

3D geometric morphometrics of the pollical proximal phalanx from the Ruidera Middle Pleistocene site (Ciudad Real, Spain)



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Introduction

The Ruidera site is a dismantled rock shelter dated to approximately 350–300 ka and represents a key locality for understanding human evolution during the European Middle Pleistocene (García-Martínez et al., 2026). As the only Middle Pleistocene human-bearing site currently known from the southern Iberian Meseta, it provides valuable information on the morphology of human populations during the "Muddle in the Middle".

Recent fieldwork led to the recovery of a new hand fossil, RVH-76 (figura 1), consisting of a right thumb proximal phalanx. Although the bone appears proportionally small compared with *Homo sapiens* specimens (Figure 2), its maximum length exceeds the Neandertal mean while remaining shorter than both fossil and recent *H. sapiens* individuals. Other Ruidera hand remains are larger than those of both Neandertals and *H. sapiens* (Torres-Medina, 2024).

The phalanx exhibits a high breadth-to-length ratio, resulting in marked robusticity. This robusticity exceeds that typically observed in *H. sapiens* and falls within the range characteristic of Neandertals. Increased phalangeal robusticity was identified by Musgrave (1971) as a distinctive Neandertal feature.

Of particular interest, the ulnar side of the bone exhibits two deep cortical depressions associated with bone remodeling, suggesting the presence of a pathological condition.

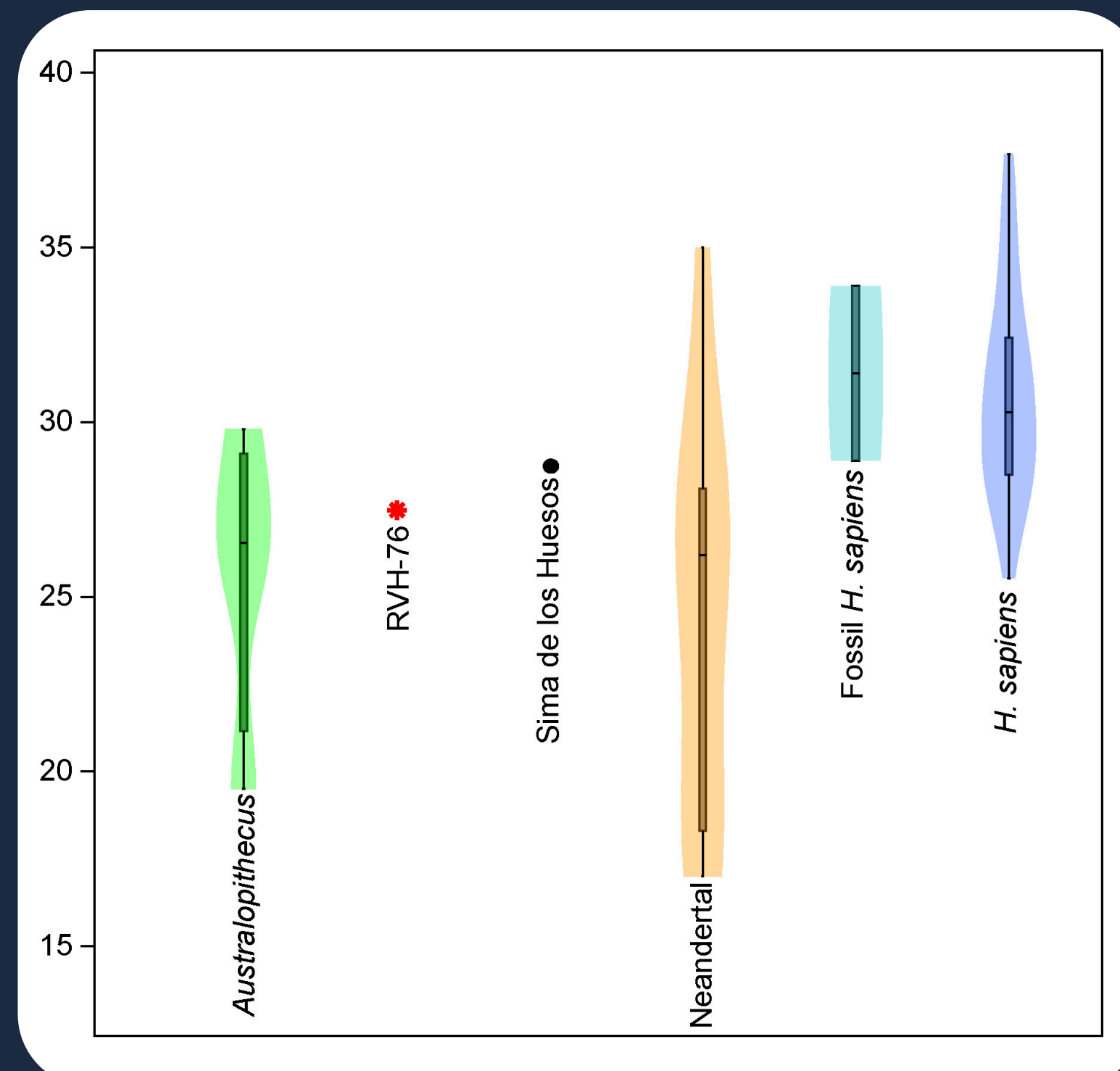


Figure 2: Violin and Boxplot for maximum length



Figure 1: Bone specimen shown in multiple anatomical views. Scale bar = 1 cm.

Methodology

The specimen was analyzed using three-dimensional geometric morphometric (3D GM) techniques and compared with a broad comparative sample including *H. sapiens* (n = 38), Neandertals (n = 9), the Sima de los Huesos specimen (AT-258), *Homo naledi* (UW 101), and *Australopithecus sp.* (StW 575).

A total of 63 landmarks were collected, comprising 20 fixed landmarks and 43 curve semilandmarks. Semilandmarks were subsequently slid to the consensus configuration using a minimum bending energy criterion, and missing landmarks were estimated using Thin-Plate Spline (TPS) interpolation based on conspecific specimens.

Results and Conclusion

Principal Component Analysis (PCA), after allometric correction, separates the sample along PC1 (28.5%) into two main groups (Figure 3). Neandertals, the Sima de los Huesos specimen, and RVH-76 occupy the second most negative value, whereas *H. sapiens*, *H. naledi*, and *Australopithecus sp.* (StW 575) plot at positive values.

The between-group PCA (bgPCA) further supports this pattern, placing RVH-76 within the Neandertal–Sima de los Huesos morphospace (Figure 4) and clearly separated from both Modern and Pre-Industrial *H. sapiens*. Interestingly, the most archaic taxa included (*H. naledi* and *Australopithecus sp.* StW 575) plot within the Pre-Industrial *H. sapiens* morphospace. Hierarchical cluster analysis based on Procrustes distances places RVH-76 in a basal position basal to the Neandertal–Sima de los Huesos group (Figure 5) and the *H. sapiens* group, highlighting its relatively archaic morphology but related to the Neandertal lineage.

Overall, RVH-76 is consistent with a European Middle Pleistocene hominin, showing closest morphological affinities with Neandertals and the Sima de los Huesos population. The specimen combines a relatively large size with marked robusticity, a trait characteristic of Neandertals, and also exhibits cortical depressions with bone remodeling on the ulnar side of the phalanx, suggestive of a possible pathological condition.

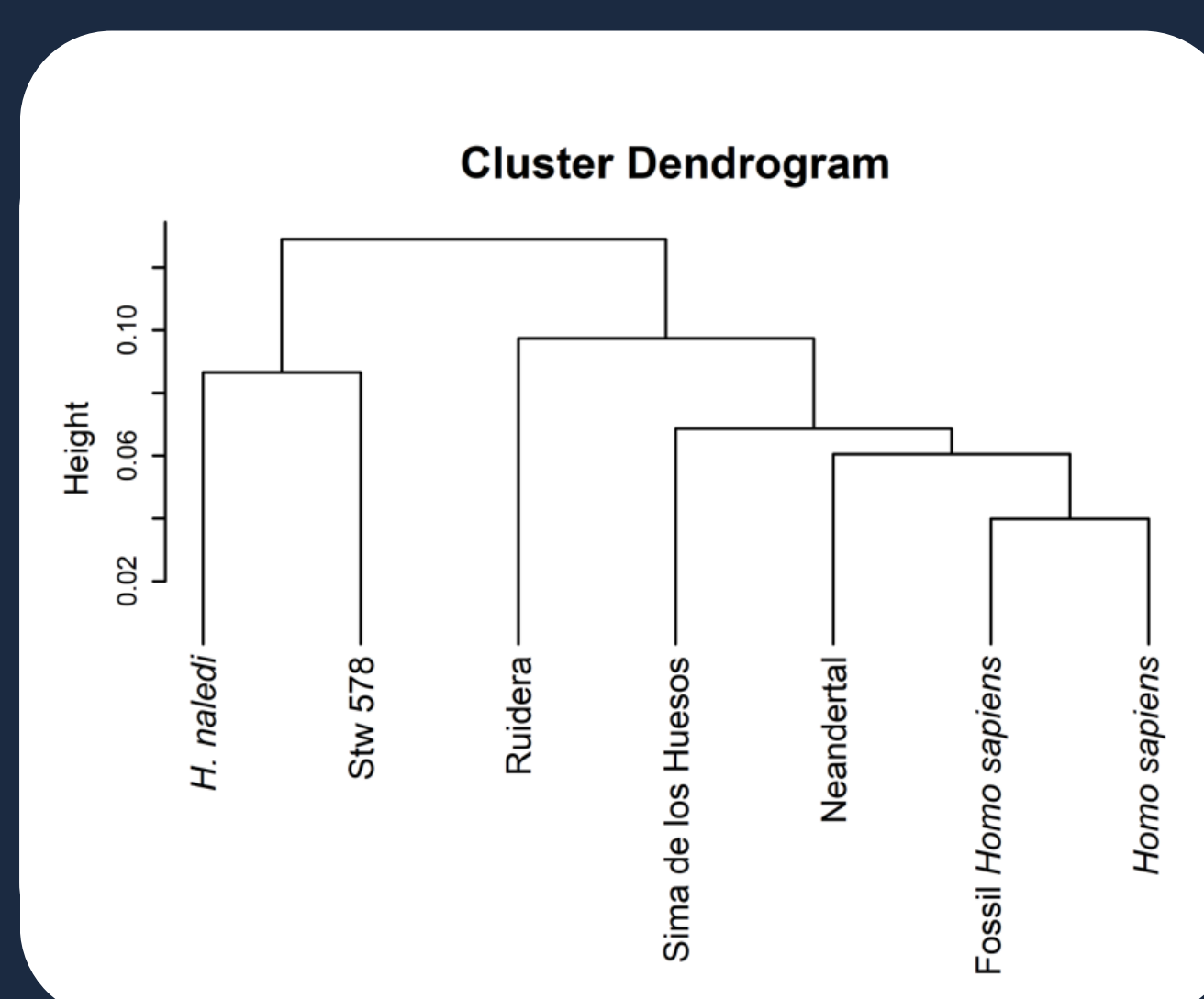


Figure 5: UPGMA cluster dendrogram based on the 2B method, illustrating the relationships among the sample

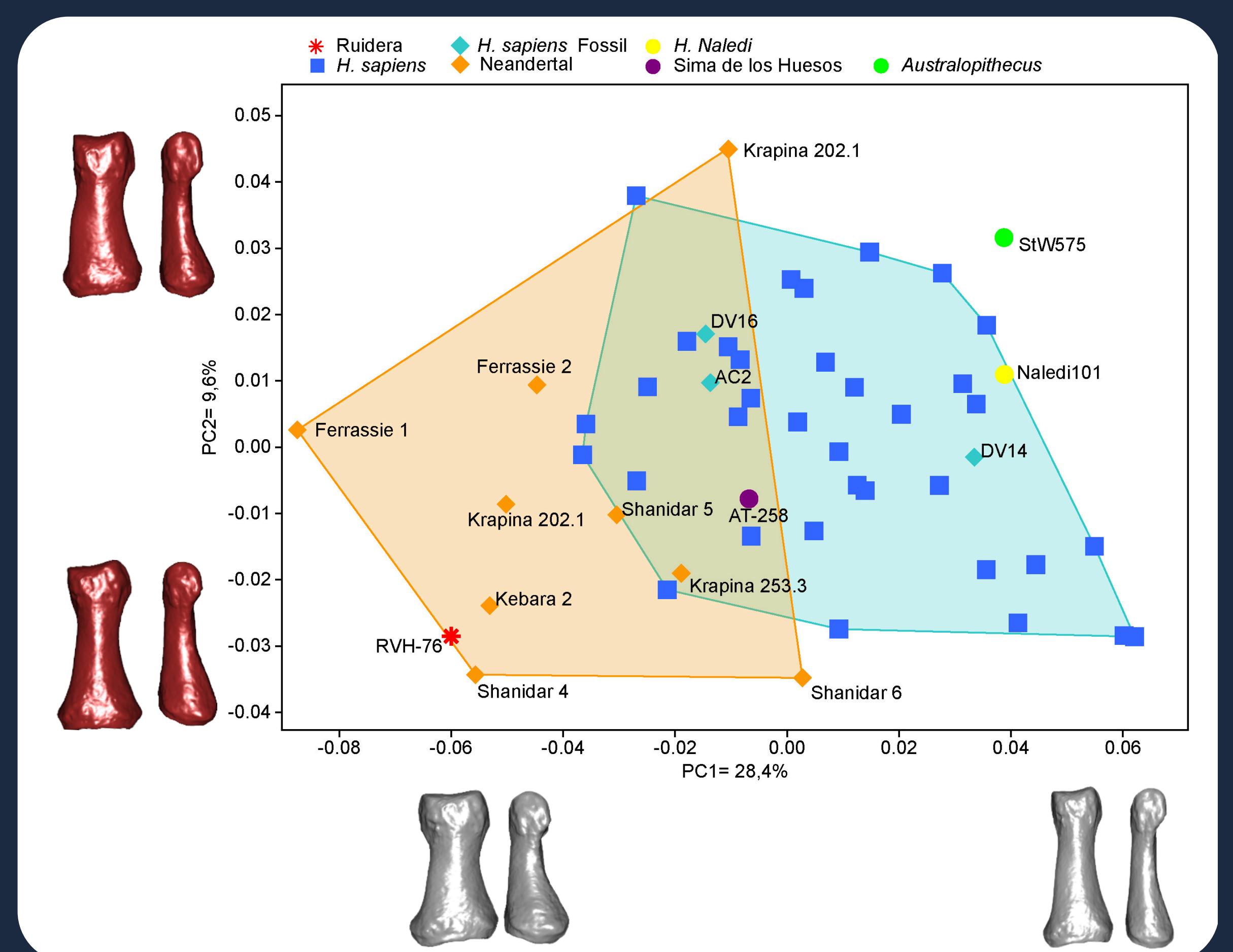


Figure 3: Principal Component Analysis (PCA) with warps for max. and min. values of every PC

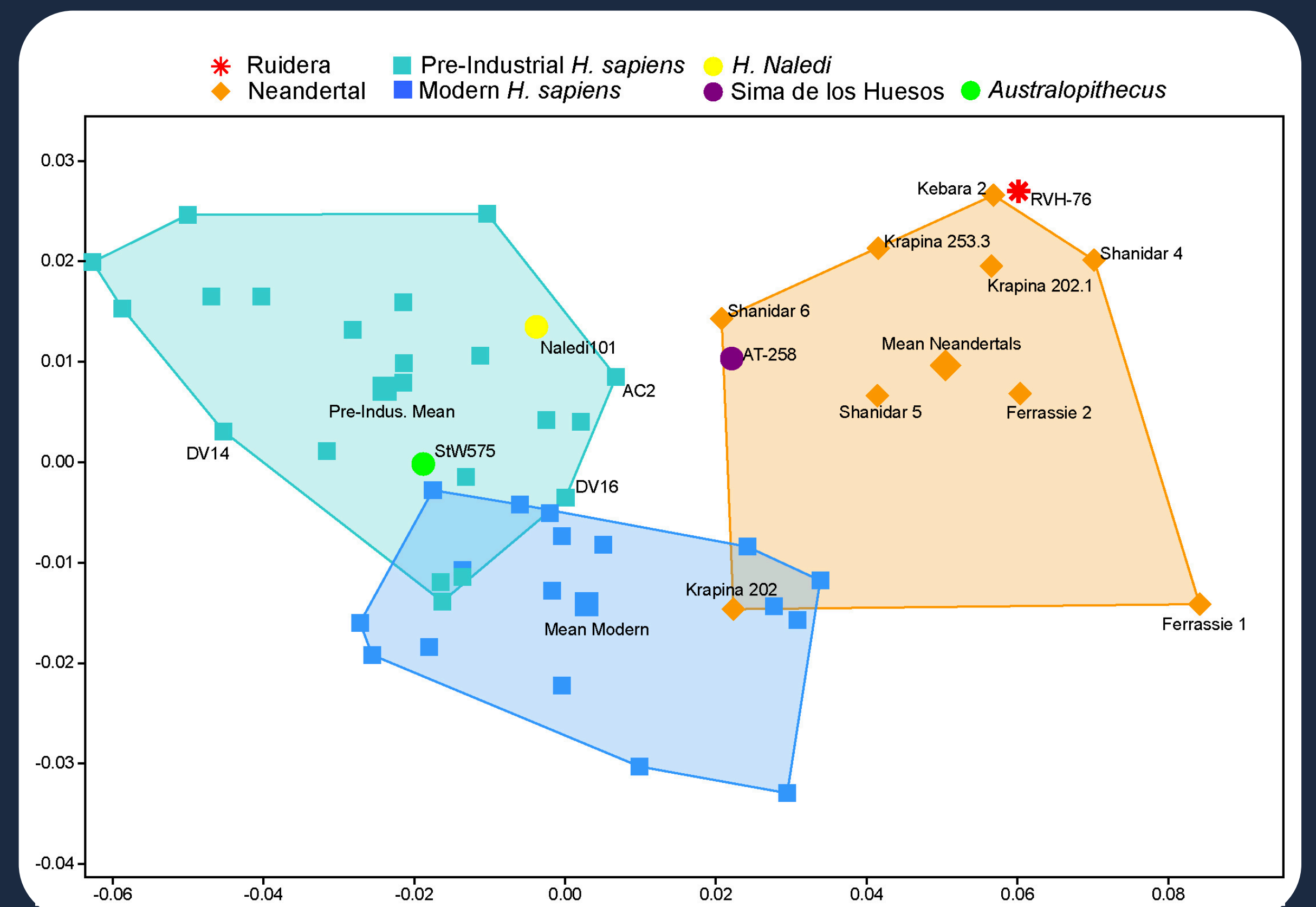


Figure 4: BGPC plot showing the distribution of Neandertals, modern *H. sapiens*, and preindustrial modern *H. sapiens* along the two principal components. Plotting other fossils on the morphospace