of bone surface ranges from grade 1 to 5 according to the scale of BEHRENSMAYER (1978), and the bones of grade 2 and 3 are dominant. This suggests that the fossils were either buried almost immediately or exposed only long enough to allow removal of only a few elements, and damage to the bones by scavengers.

Geologic Age

Paleomagnetism of the Maragheh Formation suggests that the White Fine Tuff, which lies between the Upper and Lower Pumice Beds and the Mordagh Tuff, corresponds with a normal interval, while the biotite bearing ash flow (Basal Tuff) corresponds with a reversed interval and unconformably overlies the basement (KAMEI et al. 1977).

The fossiliferous horizons excavated are between the Upper and Lower Pumice Beds, and between the Lower Pumice Beds and the Mordagh Tuff. The White Tuff is located in between the Upper and Lower Pumice Beds, and the Mordagh Tuff is in lower horizon than the Lower Pumice Bed.

The Fission Track age was determined on volcaniclastics in the Maragheh Formation, on the fossiliferous horizons. The ages are as follows:

Upper Pumice Bed (='Loose Chips' pumice)	: 6.6 Ma
Lower Pumice (Gürt Dareseh Pumice at Murdaq)	: 5.5, 6.5 Ma
Mordagh tuff (Ignimbritic Tuff at Murdaq)	: 7.0 Ma
Biotite bearing ash flow (Basal Tuff at Western area)	: 7.2 Ma

The name of tuffs within parentheses have been used by CAMPBELL et al. (1980).

These volcaniclastics are correlated with a normal paleomagnetic interval.

KAMEI et al. (1977) concluded that the White fine tuff with normal magnetic polarity could be correlated with the top of Epoch 7, taking into account radiometric data. The fossil beds in the Maragheh Formation were considered to range from 6.6 to 6.9 Ma. This age is late Turolian, younger than that of Samos, Greece (VAN COUVERING and MILLER, 1971) or almost equivalent to that.

On the other hand, the dating by CAMPBELL et al. (1980) with K-Ar and Fission Track methods is different from that by KAMEI et al. (1977). They dated the Upper pumice ('Loose Chips' Pumice in their terminology) 7.4±0.3 and 7.8±0.4 Ma, and the Mordagh tuff (Ignimbritic tuff in their terminology) 10.6±0.8 Ma. The Biotite Bearing Ash Flow (Basal Tuff) was dated 11.2±0.6 and 12.8±0.5 Ma by them.

This means a longer range of the Maragheh fauna than the short range of KAMEI et al. (1977). The assignment of the Maragheh Formation by CAMPBELL et al. (1980) is not necessarily contradictory to magnetic polarity data.

5. Third Metacarpal (MC III)

A. Result

The complete MC III specimens from Maragheh are mainly kept in the MNHN and Kyoto University collections. Most of the KNHM specimens are fragmentary. The proportions of MC III are well expressed by width measurements compared with total length values.

There are three morphotypes among the MC III from the locality: medium sized and robust; large sized and slender; and small sized and slender. The two slender morphotypes have similar proportions (Fig. 4).

B. Correspondence of the sizes in each part of MC III

1) Medium to large-sized, robust MC III: large distal dimensions (DAW, DAD); large proximal dimensions (PW, PD) (Fig. 5, 6).

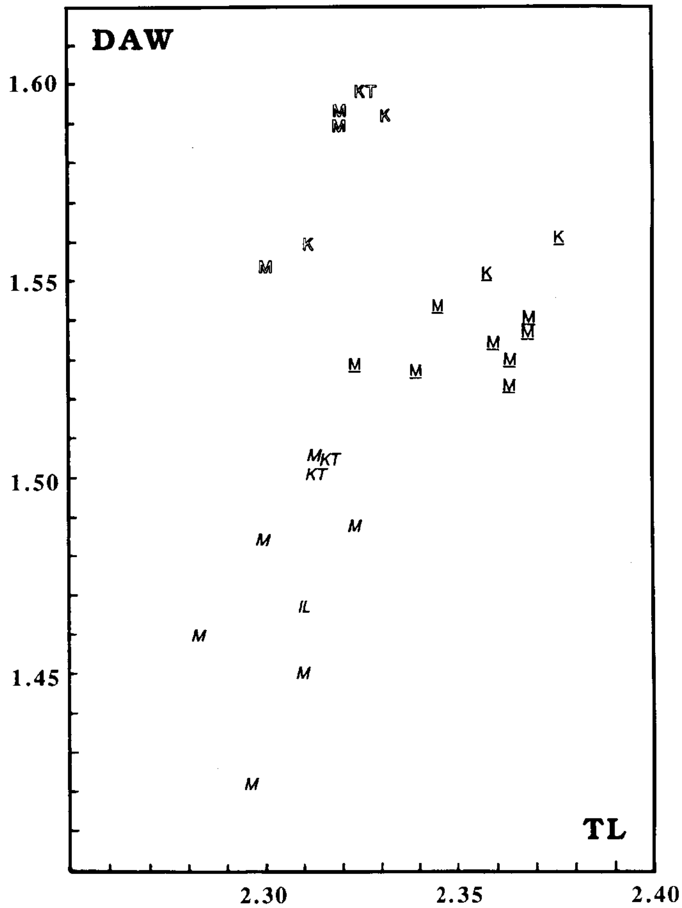


Fig. 4. Distal articular width of MC IIIs in Maragheh hipparions plotted against total length. Logarithmic scale. Symbols: Italic, *H. moldavicum*; underlined, *H. urmiense*; outlined, *H. prostylum*; plain roman, undeterminable taxon. Sub-localities: M, MNHN sites; IL, Ildtschi; KT, Ketschawa; K, Kyoto University sites.

The facets for the magnum and the hamatum are large in relation to the large proximal dimensions. The size of these facets is rather variable in all morphotypes of the locality, compared to other measurements of MC III. The angle between these two facets is similar to that of the small and slender morphotype (fig. 6).

2) Large-sized, slender MC III: medium distal dimensions (DAW, DAD); medium proximal dimensions (PW, PD) (Fig. 5, 6).

The facets for the magnum and hamatum are similar in size to those of the robust MC III, although the width of the facet for the hamatum is smaller than the latter. The angle between these facets are smaller than those of the small and slender morphotype and of the

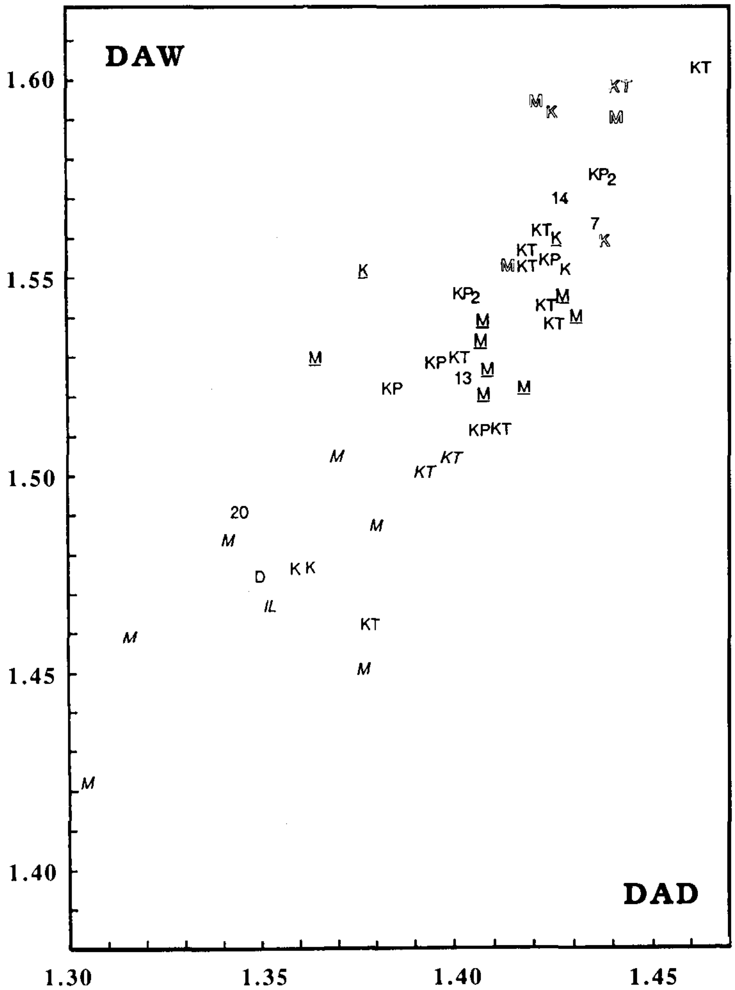


Fig. 5. Distal articular width of MC IIIs plotted against distal articular diameter in Maragheh hipparions. Longarithmic scale. Sub-localities: D, Dschingirdera; KP, Kopran; KP_2, Kopran II; 7–20 (numeric), sites of University of California. For the symbols for taxa and other sub-localities, see Fig. 4.

medium-sized robust morphotype (Fig. 6).

3) Small-sized, slender MC III: small distal dimensions (DAW, DAD); small proximal dimensions (PW, PD) (Fig. 4, 5).

The facets for the carpal elements are small and the angle between them is large.

There is no significant difference between the small and large slender third metacarpals in the mean values of their "slenderness index" (DAW/TL by Gromova, 1952). However, the two slender morphotypes are both significantly different from the robust one

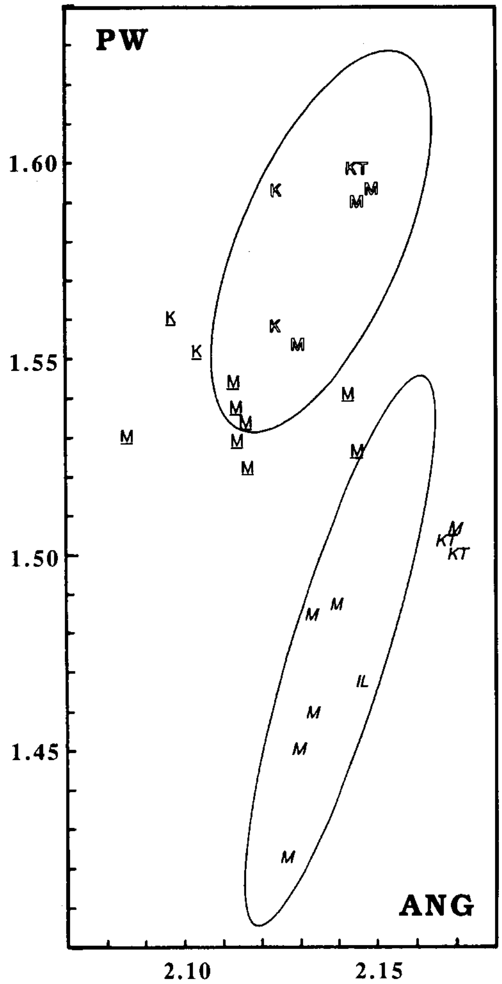


Fig. 6. Relationship between the proximal width and the angle between the facets for the Magnum and Hamatum in MC IIIs from Maragheh. Logarithmic scale. Third metacarpals with large size and slender proportions (*H. urmiense*) have steep angle, and they plot small-sized area of 95% equi-probability ellipsoid of robust MC IIIs (*H. prostylum*). For the symbols, see Fig. 4 and 5.

(t-Test, $p=0.01$). It is probably due to the limited number of available specimens that the two slender morphotypes could not be distinguished from each other (contrary to the case of MT III).

C. Occurrence of different morphotypes of MC III in each sub-locality and comparison with those from other Turolian localities

The medium-sized, robust MC III morphotype is recognized at Ketschawa (KNHM:

−52 m/−30m), Kyoto Univ. (−20 m), UC (−18 m horizon: epiphysial portion only), Kopran II (−115 m: epiphysial part only) and MNHN collections (−52 m/−28 m) (Table 1). The size and proportions of this morphotype are comparable to those of *H. brachypus* (*H. primigenium*) from Pikermi. This similarity can be seen in the distal dimensions too.

Table 1. Stgratigraphic occurrence of morphotypes of MC III in the Maragheh Formation. The stratigraphic position of each sub-locality is based on BERNOR (1986).

Horizons (m)	Sub-localities	Slender-Small	Slender-Large	Robust
+7	UC 26			
+4	UC 39			
-18	UC 13; Ildtschi	C	d	
-20	Kyoto Univ.	C		C
-28	UC 7, 14			d
-30	UC 20			
-28 ~-52	Kara Kend			
-28 ~-52	MNHN	C	C	C
-30 ~-52	Ketschawa	C	d	C
-115	Kopran II; UC 41, 44		d	d
-115 ~-150	Kopran; UC 43, 9, 48		d	

C: represented by complete specimens; d: represented by distal part of MC III.
Horizons means the meter above the Loose Chippings Marker.
Kopran and Kopran II are sub-localities where the samples of KNHM were collected.
UC: localities by University of California.
MNHN: localities by MNHN, Paris.
Kopran, Ketschawa, Kara Kend, & Ildtschi: localities by KNHM, Wien.

The large-sized, slender MC III are found at Ketschawa (−52 m/−30 m: epiphysial portion only), Kopran (−150 m/−115 m) and II (−115 m: epiphysial portion only), Kyoto Univ. (−20 m), and MNHN collections (−52 m/−28 m). The proportions of this morphotype are similar to those of *H. mediterraneum* from Pikermi. The size, i.e. distal dimensions, is intermediate between *H. brachypus* and *H. mediterraneum*.

The small-sized, slender MC III morphotype appears at Ketschawa (−52 m/−30 m), Ildschi (=Ilkhchi) (−18 m), Kyoto Univ. (−20 m: epiphysial portion only), UC (−30 m horizon) and MNHN collections (−52 m/−28 m). Its proportions are comparable with the large and slender morphotype and with *H. mediterraneum*. Its size is close to that of the latter. The proportions and size of the small and slender MC III from Samos and Saloniki, which are probably assigned to *H. matthewi*, are also similar to the Maragheh small morphotype.

The MC III from the Kopran sub-locality are all fragmentary, but their distal portion is of medium size, similar to that of the large and slender morphotype. One large distal portion, KNHM W 8647 from Kopran II is close to those of the robust morphotypes. The proximal dimensions and the angle of the facets can be compared with those of the large and slender morphotype.

The Kopran MC III do not necessarily exhibit primitive features, compared to those from other Maragheh sub-localities.

6. Third Metatarsal (MT III)

A. Result

The complete MT III speciments from Maragheh are mainly in the MNHN and Kyoto Univ. collections. Most of the KNHM specimens are fragmentary. The proportions of MT III are well expressed by comparing width measurements against total length values.

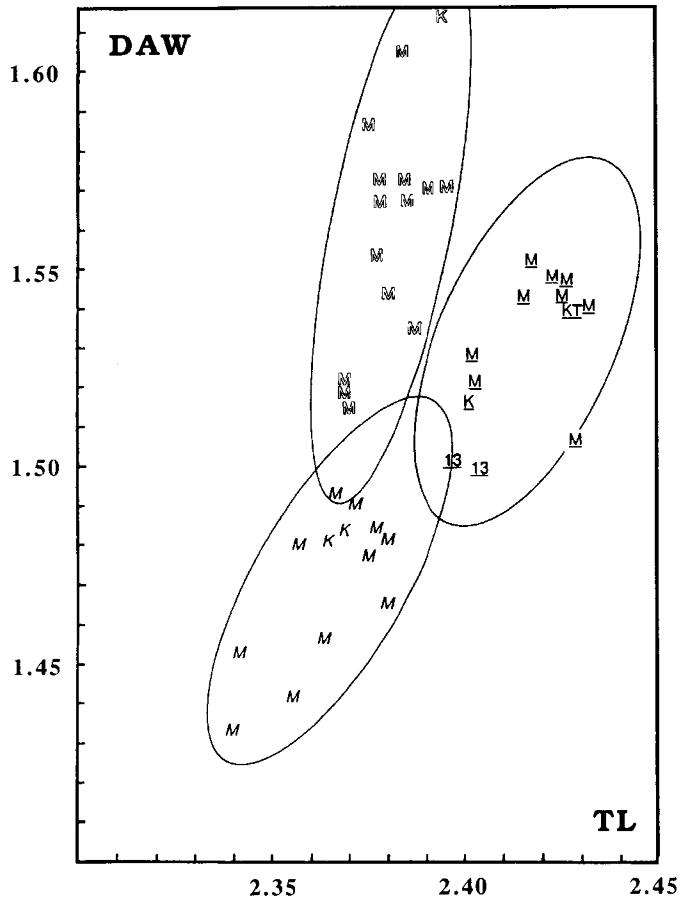


Fig. 7. Distal articular width of MT IIIs plotted against total length in Maragheh hipparions. Logarithmic scale. 95% equi-probability ellipsoids were drawn for each morphotypes. Smaller specimens of the robust morphotypes (outlined) plot close to other two slender morphotypes. For the symbols, see Fig. 4 and 5.

As in the case of MC III, there are three morphotypes of MT III from the locality: medium-sized and robust; large and slender; and small-sized and slender (Fig. 7). The two slender morphotypes have similar proportions to each other. These three morphotypes may directly correspond to the three morphotypes of MC III.

B. Correspondence of the size of each part of MT III

1) Medium to large-sized, robust MT III: large distal dimensions (DAW, DAD); large proximal dimensions (PW, PD) (Fig. 8).

Large proximal size corresponds to large distal dimensions in this morphotype. The size of the facet for the cuneiform II is variable.

2) Large-sized, slender MT III: medium distal dimensions (DAW, DAD); medium proximal dimensions (PW, PD)

The distal dimensions of this morphotype of MT III are intermediate between the small-sized, slender morphotype and the medium-sized, robust one. The facet for the

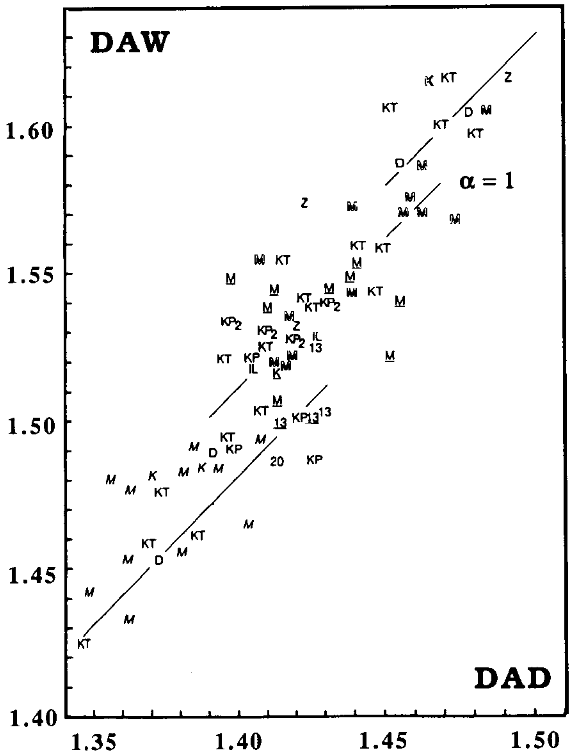


Fig. 8. Distal articular width of MT IIIs plotted against distal articular diameter in Maragheh hipparions. Logarithmic scale. Hypothetical isometric growth lines were drawn for three morphotypes, however, they can not be distinguished clearly. Fragmentary specimens increases the number of plots. For the symbols, see Fig. 4 and 5.

cuneiform II is well developed and less variable than in the robust morphotype.

3) Small sized, slender MT III: small distal dimensions (DAW, DAD); small proximal dimensions (PW, PD)

The facet for the cuneiform II relatively develops as well as in the large and slender morphotype. However, the facet is absent in some cases, as a reflection of its smaller overall size of proximal portion (Fig. 9). The facet for the cuboid also decrease in its mean size correlated with overall size of the MT III. As the average size of the facet for the cuneiform II decrease in association with decrease of overall size of the MT III, the facet often becomes very small and does not show clear articular facet. Light and gracile-built body of the animal with the small and slender metapodials, which might be *Hipparion moldavicum* makes such lacking of the facet possible by shifting of body weight to MT III.

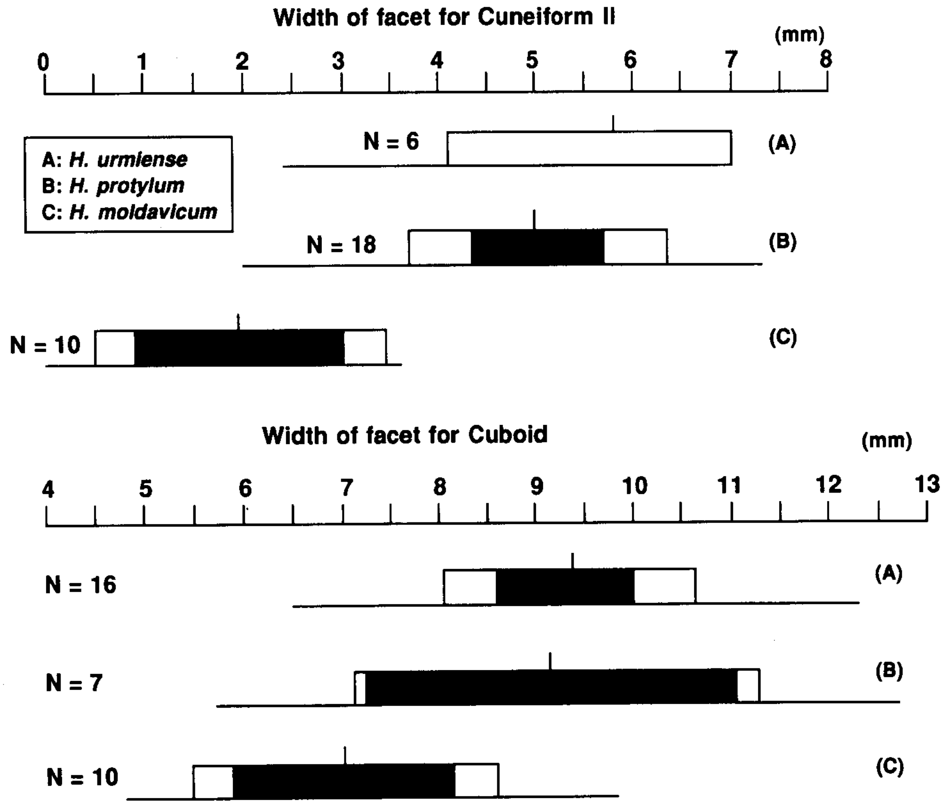


Fig. 9. Box diagrams showing the size of the facets for the Cuneiform II and Cuboid on proximal portions of MT III in Maragheh. Horizontal line shows range, the open rectangle mean$\pm$1 standard deviation, soid rectangle mean$\pm$2 standard errors (nearly equal to 95% confidence interval of mean). Small size of the facets in the small and slender morphotype (*H. moldavicum*) is due to small overall size of the bone. (A): Large and slender morphotype; (B): Medium-robust morphotype; (C): Small and slender morphotype.

The two slender morphotypes, the small and the large, are significantly different from each other in their mean "slenderness index" (DAW/TL by GROMOVA, 1952) (t-Test, $p = 0.05$). These slender morphotypes are also significantly different from the robust one ($p = 0.01$).

C. Occurrence of different morphotypes of the MT III in each collection and comparison with morphotypes from other Turolian localities

The medium-sized, robust MT III morphotype is found at Ketschawa (distal and proximal parts only), stored in the Kyoto Univ., and MNHN collections (Table 2). The size and proportions of this morphotype are comparable to those of *H. brachypus* (*H. primigenium*) from Pikermi and to Vallesian hipparions (*H. primigenium* from Inzersdorf and *H. africanum* from Bou Hanifia).

Table 2. Stgratigraphic occurrence of morphotypes of MT III in the Maragheh Formation. For abbreviations see Table 1.

Horizons (m)	Sub-localities	Slender-Small	Slender-Large	Robust
+7	UC 26	p		
+4	UC 39	p	p	
-18	UC 13; Ildtschi		C	
-20	Kyoto Univ.	C	C	C
-28	UC 7		C	C
-30	UC 20	C		
-28˜-52	Kara Kend (KNHM)		C	
-28˜-52	MNHN	C	C	C
-30˜-52	Ketschawa (KNHM)	d	C	d
-115	Kopran II; UC 41, 44	p	d	
-115˜-150	Kopran; UC 43, 9, 48		d	

p: represented by proximal part of MT III.

The similarity of the Maragheh robust morphotype to the Pikermi large one can be seen in the epiphysial dimensions too. The distal dimensions of the above mentioned Vallesian hipparions is slightly smaller than that of this morphotype and more similar to that of the large and slender morphotype of Maragheh (discussed below).

The large-sized, slender MT III are found at KNHM (epiphysial portions only), KUAC, and MNHN collections. The proportions of this morphotype are similar to those of *H. mediterraneum* from Pikermi. The epiphysial size, distal and proximal dimensions, are intermediate between *H. brachypus* and *H. mediterraneum*.

The small-sized, slender MT III morphotype appears at KNHM (epiphysial portions only), KUAC (epiphysial portions only), and MNHN collections. Its proportions are comparable with those of the large and slender morphotype of Maragheh and with *H. mediterraneum*, from Pikermi although the latter is slightly larger than the former in overall size (DAW/TL scatter). The proportions and size of this morphotype of MT III are similar to the small and slender metatarsals from Samon and Saloniki, which probably belong to *H. matthewi*.

The MT III from the Turolian localities, Mt Luberon in southern France from which the type of *H. prostylum*, are also similar to this morphotype in size and proportions.

The MT III from the Kopran sub-locality are all fragmentary, but their distal portion is medium to large-sized, similar to that of the large and slender morphotype. The Kopran MT III do not necessarily exhibit primitive features, compared to those from other Maragheh sub-locality samples.

7. Proximal Phalange III

A. Result

Twenty seven proximal phalanges from Maragheh were examined. Most of them were from the MNHN collection. The measurements were taken on the following variables: 1) Total length (TL); 2) Anterior length (ANTL); 3) Medial width (MW); 4) Proximal width (PW); 5) Proximal diameter (PD); 6) Distal width (DW); 7) Distal

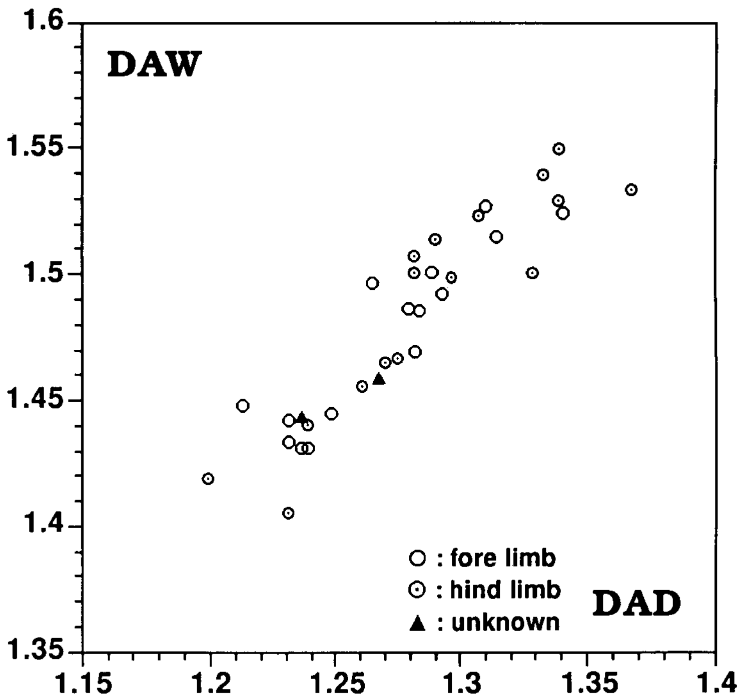


Fig. 10. Distal articular width of the Proximal phalanges III plotted against distal articular diameter in Maragheh hipparions. For determination of fore and hind limbs, see Fig. 11.

articular width (DAW); and 8) Distal articular diameter (DAD).

The size difference is well expressed in the scatter diagram plotting distal articular width to distal articular diameter (Fig. 10). Two groups are distinguished in the scatter plot: large and small specimens.

Large: KUAC 95019, KUAC 95308, MNHN MAR 108, 110, 114, 116, 131, 137, 138, 140, 237, 111, 118, 119, 122, 124, 128, 129, 133, 135, 139; Small: KUAC 95309, MNHN MAR 112, 113, 115, 121, 123, 125, 126, 127, 130, 132, 134, 136

On the basis of their size, association with the third metapodials are suggested as follows: the large morphotype corresponds to the medium-sized and robust, and the large and slender metapodials, and the small morphotype do to the small-sized and slender metapodials.

B. Discrimination between fore and hind Proximal Phalange III from Maragheh

KOUFOS (1987a, b), studying Pikermi hipparions, proposed that fore and hind limb proximal phalanges was able to be differentiated on the basis of their proportions, between proximal width and total length in scatter plots.

EISENMANN and DE GIULI (1974) showed a distinction between fore and hind proximal phalange III in recent *Equus,* and applied their method to fossil *E. stenonis*. According to them, in the anterior proximal phalanges the supraarticular tuberosities are closer to the distal end of the bone; the trigonum phalangis is longer; the index of the proximal antero-posterior diameter to the length is less (robust in fore limb). Their study shows that the anterior proximal phalange III is anteroposteriorly narrow and mediolaterally wide, compared with the posterior one. This corresponds to the flatter distal end of MC III.

As we did not measure the internal and external length of supraarticular tuberosities, a more precise discrimination of anterior and posterior proximal phalanges could not be attained. The applicability of Eisenmann and De Diuli's criterion to *Hipparion* proximal phalanges has not yet been documented.

The proximal phalange III specimens were sorted to the fore and hind limb parts on the basis of the PD v.s. ANTL scatter diagram (Fig. 11) as follows:

Fore limb: MNHN MAR 111, 112, 113, 114, 116, 118, 122, 126, 132, 133, 134, 135, 136, 139, KUAC 98019; Hind limb: MNHN MAR 108, 109, 110, 115, 119, 121, 123, 124, 125, 128, 129, 131, 137, 138, 140, 237.

It is impossible to avoid arbitrariness in assignment of the specimens distributed in boundary area.

The discriminant function analysis was applied to these data and its result is:

$Z = -1.333ANTL + 2.429PD + 1.368$ ($F > 0.01$; degree of freedom: 1, 28; $N = 31$) (Fig. 11).

Both measurements contribute the discrimination of two groups: fore and hind

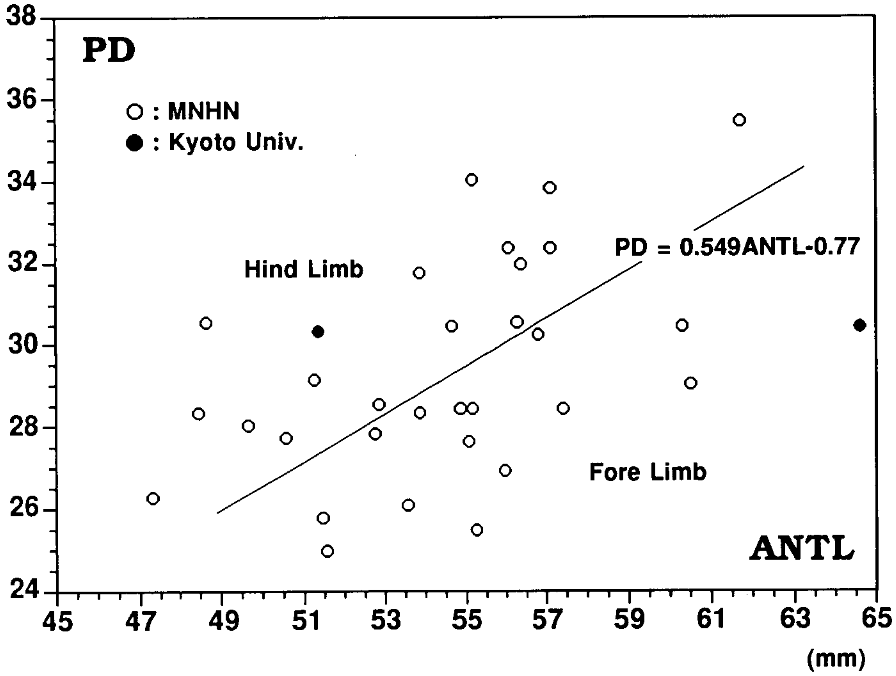


Fig. 11. Proximal diameter plotted against the length of anterior side of the proximal phalanges III in Margheh hipparions. The discriminant score scale (Sneath and Sokal, 1973) was obtained as $Z=-1.333ANTL+2.429PD+1.368$. When $Z>0$, the phalanges belong to hind limb, and if $Z<0$, to fore limb. A line: $PD=0.549ANTL-.77$ ($Z=0$) divides the phalanges into two groups.

Table 3. Stgratigraphic occurrence of morphotypes of Proximal Phalanges III in the Maragheh Formation.

Horizons (m)	Sub-localities	Small	Large
+7	UC 26		
+4	UC 39		
-6	UC 47		
-12	UC 25		
-18	UC 13, 37; Ildtschi		
-20	Kyoto Univ.		C
-28	UC 7, 14		
-30	UC 20		
-40	UC 3		
-28˜-52	Kara Kend (KNHM)		
-28˜-52	MNHN	C	C
-30˜-52	Ketschawa		
-115	Kopran II; UC 41, 44		
-115˜-150	Kopran; UC 43, 9, 48		

elements. When the specimens assigned to small and large morphotypes on the basis of the distal dimension are dealt together, the mean of the proximal diameter (anteroposterior) of the fore digit is 27.8 and that of the posterior 30.7.

The larger anteroposterior diameter in the hind proximal phalange III than in the fore one corresponds to the larger epi- and diaphysial anteroposterior diameter observed on the MT III than the MC III. The size of the proximal diameter of the anterior proximal phalange III is 91% of that of the posterior one in Maragheh specimens. The size of the distal diamenter in the distal articular facet of MC III is 96% of that of MT III.

On the other hand the proximal diameter of the MC III is 85.6% of that of the MT III. The same value of Pikermi MC IIIs is 82% of that of MT III (*H. mediterraneum* and *H. brachypus* together, after the data by KOUFOS, 1987a, b). The stratigraphic occurrences of the morphotypes of proximal phalanges III are shown in Table 3.

8. Medial Phalange III

Limited number of the medial phalange III specimens were available for this study. They all show similar size and proportions, suggesting that they belong to a single morphotype. It is impossible to assign the Maragheh medial phalanges III to specific groups.

9. Astragalus

There are astragali in all three collections examined, namely: MNHN, KNHM, KUAC, and among the data published by BERNOR (1985).

It is difficult to find differences in proportions in the Maragheh astragali. The scatter diagrams show no grouping of different sizes among the specimens. With reference to the data presented by KOUFOS (1987a, b) for the Pikermi hipparions, the heterogeneity of Maragheh astragali is clear, showing that more than two morphotypes are involved there.

The materials from the Kopran and the Kopran II sub-localities (lower Maragheh: −150 m/−115 m from the 'Loose Chips' marker bed) are divided into two groups: medial and large sized specimens (Fig. 12). The specimens from the Ketschawa sub-locality (−52 m/−30 m from the 'Loose Chips' marker bed) are quite heterogoneous in size, ranging from large to small; the smaller being less than the former medium-sized morphotype. The astragali from the upper horizon, represented by BERNOR's data (UC's 13, 25, 26, and 37), also show size heterogeneity. The exceptionally small specimens (26/1677 and 26/2565) are included. There is no information, whether those are very small adults or juveniles.

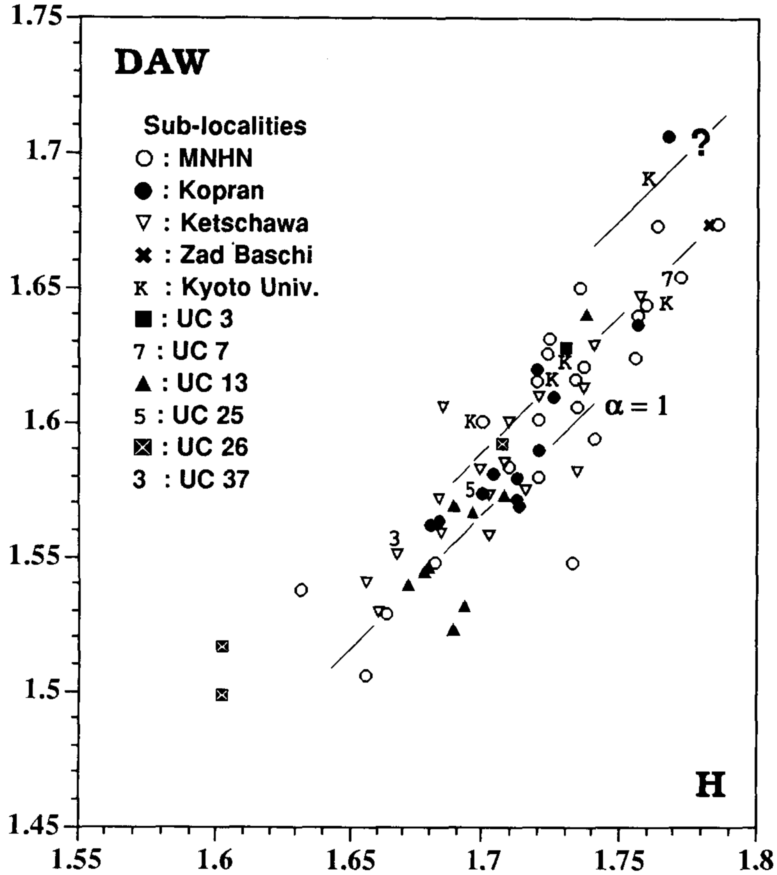


Fig. 12. Distal articular width plotted against maximum height of Astragali in Maragheh. Logarithmic scale. Hypothetical isometric growth lines were drawn for each morphotypes, however, they were not distinguished one another.

The Kyoto Univ. specimens from −20 m below the 'Loose Chips' marker bed are also heterogeneous and include medium and large sized specimens. Large-sized astragali from the Kyoto sites and Ketschawa are possibly associated with medium-sized and robust MT III from the same locality, and with large proximal phalanx. The size of the large astragali from Maragheh is similar to that of those from such Vallesian localities as Bou Hanifia in North Africa and Inzersdorf in the Vienna basin, Austria.

Medium-sized astragali from the same sites (sub-localities) correspond to the large and slender MT III from these sites, and are correlated with medium-sized proximal phalanx III. The size of this morphotype is comparable with that of the large astragali of *H. mediterraneum* from Pikermi. A part of the astragali from the Turolian of Saloniki, Greece, and those from Mt Luberon of South France are similar in their size.

As the size of the small astragali gradually chages to medium ones, separation of those two morphotypes is difficult. These small astragali might belong to the taxon with small and slender MT III from the same sites, and with small proximal phalanx III. A part of the Pikermi (*H. mediterraneum*) and Saloniki (*H. matthewi*?) astragali are of similar size to this small morphotype.

The medium-sized astragali from the Kopran sub-locality can be correlated with the medium-sized proximal and distal ends of MT III from the sub-locality. A large-sized proximal end of a MT III was discovered from the sub-locality. It is comparable with the large astragali, but these large specimens are limited in number compared with other morphotypes. There is a possibility that these materials (small and large) were collected from different horizons in or near the Kopran sub-locality.

In the size of the distal and proximal ends of MT III, and of astragalus it is impossible to distinguish between the Kopran (lower Maragheh) medium-sized mophotype and the Ketschawa and Kyoto (upper Maragheh) medium-sized morphotype. The ossification of the astragalus takes place by an endochondral process, with epiphyses in its posterior tuberosity, showing no epiphysial suture. The immature astragalus is smaller in size than the mature one. This change in size during ontogeny was observed in the case of *H. africanum* from Bou Hanifia and of *H. primigenium* from the Vienna Basin. The stratigraphic occurrences of the astragali from the Maragheh Formation are summarized in Table 4.

Table 4. Stgratigraphic occurrence of morphotypes of Astragali in the Maragheh Formation.

Horizons (m)	Sub-localities	Small	Medium	Large
+7	UC 26	C	C	
+4	UC 39			
-12	UC 25		C	
-18	UC 13, 37; Ildtschi		C	
-20	Kyoto Univ.		C	C
-28	UC 7, 14			C
-30	UC 20			
-28~-52	Kara Kend (KNHM)			
-28~-52	MNHN	C	C	C
-30~-52	Ketschawa (KNHM)	C	C	C
-115	Kopran II; UC 41, 44		C	
-115~-150	Kopran; UC 43, 9, 48		C	C

10. Calcaneus

Most examined calcanei consist of the MNHN collection, without precise information on the horizon (correlated with −52 m/−28 m by BERNOR, 1986). For the calcaneus the differences in proportions can be shown by the maximum width of distal portion plotted against the total length in scatter diagram (Fig. 13). Three groups can be rocognized on

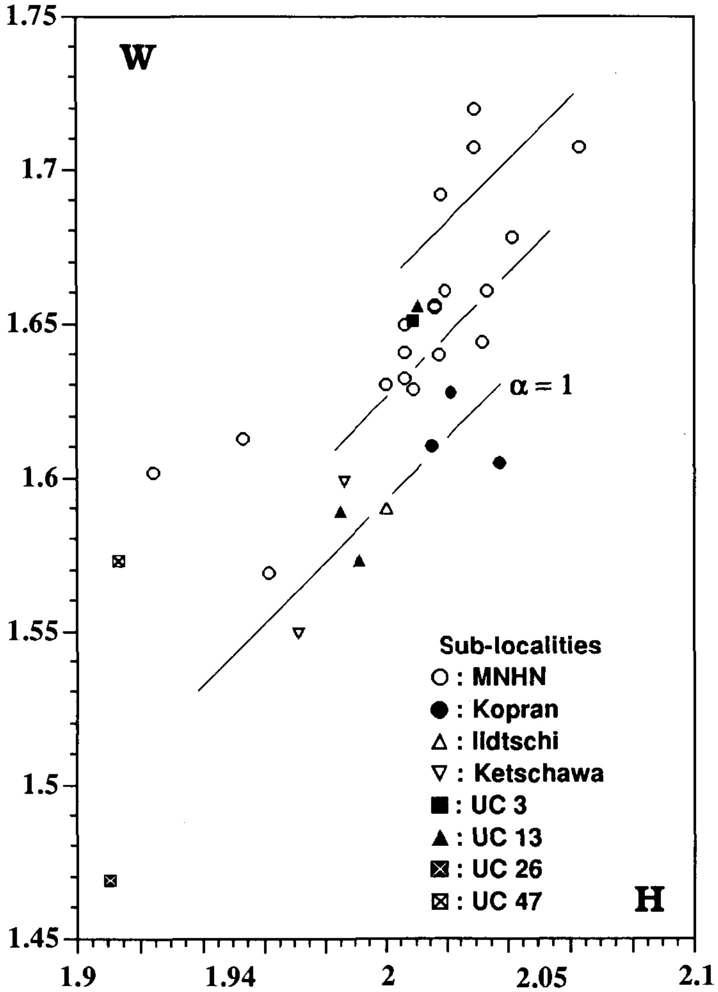


Fig. 13. Maximum width plotted against maximum height (hength) of Calcanei in Maragheh hipparions. Logarithmic scale. Hypothetical isometric growth lines were drawn for each morphotypes.

the basis of size and proportions: 1) large-sized; 2) medium-sized; and 3) small-sized.

The calcanei from Kopran (−150 m/−115 m) and Ketschawa (−52 m/−30 m) all belong to the medium-sized group. The MNHN (−52 m/−28 m) materials contain all three groups. The large-sized group is represented by only a single calcaneus: MNHN MAR 215. The specimens from UC 13 (−18 m) may be divided into two groups: the medium-sized and small-sized one. The UC 3 (−40 m) specimen is medium sized. KNHM W 8672 from the Ilkhchi (=Ildtchi) sub-locality (−18 m below the 'Loose Chips' marker bed) is medium-sized. There are two very small specimens from UC 47 (−6 m) and 26 (+7 m) sites, much smaller than the third group. It is not certain whether these two specimens are juveniles or small sized adults.

The association between the astragalus and calcaneus as articulated elements each other was discussed. Measurements on astragalus and calcaneus belong to *H. mediterraneum* from Pikermi, Greece, were analyzed for this purpose. These data were based on KOUFOS (1987a, b) and on WATABE's personal observations. The means of pulley length of the astragalus and of total length of the calcaneus belonging to the same taxon, *H. mediterraneum,* were compared. The following equations were obtained:

Calcaneus total length=(Astragalus pulley length)*2

—by WATABE's personal observation (N=4–6 in calcaneus, 13–14 in astragalus)

Calcaneus total length=(Astragalus pully length)*1.945

—by KOUFOS (1987a, b) on *H. mediterraneum* (N=14 in calcaneus, 6 in astragalus)

Calcaneus total length=(Astragalus pully length)*1.822

—by KOUFOS (1987a, b) on *H. brachypus* (*H. primigenium* of Forstén) (N=20 in calcaneus, 7 in astragalus)

From these equations it might be postulated that twice the pulley length of the astragalus is approximately equal to the total length of the calcaneus. In the case of *H. brachypus* from Pikermi, larger size and more stout-build than *H. mediterraneum,* a lower coefficient may be a reflection of allometric change. The larger and more stout-built hipparion has a relatively shorter calcaneus than the smaller one.

As the size range of the medium and the small-sized astragali from Maragheh is comparable with that of *H. mediterraneum* from Pikermi, coefficient of 2 or 1.945 were employed for inference as to the association of astragali and calcanei. By this method the followings were hypothesized:

1) The large-sized group of calcanei (MNHN: −52 m/−28 m, Ketschawa: −52 m/−30 m, Ilkhchi (=Ildtchi): −18), of medium size and robust proportions is associated with the large astragali from the same sites.

2) The medium-sized group (MNHM: −52/−28, Kopran: −150 m/−115 m, UC 13: −18 m, UC 3: −40 m) of medium size and slender proportions, is associated with the medium sized astragali from the same sites.

3) The small-sized group (MNHN: −52 m/−28 m, Ketschawa: −52 m/−30 m, UC 13: −18 m), of small size and slender proportions, is associated with the small sized astragali from the same sites.

The Kopran large astragalus has no associated calcaneus from the sub-locality.

Although we examined personally a limited materials of the calcanei from Pikermi, the Pikermi calcanei could not be separated on their proportions. *Hipparion mediterraneum* from Pikermi can be compared with the slender calcanei of medium and small size from Ketschawa, MNHN and Kopran specimens. The ossification of the calcaneus, which occurs in the epiphysial suture between the calcaneus body and the tuber calcanei, makes possible a determination of its maturity. But the degree of endochondral ossification of calcaneus is not easily estimated. Stratigraphic occurrence of the calcanei in Maragheh is presented in Table 5.

Table 5. Stgratigraphic occurrence of morphotypes of calcanei in the Maragheh Formation.

Horizons (m)	Sub-localities	Small	Medium	Large
+7	UC 26	C		
+4	UC 39			
-6	UC 47	C		
-18	UC 13, 37; Ildtschi	?	C	
-20	Kyoto			
-28	UC 7, 14			
-30	UC 20			
-40	UC 3		C	
-28~-52	Kara Kend (KNHM)			
-28~-52	MNHN	C	C	C
-30~-52	Ketschawa (KNHM)	C	C	C
-115	Kopran II; UC 41, 44		C	
-115~-150	Kopran; UC 43, 9, 48			

?: uncertrain assignment.

11. Pelvis

There are 17 specimens in the Kyoto Univ. collection. They can be divided into two groups, large and small, on the basis of their overall size (acetabulum diameter; ilium and ischium size) (Fig. 14). The small-sized group consists of: KUAC 95310, KUAC 95059, 95060, and 95063. And the large-sized group includes: KUAC 95303, KUAC 95305, 95311, 95313, KUAC 95014, 95015, 95016, 95017, 95018, 95058, 95060, 95061, and 95062. KUAC 95304 is fragmentary and its assignment is uncertain. The large group have a steep slope of the lateral edge of the ilium—acetabulum portion. On the other hand has the small group shows a well developed depression for the medial tendon of the rectus femoris, anteroventral to the acetabulum.

As the pelves from Maragheh are incomplete, it is difficult to define the sex of the specimens. The diameter of the inlet and pelvic inclination can not be estimated. Only the anteroposterior length of the obturator foramen was measured for a limited number of specimens. Its size relative to pelvis size (acetabulum craniocaudal diameter) was used for the estimation of sex.

Among the smaller specimens, KUAC 95058 and 95311 have a relatively great length of the obtuarator foramen, and among the larger specimens, KUAC 95018 has that. As these specimens, measured for the obturator foramen length, are incomplete, their values might not reliable for sex discrimination.

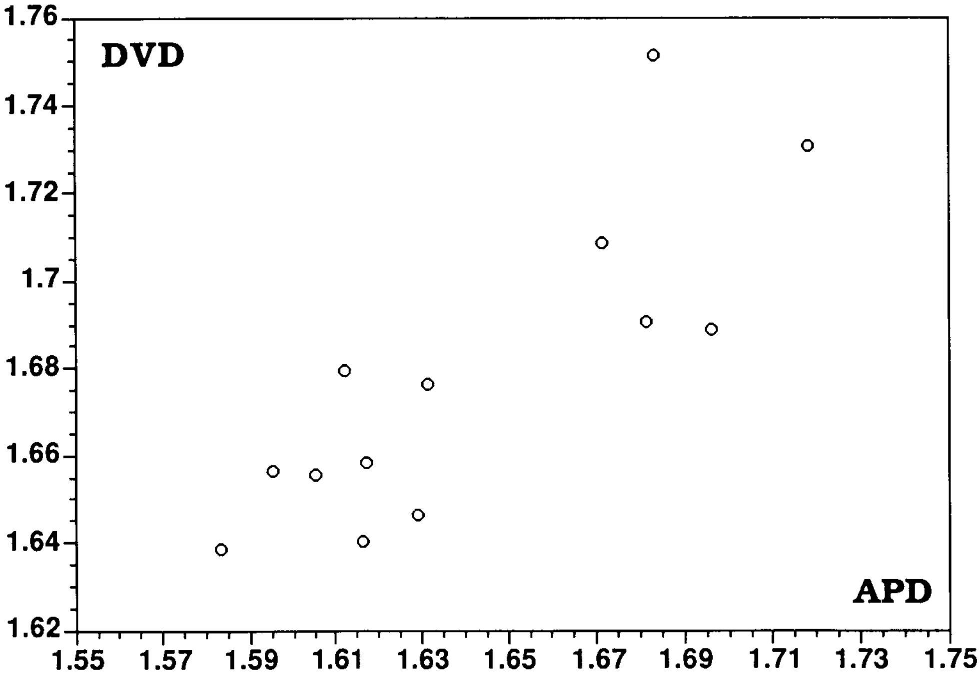


Fig. 14. Dorsoventral diameter of the acetabulum plotted against craniocaudal (anteroposterior) diameter in the Pelvic bone from Maragheh. Logarithmic scale. Two groups are disginguished by overall size. Small forms are probably of *H. moldavicum*. All samples belong to Kyoto University.

12. Association Scheme of Maragheh Postcranials

The three morphotypes recognized in MC III can be directly associated with hind limb morphotypes, however, the number of specimens of MC III is limited.

If specimens of MC III and MT III are completely preserved, the epiphysial dimensions and proportions are obtained on each speimen. The fragmentary third metapodials such as distal and proximal portions which only yield dimensions are classified into each morphotype by guided pattern of the size-proportions correspondence which were obtained for complete specimens.

The association of whole elements in fore and hind limb is as follows:

1) First combination: large to medium, robust morphotype (from upper, middle, and lower Maragheh levels).

MC III overall: medium, robust; MC III distal: large; MC III proximal: large; MC III angle between the facets for the magnum and hamatum: mean 137°; MT III overall: medium, robust; MT III distal part: large; MT III proximal part: large; Cuneiform II facet: less developed; Proximal digit III: large sized; Astragalus: large sized; Calcaneus: large-medium(?) sized.

2) Second combination: large to medium and slender morphotype (from upper and middle Maragheh levels).

MC III overall: large, slender; MC III distal part: medium; MC III proximal part: medium; MC III angle between the facets for the magnum and hamatum: mean is 130°, smaller than those of the other two morphotypes; MT III overall: large, slender; MT III distal: medium; MT III proximal: medium; Cuneiform II facet: developed; Proximal digit III: smaller members of the large-sized group; Astragalus: medium-sized; Calcaneus: medium-sized.

3) Third combination: small and slender morphotype (from upper and middle Maragheh levels).

MC III overall: small, slender; MC III distal part: small; MC III proximal part: small; MC III angle between the facets for the magnum and hamatum: mean is about 136°, or smaller; MT III overall: small, slender; MT III distal: small; MT III proximal: small; Cuneiform II facet: less developed; Proximal dight III: small; Astragalus: small-

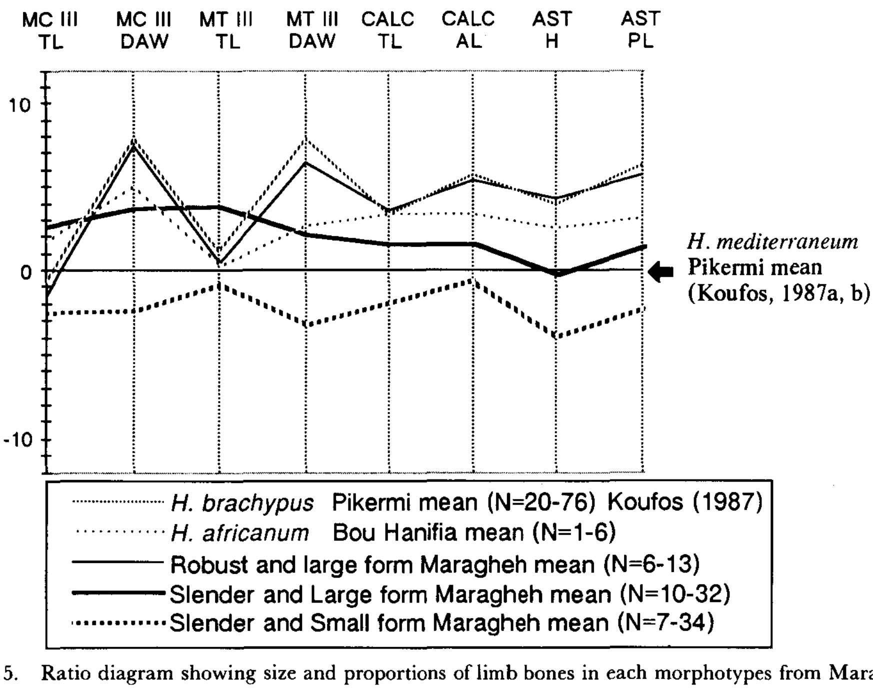


Fig. 15. Ratio diagram showing size and proportions of limb bones in each morphotypes from Maragheh. Vertical axis means 100×log. differences. Robust morphotype from Maragheh assigned to *H. prostylum* shows similarity to large and robust *H. brachypus* from Pikermi. They exhibit more robust third metapodials than Vallesian *H. africanum* from North Africa. Proportions of the large and slender, and small and slender morphotypes from Maragheh (*H. urmiense* and *H. moldavicum*) are similar to those of *H. mediterraneum* from Pikermi. TL: Total length; DAW: Distal articular width; AL: Length of proximal portion; H: Height; and PL: Diameter of the medial condyle.

sized; Calcaneus: small-sized.

The overall proportions of limb bone elements for each postcranial morphotype are shown in Fig. 15. They are compared with those of hipparions from Pikermi (Turolian) and Bou Hanifia (Vallesian).

The robust and large morphotype of limbs is similar to *H. brachypus* from Pikermi. *H. africanum* from Bou Hanifia, Algeria shows smaller size and slender metapodials than those two forms. The large and slender, and small and slender morphotypes of limbs from Maragheh are similar in proportions each other, showing similarity to *H. mediterraneum* from Pikermi.

A detailed discussion of the association between these posteranial morphotypes and skull morphotypes will be presented in another paper (WATABE and NAKAYA, this volume).

13. Stratigraphic Occurrence of Postcranial Combinations in Maragheh Sub-localities

The sub-localities of Maragheh yielding abundant postcranial samples with stratigraphic data are as follows: the UC sub-localities with a range from −115 m to +7 m compared with the 'Loose Chips' pumice bed; the KNHM, Ildtschi with the position of −18 m from that pumice bed; the Kyoto Univ. site −20 m from that pumice bed; the MNHN with a stratigraphic range from −52 m to −28 m; the KNHM, Ketschawa from −52 m to −30 m; the KNHM, Kopran II about −115 m; the KNHM, Kopran with a range from −150 m to −115 m (Fig. 7, 11, 14, 16, and 18). For the detailed stratigraphic position of the UC localities, see BERNOR (1985).

The stratigraphic position for the above mentioned sub-localities, except the Kyoto Univ. site, are based on the data by BERNOR (1985).

The large and slender metapodials combined with a medium-sized astragalus, calcaneus, and proximal phalanx III came from the lowest Kopran (−150 m/−115 m) to the uppermost UC 26 (+7 m) site (solely represented by an astragalus with medium size).

The small and slender metapodials combined with a small-sized astragralus, calcaneus, and proximal phalanx III were found at Kopran II (−115 m m) in the UC 39 (+4 m) site. From Kopran II only a proximal part of MT III of small dimension was discovered. Other postcranial elements of this morphotype (small and slender) begin to appear above Ketschawa (−52 m/−30 m) level.

Though a proximal part of MT III with small size was mentioned in UC 39 (+4 m) other elements of that group were not so. According to BERNOR's (1985) data, very small calcanei were collected from UC 26 (+7 m) and 47 (−6 m). It can not be ascertained whether these are very small adults or juveniles.

Robust metapodials combined with a large astragalus, calcaneus, and proximal phalanx III were collected from the sequence from Kopran II (−115 m: only astragalus) to the Kyoto Univ. site (−20 m). There is a large astragalus from Kopran. Robust elements are well represented at Ketschawa, in the MNHN, and Kyoto Univ. collections. The occurrence of these elements is terminated at the level of the Kyoto Univ. site (−20 m).

In the middle part of the Maragheh Formation (from −52 m to −18 m) three morphotypes of the postcranial size groups co-exist. In a single site (Site III of Kyoto University Excavation), the above three groups (robust, large slender, and small slender.) co-exist.

14. Discussion

Among the postcranial elements from Maragheh three morphotypes were recognized: 1) medium to large-sized and robust morphotype; 2) large-sized and slender morphotype; and 3) small-sized and slender morphotype.

From the Kopran sub-locality, which is considered lower in its horizon than other sub-localities (Bernor, 1986), the medium-sized postcranial bones were found. In the materials labelled "Kopran" specimens, the large specimens were occasionally found, e.g. among the astragalus. It is difficult to decide whether this resulted from contamination after excavation or from their real existence of the large morphotype at the sub-locality.

The two slender morphotypes from Maragheh are similar in their proportions to *Hipparion mediterraneum* from Pikermi of Greece and *H. moldavicum* from Taraklia of Moldavian S.S.R. However, the Maragheh small and slender morphotype is smaller and the large and slender morphotype is larger than *H. mediterraneum* from Pikemi. The robust morphotype is similar in its proportions to *H. brachypus* (=*H. primigenium* of Forstén) from Pikermi and to the Vallesian robust forms (e.g. *Hipparion africanum* from Bou Hanifia, Algeria).

The occurrence of two different proportions of the third metapodials, robust and slender, in the Maragheh was suggested by Forstén's revision on Palearctic hipparions (Forstén, 1968). In contrast to Pikermi, the slender third metapodials from Maragheh combined ignoring size show a wide range of size variation and presumably consist of two distinct morphotypes (a larger and a smaller: as fig. 10 in Forstén, 1968).

Four morphotypes of skulls were distinguished by facial morphology and other metric characters in Maragheh (Watabe and Nakaya, this volume): 1) *Hipparion moldavicum* with narrow POB (small skull: also including *H.* cf. *matthewi* by Bernor, 1985); 2) *H. urmiense* with a shallow POF (=*H. campbelli* by Bernor, 1985); 3) *H. prostylum* with the POF far from the orbit; and 4) *H. gettyi* from the Kopran sub-locality.

Eisenmann and Karchoud (1982) mentioned the correlation between cranial length, and length and distal width of third metapodials of recent *Equus*. They found high correlation between the cranial basal length and the distal width of metapodials. The coefficient of correlation between them is higher than 0.7. In the Maragheh skull material, the cranial basal length could not be measured because of poor preservation. For this reason, we used P2-Orbit distance as skull length, instead of basal length. The proposed correspondence of the Maragheh hipparionine materials are as follows:

For the metarials from the upper and middle Maragheh horizons:

1) the small and slender metapodials belong to the small skull of *H. moldavicum*; 2) the large and slender metapodials belong to the large skull of *H. urmiense*; 3) the large and robust metapodials belong to *H. prostylum*; 4) *Hipparion gettyi* from Kopran sub-locality (lowermost horizon) probably has slender metapodials of medium to large size.

Hipparion moldavicum from Maragheh (large and small together) shows similar facial morphology (POF shape and location) to *H. mediterraneum* from Pikermi, which has similarly slender proportioned metapodials. *Hipparion moldavicum* from Taraklia and *H. elegans* from Pavlodar, Kazakh S.S.R. have slender proportions of third metapodials (FORSTÉN, 1968; 1980).

The postcranial bones larger than those of *H. moldavicum* have been reported from Taraklia, Moldavian S.S.R. by CROMOVA (1952). *Hipparion platygenys* with reduced POF has also been mentioned from the locality by her with proposal of the possibility that *H. platygenys* has large postcranial bones. *Hipparion platygenys* with reduced POF and the postcranials larger than those of *H. moldavicum* from the same locality is phylogenetically closely related to *Hipparion urmiense* (=*H. campbelli*) from Maragheh.

Robust metaposials are found at Vallesian localities such as Inzersdorf (West Germany) and Bou Hanifia (Algeria), and at such Turolian localities as Pikermi, Samos (FORSTÉN, 1968) and some Turkish sites (Staesche and Sondaar, 1979) in the western old World.

If geological precedence is used as a criterion for determination of character transformation polarity, the robust proportions of third metapodials is considered a primitive state (plesiomorphy).

As shown by GROMOVA (1952), the metapodials of *H. primigenium* from Germany, the oldest Eurasian hipparion at present, has proportions somewhat intermediate between the robust *H. brachypus* (=*H. primigenium* of FORSTÉN) and the slender *H. mediterraneum* of Pikermi.

This pattern is also observed in other Vallesian hipparions such as *H. africanum* (North Africa) and *H. ankyranum* (Turkey: notice that *H. ankyranum* from Esme-Akçakoy has smaller overall size than other Vallesian forms: STAESCHE and SONDAAR, 1979).

Slender third metapodials are typically associated with Turolian medium-sized and small hipparions. The state is derived (apomorphic), compared with robust one.

Hipparion gettyi from the Kopran sub-locality shows derived metapodial proportions, differing from Vallesian and Turolian large "*Hipparion primigenium*"-like forms.

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Appendix 1 Measurement of MC III from Maragheh.

SPECIMENS	TL	MW	MD	DAW	DW	DAD	DAD/2	DD	PW	PD	MAG	HAM	ANG	SUB-LOC.
MNHN MAR 44	204.0	22.5	19.6	28.2	30.6	23.8	22.5	24.9	33.4	23.3	27.3	9.1	135	Paris
MNHN MAR 43	206.0	24.6	19.2	32.0	32.2	23.5	21.6	25.6	32.8	23.7	26.0	8.7	142	Paris
MNHN MAR 45	192.0	21.3	18.9	28.8	30.5	20.7	20.4	24.4	32.3	22.7	27.4	9.2	136	Paris
MNHN MAR 47	211.0	24.7	21.8	30.7	33.1	24.0	22.7	25.6	35.8	26.0	30.1	9.5	138	Paris
MNHN MAR 46	211.0	25.6	20.0	33.8	34.8	23.2	22.0	25.0	37.0	23.4	30.6	11.5	130	Paris
MNHN MAR 38	231.0	26.0	22.9	33.3	35.7	26.2	23.0	28.8	39.2	26.7	30.4	10.6	131	Paris
MNHN MAR 36	229.0	25.8	22.4	34.2	37.0	25.5	23.5	28.7	39.2	25.5	33.4	9.8	131	Paris
MNHN MAR 40	234.0	26.2	23.4	34.4	36.0	25.6	23.0	28.8	39.4	27.0	34.6	9.2	130	Paris
MNHN MAR 42	200.0	21.7	20.5	30.5	30.7	22.0	-	24.5	31.2	22.9	26.6	8.3	136	Paris
MNHN MAR 41	198.0	19.6	18.8	26.4	27.1	20.2	18.4	22.4	29.9	22.4	25.6	7.7	134	Paris
MNHN MAR 54	200.0	27.0	22.7	35.7	38.0	26.0	24.6	-	42.2	26.6	35.0	9.5	135	Paris
MNHN MAR 53	209.0	26.8	22.8	39.2	39.8	26.4	24.9	29.6	41.9	28.4	34.0	11.7	141	Paris
MNHN MAR 56	-	21.8	20.2	-	-	-	-	-	33.3	22.2	27.6	10.0	144	Paris
MNHN MAR 55	209.0	32.9	23.3	38.9	42.4	27.6	26.9	29.7	42.3	27.6	33.6	12.6	140	Paris
MNHN MAR 59	-	30.2	23.8	-	-	-	-	-	41.4	28.6	35.9	10.5	131	Paris
MNHN MAR 49	-	27.7	24.0	-	-	25.4	-	-	39.0	26.7	34.1	9.3	140	Paris
MNHN MAR 48	219.0	26.2	20.0	33.6	35.5	25.6	23.9	28.5	35.0	-	-	8.6	140	Paris
MNHN MAR 51	231.0	24.8	23.6	33.9	36.7	25.6	23.7	27.5	37.2	25.8	32.8	8.4	122	Paris
MNHN MAR 50	234.0	26.2	22.2	34.7	37.3	27.0	25.9	29.7	38.0	-	32.3	9.2	139	Paris
MNHN MAR 52	222.0	26.4	22.2	@35	33.4	26.8	@25	29.5	37.4	25.9	31.8	9.5	130	Paris
KNHM W 8634	-	23.0	20.4	29.8	31.4	22.4	20.6	24.2	-	-	-	-	-	DSCHINGIRDERA
KNHM A 4837	204.0	22.6	19.9	29.3	31.1	22.5	20.7	25.0	33.2	23.7	27.9	8.8	140	ILDTSCHI
KNHM W 8691	-	-	-	34.8	37.5	26.6	23.9	28.7	-	-	-	-	-	KETSCHAWA
KNHM W 8689	-	-	-	32.4	34.5	25.7	23.5	27.3	-	-	-	-	-	KETSCHAWA
KNHM W 8688	-	29.6	-	34.6	37.2	26.6	25.7	28.7	-	-	-	-	-	KETSCHAWA
KNHM W 8680	-	-	-	-	-	-	-	-	42.8	25.4	34.9	11.2	140	KETSCHAWA
KNHM W 8681	-	26.8	24.2	-	-	-	-	-	40.1	27.2	34.5	9.2	134	KETSCHAWA
KNHM W 8692	-	-	-	33.9	36.4	25.2	23.4	27.2	-	-	-	-	-	KETSCHAWA
KNHM W 8684	-	24.3	21.0	-	-	-	-	-	35.1	22.6	30.5	7.4	147	KETSCHAWA
KNHM W 8683	-	25.5	-	-	-	-	-	-	34.6	26.0	31.9	-	120	KETSCHAWA
KNHM W 8682	-	-	-	-	-	-	-	-	40.5	28.0	32.8	11.2	133	KETSCHAWA
KNHM W 8687	-	22.1	20.2	29.0	31.1	23.9	22.4	25.2	-	-	-	-	-	KETSCHAWA
KNHM W 8686	-	31.6	23.6	40.0	39.9	29.0	27.4	-	-	-	-	-	-	KETSCHAWA
KNHM W 8685	-	24.3	-	-	-	-	-	-	36.7	-	29.5	11.2	140	KETSCHAWA
KNHM W-NO/3	-	-	-	36.4	37.8	26.4	25.0	27.8	-	-	-	-	-	KETSCHAWA
KNHM W 86114	-	28.1	23.3	35.7	37.4	26.2	24.5	29.1	-	-	-	-	-	KETSCHAWA
KNHM A 4838	212.0	31.2	23.1	39.6	40.0	27.7	26.2	30.6	44.4	-	38.1	12.8	140	KETSCHAWA
KNHM A 4840/2	206.0	24.6	20.5	31.7	34.5	24.8	22.8	26.7	33.0	26.9	27.5	8.0	142	KETSCHAWA

Appendix 1 (continued)

SPECIMENS	TL	MW	MD	DAW	DW	DAD	DAD/2	DD	PW	PD	MAG	HAM	ANG	SUB-LOC.
KNHM A 4840	207.0	25.6	20.6	31.9	35.3	25.0	24.1	28.1	37.9	26.3	32.1	9.0	142	KETSCHAWA
KNHM W 8677	-	-	23.6	-	-	-	-	-	42.9	29.0	36.0	11.8	130	KETSCHAWA
KNHM W-NO/5	-	22.9	20.7	-	-	-	-	-	34.5	-	29.2	9.1	139	KETSCHAWA
KNHM W-NO/4	-	-	-	36.0	37.8	26.2	25.1	27.8	-	-	-	-	-	KETSCHAWA
KNHM W 8678	-	23.4	20.5	-	-	-	-	-	34.0	23.9	27.4	10.0	142	KETSCHAWA
KNHM W 8679	-	-	-	-	-	-	-	-	45.0	30.0	37.4	11.0	143	KETSCHAWA
KNHM W 8669	-	-	-	33.3	31.9	24.2	22.2	26.4	-	-	-	-	-	KOPRAN
KNHM W 8638	-	-	-	35.7	35.0	26.5	24.1	-	-	-	-	-	-	KOPRAN
KNHM W 8637	-	-	-	33.8	35.6	25.0	23.3	26.8	-	-	-	-	-	KOPRAN
KNHM W-NO/2	-	-	-	32.4	32.5	25.6	23.8	27.6	-	-	-	-	-	KOPRAN
KNHM W-NO/1	-	-	-	32.4	•	25.6	23.8	25.7	-	-	-	-	-	KOPRAN
KNHM W 8647	-	-	-	37.6	38.7	27.3	26.1	30.4	-	-	-	-	-	KOPRAN II
KNHM W 8646	-	-	-	-	-	-	-	-	38.6	24.0	32.6	9.1	140	KOPRAN II
KNHM W 8648	-	-	-	35.1	34.8	25.2	23.3	27.8	-	-	-	-	-	KOPRAN II
KUAC 95020	215.0	31.4	24.1	39.1	40.0	26.6	25.9	30.2	41.0	27.7	35.0	11.1	133	KYOTO
KUAC 95317	235.0	29.4	24.0	36.3	37.8	27.1	24.3	30.2	40.5	28.1	33.6	10.6	-	KYOTO
KUAC 95315	-	27.5	23.1	35.5	37.4	26.7	25.7	28.9	-	-	-	-	-	KYOTO
KUAC 95068	228.0	25.7	21.7	35.6	36.2	23.8	23.3	28.1	33.9	-	-	8.4	127	KYOTO
KUAC 95321	205.0	28.4	21.4	36.2	36.8	27.4	25.7	30.6	42.0	28.0	33.8	12.0	133	KYOTO
KUAC 95322	-	28.0	23.2	35.6	37.4	26.8	25.4	28.8	-	-	-	-	-	KYOTO
KUAC 95065	-	22.9	20.3	30.0	31.3	23.0	20.5	24.2	-	-	-	-	-	KYOTO
KUAC 95066	-	22.9	20.4	29.9	32.0	22.9	20.9	23.9	-	-	-	-	-	KYOTO
KUAC 95067	238.0	26.7	23.7	36.3	37.3	26.6	25.2	29.9	40.6	28.0	34.3	10.0	125	KYOTO
UC 13/1378	-	24.6	22.5	33.4	32.7	25.3	-	27.4	-	-	-	-	-	UC 13 (-18m)
UC 13/1154	-	-	-	-	-	-	-	-	37.6	23.6	30.7	8.9	-	UC 13 (-18m)
UC 37/2194	-	25.7	21.9	-	-	-	-	-	38.7	23.0	29.5	10.8	149	UC 37 (-18m):ILDTSCHI
UC 37/2040	-	-	-	-	-	-	-	-	37.8	26.3	33.0	10.0	-	UC 37 (-18m):ILDTSCHI
UC 7/1995	-	-	-	36.6	38.4	27.3	-	29.6	-	-	-	-	-	UC 7 (-28m)
UC 14/1529	-	-	-	37.1	39.4	26.7	-	30.4	-	-	-	-	-	UC 14 (-28m)
UC 7/1997	-	-	-	-	-	-	-	-	43.0	34.9	-	-	-	UC 7(-28m)
UC 20/1657	-	-	-	31.0	30.8	22.1	-	26.3	-	-	-	-	-	UC 20 (-30m)

TL: Total length
MW: Medial width
MD: Medial diameter
DAW: Distal articular width
DW: Distal width

PW: Proximal width
PD: Proximal diameter

Appendix 1 (continued)

SPECIMENS	TL	MW	MD	DAW	DW	DAD	DAD/2	DD	PW	PD	MAG	HAM	ANG	SUB-LOC.

DAD: Distal articular diameter (medial)
DAD/2: Distal articular diameter (lateral)
DD: Distal diameter in sagittal keel

MAG: Width of the facet for the Magnum
HAM: Width of the facet for the Hamatum
ANG: Angle between those facets

SUB-LOC: Sub-localities

() means the level in relation to the 'Loose Chips' pumice bed.

Paris: MNHN (-28 m - -52 m)
ILDTSCHI: KNHM (-18 m)
KETSCHAWA: KNHM (-30m - -52 m)
DSCHINGIRDERA: KNHM (?)
KARA KEND: KNHM (?)
ZAD BASCHI: KNHM (?)
KOPRAN: KNHM (-115m - -150 m)
KOPRAN II: KNHM (-115m)
KYOTO: Kyoto Univ. (-20m)
UC: Univ. California

Appendix 2 Measurement of MT III from Maragheh.

SPECIMENS	TL	MW	MD	DAW	DW	DAD	DAD/2	DD	PW	PD	CUN/2	CUN/3	CUBD	TYPE	SUB-LOC.
MNHN MAR 15	239.0	27.8	26.5	37.0	38.9	-	24.7	30.4	41.8	32.7	-	37.2	8.2	3	Paris
MNHN MAR 16	234.0	26.6	26.6	33.0	37.4	25.9	24.6	29.3	37.0	28.1	3.8	34.6	8.7	-	Paris
MNHN MAR 14	242.0	27.0	26.2	37.3	37.8	27.4	25.6	31.5	42.0	31.3	6.1	38.3	-	3	Paris
MNHN MAR 13	249.0	26.6	27.1	37.2	39.4	28.6	25.7	32.0	37.8	-	6.3	37.7	9.5	3	Paris
MNHN MAR 2	228.0	23.3	23.1	30.2	34.0	22.7	20.9	26.3	33.2	27.4	3.6	31.3	4.8	1	Paris
MNHN MAR 19	238.0	29.8	26.7	35.8	37.6	25.6	22.8	29.1	40.6	30.0	4.6	36.7	10.9	2.5	Paris
MNHN MAR 17	234.0	27.4	26.5	33.2	37.7	26.2	24.6	28.5	37.4	28.9	2.0	-	6.5	2	Paris
MNHN MAR 18	239.0	29.8	27.3	37.4	38.4	28.7	25.2	33.4	41.0	30.6	6.8	37.5	9.3	3	Paris
MNHN MAR 1	231.0	20.4	23.6	28.6	30.2	24.1	21.5	26.1	31.2	27.4	0.5	29.2	8.8	3	Paris
MNHN MAR 10	244.0	27.9	27.2	34.3	-	26.2	24.3	29.3	40.0	29.3	5.1	36.1	-	-	Paris
MNHN MAR 9	266.0	25.7	25.6	35.3	36.3	25.0	23.6	29.3	-	-	-	-	5.6	1	Paris
MNHN MAR 8	240.0	24.1	25.7	29.2	30.9	25.3	22.4	28.8	33.3	28.4	1.0	30.4	7.3	2	Paris
MNHN MAR 12	234.0	27.6	27.1	33.0	35.5	26.0	23.4	29.5	37.8	32.0	5.8	35.0	-	-	Paris
MNHN MAR 125	-	-	-	-	-	-	-	-	35.7	27.9	4.8	33.4	11.3	3	Paris
MNHN MAR 104	-	23.0	23.5	-	-	-	-	-	32.9	27.4	2.5	31.4	6.7	1.5	Paris
MNHN MAR 11	253.0	26.2	26.8	33.2	33.8	28.3	25.5	31.2	38.7	-	6.7	35.4	9.9	3	Paris
MNHN MAR 20	240.0	24.8	26.7	35.0	36.9	27.5	24.0	30.7	41.0	33.0	2.9	37.8	9.6	2	Paris
MNHN MAR 3	237.0	28.0	27.8	38.6	41.0	29.0	25.1	32.0	43.8	34.8	2.4	39.5	5.7	2.5	Paris

Appendix 2 (continued)

SPECIMENS	TL	MW	MD	DAW	DW	DAD	DAD/2	DD	PW	PD	CUN/2	CUN/3	CUBD	TYPE	SUB-LOC.
MNHN MAR 29	261.0	29.0	27.7	35.7	38.3	27.6	24.7	31.4	40.7	37.8	4.9	38.2	9.4	2.5	Paris
MNHN MAR 30	246.0	30.6	27.8	37.2	38.8	28.9	25.6	-	-	30.8	6.1	-	-	3	Paris
MNHN MAR 27	266.0	25.8	28.3	35.0	38.2	27.0	25.0	30.8	41.2	34.0	5.8	38.0	9.1	3	Paris
MNHN MAR 26	237.0	24.8	26.0	30.0	32.0	23.0	21.4	25.1	33.7	26.7	3.0	31.0	5.0	2	Paris
MNHN MAR 25	252.0	25.8	26.1	34.6	36.0	25.7	22.1	29.8	39.4	31.2	4.6	35.7	8.6	3	Paris
MNHN MAR 26	-	24.5	23.7	-	-	-	-	-	33.7	27.1	3.4	32.2	6.1	2	Paris
MNHN MAR 24	227.0	21.2	22.6	27.6	30.8	22.3	20.1	24.8	30.2	25.7	3.6	28.2	6.7	2	Paris
MNHN MAR 22	238.0	23.5	24.0	30.5	31.9	24.7	22.0	-	33.9	-	0.0	30.7	-	1	Paris
MNHN MAR 23	242.0	27.9	27.1	37.0	37.8	29.8	27.6	34.1	41.6	30.3	-	38.0	9.2	1.5	Paris
MNHN MAR 28	268.0	25.1	26.5	32.1	33.9	25.9	23.5	30.2	38.9	-	4.0	35.8	8.8	2	Paris
MNHN MAR 5	219.0	21.6	22.6	27.1	30.3	23.0	20.1	-	32.3	26.1	2.1	29.7	7.2	-	Paris
MNHN MAR 4	233.0	22.3	24.1	31.1	32.2	25.6	23.4	28.9	24.9	25.9	-	31.3	9.8	1.5	Paris
MNHN MAR 6	240.0	22.6	23.5	30.4	33.6	24.1	22.1	27.8	36.3	28.0	2.6	34.0	6.0	1.5	Paris
MNHN MAR 21	220.0	22.5	23.3	28.4	28.8	23.0	21.0	24.0	30.2	28.8	0.0	-	-	1	Paris
MNHN MAR 7	235.0	23.9	24.4	31.0	33.3	24.3	21.4	-	34.6	26.2	3.3	32.3	6.5	2	Paris
MNHN MAR 32	260.0	26.2	26.0	35.0	37.1	25.9	23.2	28.6	39.4	29.0	6.6	37.1	10.0	3	Paris
MNHN MAR 31	268.0	28.7	28.0	34.7	37.4	28.5	25.6	31.4	38.6	35.0	5.0	37.2	7.6	3	Paris
MNHN MAR 33	265.0	26.6	28.8	35.3	38.1	27.4	25.6	31.2	39.9	32.4	7.3	37.5	9.3	3	Paris
MNHN MAR 35	242.0	31.7	29.4	40.3	42.0	30.5	26.8	34.0	44.0	34.2	7.0	40.1	12.7	3	Paris
MNHN MAR 34	250.0	29.4	28.3	-	41.8	30.2	27.9	33.8	43.1	32.8	5.7	38.1	7.8	3	Paris
KNHM W 8629	-	23.4	24.0	-	-	-	-	-	31.4	-	4.3	29.0	7.4	2	DSCHINGIRDERA
KNHM W 8630	-	22.7	22.5	-	-	-	-	-	33.8	29.4	2.9	32.0	10.2	2	DSCHINGIRDERA
KNHM W 8631	-	28.5	27.1	-	-	-	-	-	41.5	30.0	6.2	37.9	11.0	2	DSCHINGIRDERA
KNHM W 8626	202.0	23.9	24.5	28.4	31.0	23.6	21.7	27.0	-	-	-	-	-	-	DSCHINGIRDERA
KNHM W 8628	-	-	-	-	-	-	-	-	41.3	32.3	7.8	36.6	7.4	2	DSCHINGIRDERA
KNHM W 8625	-	31.9	28.7	40.2	42.5	30.1	27.8	-	-	-	-	-	-	-	DSCHINGIRDERA
KNHM W 8632	-	28.8	28.4	38.6	38.2	28.6	24.8	30.5	-	-	-	-	-	-	DSCHINGIRDERA
KNHM W 8633	-	25.5	23.3	30.8	31.2	24.6	22.4	28.3	-	-	-	-	-	-	DSCHINGIRDERA
KNHM W 8673	-	26.3	24.2	-	-	-	-	-	35.7	-	-	-	-	2	ILDTSCHI
KNHM W 8676	-	-	-	33.6	32.6	26.7	24.0	30.6	-	-	-	-	-	-	ILDTSCHI
KNHM W 8674	-	26.0	25.3	33.0	34.8	25.4	23.2	29.2	-	-	-	-	-	-	ILDTSCHI
KNHM W 8675	-	-	-	-	-	-	-	-	38.3	28.5	-	-	-	-	ILDTSCHI
KNHM W 8627	-	25.2	29.6	-	-	-	-	-	35.0	32.0	4.4	34.0	-	2.5	KARA KEND
KNHM W 86115	-	23.7	24.7	28.9	31.4	24.3	22.4	27.0	-	-	-	-	-	-	KETSCHAWA
KNHM W 86104	-	23.9	24.1	-	-	-	-	-	34.6	28.9	3.1	31.4	7.4	2	KETSCHAWA
KNHM W 86105	-	30.2	30.2	-	-	-	-	-	43.2	31.7	5.2	39.8	9.4	2	KETSCHAWA
KNHM W 86106	-	-	-	-	-	-	-	-	40.6	34.2	4.7	37.5	9.3	3	KETSCHAWA
KNHM W 86103	-	25.5	22.8	-	-	-	-	-	34.9	27.1	2.4	31.7	7.5	2	KETSCHAWA
KNHM W 86100	-	27.1	28.0	-	-	-	-	-	38.6	28.7	6.8	35.0	11.3	2	KETSCHAWA
KNHM W 86101	-	23.2	23.3	-	-	-	-	-	34.6	28.7	3.2	31.3	7.8	1	KETSCHAWA
KNHM W 86102	-	27.5	26.6	-	-	-	-	-	38.6	31.6	7.3	37.1	10.3	3	KETSCHAWA

Appendix 2 (continued)

SPECIMENS	TL	MW	MD	DAW	DW	DAD	DAD/2	DD	PW	PD	CUN/2	CUN/3	CUBD	TYPE	SUB-LOC.
KNHM W 86111	-	28.8	27.8	-	-	-	-	-	41.8	35.0	3.1	37.7	10.0	1	KETSCHAWA
KNHM W 86112	-	20.6	23.1	-	-	-	-	-	32.0	26.0	0.0	30.1	6.6	1	KETSCHAWA
KNHM W 86113	-	29.1	29.3	-	-	-	-	-	42.9	31.5	3.8	39.2	10.7	-	KETSCHAWA
KNHM W 86110	-	26.8	27.7	-	-	-	-	-	39.3	32.6	6.5	36.9	9.2	3	KETSCHAWA
KNHM W 86107	-	30.1	25.8	-	-	-	-	-	41.2	30.1	5.2	39.0	8.9	3	KETSCHAWA
KNHM W 86108	-	-	-	-	-	-	-	-	37.2	29.1	4.7	34.5	8.3	2	KETSCHAWA
KNHM W 86109	-	-	-	-	-	-	-	-	35.0	28.7	2.2	31.9	8.0	2	KETSCHAWA
KNHM W/NO/16	-	-	-	26.6	25.9	22.2	21.7	24.9	-	-	-	-	-	-	KETSCHAWA
KNHM W/NO/2	-	-	-	39.5	42.6	30.2	26.4	33.0	-	-	-	-	-	-	KETSCHAWA
KNHM W/NO/15	-	-	-	40.4	41.6	28.3	25.0	32.9	-	-	-	-	-	-	KETSCHAWA
KNHM W/NO/13	-	23.3	20.6	28.8	31.5	23.4	20.8	26.3	-	-	-	-	-	-	KETSCHAWA
KNHM W/NO/14	-	-	-	30.1	-	-	-	26.2	-	-	-	-	-	-	KETSCHAWA
KNHM W/NO/3	-	-	-	41.4	43.2	29.6	26.7	35.1	-	-	-	-	-	1	KETSCHAWA
KNHM W/NO/8	-	-	-	34.6	37.7	26.6	23.1	-	-	-	-	-	-	-	KETSCHAWA
KNHM W/NO/9	-	-	-	36.2	43.6	28.1	24.7	29.6	-	-	-	-	-	-	KETSCHAWA
KNHM W/NO/6	-	30.9	29.0	-	-	-	-	-	-	-	-	-	-	-	KETSCHAWA
KNHM W/NO/4	-	28.6	27.8	-	-	-	-	-	-	-	-	-	-	-	KETSCHAWA
KNHM W/NO/5	-	28.0	30.1	39.2	40.9	-	25.6	-	-	-	-	-	-	-	KETSCHAWA
KNHM W 8695	-	-	-	31.9	32.9	25.6	23.2	29.2	-	-	-	-	-	-	KETSCHAWA
KNHM W 8697	-	25.1	21.2	31.2	32.2	24.9	22.0	26.7	-	-	-	-	-	-	KETSCHAWA
KNHM W 8694	-	-	-	-	34.6	26.0	23.1	28.3	-	-	-	-	-	-	KETSCHAWA
KNHM W 8690	-	-	-	36.2	35.4	27.6	25.4	31.0	-	-	-	-	-	-	KETSCHAWA
KNHM W 8693	-	26.2	24.3	35.8	36.0	26.0	23.7	30.1	-	-	-	-	-	-	KETSCHAWA
KNHM W 8698	-	24.0	24.3	33.5	35.9	25.7	23.5	28.9	-	-	-	-	-	-	KETSCHAWA
KNHM W/NO/11	-	-	-	33.2	34.8	24.8	22.1	25.8	-	-	-	-	-	-	KETSCHAWA
KNHM W/NO/12	-	-	-	30.0	32.1	23.6	21.6	26.5	-	-	-	-	-	-	KETSCHAWA
KNHM W/NO/10	-	-	-	39.8	41.2	29.4	26.4	-	-	-	-	-	-	-	KETSCHAWA
KNHM W 8699	-	27.6	26.5	35.0	36.1	28.0	25.5	28.8	-	-	-	-	-	-	KETSCHAWA
KNHM W/NO/1	-	29.4	28.5	-	-	-	-	-	-	-	-	-	-	-	KETSCHAWA
KNHM A 4843	268.0	27.4	29.0	34.7	38.0	26.5	24.3	31.1	38.8	31.5	6.5	36.8	9.8	3	KETSCHAWA
KNHM A 4843/2	-	26.3	30.2	-	-	-	-	-	40.2	33.4	7.4	37.7	9.5	3	KETSCHAWA
KNHM W 8602	-	-	-	-	-	-	-	-	43.9	34.8	7.8	40.8	10.4	2.5	KETSCHAWA
KNHM W 8601	-	-	-	-	-	-	-	-	42.6	32.2	2.6	39.9	9.6	1	KETSCHAWA
KNHM W 8636	-	24.1	22.1	31.7	31.4	26.4	22.6	26.8	-	-	-	-	-	-	KOPRAN
KNHM W 8639	-	25.0	23.3	33.2	36.3	25.4	23.6	27.7	-	-	-	-	-	-	KOPRAN
KNHM W 8670	-	-	-	31.0	31.4	25.0	23.2	26.7	-	-	-	-	-	-	KOPRAN
KNHM W 8635	-	23.5	22.9	30.7	30.7	26.6	23.4	29.0	-	-	-	-	-	-	KOPRAN
KNHM W 8650	-	-	-	-	-	-	-	-	38.0	29.8	6.9	35.3	9.7	3	KOPRAN II
KNHM W 8649	-	-	-	-	-	-	-	-	-	-	-	-	-	-	KOPRAN II
KNHM W 8651	-	-	-	-	-	-	-	-	33.5	26.9	0.0	31.4	7.7	1	KOPRAN II
KNHM W 8655	-	-	-	34.1	-	24.9	23.5	27.6	-	-	-	-	-	-	KOPRAN II

Appendix 2 (continued)

SPECIMENS	TL	MW	MD	DAW	DW	DAD	DAD/2	DD	PW	PD	CUN/2	CUN/3	CUBD	TYPE	SUB-LOC.
KNHM W 8656	-	-	-	-	-	26.3	24.5	29.3	-	-	-	-	-	-	KOPRAN II
KNHM W 8654	-	-	-	34.7	-	26.8	25.1	29.2	-	-	-	-	-	-	KOPRAN II
KNHM W 8652	-	-	-	33.7	-	26.2	24.4	30.3	-	-	-	-	-	-	KOPRAN II
KNHM W 8653	-	-	-	33.9	-	25.6	23.2	29.0	-	-	-	-	-	-	KOPRAN II
KNHM W 8645	-	-	-	37.4	-	26.4	-	30.0	-	-	-	-	-	-	ZAD BASCHI
KNHM W 8644	-	-	-	34.1	34.8	26.3	24.3	31.2	-	-	-	-	-	-	ZAD BASCHI
KNHM W 8643	-	-	-	41.3	-	31.0	28.6	34.5	-	-	-	-	-	-	ZAD BASCHI
KUAC 95049	-	25.7	28.1	-	-	-	-	-	37.9	30.8	6.8	34.7	8.2	1	KYOTO
KUAC 95006	248.0	30.8	29.4	41.1	44.1	29.2	26.2	33.9	45.0	34.1	-	41.5	9.5	-	KYOTO
KUAC 95050	-	26.8	25.6	-	-	-	-	-	38.1	29.0	5.8	37.1	8.8	2	KYOTO
KUAC 95090	234.0	23.1	23.1	30.5	32.3	24.5	22.0	26.8	31.0	27.0	2.7	29.0	6.4	2	KYOTO
KUAC 95051	252.0	24.6	25.7	32.9	32.9	25.9	22.8	28.5	37.4	28.9	4.9	34.2	8.8	1.5	KYOTO
KUAC 95318	232.0	23.5	23.9	30.3	32.3	23.5	20.8	24.9	32.4	27.0	-	30.3	8.0	-	KYOTO
KUAC 95316	-	-	-	-	-	-	-	-	34.5	27.7	3.0	31.5	7.4	2	KYOTO
KUAC 95319	-	23.5	23.6	-	-	-	-	-	34.0	27.1	4.3	31.0	8.5	2.5	KYOTO
UC 39/2374	-	-	-	-	-	-	-	-	33.9	24.5	5.1	30.3	7.7	3	UC 39 (+4m)
UC 39/2372	-	-	-	-	-	-	-	-	36.6	33.0	6.7	34.9	7.3	3	UC 39 (+4m)
UC 26/1681	-	-	-	-	-	-	-	-	35.1	29.8	5.3	32.5	7.6	3	UC 26 (+7m)
UC 13/RLB 26	-	-	-	33.5	30.9	26.7	-	30.0	-	-	-	-	-	-	UC 13 (-18m)
UC 13/E	250.3	23.6	24.2	31.7	30.7	26.6	-	28.4	34.3	28.4	4.9	31.1	10.1	3	UC 13 (-18m)
UC 13/1380	-	20.4	21.0	-	-	-	-	-	-	-	-	-	-	-	UC 13 (-18m)
UC 13/1384	-	22.2	25.4	-	-	-	-	-	-	-	-	-	-	-	UC 13 (-18m)
UC 13/1622	253.8	23.2	25.0	31.6	33.5	26.0	-	28.9	37.3	31.0	4.9	33.7	12.3	3	UC 13 (-18m)
UC 13/1156	-	-	-	31.8	30.7	26.8	-	-	-	-	-	-	-	-	UC 13 (-18m)
UC 7/2314	-	-	-	-	-	-	-	-	38.3	34.0	6.7	33.4	11.1	3	UC 7 (-28m)
UC 7/2302	-	-	-	-	-	-	-	-	39.4	33.1	5.5	35.7	10.1	3	UC 7 (-28m)
UC 7/2147	-	-	-	-	-	-	-	-	41.8	31.3	5.0	35.8	10.1	3	UC 7 (-28m)
UC 20/1698	-	-	-	30.6	31.8	25.9	-	30.0	-	-	-	-	-	-	UC 7 (-28m)

TL: Total length
MW: Medial width
MD: Medial diameter
DAW: Distal articular width
DAD: Distal articular diameter (medial)
DAD/2: Distal articular diameter (lateral)
DD: Distal diameter in sagittal keeel
PW: Proximal width
PD: Proximal diameter

CUN/2: Width of the facet for the Cuneiform II
CUN/3: Width of the facet for the Cuneiform III
CUBD: Width of the facet for the Cuboid
TYPE: morphology of the facet for the Cuneiform II
1: no marked facet.
2: narrow facet tilted posteriorly
3: nearly horizontal wide facet

Appendix 3 Measurement of Proximal Phalange III from Maragheh.

SPECIMENS	TL	ANTL	MW	PW	PD	DW	DAW	DAD	DAD/2	VL	10
MNHN MAR 125	50.9	47.3	21.0	29.6	26.2	25.2	•	15.8	•	17.3	•
MNHN MAR 126	54.5	51.4	22.7	33.6	25.7	27.8	27.6	17.0	•	18.5	•
MNHN MAR 121	55.2	50.5	23.2	31.7	27.7	28.6	25.4	17.0	•	13.8	•
MNHN MAR 123	56.0	48.6	22.2	31.8	30.5	27.0	26.2	15.8	•	•	•
MNHN MAR 115	56.0	49.6	23.9	33.8	28.0	29.0	27.5	17.3	•	12.1	•
MNHN MAR 124	56.2	48.4	28.2	37.6	28.3	30.9	28.5	18.2	•	17.8	•
MNHN MAR 132	56.8	53.5	22.0	31.3	26.0	27.7	26.9	17.3	•	14.9	•
MNHN MAR 136	57.0	51.5	21.5	31.7	24.9	25.8	28.0	16.3	•	15.8	•
MNHN MAR 119	57.3	51.2	25.3	36.0	29.1	30.3	29.2	18.8	•	18.4	•
MNHN MAR 135	58.4	55.9	25.4	36.4	26.9	31.0	30.5	19.2	•	16.7	•
MNHN MAR 118	58.5	55.1	26.1	37.0	28.4	31.5	31.6	19.4	•	24.0	•
MNHN MAR 112	58.5	52.7	23.8	33.5	27.8	28.4	26.9	17.2	•	17.7	•
MNHN MAR 122	58.7	53.8	25.1	35.7	28.3	29.6	30.6	19.0	•	17.2	•
MNHN MAR 133	58.9	54.8	26.5	38.5	28.4	30.7	31.3	18.4	•	21.4	•
MNHN MAR 134	59.0	55.2	21.3	32.7	25.4	26.9	27.1	17.0	•	19.0	•
MNHN MAR 129	59.0	52.8	23.8	36.0	28.5	29.6	29.1	18.6	•	19.0	•
MNHN MAR 131	59.3	53.8	29.0	42.2	31.7	33.9	34.1	23.3	•	21.4	•
MNHN MAR 109	59.7	56.2	27.7	•	30.5	33.0	32.1	19.1	•	30.3	•
MNHN MAR 128	59.9	54.6	27.0	38.2	30.4	31.2	31.6	19.1	•	25.4	•
MNHN MAR 138	60.5	55.1	30.2	•	34.0	37.1	31.6	21.3	•	20.3	•
MNHN MAR 114	60.8	56.8	28.4	•	30.2	33.1	32.7	20.6	•	26.0	•
MNHN MAR 110	60.8	56.0	28.3	38.8	32.3	32.0	31.5	19.8	•	28.4	•
MNHN MAR 113	60.9	57.4	24.0	32.9	28.4	27.9	27.8	17.7	•	15.8	•
MNHN MAR 130	61.2	57.6	21.6	•	•	26.8	27.7	17.2	•	•	•
MNHN MAR 139	61.5	55.0	24.8	35.1	27.6	30.4	29.4	19.1	•	22.2	•
MNHN MAR 137	61.8	56.3	29.0	42.8	31.9	32.6	35.4	21.8	•	22.0	•
MNHN MAR 140	62.8	57.1	31.0	43.7	33.8	34.0	34.6	21.5	•	26.7	•
MNHN MAR 237	63.5	57.1	28.6	40.2	32.3	33.5	33.3	20.3	•	28.0	•
MNHN MAR 111	64.4	60.5	24.1	35.9	29.0	29.1	31.0	19.6	•	18.5	•
MNHN MAR 116	64.8	60.3	29.8	41.2	30.4	33.2	33.6	20.4	•	23.7	•
MNHN MAR 127	65.5	59.0	24.0	•	•	27.5	28.7	18.5	•	28.9	•
MNHN MAR 108	68.1	61.7	29.9	44.8	35.4	35.8	33.8	21.8	•	33.5	•
KUAC 95019	67.9	64.6	29.6	41.0	30.4	33.7	33.4	21.9	•	26.7	•
KUAC 95309	58.5	51.3	29.2	37.0	30.3	30.2	32.6	19.5	18.6	10.9	13.4

TL: Total length
ANTL: Anterior length
MW: Medial width
PW: Proximal width
PD: Proximal diameter
DW: Distal width
DAW: Distal articular width
DAD: Distal articualr diameter (medial)
DAD/2: Distal articular dismeter (lateral)
VL: Volar length of V-scar
10: Medial infratuberosital length
10': Lateral infratuberosital length
/Juv: juvenile

Appendix 4 Measurement of Medial Phalange III from Maragheh.

SPECIMENS	TL	ANTL	MW	PW	PD	DAW
MNHN MAR 239	42.0	31.6	33.7	43.7	28.1	39.9
MNHN MAR 241	39.5	30.3	32.8	38.6	26.4	37.0
MNHN MAR 240	38.0	31.0	29.6	36.0	25.7	35.0
KUAC 95019	41.8	35.4	34.2	40.8	28.9	36.3

TL: Total length
ANTL: Anterior length
MW: Medial width
PW: Proximal width
PD: Proximal width
DAW: Distal articular width

Appendix 5 Measurement of Astragali from Maragheh.

SPECIMENS	H(1)	PL(2)	PW(3)	W(4)	DAW(5)	DAD(6)	D(7)	LOCALITY
MNHN MAR 227	54.0	56.7	23.7	47.3	35.2	31.4	43.8	Paris
MNHN MAR 234	54.4	55.2	26.2	49.1	41.7	30.4	42.4	Paris
MNHN MAR NO-7	57.7	54.1	24.3	49.0	•	26.8	51.0	Paris
MNHN MAR 217	54.2	54.7	23.1	50.2	40.3	31.0	44.8	Paris
MNHN MAR NO-0	48.0	49.6	25.7	43.9	35.2	28.7	39.0	Paris
MNHN MAR 226	46.0	48.4	22.2	44.9	33.7	26.0	39.1	Paris
MNHN MAR NO-2	42.8	43.5	21.2	40.5	34.4	25.0	36.8	Paris
MNHN MAR 230	61.0	58.4	29.3	60.6	47.1	32.4	50.6	Paris
MNHN MAR 219	58.0	60.6	29.1	61.3	47.0	33.6	53.0	Paris
MNHN MAR 141	•	•	23.4	44.0	37.2	29.8	40.0	Paris
MNHN MAR 218	55.0	53.6	24.5	49.0	39.2	30.0	44.6	Paris
MNHN MAR 216	45.2	46.2	21.5	42.3	32.0	24.4	36.9	Paris
MNHN MAR 224	51.2	54.1	21.4	48.8	38.3	29.6	43.1	Paris
MNHN MAR 236	50.0	51.0	24.0	49.8	39.7	28.4	42.2	Paris
MNHN MAR 235	52.3	50.8	24.8	50.6	41.1	28.8	44.9	Paris
MNHN MAR 232	56.9	55.0	24.4	51.8	42.0	31.2	42.6	Paris
MNHN MAR 220	57.0	57.2	27.4	53.3	43.6	33.6	48.7	Paris
MNHN MAR 222	52.9	53.7	22.8	52.1	42.2	30.8	44.0	Paris
MNHN MAR 223	54.1	54.6	25.0	52.0	41.2	31.4	46.0	Paris
MNHN MAR 228	57.4	55.2	27.5	56.4	44.0	32.0	44.0	Paris
MNHN MAR 229	59.1	60.1	27.3	57.8	45.0	33.5	48.7	Paris
MNHN MAR 225	54.3	56.6	24.2	54.8	44.6	31.3	47.6	Paris
MNHN MAR 231	52.5	52.7	23.5	50.8	39.8	29.7	44.8	Paris
MNHN MAR 233	53.0	53.2	25.0	52.2	42.7	29.5	44.8	Paris
KNHM W 8660	51.5	50.5	22.5	45.0	37.9	29.9	40.5	KOPRAN
KNHM W 8661	58.5	61.2	27.7	60.6	50.8	34.6	53.1	KOPRAN
KNHM W 8662	53.1	47.0	23.9	51.2	40.6	31.2	40.0	KOPRAN
KNHM W 8663	50.2	49.1	23.4	46.6	38.2	28.9	38.9	KOPRAN
KNHM W 8664	52.5	52.0	23.9	47.0	38.8	29.7	40.4	KOPRAN
KNHM W 8665	50.3	47.8	22.3	45.6	38.1	28.9	39.3	KOPRAN
KNHM A 4858	49.1	49.2	22.2	44.9	36.9	29.7	40.7	
KNHM W 8607	57.0	57.7	25.0	56.3	43.3	31.3	47.8	KOPRAN
KNHM W 8608	51.5	50.2	23.4	46.7	37.2	29.8	40.1	KOPRAN
KNHM W 8609	51.7	51.0	23.0	46.2	37.0	38.4	41.4	KOPRAN
KNHM W 8610	52.0	52.0	24.6	52.2	43.5	31.6	42.2	
KNHM W 8611	50.0	49.3	21.6	44.4	36.4	29.5	40.7	
KNHM W 8641	52.3	52.1	24.3	52.2	41.6	30.4	44.1	KOPRAN
KNHM W 8642	60.6	57.8	29.7	61.3	47.1	34.4	45.2	ZAD BASCHI
KNHM W 86132	48.3	43.5	24.5	49.4	40.3	30.2	40.0	KETSCHAWA
KNHM W 86133	50.9	50.9	24.5	48.9	38.4	30.4	41.2	KETSCHAWA
KNHM W 86134	55.0	55.5	25.7	53.0	42.5	31.1	45.4	KETSCHAWA
KNHM W 86135	51.2	52.8	22.1	50.0	39.7	28.8	43.6	KETSCHAWA
KNHM W 8666	47.9	50.3	21.7	46.0	36.4	27.3	40.2	KOPRAN
KNHM W 8667	50.0	48.4	22.0	45.4	37.4	29.0	39.4	KOPRAN
KNHM W 86126	54.0	54.5	25.1	54.4	41.3	32.0	47.4	KETSCHAWA
KNHM W 86127	57.1	57.2	26.6	53.0	44.3	34.3	48.8	KETSCHAWA
KNHM W 86128	45.2	45.7	22.4	44.9	34.7	27.2	38.2	KETSCHAWA
KNHM W 86129	48.2	49.6	23.4	46.1	37.2	29.0	40.3	KETSCHAWA
KNHM W 86130	48.2	46.4	22.1	46.4	36.6	29.7	40.2	KETSCHAWA
KNHM W 86131	50.4	50.5	•	47.0	37.3	29.8	42.9	KETSCHAWA
KNHM W 86118	46.4	47.6	21.5	42.7	35.5	28.4	39.4	KETSCHAWA
KNHM W 86119	45.7	44.5	20.3	40.8	33.8	26.6	37.2	KETSCHAWA
KNHM W 86120	48.2	50.2	•	•	36.3	28.2	43.1	KETSCHAWA
KNHM W 86121	54.2	53.4	22.7	49.8	38.1	31.7	43.7	KETSCHAWA
KNHM W 86122	50.2	52.0	23.2	44.8	36.2	28.4	42.6	KETSCHAWA
KNHM W 86123	51.9	51.8	23.5	48.2	37.5	30.4	42.4	KETSCHAWA
KNHM W 86124	52.5	53.1	24.6	51.0	40.6	30.3	44.7	KETSCHAWA
KNHM W 86125	50.0	47.5	22.4	46.3	38.1	29.9	40.5	KETSCHAWA
KUAC 95301	49.7	50.2	22.7	48.5	40.0	28.8	42.9	KYOTO

Appendix 5 (continued)

SPECIMENS	H(1)	PL(2)	PW(3)	W(4)	DAW(5)	DAD(6)	D(7)	LOCALITY
KUAC 95302	•	•	24.6	•	39.3	30.6	•	KYOTO
KUAC 95320	45.5	43.8	21.2	39.3	33.2	26.6	34.2	KYOTO
KUAC 95055	53.6	55.5	23.8	51.4	42.2	31.5	46.0	KYOTO
KUAC 95054	52.3	54.3	24.5	51.3	41.5	31.0	45.4	KYOTO
KUAC 95007	57.6	57.6	28.9	62.1	49.2	32.5	52.0	KYOTO
KUAC 95008	58.3	59.3	28.7	57.9	44.3	35.5	51.0	KYOTO
UC 41/2492	52.5	52.5	25.4	48.8	37.9	30.9	44.0	UC 41 (-115m)
UC 44/2566	•	•	26.3	•	42.0	30.5	•	UC 44 (-115m)
UC 3/48	53.6	55.4	25.0	•	42.3	33.0	44.8	UC 3 (-40m)
UC 4/107	48.0	49.3	24.6	47.4	•	•	•	UC 4 (-35m)
UC 7/1913	58.5	59.0	30.6	50.3	45.2	36.4	50.3	UC 7 (-28m)
UC 14/1522	55.0	53.2	•	55.5	•	33.5	46.6	UC 14 (-28m)
UC 37/2415	46.4	45.6	20.1	42.8	36.0	36.0	39.2	UC 37 (-18m)
UC 13/A	48.7	48.3	19.6	44.4	33.3	27.1	48.3	UC 13 (-18m)
UC 13/B	47.5	45.6	21.3	43.3	35.0	27.0	38.6	UC 13 (-18m)
UC 13/1731	47.8	45.0	20.9	41.8	35.1	27.7	36.1	UC 13 (-18m)
UC 13/1366	48.7	48.8	21.2	46.9	37.0	28.8	40.6	UC 13 (-18m)
UC 13/1189	54.6	54.3	24.0	52.4	43.7	30.0	54.5	UC 13 (-18m)
UC 13/1228	•	•	26.2	51.2	40.8	30.6	•	UC 13 (-18m)
UC 13/2321	49.2	49.0	18.7	43.2	34.0	29.1	48.0	UC 13 (-18m)
UC 13/1274	49.5	49.4	21.1	46.1	36.8	27.8	39.8	UC 13 (-18m)
UC 13/2548	46.9	45.9	22.8	44.6	34.6	28.6	36.6	UC 13 (-18m)
UC 13/	50.9	50.8	20.9	48.6	37.3	31.2	50.8	UC 13 (-18m)
UC 25/1687	49.5	49.5	20.9	50.0	37.7	29.5	42.3	UC 25 (-12m)
UC 39/2375	52.7	47.8	23.0	50.3	•	28.6	40.5	UC 39 (+7m)
UC 26/2565	40.0	41.6	19.3	40.8	31.5	23.1	32.7	UC 26 (+7m)
UC 26/1677	40.0	40.7	18.5	39.2	32.8	29.5	33.7	UC 26 (+7m)
UC 26/1581	50.8	50.7	21.0	48.6	39.0	29.5	42.6	UC 26 (+7m)

H: Maximum height
PL: Maximum diameter of the medial condyle
PW: Width of the trochlea (at the apex of each condyle)
W: Maximum width
DAW: Distal articular width
DAD: Distal articular depth
D: Maximum medial depth

KUAC 95306	•	56.7	18.4	•	•	39.6	40.4	L	KYOTO
KUAC 95307	•	•	18.8	•	•	42.0	43.1	L	KYOTO
UC 1-A/1840	•	•	17.4	•	•	35.6	45.6		UC 1 (-52m)
UC 13/1194	•	•	•	31.0	40.3	•	•		UC 13 (-18m)
UC 13/1385	97.9	67.5	15.5	25.3	41.1	37.3	41.0		UC 13 (-18m)
UC 13/964	•	•	•	32.1	39.0	•	•		UC 13 (-18m)
UC 13/D	96.5	66.0	15.3	28.3	38.0	38.7	40.3		UC 13 (-18m)
UC 13/F	102.3	•	17.4	30.3	42.8	45.2	42.2		UC 13 (-18m)
UC 14/1553	•	•	•	•	•	42.7	42.9		UC 14 (-28m)
UC 26/1882	81.3	54.2	15.7	23.7	32.0	29.4	33.8		UC 26 (+7m)
UC 3/49	102.0	65.0	20.5	27.0	42.9	44.7	42.3		UC 3 (-40m)
UC 31/1919	•	•	•	•	•	37.9	42.0		UC 31 (-17m)
UC 4/107	•	•	15.5	•	•	37.1	39.1		UC 4 (-35m)
UC 4/1524	•	•	20.0	•	•	•	47.9		UC 4 (-35m)
UC 41/2002	•	•	19.0	30.0	41.1	•	•		UC 41 (-115m)
UC 47/	81.9	54.1	17.4	25.7	35.5	37.3	38.0		UC 47 (-6m)
MNHN MAR 109	110.0	75.2	75.2	32.4	46.6	47.5	46.2	L	Paris
MNHN MAR 141	•	•	•	•	•	40.8	42.4	L	Paris
MNHN MAR 200	89.8	59.3	59.3	29.0	43.2	40.9	40.5	L	Paris
MNHN MAR 200a	107.0	71.0	71.0	35.4	50.1	52.4	56.5	L	Paris
MNHN MAR 201	100.0	66.9	66.9	30.2	46.0	42.6	42.8	L	Paris

Appendix 6 Measurement of Calcanei from Maragheh.

SPECIMENS	TL (1)	AL(2)	NW(3)	HW(4)	HL(5)	W(6)	APL(7)	SIDE	SUB-LOC.	REM
MNHN MAR 202	106.8	72.0	72.0	31.4	49.7	50.8	•	L	Paris	
MNHN MAR 203	103.8	67.2	67.2	31.0	43.5	45.2	44.1	L	Paris	
MNHN MAR 204	108.0	71.8	71.8	31.8	47.5	•	43.2	L	Paris	
MNHN MAR 205	101.5	69.6	69.6	28.7	41.0	44.6	41.7	L	Paris	
MNHN MAR 206	101.4	67.7	67.7	28.3	47.8	43.7	47.0	R	Paris	
MNHN MAR 207	103.7	66.3	66.3	32.0	47.2	45.1	47.3	L	Paris	
MNHN MAR 208	104.3	70.8	70.8	34.8	50.7	49.1	49.8	L	Paris	
MNHN MAR 209	104.5	69.1	69.1	32.5	42.4	45.7	45.0	L	Paris	
MNHN MAR 210	91.5	63.0	63.0	28.6	40.3	37.0	40.2	L	Paris	
MNHN MAR 211	101.4	66.4	66.4	30.8	46.9	42.8	49.5	L	Paris	
MNHN MAR 212	102.1	65.9	65.9	27.6	41.6	42.5	41.3	R	Paris	
MNHN MAR 213	108.0	68.2	68.2	29.0	43.9	45.7	46.8	R	Paris	
MNHN MAR 214	106.9	67.3	67.3	33.6	44.9	46.4	45.6	R	Paris	
MNHN MAR 215	115.6	77.5	77.5	31.4	54.4	50.8	48.7	R	Paris	
MNHN MAR 216	83.9	•	•	26.3	38.4	39.9	36.7	R	Paris	
MNHN MAR 217	104.1	•	•	28.7	43.8	43.6	44.0	R	Paris	
MNHN MAR 218	107.6	•	•	29.0	47.7	44.0	45.7	R	Paris	
MNHN MAR 36	•	64.7	64.7	30.3	•	49.0	52.4	R	Paris	
MNHN MAR 67	•	•	•	•	•	44.3	47.1	L	Paris	
MNHN MAR NO(1)	•	•	•	•	•	35.0	37.3	L	Paris	
KNHM A 4858	95.1	63.6	63.6	29.6	40.0	41.4	40.9	R	?	with A 4858 (astragalus)
KNHM W 86116	93.5	62.7	62.7	26.6	39.8	35.4	39.0	L	KETSCHAWA	Juvenile?
KNHM W 86117	96.8	62.8	62.8	27.8	41.2	39.6	40.6	L	KETSCHAWA	
KNHM W 8640	108.9	69.6	69.6	30.0	42.0	40.2	41.5	L	KOPRAN	
KNHM W 8658	103.4	63.8	63.8	30.3	42.7	40.7	41.8	R	KOPRAN	
KNHM W 8659	•	62.2	62.2	29.9	43.2	•	41.2	R	KOPRAN	
KNHM W 8668	104.9	66.0	66.0	31.6	43.0	42.4	44.4	L	KOPRAN	
KNHM W 8671	•	61.8	61.8	27.8	40.2	•	41.6	R	KOPRAN	
KNHM W 8672	100.0	67.2	67.2	30.3	46.5	38.8	41.0	L	ILDTSCHI	
KNHM W NO (1)	103.7	67.8	67.8	33.1	48.6	•	49.7	L	?	
KNHM W NO (2)	•	64.8	64.8	29.0	45.0	•	43.6	R	KETSCHAWA	
KNHM W NO (3)	•	•	•	•	•	42.8	43.9	R	KETSCHAWA	
KNHM W NO (4)	•	•	•	•	•	46.0	44.8	R	KETSCHAWA	
KNHM W NO (5)	107.4	69.7	69.7	29.5	51.7	•	47.2	R	KETSCHAWA	
KNHM W NO (6)	•	60.3	60.3	27.1	•	•	•	R	KOPRAN	
KNHM W NO (7)	•	60.6	60.6	29.4	•	•	•	L	KOPRAN II	
KNHM W NO (8)	•	•	•	34.7	•	•	•	L	ZAD BASCHI	

TL: Maximum length
AL: Length of proximal part
NW: Minimum width
HW: Proximal maximum width
HL: Proximal maximum depth
W: Distal maximum width
APL: Distal maximum depth

See Eisenmann et al. (1988, p. 55) for points of measurement.

Appendix 7 Measurement of Pelvis from Maragheh.

SPECIMENS	ACET APL	ACET DVD	SB	SBDVH	SBI	SHI	ACET H	ACET LFO	ACET LS
KUAC 95313	•	•	•	•	30.9	19.2	•	•	•
KUAC 95304	•	•	•	•	30.8	18.6	•	•	•
KUAC 95060	45.5	41.4	29.2	20.4	29.4	17.6	39.1	•	•
KUAC 95058	43.7	41.3	31.6	19.3	26.9	16.3	36.7	60.0	•
KUAC 95059	43.3	•	28.6	17.5	28.0	16.8	37.0	•	•
KUAC 95311	47.8	40.9	30.0	22.3	31.6	18.7	39.4	62.3	•
KUAC 95061	45.3	39.4	30.5	19.0	27.5	16.9	38.4	54.6	•
KUAC 95063	42.0	•	30.2	17.3	28.2	16.2	37.1	53.4	•
KUAC 95017	49.0	48.0	34.7	22.6	29.8	20.6	45.9	57.5	116.0
KUAC 95014	47.4	42.8	•	•	31.1	18.3	39.0	57.6	•
KUAC 95018	53.7	52.2	35.4	26.6	35.2	20.8	49.0	70.2	•
KUAC 95016	56.4	48.2	38.0	21.8	32.3	19.6	48.4	61.0	•
KUAC 95303	43.5	38.3	31.9	17.6	28.0	15.9	39.0	53.0	•
KUAC 95305	45.2	40.3	29.0	19.5	25.8	14.5	37.1	55.0	•
KUAC 95312	48.8	49.7	36.2	23.0	31.1	18.0	46.3	•	•
KUAC 95062	44.3	42.6	28.6	17.4	•	•	•	•	•
KUAC 95015	51.1	46.9	33.8	23.0	27.7	16.9	43.1	56.8	•
KUAC 95310	43.1	•	•	•	28.2	15.0	42.4	•	•

ACET APL: Anteroposterior (craniocaudal) diameter of the acetabulum
ACET DVD: Dorsoventral diameter of the acetabulum
SB: Smallest breadth of the shaft of the ilium
SBDVH: Smallest height of the shaft of the ilium
SBI: Smallest distance between medial plane and lateral surface of the ischia
SHI: Smallest height of the ischia
ACET H: Mediolateral thickness of dorsal edge of the acetabulum
ACET LFO: Inner length of the foramen obturatum
ACET LS: Length of the symphysis.

Plate 1

1. KUAC 95020, robust morphotype of MC III from Maragheh.
2. KUAC 95068, large and slender morphotype.
3. KUAC 95067, large and slender morphotype.
4. Large Morphotype of Astragali from Maragheh.
   Left: KUAC 95007; Right: 95008
5. Small Morphotype of Astragali from Maragheh.
   From left to right: KUAC 95054 and 95055.

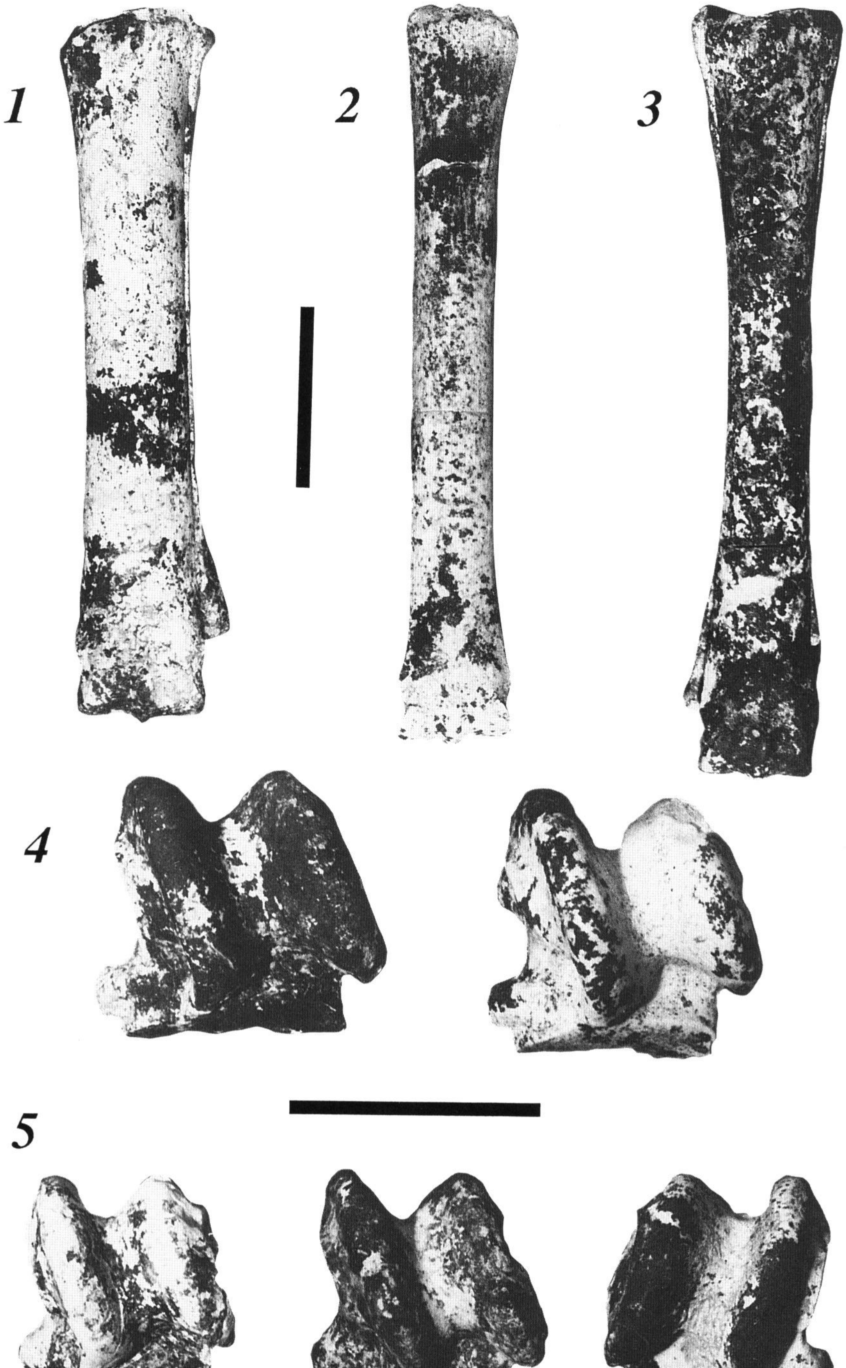
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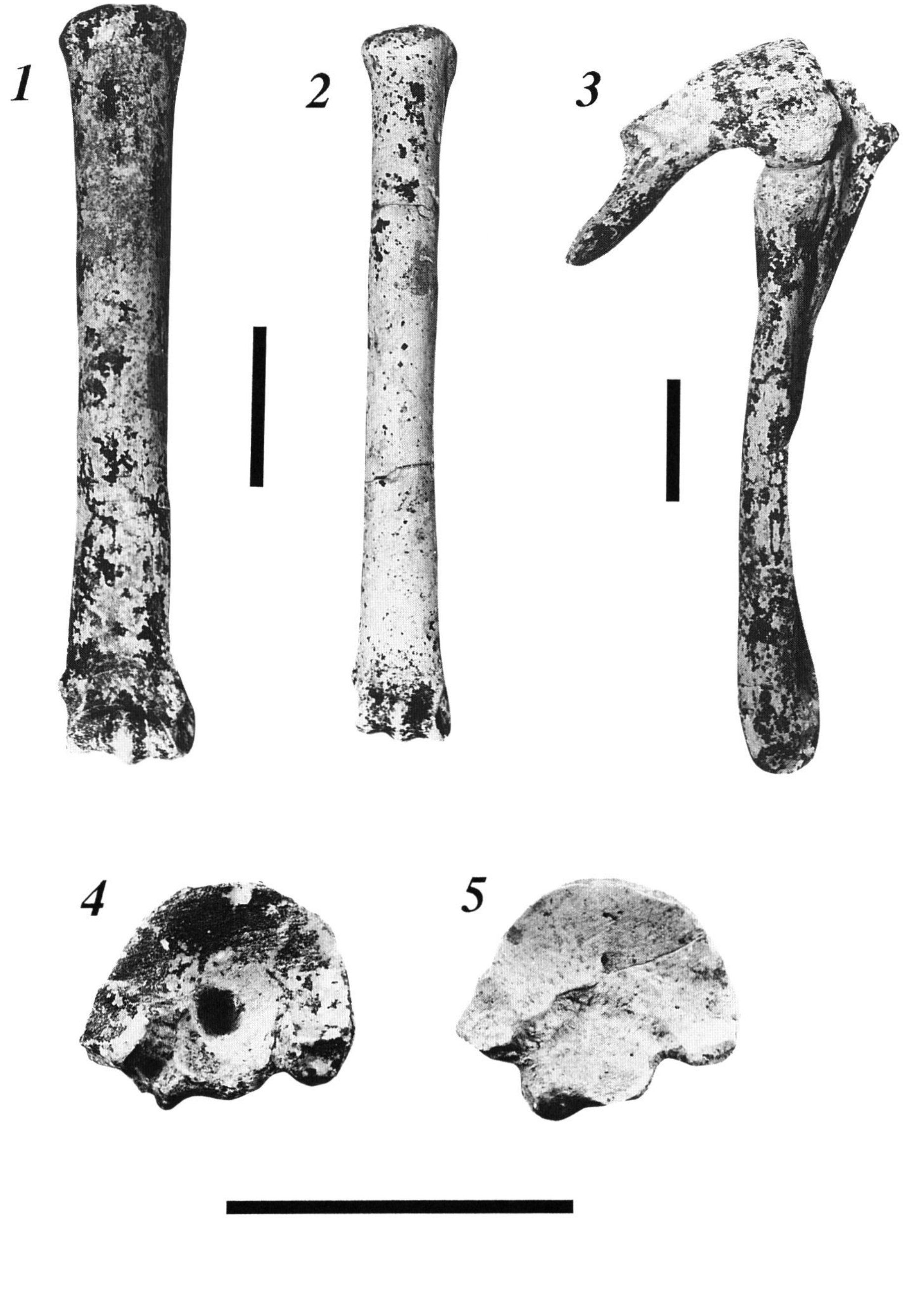
Plate 2

1. MT III from Maragheh. KUAC 95006, robust morphotype.
2. MT III, KUAC 95090, large and slender morphotype.
3. Distal portion of Humerus articulated Radius and ulna (Right side; medial view) KUAC 95314. The nibbling mark on the distal-medial side of the humerus and sharpen surface of breakage were made before burial. The proximal epiphysis of the radius were missed before burial by carnivorous damage.
4. Proximal portion of MT III, the robust morphotype from Maragheh (proximal view). MNHBN MAR 18 with developed facet for the cuneiform II.
5. MNHN MAR 3 with undeveloped facet.

Solid bar is 5 cm.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