STUDIA UBB CHEMIA, LXVI, 1, 2021 (p. 153-163)
(RECOMMENDED CITATION)
DOI:10.24193/subbchem.2021.1.12

RADIOCARBON INVESTIGATION OF THE BIG BAOBAB OF OUTAPI, NAMIBIA

ADRIAN PATRUT[a,b*], ROXANA T. PATRUT[a], LASZLO RAKOSY[c], DEMETRA RAKOSY[d], ILEANA-ANDREEA RATIU[a,b], KARL F. VON REDEN[e]

ABSTRACT. The article reports the AMS (accelerator mass spectrometry) radiocarbon dating results of the Big baobab of Outapi, which is the largest African baobab of Outapi, Namibia. The investigation of this monumental baobab revealed that it consists of 8 fused stems, out of which 4 are false stems. The Big baobab exhibits a closed ring-shaped structure. Three stems build the ring, which is now incomplete due to previous damage to the false cavity. Three wood samples were collected from the false cavity and from the longest false stem. Seven segments were extracted from the samples and dated by radiocarbon. The oldest investigated sample segment had a radiocarbon date of 820 ± 17 BP, corresponding to a calibrated age of 780 ± 10 calendar years. According to dating results, the Big baobab of Outapi is 850 ± 50 years old.

Keywords: *AMS radiocarbon dating, Adansonia digitata, dendrochronology, age determination, false cavity, multiple stems.*

INTRODUCTION

The African baobab (*Adansonia digitata* L.) is the most widespread and utilized of the eight or nine species of the *Adansonia* genus, which belongs to the Bombacoideae subfamily of Malvaceae. The African baobab is endemic to the arid savanna of mainland Africa [1–6].

[a] *Babeş-Bolyai University, Faculty of Chemstry and Chemical Engineering, 11 Arany Janos, RO-400028, Cluj-Napoca, Romania.*
[b] *Babeş-Bolyai University, Raluca Ripan Institute for Research in Chemistry, 30 Fantanele, RO-400294 Cluj-Napoca, Romania.*
[c] *Babeş-Bolyai University, Faculty of Biology and Geology, 44 Republicii, RO-400015, Cluj-Napoca, Romania.*
[d] *AG Spatial Interaction Centre, German Centre for Integrative Biodiversity Research, 5e Deutscher Platz, D-04103 Leipzig, Germany.*
[e] *NOSAMS Facility, Dept. of Geology & Geophysics, Woods Hole Oceanographic Institution, Woods Hole, MA 02543, U.S.A.*
** Corresponding author: apatrut@gmail.com*

In 2005, we initiated an extended research project to clarify several controversial aspects related to the architecture, growth and age of the African baobab. The research is based on AMS radiocarbon investigation of very small wood samples collected from inner cavities, deep incisions in the stems, fractured stems and from the outer part/exterior of large baobabs [7–15]. According to the research results, all large and old baobabs are multi-stemmed and exhibit preferentially closed or open ring-shaped structures. The oldest specimens were found to have ages up to 2,500 years [9,10,12,13].

Namibia is one of the African countries with the highest number of baobabs, which show different local abundance and distribution in the 12 regions [16]. The highest number and density of baobabs can be found in the Omusati region, in the north-central part of Namibia (26,573 km^2). According to a recent survey, the mean density of baobabs in Omusati is 6.7 (± 2.5) trees/ha, which corresponds to a total number of 17.80 (± 6.64) million individuals [17].

The climate of Omusati is described as semi-arid, with the rainfall restricted to summer months (November to April). The vegetation in the Omusati region belongs to the Mopane savanna, according to Giess classification of vegetation zones [17].

Our survey in Omusati identified a number of 11 superlative baobabs, with a circumference of over 20 m, out of which 6 are located in and around Outapi, 3 in Onesi and one each in Tsandi and Okahao. The high density of baobabs and the number of superlative specimens is also due to large areas with sandy soils, rich in sodium and calcium.

Outapi (also called Uutapi and Ombalantu), located close to the border with Angola, is the capital of the Omusati region. It hosts 6 superlative baobabs in an area of less than 10 km^2. The most famous is the Ombalantu baobab, which is part of a national heritage site. However, the largest specimen is the Big baobab.

Here we present the investigation and AMS radiocarbon dating results of the Big baobab of Outapi.

RESULTS AND DISCUSSION

The Big baobab of Outapi and its area. Ten years ago, the large baobab was situated on a vacant land with sandy soil at the intersection of Nakakanda Mukatala and Natanael Mahwilili streets in Outapi, close to the Outapi Town Hotel. The baobab is currently in the yard of a newly built social shelter for young people. They use it for trash and waste disposal. This tree is known only to nearby residents as a large baobab in the area. Because it is the largest baobab in town, we named it the Big baobab of Outapi.

The GPS coordinates of the tree are 17º30.141' S, 014º58.982' E and the altitude is 1116 m. The mean annual rainfall in the area is 467 mm, while the mean annual temperature reaches 21.1 °C (Outapi station). The Big baobab has a maximum height of 22.1 m, the circumference at breast height (cbh; at 1.30 m above ground level) is 31.01 m and the overall wood volume is around 330 m^3 (**Figure 1**). The horizontal dimensions of the canopy are 33.6 x 32.8 m. In terms of circumference, the Big baobab of Outapi ranks sixth in the world, after Holboom, Sagole big tree, Makuri Lê boom, Dorslandboom and Sir Howard baobab at Tsandi, all from Namibia, except Sagole big tree, which is from South Africa [9, 12, 18].

The monumental baobab consists of 8 stems, out of which 4 are false ones [19]. It also has several buttress branches. The baobab exhibits a closed ring-shaped structure, with a false cavity defined by three stems. The false cavity opened some time ago, by the splitting of two stems. The resulting opening occupies an angle of more than 30° of the circumference. The false cavity has a bell shape with a height of 2.95 m and an ellipsoidal base with the axes of 2.24 x 1.88 m (**Figure 2a** and **2b**). On the other hand, two false stems are disposed in V-shape with an opening of around 50°. Their lengths at ground level are 2.80 and 3.61 m (**Figure 3**). Such false stems disposed in V-shape provide better stability in sandy soils.

Figure 1. General view of the Big baobab of Outapi from the south-west.

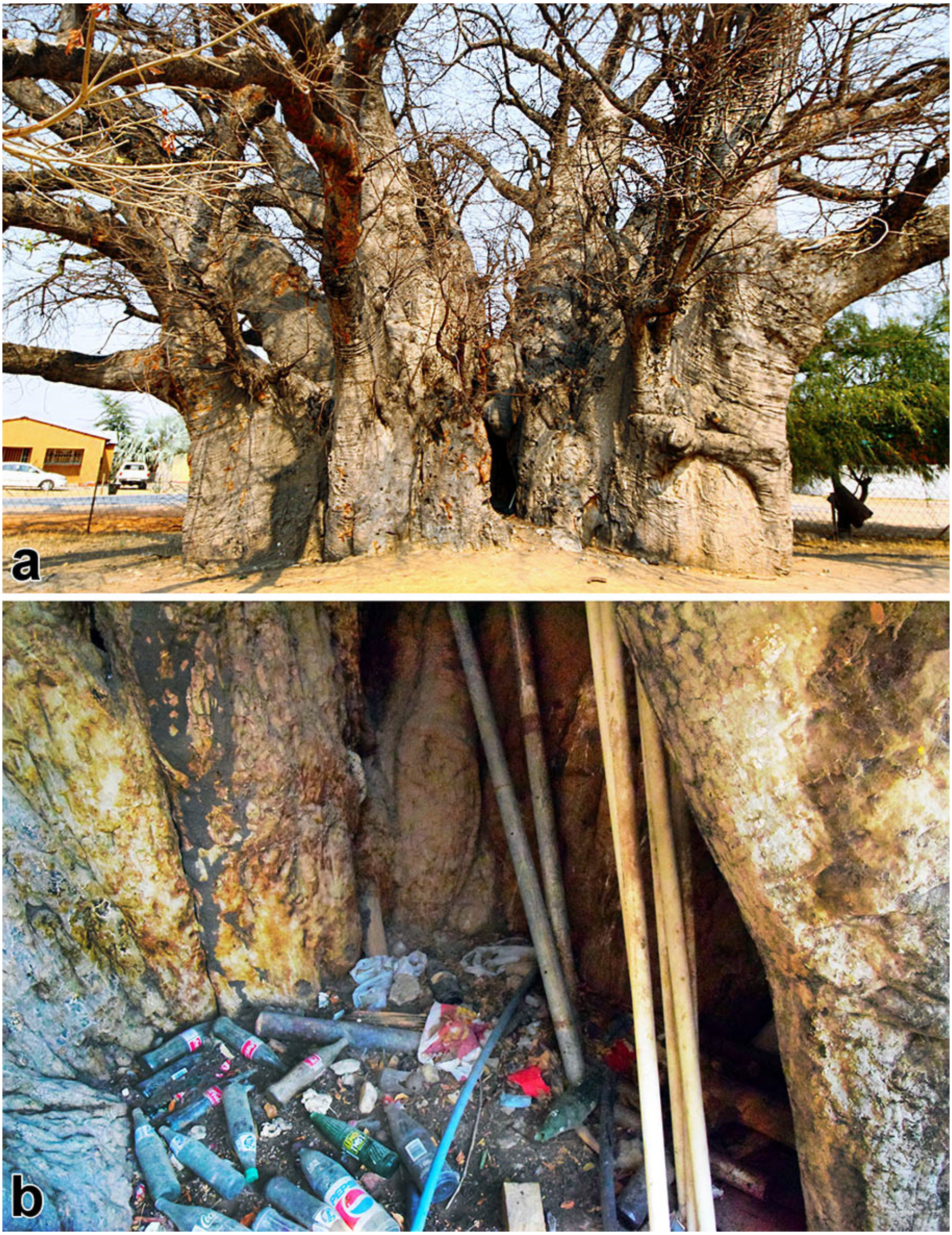

Figure 2.a. View of the Big baobab from the south-east, showing in the centre the entrance to the false cavity; **b.** The base of the false cavity covered by trash and waste.

Wood samples. Three wood samples were collected with an increment borer. One wood sample (labeled BB-1) was collected from the inner walls of the false cavity. Other two samples (labeled BB-2 and BB-3) were collected from the deepest end/origin and from the middle of the longest false stem of the pair disposed in V-shape. All samples were collected at convenient heights, between 1.20 and 2.10 m.

A number of seven tiny segments were extracted from determined positions of the three samples. Five segments (marked from 1a to 1e) were extracted from sample BB-1, while one segment each (marked 2x and 3x) was extracted from samples BB-2 and BB-3.

AMS results and calibrated ages. Radiocarbon dating results of the 7 sample segments are listed in Table 1. The radiocarbon dates are expressed in ^{14}C yr BP (radiocarbon years before present, i.e., before the reference year 1950). Radiocarbon dates and errors were rounded to the nearest year.

Calibrated (cal) ages, expressed in calendar years CE (CE, i.e., Common Era), are also presented in Table 1.

Table 1. Radiocarbon dating results and calibrated ages of samples collected from the Big baobab of Outapi.

Sample/ segment code	**Depth[1] [height[2]] (m)**	**Radiocarbon date [error] (^{14}C yr BP)**	**Cal CE range 1σ [confidence interval]**	**Assigned year [error] (cal CE)**	**Sample/ segment age [error] (cal CE)**
BB-1a	0.01 [1.20]	-	-	>1950	>Modern
BB-1b	0.10 [1.20]	101 [± 18]	1816-1830 (22.8%) **1892-1922 (45.4%)**	1907 [± 35]	115 [± 15]
BB-1c	0,25 [1.20]	308 [± 18]	1517-1538 (17.4%) **1627-1654 (50.8%)**	1640 [± 15]	380 [± 15]
BB-1d	0.40 [1.20]	438 [± 17]	**1452-1488 (68.3%)**	1470 [± 20]	550 [± 20]
BB-1e	0.54 [1.20]	820 [± 17]	**1230-1250 (45.7%)** 1260-1271 (22.5%)	1240 [± 10]	780 [± 10]
BB-2x	0.40 [2.10]	331 [± 16]	**1512-1546 (43.2%)** 1624-1643 (25.1%)	1529 [± 15]	480 [± 15]
BB-3x	0.60 [2.10]	310 [± 19]	1516-1540 (21.3%) **1627-1654 (46.9%)**	1640 [± 15]	380 [± 15]

[1]Depth into the wood.
[2]Height above ground level.

The 1σ probability distribution (68.3%) was selected to derive calibrated age ranges. For one segment (BB-1d), the 1σ distribution is consistent with one range of calendar years. For other five segments (BB-1b, BB-1c, BB-1e, BB-2x, BB-3x), the 1σ distribution corresponds to two ranges of calendar years. In these cases, the confidence interval of one range is considerably greater than that of the other; therefore, it was selected as the cal CE range of the sample for the purpose of this discussion. For obtaining single calendar age values of samples, we derived a mean calendar age of each sample from the selected range (marked in bold). Sample ages represent the difference between the year 2021 CE and the mean value of the selected range, with the corresponding error. Sample ages and errors were rounded to the nearest 5 yr. We used this approach for selecting calibrated age ranges and single values for sample ages in our previous articles on AMS radiocarbon dating of large angiosperms, especially baobabs [7-15, 18-22].

Figure 3. The photograph presents the two false stems disposed in V-shape.

Dating results of samples. For the five segments extracted from sample BB-1, which was collected form the inner walls of the false cavity, segment ages increase with the depth in the wood, i.e., from BB-1a to BB-1e.

For the first segment BB-1a, the age falls after 1950 CE (0 BP), namely the ^{14}C activity, expressed by the ratio $^{14}C/^{12}C$, shows a higher value than the standard activity registered in the reference year 1950. This result, that corresponds to a negative radiocarbon date, is termed greater than Modern (>Modern). Such cases indicate a very young age of the dated wood, which was formed after 1950 CE. In the case of segment BB-1a, the result shows that the baobab is still growing in the direction of the false cavity.

The oldest segment BB-1e represents the sample end and corresponds to a distance of 0.54 m from the cavity walls toward the exterior. Its radiocarbon date of 820 ± 17 BP amounts to a calibrated age of 780 ± 10 calendar yr. The continuous increase of segment ages shows that sample BB-1 has not reached the point of maximum age in the sampling direction. The depth of the cavity walls in the sampling direction is around 1.10 m. Because for the false cavity walls, the point/area of maximum age is always located closer to the cavity than to the exterior, one can estimate that this point is positioned at a distance of at least 0.60 m from the sampling point.

We also dated two segments BB-2a and BB-3a, which originate from samples collected from the deepest end/origin of the longest false stem, i.e., its emergence point from the adjacent ordinary stem and from the middle of this false stem, respectively. Their radiocarbon dates are 331 ± 16 and 310 ± 19 BP. These values correspond to calibrated ages of 480 ± 15 and 380 ± 15 calendar yr.

Age of the Big baobab. The age of the baobab can be calculated by extrapolating the age of the oldest segment BB-1e, which represents the deepest end of sample BB-1, i.e., 780 ± 10 calendar yr, to the point of maximum age inside the cavity walls. This gives us an age of 850 ± 50 years for the oldest part of the Big baobab. According to this value, the Big baobab of Outapi started growing around the year 1170 CE.

Ages of segments BB-2x and BB-3x, namely 480 ± 15 and 380 ± 15 calendar years, are associated with the age and growth of the largest false stem. These values indicate that the longest false stem emerged from the adjacent ordinary stem around 480–500 years ago and that it grew very fast, around 1.80 m in length in the first 100 years.

Architecture of the Big baobab. Our research based on radiocarbon dating has identified a new very stable architecture that enables African baobabs to reach large sizes and old ages. We named it ring-shaped structure (RSS). In this multi-stemmed architecture, the stems describe at ground level a circle or an ellipse. The most frequent is the closed RSS, in which the stems are pointed upward and are fused almost completely. The fused stems are disposed in a ring with a natural empty space inside, which was named false cavity [9, 11]. As mentioned, the Big baobab of Outapi exhibits a closed RSS, with a damaged false cavity, whose walls are covered by bark.

All large baobabs are multi-stemmed. The vast majority are common stems, which shoot from the roots or emerge from fallen stems. Some baobabs have peculiar structures, which are trapezoidal or triangular in horizontal section. According to radiocarbon dating, the oldest age can be found toward the upper contact with the larger adjacent ordinary stem, from which the false stem emerges. The age decreases toward the opposite sharp extremity. This false stem plays the role of an anchor and is a special type of buttress, very different from the so-called buttress branch. Certain baobabs have two adjacent false stems disposed in V-shape, with an opening of 30–60º [19]. The Big baobab possesses 4 false stems, out of which two are disposed in V-shape.

PROTECTION AND CONSERVATION

Although Namibia has strict laws for protection and conservation of the vegetation and fauna, its monumental baobabs, which are among the largest and oldest in the world, are practically unattended and unprotected. Even if Outapi is the capital of the Omusati region, the largest tree in town, the Big baobab, is used as trash and waste disposal. This action deteriorates even further the false cavity, which is already damaged. Another large baobab (cbh = 23.05 m), located very close to the central market, is used as a public toilet by both men and women. It is known by locals as the “Market Toilet tree”.

CONCLUSIONS

The research discloses the AMS radiocarbon dating results of the Big baobab of Outapi, which is the largest African baobab from Outapi, Namibia. The aim of the research was to determine the architecture and the age of this monumental baobab. The Big baobab consists of 8 stems, out of which 4 are ordinary and 4 are false stems. Two false stems are disposed in V-shape. The tree exhibits a closed ring-shaped structure, with a damaged false cavity inside.

Three wood samples were collected from the false cavity and from the longest false stem, out of which seven segments were extracted, processed and radiocarbon dated. The oldest investigated sample segment had a radiocarbon date of 820 ± 17 BP, which corresponds to a calibrated age of 780 ± 10 calendar yr. According to dating results, the Big baobab of Outapi started growing of 850 ± 50 years ago. The longest false stem is 480 ± 15 years old and it grew very fast during the first 100 years.

EXPERIMENTAL SECTION

Sample collection. The three small wood samples were collected with a Haglöf CH 800 increment borer (0.80 m long, 0.0054 m inner diameter). A number of seven segments of the length of 0.001 m were extracted from predetermined positions along the wood samples. The segments were processed and investigated by AMS radiocarbon dating.

Sample preparation. The standard acid-base-acid pretreatment method was used for removing soluble and mobile organic components [23]. The pretreated samples were combusted to CO_2 by using the closed tube combustion method [24]. Next, CO_2 was reduced to graphite on iron catalyst, under hydrogen atmosphere [25]. Eventually, the resulting graphite samples were investigated by AMS.

AMS measurements. AMS radiocarbon measurements were done at the NOSAMS Facility of the Woods Hole Oceanographic Institution (Woods Hole, MA, U.S.A.), by using the Pelletron ® Tandem 500 kV AMS system. The obtained fraction modern values, corrected for isotope fractionation with the normalized $\delta^{13}C$ value of -25 $^{0}/_{00}$, were finally converted to a radiocarbon date.

Calibration. Radiocarbon dates were calibrated and converted into calendar ages with the OxCal v4.4 for Windows [26], by using the SHCal20 atmospheric data set [27].

ACKNOWLEDGEMENTS

The investigation and sampling of the baobab was authorized by the Ministry of Environment and Tourism of Namibia under the Research/Collecting Permit No. 1934_2014. The research was funded by the Romanian Ministry of Education and Research CNCS-UEFISCDI under grant PN-III-P4-ID-PCE-2020-2567, No. 145/2021.

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