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Chopping Down The Family Tree: A Look At Our Earliest Ancestors

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INTRODUCTION

Within the past five years, new fossils discovered in Africa are shaking the tidy family tree of humans. *Kenyanthropus platyops, Ardipithecus ramidus kadabba, Orrorin tugenensis,* and *Sahelanthropus tchadensis* are the latest discoveries that are changing the way the human lineage is viewed. The tree is beginning to look more like a bush, with an increase in the appreciation for hominid variation. This paper will discuss the new hominid finds, revealing their general cranial and post-cranial characteristics and focusing on the dental traits. Each new hominid will then be compared with modern humans and other possible hominid ancestors, and any issues relating to their inclusion or exclusion into the direct hominid ancestry of modern humans will then be addressed. Ultimately, this paper is trying to determine—based on current information—what early hominids are most likely to be the ancestors to *H. sapiens.*

Before these latest fossil finds, previous interpretations of the human family tree has been characterized as being very straight, with a few branches shooting off and dead-ending. One of the more popular models of the hominid line includes the *Australopithecus* genus and the current occupants of the *Homo* genus (Relethford, 2000). According to this model, there are a few species that eventually branch off and became extinct, but most of the species are included in the direct line of our ancestry. However, these latest finds are going to forever change this tidy view of human ancestry (Balter, 2001). At the very least, the family tree will be turned into a family bush, with many twigs containing the offshoots and extinct species of the hominid line.

SIGNIFICANCE OF THE FAMILY BUSH

Understanding this new model of human evolution is important to physical anthropology. In the past, scientists have tried to place every new hominid find in the direct ancestry *H. sapiens.* However, this has placed the hominid species in a special category with different rules than other mammalian species. Under the guise of a uni-lineal ancestral line, more variation is permitted in hominid species than in other species (Wood and Collard, 1999). Humans also have the only uni-lineal line—phylogenies of other species appear most like the bush analogy, with many offshoots and dead-ends. With the latest discoveries, our ancestry will now appear like other species' ancestry with lots of variation. This variation is the basis for hominid ancestors to be seen as many twigs in the family bush, instead of a few branches on the family tree.

LITERATURE REVIEW

Dentition as a Phylogenetic Model

Cranial remains tell a great deal. Brain cases, facial features, attachment evidence, and dental traits can give a very detailed picture of the derived and primitive characteristics of a specimen, as well as the type of resources they exploited in their environment (Martin, 1986). Of the above, teeth provide the most information about the species to which the fossil belongs. Types of food eaten, mastication processes, age of the specimen, and even times of stress can all be determined from the examination of a specimen's dentition. The forms of the teeth vary depending on phylogeny and taxonomy, and are relevant traits that can be used to show evolutionary patterns (Foley and Cruwys, 1986).

The main dental traits that will be looked at in this paper are enamel thickness, canine size and wear, tooth size, and the canine honing complex. Thicker enamel, especially on the molars, is viewed as a derived hominid trait (Foley and Cruwys, 1986). Thicker enamel evolves in some of the hominoid groups and does not in others—humans have thick enamel, whereas most African and Asian apes have thinner enamel. The thickness of the enamel can determine diet , as well as certain other phylogenetic relationships.

Tooth size is another important variable in describing hominids. Looking at jaw and teeth sizes can help place specimens in appropriate categories. Before these most recent hominid discoveries, early hominids (Australopithecines) were believed to have developed large teeth and jaws, large molars and small incisors, which then decreased in size with Homo. There was no logical explanation for this reduction, and it was assumed that it was due to a change in diet. However, this and other explanations used to describe the phenomena were never satisfactory (Foley and Cruwys, 1986). The Australopithecines, despite these differences, were still placed in the direct line of human ancestry. Now, with the new fossils showing smaller jaws and teeth, the model can be reassessed based on the sizes.

Foods and mastication are reflected in the morphology of the teeth (Foley and Cruwys, 1986; Robinson et al., 1986; Williams and Woodhead, 1986). These can be used to show the types of food eaten—hard foods leave pits and depressions in the teeth, and softer foods round and polish the teeth. The canine honing complex is present in apes; as the apes chew, they sharpen their canines against the other teeth, removing part of the tooth surface (Williams and Woodhead, 1986; Lucas et al., 1985). This is absent in humans, and can be used to distinguish early species as in the hominid or ape lineage.

Characteristics of Modern Human Teeth

One of the purposes of this paper is to determine whether or not recent hominid discoveries fit into the direct ancestral line of modern humans. The focus is on the dental characteristics of the various fossils, and, in order to understand their place, a general description of modern dental characteristics is in order, as well as a rough comparison with ape dental characteristics.

Human teeth can be distinguished from other primate teeth based on a few important characteristics. The incisors and canines are smaller than the molars, and the molars have thicker enamel. Canines are small, and lack the honing complex that sharpens ape teeth. Instead, canines are worn on the tip and there is a lack of a canine diastema. There is also a lack of sexual dimorphism in the canines of humans, as well as for the other teeth. This is opposed to the other apes where the male canines are significantly larger than the female canines (Oxnard, 1987).

New Fossil Finds

In order for the new relationships between all of the early hominid species to be assessed, first one must be aware of the new species in question, as well as their primitive and derived characteristics. The most recently discovered species include: *Kenyanthropus platyops, Ardipithecus ramidus kadabba, Orrorin tugenensis,* and *Sahelanthropus tchadensis.* For each species, general geographic, palaeoecologic, and morphologic characteristics are covered. Discussion of morphologic characteristics focuses on dentition. Furthermore, a brief discussion of the issues surrounding their possible inclusion or exclusion in the hominid line will be included.

Kenyanthropus platyops

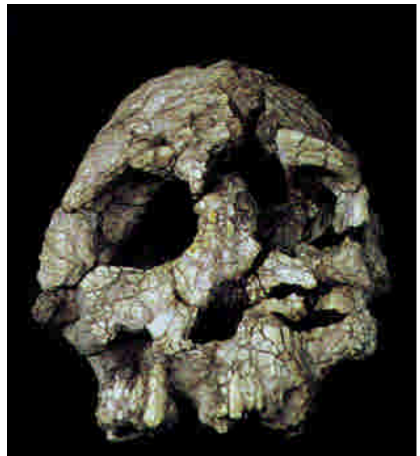

Figure 1: KNM-WT 40000, holotype for *Kenyanthropus platyops*

Meave Leakey of the National Museum of Kenya discovered *Kenyanthropus platyops* (Figure 1) during the 1998 and 1999 field seasons. The site is located in northern Kenya, west of Lake Turkana near the Lomekwi River (Figure 7). The following is a list of the fossils uncovered at the site: temporal bone, mostly complete distorted crani isolated teeth (Figure 5). The fossils were situated between sediments containing volcanic detritus that was dated using 40Ar-39Ar dating. The dates yielded an age of 3.5 million years ago for *Kenyanthropus* (Leakey et al., 2001).

Palaeoecology of the site reveals that the environment consisted of many different habitats connected together. This information was taken from the sediments and fossils found associated with *K. platyops.* It was well watered, with woodlands and forests dominating the landscape. The deposits represent lakeshore or river floodplain deposits (Leakey et al., 2001; Wong, 2001). Lieberman (2001) concluded from the mammalian fossils that *K. platyops* lived in an area with a mixture of grassland and wooded forests near a river or lake.

The fossils showed a combination of primitive and derived features. The cranium is within the *Australopithecine* range—it is roughly the size of a chimp cranium—but it has a large, orthognathic face with small teeth. A contemporary, *Australopithecus afarensis*, has a similar sized cranium, but a prognathic face with large teeth (Schuster, 2001). *Kenyanthropus* is very similar to *H. rudolfensis* in its structure of the face and teeth (Figure 6; Table 1). Both have flat faces and similar brow ridges (Bower, 2001; Leakey et al., 2001; Lieberman, 2001).

The following information on the teeth reveal a hominid morphology: incisor sockets are parallel and slightly anterior to the bi-canine line, upper incisor roots are equal in size, upper premolars have three roots, upper first and second molars are small with thick enamel. The dental characteristics of *K. platyops* differ from the contemporary and later *Australopithecines*. *K. platyops* has upper incisors similar in size to one another and small molar crowns. However, it does show dental characteristics related to *H. habilis* and *H. rudolfensis* (Leakey et al., 2001). Lieberman (2**Proofreading Problem** 201) feels that *K. platyops* will act as a "party spoiler" to the current human ancestral line. While no one is claiming that *K. platyops* is not a *H. sapiens* ancestor, its exact place in our evolution **Proofreading Problem** in not to be determined.

Further research, as well as new finds, will help to place *K. platyops* in its evolutionary spot.

Ardipithecus ramidus kadabba

Yohannes Haile-Selassie of the University of California, Berkeley discovered A*rdipithecus ramidus kadabba* (Figure 2) in 1997. The remains were found in the Middle Awash area of Ethiopia's Rift

Figure 2: ALA-VP-2/10, holotype mandible and teeth for *Ardipithecus ramidus kadabba*

39Ar dating methods (Robinson, 2001). Based on volcanic deposits above and below the hominid remains, the age yielded is 5.8 to 5.2 million years old. Five individuals are represented by the eleven fossils uncovered--the fossils (Figure 9) consist of isolated teeth, partial lower jaw with associated teeth, hand and foot bones, arm bone and collarbone fragments (Haile-Selassie, 2001).

The ancient environment in the Middle Awash Valley is very similar to what has already been described. Woodland and forest habitats dominated, but due to climatic changes, were beginning to decrease in size. Small patches of grasslands were beginning to develop from the drier conditions. The climate was warmer, and the woodlands were made up of grassy woodlands and floral woodlands for the hominid environment (Woldegabriel et al., 2001). Evidence for the environmental construction came from vertebrate fossils found in the strata where the fossils were uncovered.

Kadabba had derived and primitive characteristics. The specimens contain derived dental features that are present in younger hominids. A toe bone, the fourth proximal phalanx, has a shape like modern toe bones, and reveals that this hominid was bipedal. There are many primitive characteristics as well, such as the small body size--estimated from the arm bone fragments and toe bone. Some of the dental features are also more primitive and reveal the small gap between *Ardipithecus ramidus kadabba* and the common ancestor of chimps and humans. The distally worn canine, one of the primitive characteristics, shows some evidence for the canine honing complex, though this was not as developed as in other apes (Haile-Selassie, 2001; Robinson, 2001).

The following dental characteristics are more primitive than *Ardipithecus ramidus ramidus* but still retain enough derived features to be in the hominid line. The lower canines and upper premolars are ape-like, but have certain human-like traits as well. The incisors are comparable to those of later hominids and are narrower than those of a chimpanzee. The canines show different wear from ape canine wear. They are worn apically and distally, but lack the honing canine-premolar complex present in apes. Apes sharpen their teeth as they chew due to their mastication process, and this is not present in the human masticatory process. The back teeth are large with narrower front teeth, reflecting a specific diet, consisting of fibrous foods (Haile-Selassie, 2001).

Orrorin tugenensis

French team leaders, Brigitte Senut and Martin Pickford, discovered the remains of *Orrorin tugenensis* (Figure 3). The fossils were located at Tugen Hills in northern Kenya, and were part of the Lukeino Formation. dated volcanic tuffs and ranges from 5.6 to 6.2 million years old. *Orrorin*, due to

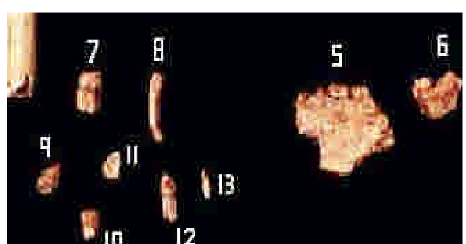

Figure 3: Teeth and mandible fragments of *Orrorin tugenensis*

its age, is near the estimated ape/human divergence. Thirteen fossils (Figure 11) were discovered that included thigh and arm bone fragments, isolated teeth, and jaw fragments (Balter, 2001).

One of the femurs contains the head that fits into the pelvis. It is larger than in Australopithecines, and is proposed to have held more weight due to a bipedal stance more advanced than in other early hominids. The evidence appears to have *O. tugenensis* having a more modern bipedality than later Australopithecines, and based on this and some of the fossils other derived characteristics, Senut and Pickford are arguing against the inclusion of the Australopithecines in the human lineage (Balter, 2001).

Most of the dental evidence comes from molars found. They are distinctly similar to later hominids by their small, squared shape with thick enamel. Later Australopithecines have larger molars with thin enamel (Aiello and Collard, 2001).

Evidence for *O. tugenensis* is fragmentary, and many other scientists do not feel that it should be included, just yet, as a human ancestor (Haile-Selassie, 2001). New evidence is on the horizon for *O. tugenensis*, and while we wait for new information, a temporary decision can still be made in regards to its place in the hominid line.

Sahelanthropus tchadensis

Michel Brunet of the University of Poitiers discovered *Sahelanthropus tchadensis* (Figure 4) in July of 2001. The fossils were located in Torus-Menalla in the Djurab Desert of northern Chad, bordering the southern boundary of the

Sahara Desert (Figure 15). Since there are no ash layers in the area, dating was based on the vertebrate fossil record of Torus-Menalla compared to local equivalents that had been dated with absolute dating techniques (Wood, 2002). This method of dating is very reliable, since it compares the fossil assemblages from this location with other locations with the same assemblages that have consistent, hard dates. This provided an age of 6.0 to 7.0 million years ago, in the Late Miocene. The fossils (Figures 13 and 14) are isolated teeth, a jaw fragment, and a nearly complete cranium (Bower, 2002; Lemonick and Dorfman, 2002; Pickford and Senut, 2002).

Figure 4: TM 266-01-060-1, holotype for *Sahelanthropus tchadensis*

Central Africa contained aquatic environments. Based on the enormous amount of vertebrate fossils discovered at the site grassland, wooded savannah, fresh water, and gallery forests have been reconstructed for the area. Early hominids live in a mosaic of habitats near the boundary of a lake (Vignaud et al., 2002). Like the other hominids discussed, the environmental reconstruction came from the evidences in the associated sediments and fossils.

Like the other hominids previously discussed, *Sahelanthropus* also contains an odd mixture of primitive and derived features (Gee, 2002). The braincase is small and ape shaped. However, the face and teeth show very modern hominid characteristics. The sub-nasal area of the face is less prognathic than later hominids, there is a small and narrow U-shaped dental arch, and various modern dental traits. Due to its early age, it is unusual to find the face of a 1.75 million year old advanced Australopith on a 7 million year old skull (Brunet et al., 2002; Guterl et al., 2002; Whitfield, 2002).

The teeth show more derived characteristics than primitive ones. The canines are smaller and apically worn, with no sign of the honing complex found in apes. The upper premolars and molars are smaller than later hominids, and have thick enamel. The tooth size and enamel thickness is intermediate between chimpanzees and Australopithecines. There is also no lower canine diastema and the incisors are generally small in form (Brunet et al., 2002).

Like most of the other hominids discussed, *S. tchadensis* has its fair share of controversy surrounding its inclusion or exclusion in the hominid ancestry. Some scientists feel that the dental, facial, and post-cranial morphologies described reflect a closer relationship to the apes than to humans (Wolpoff et al., 2002; Parsell, 2002). Characteristics that Brunet says link the fossil with hominids—such as apically worn canines, tooth size, and possible bipedalism, though these are just a few discussed—are explained as closer to apes by Wolpoff. Part of this controversy occurred in *Nature*, and Brunet et al. had an opportunity to reply (Brunet et al., 2002). While the debate is obviously heated, Brunet et al. adequately support their stance that their fossils can still be considered in the hominid line. Most of their evidence addresses Wolpoff's statements directly in regards to the canine sharpening and projection of the face.

Hominid Comparisons

Kenyanthropus platyops, Orrorin tugenensis, and *Sahelanthropus tchadensis* all reflect the derived hominid dental characteristics described above. All three have relatively small canines, lack the canine honing complex, small molars and thick enamel. Only *Ardipithecus ramidus kadabba* does not have relatively smaller molars and thick enamel—traits that older and contemporary hominids do show.

Compared with the gracile Australopithecines (Jungers and Grine, 1986), these earlier fossils appear to have more modern characteristics. The Australopithecines have heavily prognathic sub-nasal faces, large molars and canines, thin enamel, and canine diastemas. Species in the genus *Homo* have characteristics that are closer to the six and seven million year old fossils than to the three and four million year old fossils. The cranial morphologies of the *Homo* and *Australopithecus* genus's greatly differ when *Homo* is compared to the newer hominids. This new tangle in human ancestry requires a new look to be given to the human lineage—the tree needs to be replaced with a bush.

STUDY RESULTS

Based on the current amount of information available on the newer hominid finds, as well as the current knowledge already established on other hominids, a new human ancestral line can be constructed. The new lineage resembles a bush more than a tree, with more offshoots and twigs that dead end. The human lineage can be seen as the main branch, weaving its way through the multitude of evolutionary experiments.

Australopithecines, despite some of the similarities with *Homo*, are an evolutionary offshoot. Based on the dental traits, this genus does not make sense as potential ancestors to the smaller toothed, thicker enameled species of *Homo*. *Ardipithecus* can be seen as the ancestors to the Australopithecines, but not to humans. Currently, the species included in *Homo*, excluding *H. neanderthalensis,* and *H. rudolfensis* which I have placed into the genus *Kenyanthropus*, can be seen as ancestors to modern humans. *Kenyanthropus platyops, Orrorin tugenensis,* and *Sahelanthropus tchadensis* are included as ancestors to *H. sapiens*. This is concluded based on the smaller teeth, thick enamel, and signs of particular ways of processing food. Figure 17 shows the updated model of the hominid family bush.

DISCUSSION AND CONCLUSION

The above information is based on the most up to date information presented on the new and established hominids. However, some of the species lack sufficient information to make a more certain assertion in regards to our human lineage. Orrorin tugenensis is based on very fragmentary evidence and more fossils need to be uncovered to provide good comparable specimens. Sahelanthropus tchadensis needs post-cranial bones to be uncovered, to supplement the current information—especially in regards to its bipedal ability.

However, one of the largest problems faced in this study, and for every study relating to the ancestry of man, is the lack of consensus among scientists about what characteristics are considered to be part of our human lineage. Some suggest that teeth are valid and consistent bases of human ancestral inclusion. Others suggest that teeth are so variable that no phylogenetic classification can be determined from those characteristics alone. Obviously, before any solid models of human evolution can be constructed, a better handle on what is expected from our ancestors should be developed.

APPENDIX A: FIGURES

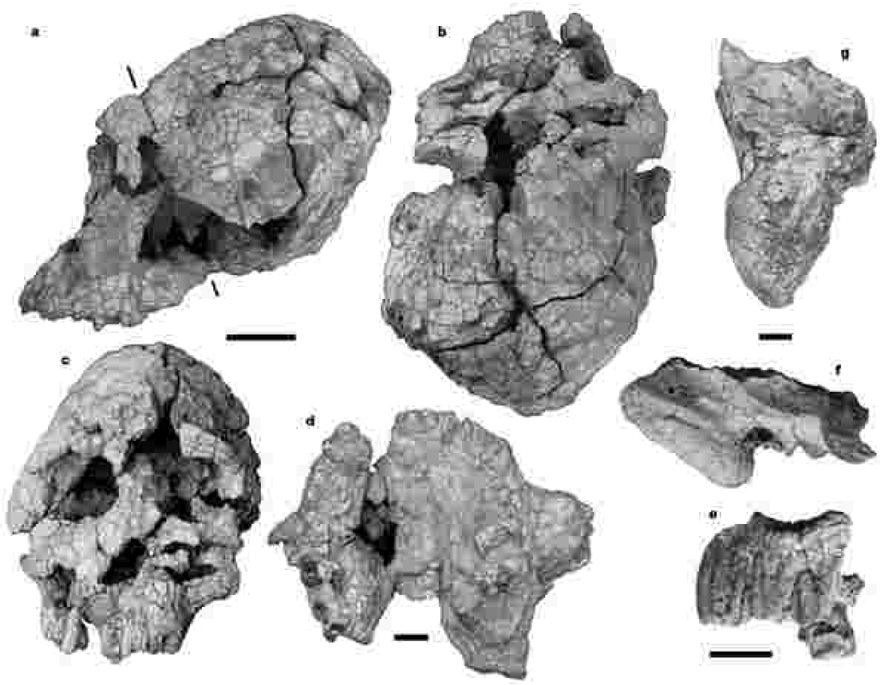

Figure 5: *Kenyanthropus platyops.* Holotype KNM-WT 40000 a. left lateral view b. superior view c. anterior view d. view of palate. Paratype KNM-WT 40000 e. lateral view of KNM-WT 40001 f. lateral view g. inferior view. A-c scale is 3 cm; d-g is 1 cm. This figure shows the relatively flat face and associated cranial characteristics (Leakey et al., 2001)

Figure 6: *Kenyanthropus platyops* (left) and *Homo rudolfensis* (right). Due to the similarities between the two, such as the flatness of the face and brow ridges, it has been suggested that *platyops* is a more ancient species of the same genus as *rudolfensis.* It is now being discussed as to whether or not *H. rudolfensis* should be placed in the *Kenyanthropus* genus due to their similarities (Bower, 2001.

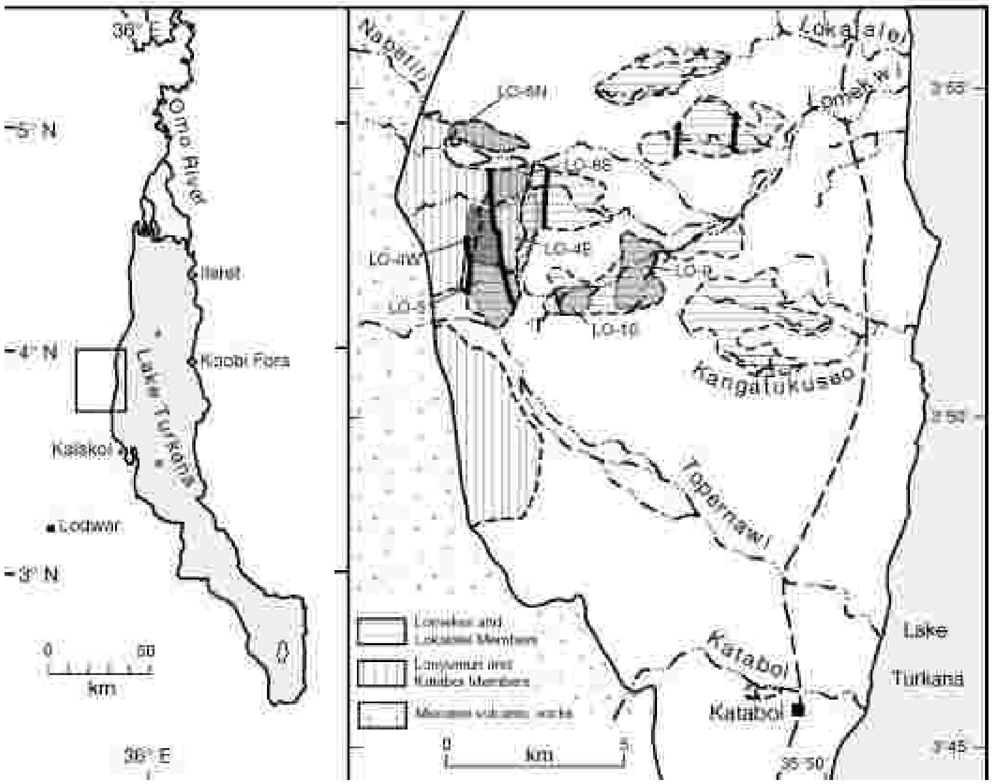

Figure 7: *Kenyanthropus platyops.* Lomekwi formation and its geology. This is the area where the fossils were discovered. The different members of the formation are indicated and separated by dashed lines (Leakey et al., 2001).

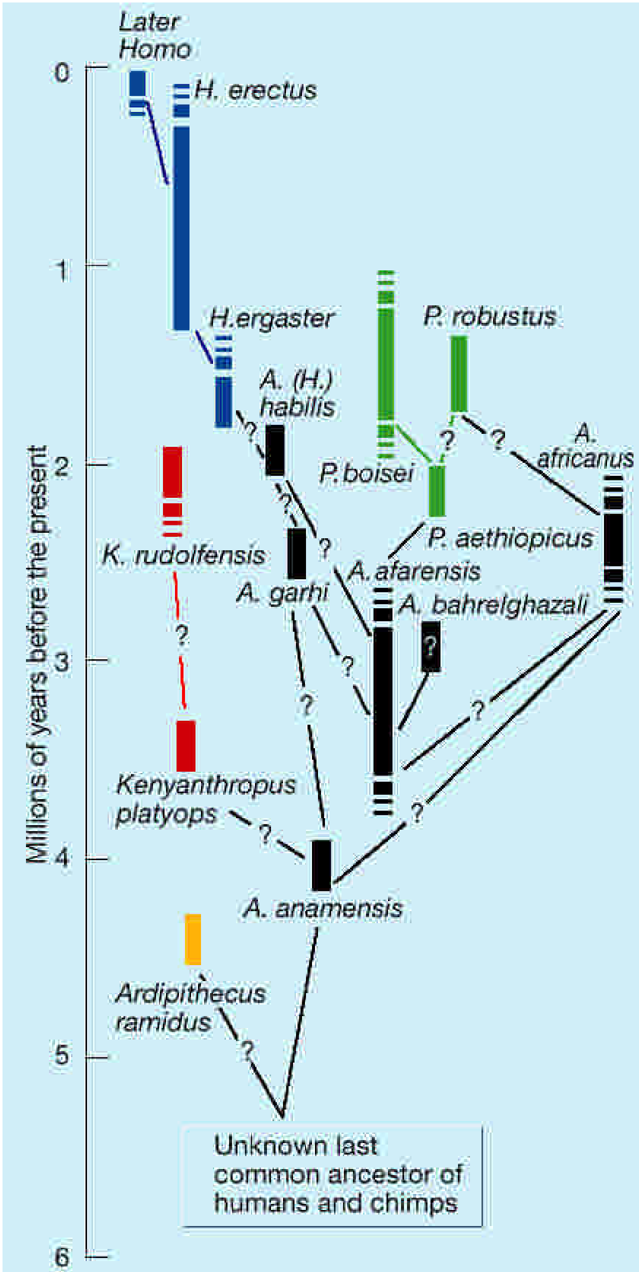

Figure 8: *Kenyanthropus platyops. Kenyanthropus* in red, *Homo* in blue, *Australopithecus* in black, *Paranthropus* in green, and *Ardipithecus* in yellow. Possible evolutionary relationships of hominids (Lieberman, 2001).

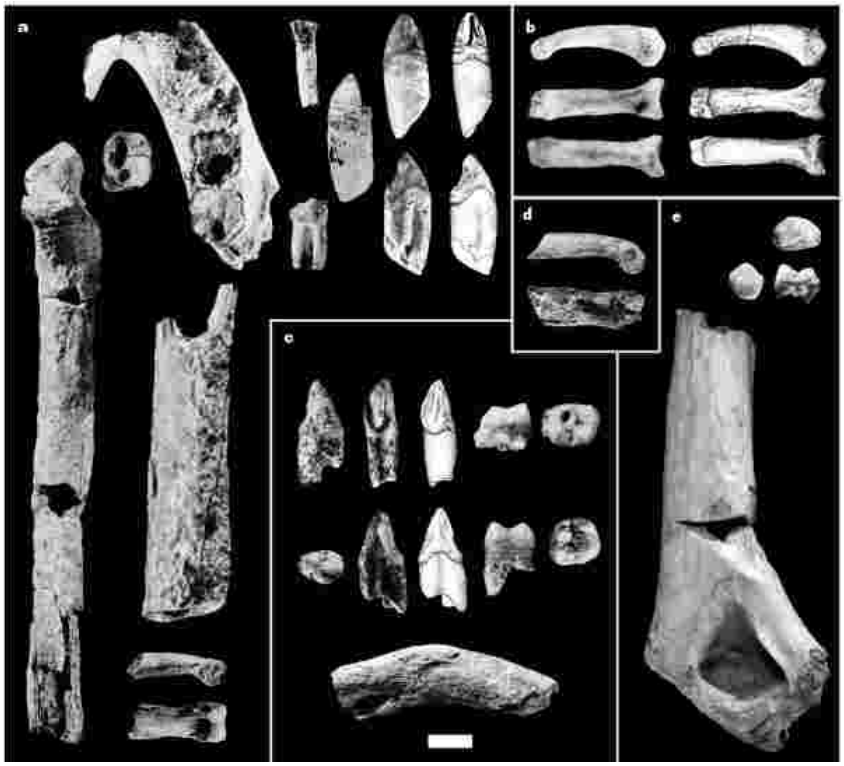

Figure 9: *Ardipithecus ramidus kadabba.* Remains from the Late Miocene Middle Awash deposits a. ALA-VP-2/10 mandible and associated teeth; ALA-VP-2/120 ulna and humerus shaft; ALA-VP-2/11 hand phalanx b. AME-VP-1/71 views of foot phalanx c. STD-VP-2 teeth and partial clavicle d. DID-VP-1/80 hand phalanx e. ASK-VP-3/160 occlusal, mesial and buccal views; ASK-VP-3/78 posterior view. Scale bar, 1 cm (Haile-Selassie, 2001).

Figure 10: *Ardipithecus ramidus kadabba.* Close-up of mandible fragments (upper and lower left), toe bone (upper right), collarbone fragment (lower right), and isolated teeth (Office of Science, n.d.)

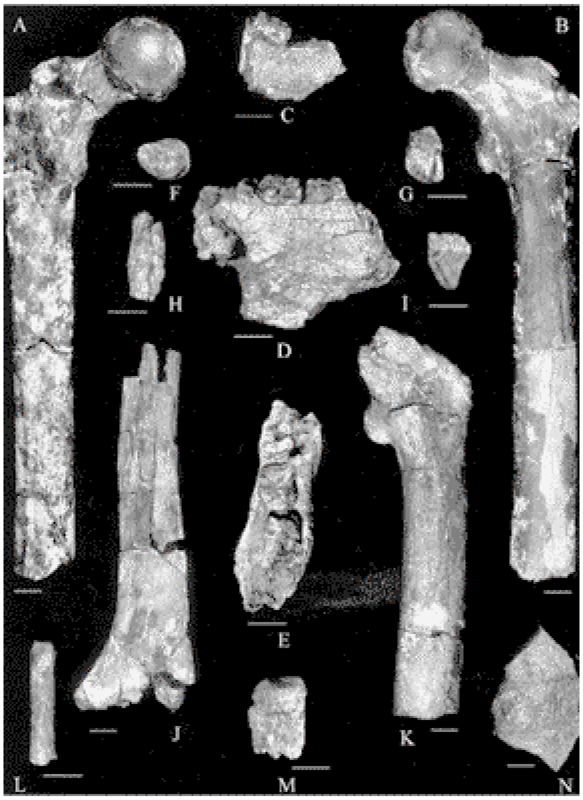

Figure 11: *Orrorin tugenensis.* Fossils from Cheboit, Hapcheberek, Aragai, and Kapsomin localities in the Tugen Hills. A-B, K. left femur; C-D. mandibular fragments; E-I, M. lower molar, upper incisor, lower premolar, upper canine, upper molars; J. right humerus; L. manual phalanx; N. right femur fragment (Science in Africa, 2002)

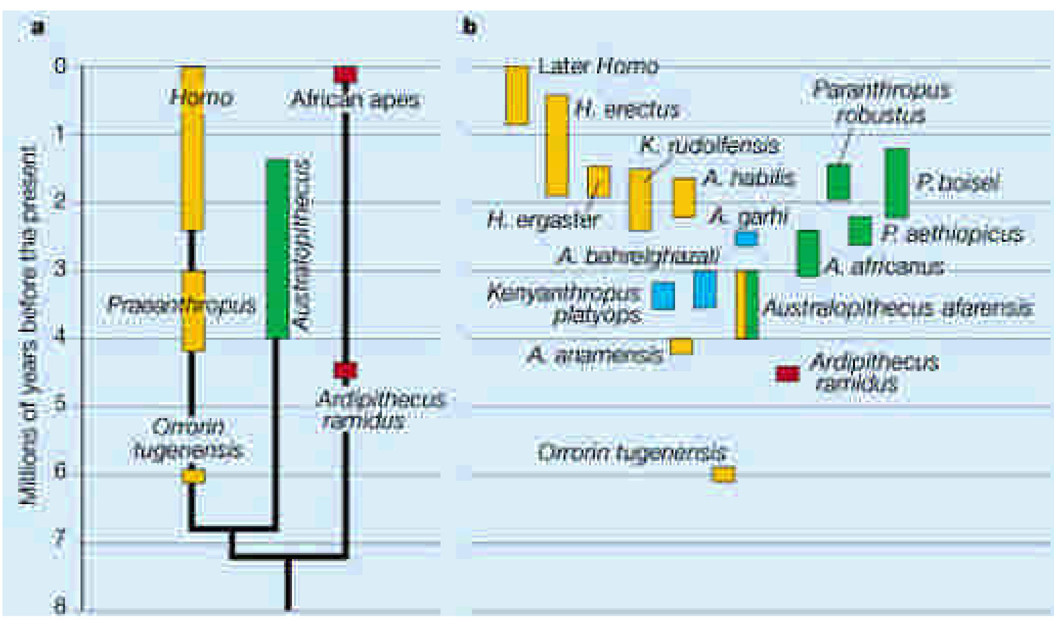

Figure 12: *Orrorin tugenensis.* a. proposed new model of the hominid ancestry b. shows species diversification (Aiello and Collard, 2001)

Figure 13: *Sahelanthropus tchadensis.* Holotype TM 266-01-060-1 a. facial view b. lateral view c. dorsal view d. basal view (Brunet et al., 2002)

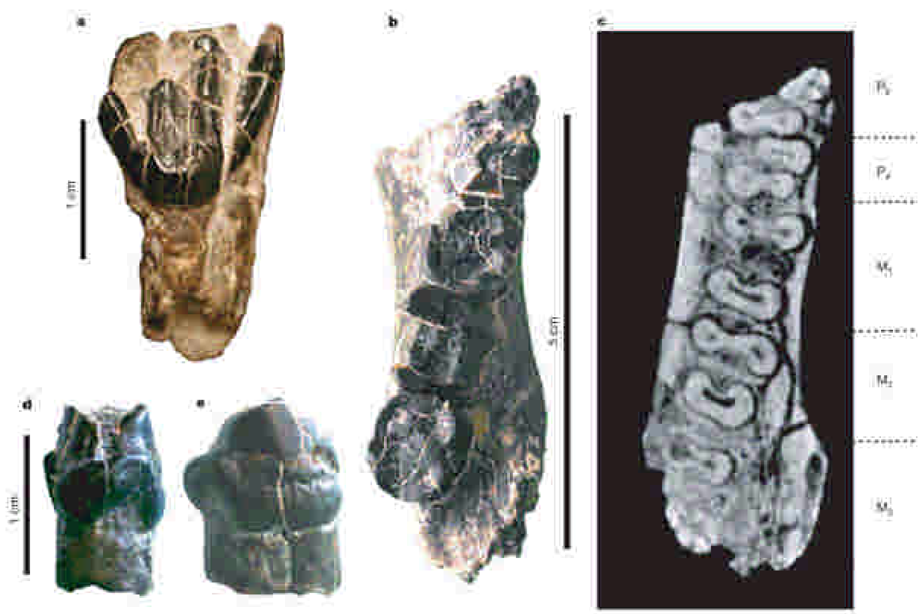

Figure 14: *Sahelanthropus tchadensis.* Paratypes: a. TM 266-01-448 right upper I^1 b,c. TM 266-02-154-1 right lower jaw d, e. TM 266-02-154-2 right lower canine (Brunet et al., 2002)

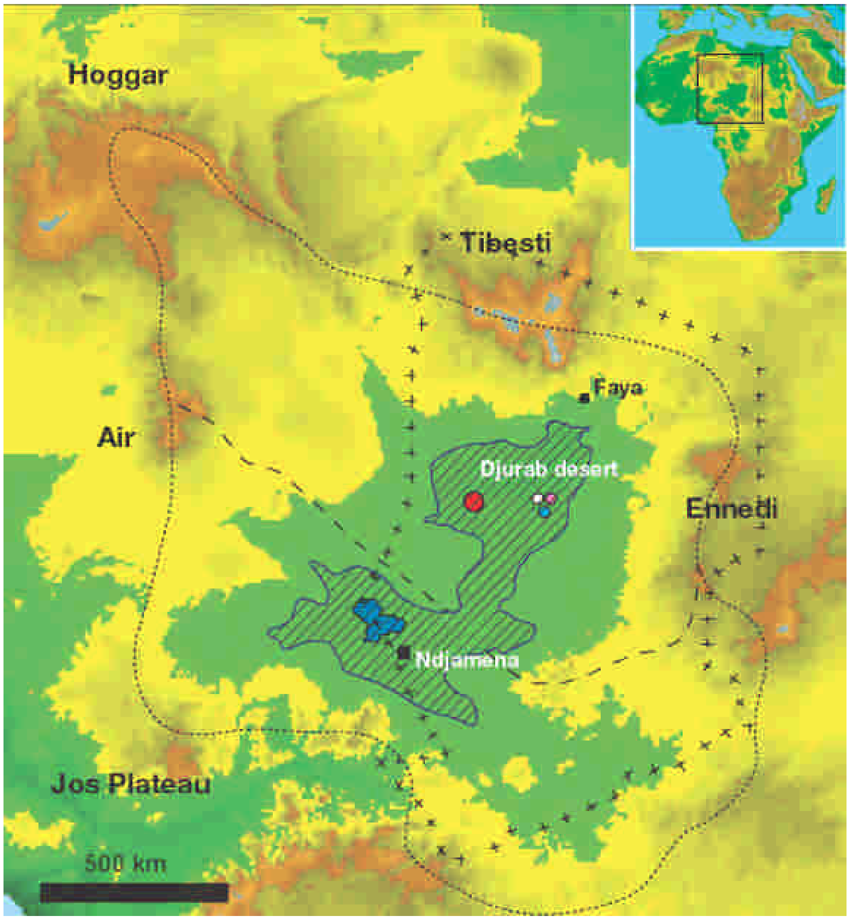

Figure 14: *Sahelanthropus tchadensis.* Toros-Menalla area of the Chad basin. The dotted line shows the boundary of the ancient Lake Chad basin. The red circle is the Toros-Menalla hominid site, TM 266 (Vignaud et al., 2002)

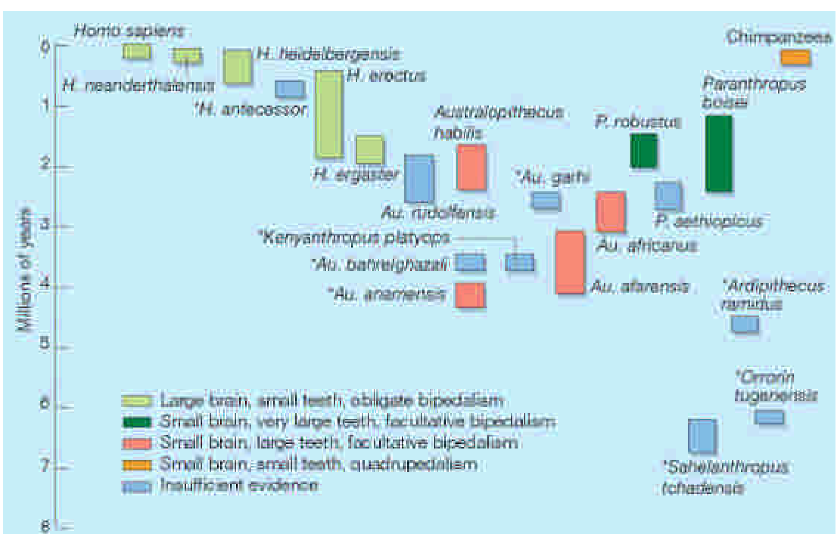

Figure 16: *Sahelanthropus tchadensis*. The newest proposed ancestral tree (Wood 2002)

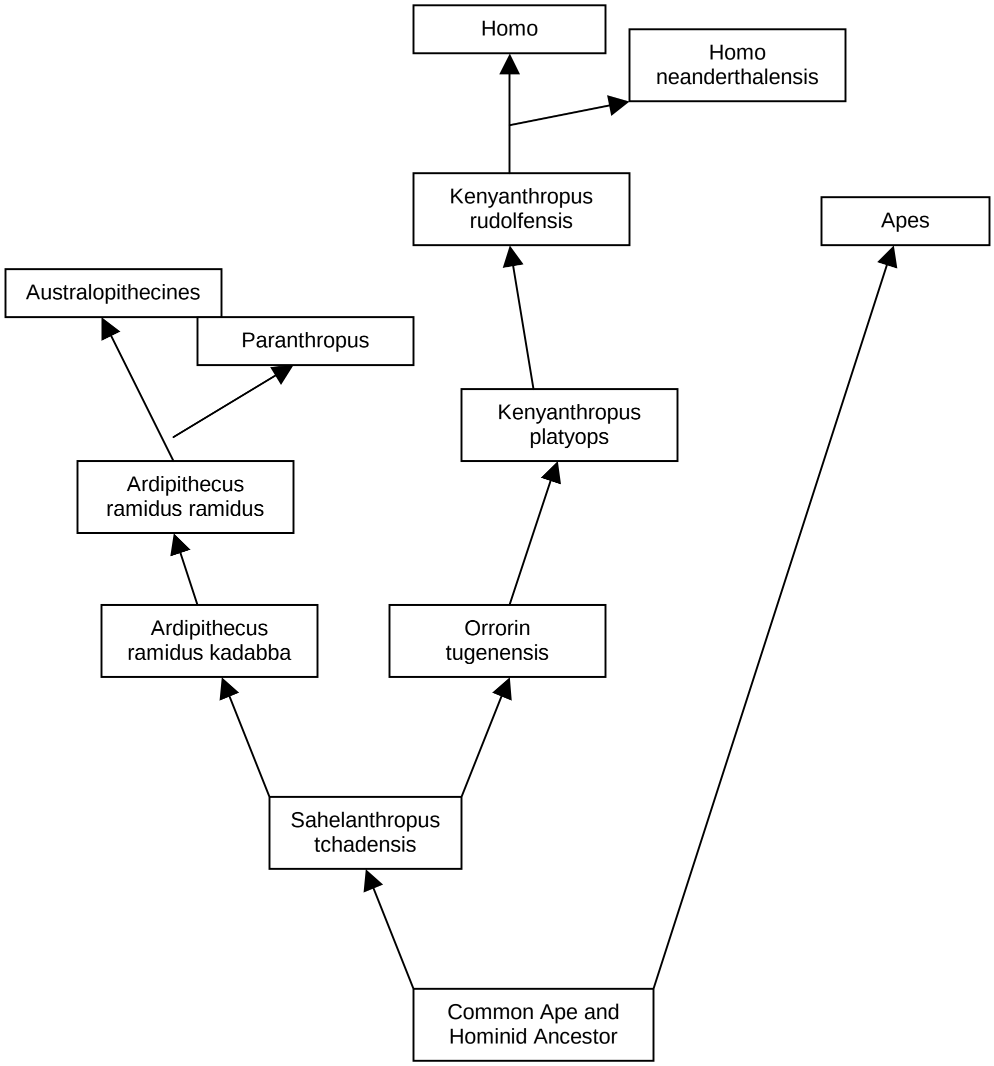

Figure 17: Proposed family ‘bush’ based on the information presented in this paper.

APPENDIX B: TABLES

Table 2 Derived cranial features of *Paranthropus*, and their character state in *K. platyops* and *H. rudolfensis*

	Paranthropus aethiopicus	*Paranthropus boisei*	*Paranthropus robustus*	*Kenyanthropus platyops*	*Homo rudolfensis*
Upper molar size	Large	Large	Moderate	Small	Moderate
Enamel thickness	Hyperthick	Hyperthick	Hyperthick	Thick	Thick
Palatal thickness	Thick	Thick	Thick	Thin	Thin
Incisor alveoli close to bicanine line*	Present	Present	Present	Present	Present
Nasoalveolar clivus	Gutter	Gutter	Gutter	Flat	Flat
Midline subnasal prognathism	Strong	Moderate	Moderate	Weak	Weak
Upper I^2 root to lateral nasal aperture	Medial	Medial	Medial	Lateral	Lateral
Nasal cavity entrance	Smooth	Smooth	Smooth	Stepped	Stepped
Zygomaticoalveolar crest	Straight, high	Straight, high	Straight, high	Curved, low	Curved, low
Anteriorly positioned zygomatic process of maxilla*	Present	Present	Present	Present	Present
Midface transverse contour	Concave, dished	Concave, dished	Concave, dished	Flat	Flat
Malar region	Wide	Wide	Wide	Tall	Tall
Malar orientation to lateral nasal margin	Aligned	Aligned	Aligned	More vertical	More vertical
Facial hafting, frontal trigone	High, present	High, present	High, present	Low, absent	Low, absent
Postorbital constriction	Marked	Marked	Marked	Moderate	Moderate
Initial supraorbital course of temporal lines	Medial	Medial	Medial	Posteromedial	Posteromedial
Tympanic vertically deep and plate-like	Present	Present	Present	Absent	Absent
Position external acoustic porus	Lateral	Lateral	Lateral	Medial	Medial
Mandibular fossa depth	Shallow	Deep	Deep	Moderate	Moderate
Foramen magnum heart shaped	Present	Present	Absent	Absent	Absent
Occipitomarginal sinus	Unknown	Present	present	Absent	Absent

Hypodigm of *H. rudolfensis* as in ref. 35. See refs 1, 8, 11, 36–40 for detailed discussions of the features.
* Character states shared by *Paranthropus* and *K. platyops*.

Table 1: *Kenyanthropus platyops*. This table shows the *Paranthropus* genus compared to the *Kenyanthropus* genus (including *H. rudolfensis*). This shows that *Kenyanthropus* is morphologically different from *Paranthropus*, and gives a greater basis for the claim that *rudolfensis* and *platyops* show enough similarities to be included in the same genus (Leakey et al., 2001).

Table 2 Comparative dental measurements

		Mesiodistal					Buccolingual				
		n	Min.	Max.	Mean	s.d.	*n*	Min.	Max.	Mean	s.d.
Upper dentition											
I^1	*S. tchadensis*	1	–	–	(13.3)	–	1	–	–	8.9	–
	O. tugenensis[8]	1	–	–	(10.0)	–	1	–	–	8.7	–
	A. r. ramidus[6]	1	–	–	(10.0)	–	2	7.5	8.2	–	–
	A. anamensis[20]	3	10.5	12.4	11.3	1.0	3	8.2	9.3	8.8	0.6
	A. afarensis[6]	3	10.8	11.8	11.2	0.6	5	7.1	8.6	8.2	0.6
	P. t. troglodytes[26]	14	–	–	12.2	0.8	14	–	–	9.4	0.8
C	*S. tchadensis*	–	–	–	–	–	1	–	–	10.2	–
	O. tugenensis[8]	1	–	–	11.0	–	1	–	–	9.3	–
	A. r. ramidus[6]	2	(11.2)	11.5	–	–	2	11.1	11.7	–	–
	A. anamensis[20]	2	(10.6)	11.7	–	–	2	10.2	11.2	–	–
	A. afarensis[6]	9	8.9	11.6	10.0	0.8	10	9.3	12.5	10.9	1.1
	P. t. troglodytes[26]	15	–	–	15.6	2.1	15	–	–	11.3	1.37
M^1	*S. tchadensis*	2	(10.9)	(11.5)	–	–	–	–	–	–	–
	A. r. kadabba[7]	1	–	–	(10.6)	–	1	–	–	12.1	–
	A. anamensis[20]	7	10.3	12.9	11.7	0.8	6	11.7	14.1	13.0	0.9
	A. afarensis[25]	14	10.5	13.8	12.2	1.0	12	12.0	15.0	13.4	0.9
	P. t. troglodytes[26]	14	–	–	10.5	0.5	14	–	–	11.3	0.6
M^2	*S. tchadensis*	1	–	–	13.0	–	1	–	–	(12.8)	–
	A. r. ramidus[6]	2	(11.8)	11.8	–	–	2	(14.1)	(15.0)	–	–
	A. anamensis[20]	6	10.9	14.2	12.5	1.2	6	13.2	16.3	14.8	1.0
	A. afarensis[6]	5	12.1	13.5	12.8	0.5	6	13.4	15.1	14.7	0.6
	P. t. troglodytes[26]	16	–	–	10.7	0.6	16	–	–	11.7	0.8
M^3	*S. tchadensis*	2	10.7	10.8	–	–	2	12.7	14.9	–	–
	O. tugenensis[8]	2	10.2	10.3	–	–	2	12.9	13.1	–	–
	A. r. kadabba[7]	1	–	–	10.9	–	1	–	–	12.2	–
	A. r. ramidus[6]	1	–	–	10.2	–	1	–	–	12.3	–
	A. anamensis[20]	7	11.1	15.7	12.4	1.6	5	13.0	14.7	13.8	0.6
	A. afarensis[6]	8	10.5	14.3	11.9	1.4	8	13.0	15.5	13.8	1.0
	P. t. troglodytes[26]	16	–	–	9.9	0.6	16	–	–	10.8	1.0
Lower dentition											
c	*S. tchadensis*	1	–	–	11.0	–	1	–	–	8.5	–
	A. r. kadabba[7]	2	10.8	11.2	–	–	2	7.8	7.8	–	–
	A. r. ramidus[6]	–	–	–	–	–	1	–	–	11.0	–
	A. anamensis[20]	7	6.6	10.4	9.0	1.3	6	9.2	11.4	10.2	1.0
	A. afarensis[27]	11	7.5	11.7	8.9	1.2	13	8.8	12.4	10.4	1.1
	P. t. troglodytes[26]	15	–	–	14.0	1.5	15	–	–	11.4	1.4
P_4	*S. tchadensis*	1	–	–	8.0	–	–	–	–	–	–
	O. tugenensis[8]	1	–	–	(8.0)	–	1	–	–	(9.0)	–
	A. r. kadabba[7]	1	–	–	(8.1)	–	1	–	–	10.0	–
	A. r. ramidus[6]	2	7.5	8.9	–	–	2	(9.9)	(11.5)	–	–
	A. anamensis[20]	8	7.4	9.8	8.8	1.0	9	9.6	11.9	10.7	0.8
	A. afarensis[6]	15	7.7	11.1	9.7	1.0	14	9.8	12.8	10.9	0.8
	P. t. troglodytes[26]	15	–	–	8.1	0.6	16	–	–	8.8	0.8
M_1	*S. tchadensis*	1	–	–	11.0	–	1	–	–	11.9	–
	A. r. ramidus[6]	2	11.0	11.1	–	–	2	(10.2)	10.3	–	–
	A. anamensis[20]	11	11.5	13.8	12.6	0.9	12	10.5	14.8	12.1	1.3
	A. afarensis[6]	17	11.2	14.0	13.0	0.6	16	11.0	13.9	12.6	0.8
	P. t. troglodytes[26]	15	–	–	10.7	0.4	15	–	–	9.2	0.6
M_2	*S. tchadensis*	1	–	–	12.5	–	–	–	–	–	–
	O. tugenensis[8]	1	–	–	(11.5)	–	1	–	–	(11.8)	–
	A. r. kadabba[7]	1	–	–	(12.7)	–	1	–	–	11.8	–
	A. r. ramidus[6]	1	–	–	(13.0)	–	1	–	–	11.9	–
	A. anamensis[20]	8	13.0	15.9	14.1	1.4	11	12.3	15.1	13.5	0.9
	A. afarensis[6]	23	12.4	16.2	14.3	1.0	22	12.1	15.2	13.5	0.9
	P. t. troglodytes[26]	15	–	–	11.3	0.5	15	–	–	10.6	0.9
M_3	*S. tchadensis*	1	–	–	13.3	–	1	–	–	12.2	–
	O. tugenensis[8]	2	(12.3)	(12.4)	–	–	2	10.4	11.2	–	–
	A. r. kadabba[7]	1	–	–	13.3	–	–	–	–	–	–
	A. r. ramidus[6]	1	–	–	12.7	–	1	–	–	11.0	–
	A. anamensis[20]	6	13.7	17.0	14.6	1.2	6	11.9	13.4	12.8	0.7
	A. afarensis[6]	14	13.7	16.3	14.8	0.8	14	12.1	14.9	13.3	0.8
	P. t. troglodytes[26]	16	–	–	11.0	0.6	16	–	–	9.6	0.8

Parentheses indicate estimated measurements.

Table 2: *Sahelanthropus tchadensis.* This table shows different measurements of teeth compared between hominids (Brunet et al., 2002)

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