Introduction

Shape analysis of tooth crowns has proved to be a useful method for taxonomic classification of extant hominoids and fossil hominins (e.g., Bailey and Lynch, 2005; Gómez-Robles et al., 2007; Skinner et al., 2009). This study uses elliptical Fourier analysis of crown outlines to investigate species affinity in two recently discovered permanent molars from the Sanxieshan Locality 2 cave site in Daxin, Guangxi, China. One left lower molar (SX15) and one right upper molar (SX09) were found in situ directly below travertine deposits securely dated to ~300 ka (uranium series dated).

Materials and Methods

The fossil molars SX15 and SX09 (see Figure 1) were compared to upper and lower first, second, and third molars of extant hominoids (n=225; see Table 1), Gigantopithecus and Early to Middle Pleistocene hominins including Homo heidelbergensis, Homo neanderthalensis, Homo ergaster, and Homo erectus (n=97; see Table 2). Standardized coordinate outlines collected for use in elliptical Fourier analysis of tooth shape. Canonical variates analyses (CVA) of molar shape were conducted using the elliptical Fourier coefficients (60 cosine and sine components of x and y increments) from 15 generated harmonics (elliptical Fourier descriptors) that describe outline shape with positional translation and size normalized away.

Table 1. Number of first, second, and third molars for extant comparative sample (n=225)

<table>
<thead>
<tr>
<th>Species</th>
<th>Lower M1</th>
<th>Lower M2</th>
<th>Lower M3</th>
<th>Upper M1</th>
<th>Upper M2</th>
<th>Upper M3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gorilla gorilla</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Hylabates agilis</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Pongo pygmaeus</td>
<td>14</td>
<td>15</td>
<td>16</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

Figure 1. Scaled occlusal photographs of SX15, SX09.

Shape discrimination- canonical variates analyses of elliptical Fourier descriptors

- CVA groups assigned a priori: SX09 and SX15 group assignment determined by discriminant analysis
- CVA results of 158 extant and fossil lower molars (see Figure 2) assign lower hominoid molar SX15 as:
  - a lower Pongo molar with 99.95% (98.1% assigned correctly)
  - a lower Pongo second molar with 93.4% probability (96.2% assigned correctly).
- CVA analyses of 164 extant and fossil upper molars (see Figure 3) assign lower hominoid molar SX09 as:
  - a Homo erectus sensu strictu upper molar with 86% probability (93.1% assigned correctly)
  - a Homo erectus sensu strictu upper first molar with 77.8% probability (94.5% assigned correctly).

Figure Key: Gorilla gorilla = light blue, Hylabates agilis = black crosses, Pongo pygmaeus = black dots, Gigantopithecus = magenta, Mid-Paleolithic hominins = brown, Homo erectus sensu strictu = green, Sanxieshan molars = purple diamonds

Shape visualization- elliptical Fourier analysis principal components analyses tooth outline shape

- Principal component analyses (PCA) of elliptical Fourier descriptors (EFDs) generated in elliptical Fourier analysis (size and positional rotation normalized away) to visualize shape changes and spread of variation without regard to group affiliation
- PCA of lower molar EFDs (see Figure 4): first 5 PCs account for 99.13% of the variation
  - PC1 (component 1) accounts for 73.67% of the variation:
  - PC2 (component 2) accounts for 16.71% of the variation
- PCA of upper molar EFDs (see Figure 5): first 5 PCs account for 99.41% of the variation
  - PC1 (component 1) accounts for 79.82% of the variation
  - PC2 (component 2) accounts for 12.87% of the variation

Figure Key: Gorilla gorilla = light blue, Hylabates agilis = black crosses, Pongo pygmaeus = black dots, Gigantopithecus = magenta, Mid-Paleolithic hominins = brown, Homo erectus sensu strictu = green, Sanxieshan molars = purple diamonds

Conclusions

- These results of the discriminant geometric morphometric analyses indicate that SX15 and SX09 are similar in aspects of their crown outline shapes to Pongo and Homo erectus sensu stricto, respectively.
- These results of species assignment are preliminary; although outline shape is a useful identifier of species status there is also considerable variation in occlusal outline shape, particularly in Genus Pongo.
- Future directions will assess other aspects of molar morphology used for species designation such as cusp areas and inter-cusp distances to attempt confirmation of these preliminary species assignments.

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Literature Cited: