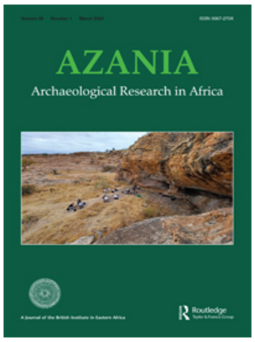


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# Using the radiocarbon dates of Central Africa for studying long-term demographic trends of the last 50,000 years: potential and pitfalls

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**ABSTRACT**

This paper presents the first review of biases impacting Pleistocene and Holocene radiocarbon dates from Central Africa. Based on the pooling of the research expertise of the co-authors, twenty-four biases are listed, explained and documented and their impact on any radiocarbon date corpus demonstrated. To achieve this, a new corpus has been created of 1764 radiocarbon and TL assays from 601 archaeological sites published in the literature. Each date has been checked for its context. The irregular dynamics of research in space and time seriously impact the end result of previous analyses aiming to achieve a regional understanding of past demographic fluctuations. While peaks in the number of dates from the late Holocene seem to correspond to a positive demographic trend, it is suggested that the declines identified cannot be of any such use for the time being and that today's picture does not presently support claims of a population "crash" at a regional or local level for any time period. The numbers are obscured by overall research deficits identifiable throughout the region. The maps of the dated sites presented offer good evidence of this and illustrate the vast expanses where no archaeological research has yet been carried out. The number of radiocarbon dates in Central Africa is more an indicator of the effort archaeologists have put into understanding a settlement than it is of ancient demographics. Successive waves of incoming people since *c.* 3500–3000 cal. BP, the two most important ones known since the 1990s, have created a cultural mosaic of coexisting technological groups. The last 40 years of research have revealed the inner complexity of these waves, some of which avoided parts of the region for centuries, thereby creating an irregular cultural mosaic of land use that is outlined by patterning in the radiocarbon dates.

**RÉSUMÉ**

Cet article présente la première étude des biais ayant un impact sur le corpus des dates radiocarbones du Pléistocène et de l'Holocène en Afrique centrale. Sur la base de la mise en commun de l'expérience des co-auteurs, vingt-quatre biais sont listés, expliqués, documentés, et leur impact sur le corpus de dates

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radiocarbone est démontré. Pour ce faire, un nouveau corpus est créé de 1764 analyses radiocarbone et TL provenant de 601 sites archéologiques publiés dans la littérature. Le contexte de chaque date a été vérifié. La dynamique irrégulière de la recherche dans l'espace et dans le temps a un impact sérieux sur le résultat final des analyses précédentes visant à obtenir une compréhension régionale de la démographie ancienne. Alors que les maximas dans le nombre de dates de la fin de l'Holocène semblent correspondre à une tendance démographique positive, on suggère que les déclins identifiés ne peuvent pas être d'une telle utilité pour le moment, et que le tableau actuel ne soutient pas les affirmations d'un "crash" de la population au niveau régional ou local pour n'importe quelle période de temps. Les chiffres sont obscurcis par les déficits globaux de recherche que identifiables dans toute la région. Les cartes des sites datés présentées ici en sont une bonne preuve et illustrent les vastes étendues où aucune recherche archéologique n'a encore été effectuée. Le nombre de datations radiocarbone en Afrique centrale est plus un indicateur des efforts déployés par les archéologues pour comprendre un site que de son ancienne démographie. Les vagues successives de populations depuis environ 3500 à 3000 ans avant le présent, les deux principales connus depuis les années 1990, ont créé une mosaïque culturelle de groupes technologiques coexistants dans l'espace. La recherche au cours de ces 40 dernières années a révélé la complexité interne de ces vagues, dont certaines ont évité certaines parties de la région pendant des siècles, créant ainsi une mosaïque culturelle et une utilisation irrégulière des terres mises en évidence par l'ensemble des dates radiocarbone.

## Introduction: from cultural history to demography

The underlying assumption behind using radiocarbon 'dates as data' to inform us about past human demographics is that the number of aggregated radiocarbon dates in a region is an indirect proxy of past human numbers such that 'fluctuations in [the]temporal frequency distributions of radiocarbon dates, which are considered proportional to human population density, … are therefore indicative of palaeodemographic trends' (Chaput and Gajewski 2016: 4) [since] 'more people will have led to a greater production and deposition of cultural carbon' (Peros *et al.* 2010: 656). Archaeologists have tried to look for such fluctuations to test hypotheses about demographic change within their research regions, sometimes forgetting that dates are not a direct measure of human population, but instead a reflection of the number of samples submitted for radiocarbon dating according to their particular research interests and biases. In Central Africa, our radiocarbon data have, for example, expanded from about 150 archaeological assays in 1982 to over 1700 in 2023.

In 1982, the first book specifically devoted to the archaeology of Central Africa listed 151 radiocarbon dates from the 'Stone Age' and 'Iron Age' (Van Noten 1982) that had been processed since the first Lv-44 date from the site of Lemba in Kinshasa, Democratic Republic of Congo (Dossin *et al.* 1962). That book was an offshoot of two earlier UNESCO book chapters (Van Noten *et al.* 1981a, 1981b). Beginning in 1977, and continuing into the 1980s, a new series of radiocarbon dates specifically devoted to

Central African archaeology was published in the *Journal of African History* (de Maret *et al.* 1977; de Maret 1982, 1985). These were the result of developing fieldwork in a still badly understood region of the continent (de Maret 1984, 1990). They were used in a classical way to help structure the first cultural sequences for the region (Lanfranchi and Clist 1991). A more critical attitude towards the interpretation of radiocarbon dates was advocated, especially a need for more careful study of the context from which the samples were collected (de Maret 1982: 11). This led to a test study of the Early Iron Age Urewe Industry of the African Interlacustrine region (Clist 1987). Urewe was thought to be ancestral to all the pottery groups belonging to the earliest expansion of Bantu-speakers in East Africa (Phillipson 1985). The paper also featured the use of a computer program developed by M. Geyh (1980) at the Hanover laboratory, Germany, to ascertain with histograms a statistical evaluation of any radiocarbon series. It had been tested in our region for Congo-Kinshasa's Iron Age (Geyh and de Maret 1982; de Maret 1992: 209–215).

More work using aggregated radiocarbon dates to infer local demography was developed in the United States through the 1980s (e.g. Berry 1982; Wright 1982). It led to the influential paper by Rick (1987), who used 328 uncalibrated Peruvian radiocarbon dates spread between 3000 and 20,000 BP. Following this pioneering work, all the regions of the world have been examined at least once using this methodology; since 1992, the use of calibrated dates and the 'summed probability density function' (Dye and Komori 1992), which later became the Summed Probability Distribution (or SPD), has been extensively developed. Some scholars nevertheless contend that SPDs have weaknesses and research biases (e.g. Attenbrow and Hiscock 2015: 3; Lupo *et al.* 2018: 13–16; Ritchison 2020: 1578; Carleton and Groucutt 2021; DiNapoli *et al.* 2021) that must be challenged before coming to interpretations.

In a region the size of the European Union, or half that of the United States of America, which is composed of eight countries (Angola, Cameroon, the Central African Republic, the Republic of Congo (hereafter Congo-Brazzaville), the Democratic Republic of Congo (hereafter Congo-Kinshasa), Equatorial Guinea, Gabon and São Tomé and Príncipe; Figure 1), the first radiocarbon dates were only processed in the early 1960s, even though archaeological research started in the 1880s (Van Noten 1982; de Maret 1990; Lanfranchi and Clist 1991).

Radiocarbon dates later formed the backbone for the first cultural sequences from the Stone Age to the Iron Age (Van Noten 1982; Lanfranchi and Clist 1991). Since the early 1990s, the temporal distribution of radiocarbon dates, and specifically the availability of larger numbers of results for the Early Iron Age, have led some to propose using patterns of date frequencies as a proxy for changes in demographic density and distribution and, based on 23 radiocarbon dates, to suggest that there was a population collapse in Gabon after *c.*1500 cal. BP (Oslisly 1992: 251). This collapse was later thought to have been possibly a regional phenomenon (de Maret 2003). Wotzka (2006) was the first to build a solid regional database of the Late Holocene using 566 dates obtained from the rainforest to provide cautious explanations using *Group Dispersion Calibration*. The past few years have witnessed the publication of several studies based on a proposed link between the number of radiocarbon dates and ancient demography, including two 2021 papers that introduce the use of SPDs (Oslisly *et al.* 2013a, 2013b; Sánchez-Elipe Lorente *et al.* 2016; de Saulieu *et al.* 2021; Seidensticker *et al.* 2021). However, we are convinced


**Figure 1.** Central Africa and its constituent countries.

after examining data from the latest catalogue of radiocarbon dates (see Supplementary Online Material 1; hereafter SOM 1), combined with our collective understanding of the archaeological research that each of us has carried out since the early 1980s in our respective areas, that we are still at a moment in our research when we cannot yet choose between several possible explanations to decipher the observed internal dynamics of our radiocarbon corpus (de Maret *et al.* 2018: 457), or even a combination of these as suggested by Wotzka (2006). This is because the data are heterogeneous, widely scattered and very incomplete in nature.

Our interpretative protocol follows a two-pronged approach that aims to test the validity of our educated opinion. This approach consists of making: 1) the best possible catalogue of the radiocarbon corpus by looking closely at the contexts of individual dates; and 2) verifying whether a lack of intensive research, or biased approaches to data gathering, might have contributed to the present chronological and areal distribution of radiocarbon dates. Three recent publications partly address the first part of the protocol (Garcin *et al.* 2018; de Saulieu *et al.* 2021; Seidensticker *et al.* 2021); here we examine the second part, which has previously been neglected. For the first time in Central Africa, we follow the two main lines of evidence: the context and possible research biases that underlay the creation of regional archaeological assemblages and their associated radiocarbon dates. These run from the Pleistocene through the Holocene. Denbow (2019) provides specific examples of such research biases from southern Africa.

There is a need to expand upon the first radiocarbon database made some time ago in the *Plateforme des datations archéologiques intertropicales* by the French Institut de Recherche pour le Développement (IRD). It already has sections on the Amazonian Basin and Central Africa that include a cartographic tool (http://vmtropicar-proto.ird.fr/archeologie/ de Saulieu *et al.* 2017a). As suggested by Wotzka (2006: 288), there is also a need to develop a web-based repository of Stone Age and Iron Age dates from archaeological sites in Central Africa. This could then be integrated into a wider catalogue that could be regularly updated and include eastern and southern Africa (Clist 2019: 29; Loftus *et al.* 2019; Vermeersch 2020).

The Central African research programs were directed by scholars speaking several languages, trained in different countries and often asking quite different questions about the Central African past. Our paper lists twenty-four biases distilled from our pooled experience that include examples taken from our own fieldwork experience in Angola, Cameroon, the Central African Republic, Congo-Brazzaville, Congo-Kinshasa and Gabon. We use three recent publications (Garcin *et al.* 2018; de Saulieu *et al.* 2021; Seidensticker *et al.* 2021) to lead us more rapidly to the latest available information for our study and to ascertain the quality of their associated databases while updating our own exhaustive DIBAC database (*Datations absolues, Inventaires archéologiques et Bibliographies en Afrique Centrale*) which contains 35 computerised dimensions (Clist 2005b). DIBAC is itself an offshoot of the *Cibadates* project of the 1980s (Sarrazin 1987). DIBAC is a better source for compiling radiocarbon date contexts because the primary publications were investigated as listed on http://www.african-archaeology.net/biblio/index.html. Part of the database for Gabon was published previously (Clist 1995: 259–280), but without the associated contexts. This is the 1995 catalogue used extensively by Seidensticker *et al.* (2021) and possibly others.

The catalogue of radiocarbon dates we present in SOM 1 is quite exhaustive with regard to several factors. First, it lists 1764 radiocarbon dates from 601 archaeological excavations. These reveal a major problem as far as geographical representativeness is concerned. For example, there are only 1.4 excavated and dated archaeological sites per 100 km, or one per approximately 2000 km$^2$ in Gabon, when compared to one per ~53,000 km$^2$ in Angola (Table 1). Documented dates from environmental or

**Table 1.** Central Africa: total of radiocarbon and TL dates, number of excavated and dated sites, density of excavated and dated sites per square block or by 100 km distances.

| Country | Dates | Sites | Site per block of | Site per 100 km |
|---|---|---|---|---|
| Cameroon | 532 | 154 | 48 × 48 km | 2.1 |
| Central African Republic | 233 | 97 | 80 × 80 km | 1.2 |
| Gabon | 258 | 127 | 45 × 45 km | 2.2 |
| Equatorial Guinea | 57 | 8 | 60 × 60 km | 1.7 |
| Congo-Brazzaville | 170 | 93 | 58 × 58 km | 1.7 |
| Congo-Kinshasa | 445 | 93 | 165 × 165 km | 0.6 |
| Angola | 69 | 29 | 230 × 230 km | 0.4 |
| **Total** | **1764** | **601** | - | **1.4** |

palaeoenvironmental fieldwork, although also registered in our database, are not included in SOM 1. The catalogue is subdivided into country lists, each of which is further subdivided, when possible, into more provincial series. The dates are then grouped by site, which permits a good visualisation of past occupation at each location. The graphics presented in Supplementary Online Material 2 (SOM 2) illustrate the differences between regional (SOM 2, section 1) and national (SOM 2, section 2) data sets. To better understand what constitutes the national catalogues, we examined the series at the provincial level, which is itself a heritage of colonial times. For example, for Cameroon we isolated six provinces: Grassfields, Central, East, Southwest, South and West Cameroon respectively.

From the lists, we group archaeological sites with just one radiocarbon date (Tier 1 sites), those with two to four dates (Tier 2 sites), between five and nine dates (Tier 3 sites) and finally those with a minimum of ten dates (Tier 4 sites). Mapping of the dated sites resulted in 17 areas where research was most concentrated with Tier 3 and 4 sites (SOM 2, section 3). We feel that these concentrations better fit ancient cultural borders than their modern administrative subdivisions. Lastly, to emphasise gaps in the occupation of individual sites or hilltops, we more closely examined the 34 Tier 4 sites, editing their site profiles (SOM 2, section 4) to gain a finer-grained understanding of ancient land-use patterns and a more realistic idea of past demographic trends.

## The twenty-four research biases: a discussion

We identify twenty-four biases that could have impacted research results and the amount of cultural carbon as an indirect measure of past human demography. We list these in terms of what we consider to be their decreasing impact on assessments of human demography. The most important ones relate to geographic and temporal biases at the regional (Biases 1–3) and local scale (Bias 4–8). The types of carbon retrieved and dated, their association with particular ecofactual and artefactual materials and the natural or modern disturbances that might have affected their preservation are then discussed (Biases 9–11). The deposited carbon is itself dependant on past land use patterns that can sometimes produce areas with low-density or even no habitation at all for several generations, resulting in an absence of datable deposits (Biases 12–13). Studying the natural and cultural context of individual dates can thus help us to remove specific dates that are not associated with human activity (Bias 14), thereby changing the metrics of the radiocarbon corpus and the inferences drawn from it (Bias 15). Contextual analysis will also help us to consider the old-wood effect (Bias 16), an issue of importance within rainforest environments, by examining the specific type of material dated — heartwood, palm nuts, or shell for example (Bias 17). As dating the carbon deposited involves geolocating and chronolocating past social and cultural events, the existence of good pottery and/or lithic sequences is important (Bias 18). Biases involving a single or a small series of dates must also be considered (Biases 19–21) before illustrations and graphics can be provided with confidence in publications; poorly presented results at this stage in our regional research can have an inordinate impact (Bias 22). A neglected factor, but one that regularly affects research, is the question of psychological biases on the part of researchers (Bias 23); we have limited this part of our discussion to three such biases that we have documented in action amongst colleagues (and ourselves). Last, but certainly not the least, we discuss the need to Africanise archaeological research because the relatively small volume of our present radiocarbon database and the vast, archaeologically unchartered lands across Central Africa are directly related to the small number of trained archaeologists on the ground able to develop the national records of identified and dated sites that we need via intensive surveys (Bias 24).

## Bias 1 — Geography

In some instances, specific areas have been more studied than others, probably because they are more accessible, even with poor road networks. This can lead to more excavations and dates from regions that are close to roads or where roads are more common. It is often the case that the sampling strategies used by archaeologists are designed with a particular region, site or culture in mind. The question of how truly representative our sampling is, which is an output of our research strategies, is crucial and should be discussed (Orton 2000). In constructing our catalogue of radiocarbon dates, we created distribution maps that plotted known excavated and radiocarbon-dated sites (cf. maps in SOM 1). Another version used a four-tier system to illustrate the number of dates per site (Figure 2): Tier 1 (only one date processed) and Tier 2 sites (from two to four dates) are represented by red dots; Tier 3 sites (from five to nine dates) are shown as blue dots; and Tier 4 sites (a minimum of ten dates) as black dots. The country maps from Figure 2 illustrate how the dated settlements are clearly concentrated spatially, as well as how the better dated Tier 4 sites are rare, numbering only 34. As can be seen in Table 1, vast areas that far exceed the lands surveyed by archaeologists remain without any excavated sites at all. This is especially clear in the Central African Republic and Congo-Kinshasa where most fieldwork has been conducted in the western parts of each country (Figures 2.2 and 2.5), with most Tier 3 and 4 sites concentrated west of the Congo River. Interpretations of settlement patterning in Angola and Equatorial Guinea cannot be made at present due to the current paucity of research in these countries.

## Bias 2 — Time

Just as there are biases in spatial sampling (Biases 1 and 3), so, too, are there temporal biases where some time periods have been studied in more detail than others depending on the specific research questions of the investigators; multiple examples of this exist throughout the region. In addition, because Early Iron Age pottery in Central Africa is more heavily decorated and thus more diagnostic than plainer Late Iron Age wares, early sites are more often selected for investigation and excavation (e.g. de Saulieu *et al* 2015: 14).

Since the mid-1980s, archaeologists in Cameroon, Gabon and Congo-Kinshasa have focused on the investigation of the earliest villages, prioritising so-called 'Neolithic' and Early Iron Age sites over others. The first paper on iron metallurgy in Gabon is a convincing illustration of this bias. It listed 23 radiocarbon dates, three before the birth of Christ that are of dubious Early Iron Age origin, 15 Early Iron Age dates from before 1500 cal. BP (65% of the series), three Iron Age dates between 1100 and 900 cal. BP, and only two Late Iron Age ones that date to after 400 cal. BP (Clist *et al* 1986).

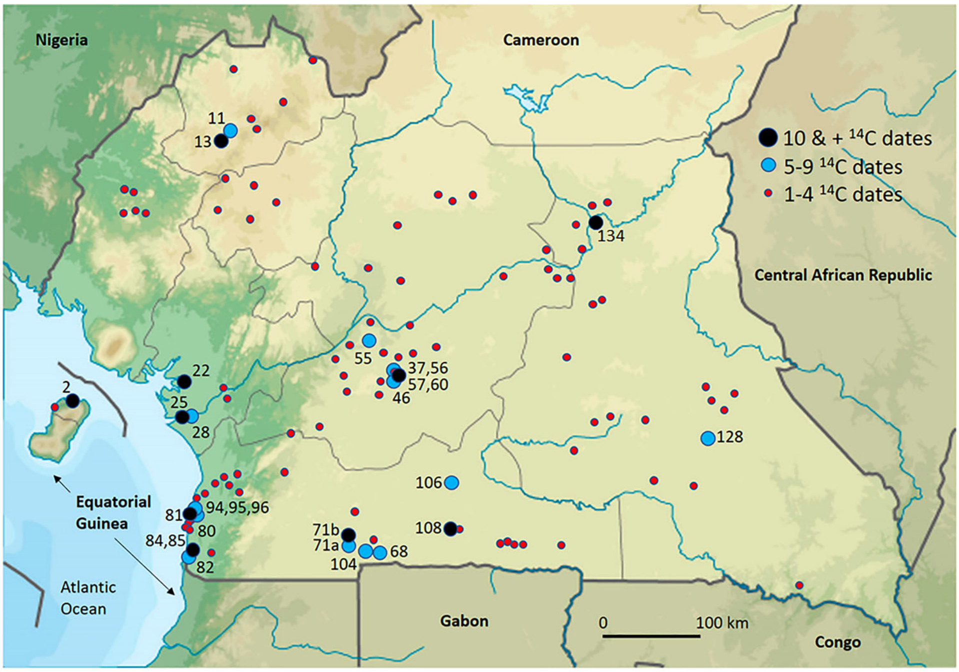


Figure 2.1. Excavated and radiocarbon-dated archaeological sites from Central Africa: Cameroon and Bioko Island, Equatorial Guinea.

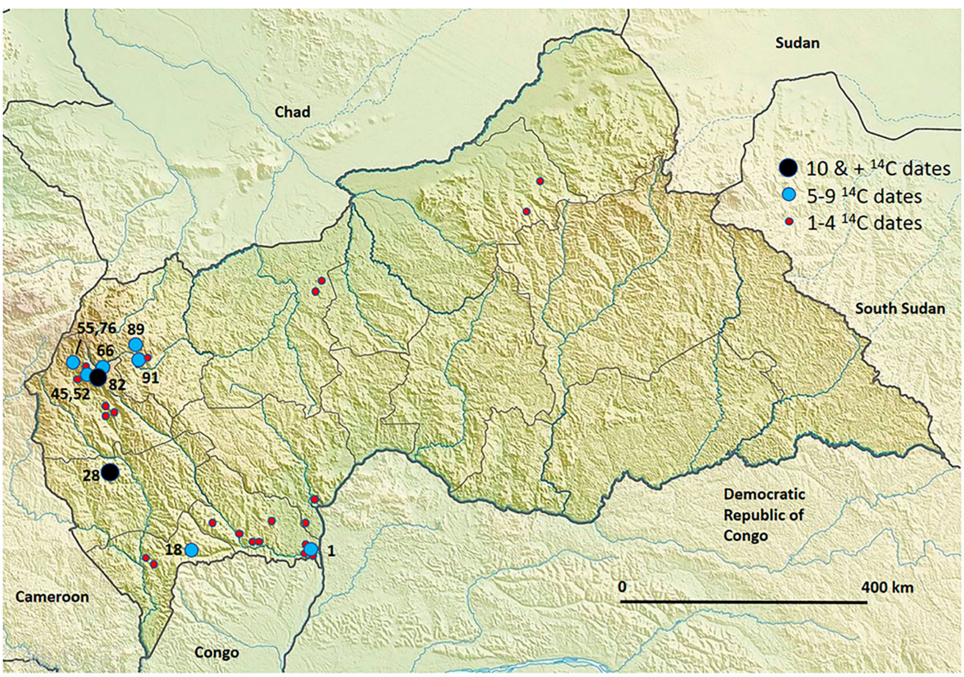


Figure 2.2. Excavated and radiocarbon-dated archaeological sites from Central Africa: the Central African Republic.

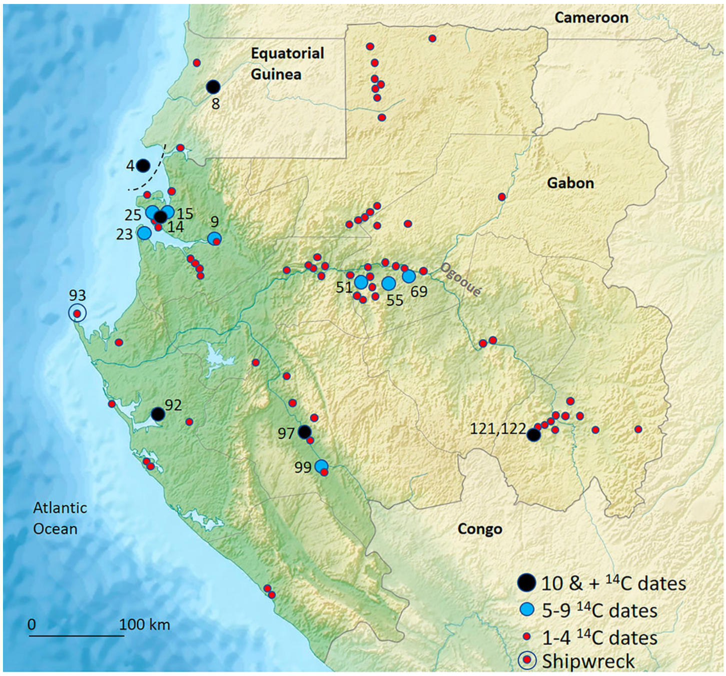


**Figure 2.3.** Excavated and radiocarbon-dated archaeological sites from Central Africa: Gabon and continental Equatorial Guinea.

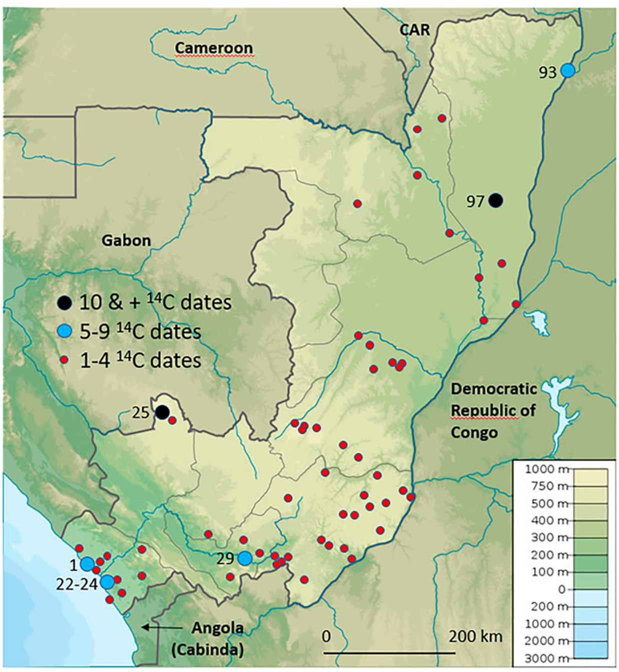


**Figure 2.4.** Excavated and radiocarbon-dated archaeological sites from Central Africa: Congo-Brazzaville.

There was clearly a trend during doctoral research here to look for, study and date sites with early pottery remains, rather than Stone Age sites (cf. Oslisly 1992; Assoko Ndong 2001; Clist 2005a).

A similar pattern is exemplified by the dozens of known sites of the Late Iron Age Lopé Group that were not excavated to the same extent as Early Iron Age and 'Neolithic' settlements; only seven assays were processed that fall in the range 820–220 cal. BP (Assoko Ndong 2001, 2002).

The same picture is found for the coastal settlements of Gabon where the catalogue lists 188 Stone Age sites (27 Middle Stone Age, 85 Later Stone Age and 76 undifferentiated sites) and 153 Iron Age pottery-using settlements (31 'Neolithic' ones belonging to the Okala Group, 12 of the Early Iron Age Oveng Group, 60 of the Late Iron Age Nanda and Angondjé Groups and 50 that were undifferentiated, but with most of them probably belonging to the Late Iron Age according to their pottery) (Clist 2005a: Appendix 1). A small number of sites were multi-component in nature. Plotting the radiocarbon dates, we find 19 associated with the Stone Age (four of them Pleistocene, 15 of them Holocene) and 50 with the 'Neolithic' and Iron Age (Clist 1995a: 259–280; 2005a: Appendix 2). In the latter group, 30 dates come from the 'Neolithic'/Early Iron Age components at 43 sites, while there are only 20 dates for Late Iron Age settlements, mostly found on 110 hilltops. In addition, SOM 1 indicates that a large number of sites were only tested, with larger scale excavations confined to just five locations designed to studying 'Neolithic'/Early Iron Age components (Kango, Okala, Oveng, Rivière Denis 1 and Rivière Denis 2). Only two involved Late Iron Age settlements (Angondjé and Okala) and of these only Angondjé was excavated because it promised to answer specific research questions in relationship to recent times.

A research bias towards 'Neolithic'/Early Iron Age sites was also explicit in northwestern Gabon (Clist 1995a: 225, 227) and southern Cameroon (Meister 2008: 47; de Saulieu 2020) while investigations and dating of the final Late Iron Age periods in Congo-Brazzaville and Congo-Kinshasa, and more broadly over the last 1000 years, has fallen far behind (de Maret 1995: 321; Wotzka 2006: 276; Clist 2012a: 177–184; Oslisly *et al.* 2013b: 5; Denbow 2014; de Maret *et al.* 2018; Seidensticker *et al.* 2021: 8). De Saulieu (2020: 102) summarises the situation clearly:

> '.. archaeologists who spot pits, where ceramic material bears roulette decorations, do not systematically date them, because they are known to belong to the Late Iron Age, or even to the Modern and Contemporary periods; archaeologists therefore prefer to invest their scarce money in "old" dating, which leads to the under-representation of dates from recent contexts in a radiocarbon database.'

This uneven approach to the past is further attested when looking at Tiers 3 and 4 in SOM 1 and is illustrated in Figure 2 above and listed in Table 2 below. First, we tabulated the number of Stone Age and 'Neolithic'/Iron Age sites. Then, to create a more detailed account, we subdivided the sites according to their associated pottery grouping the Tier 3 and 4 sites into 'early' (pre–1400 cal. BP) and 'late' site components (post–1400 cal. BP) based on their mean calibrated dates from our SOM 1 catalogue (Table 2). The Tier 4 Mosumu site in Equatorial Guinea did not have any pottery associated with it (Julio Mercader, pers. comm. 5 November 2021).

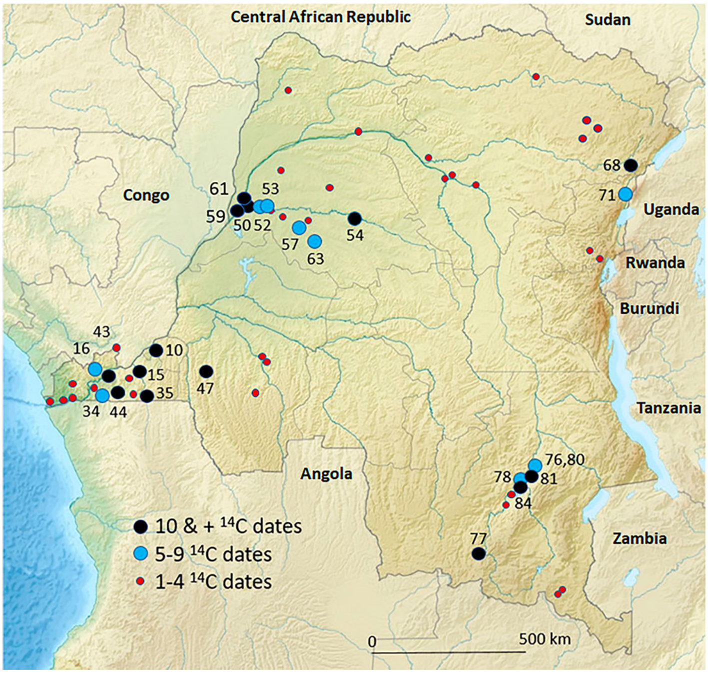


**Figure 2.5.** Excavated and radiocarbon-dated archaeological sites from Central Africa: Congo-Kinshasa.

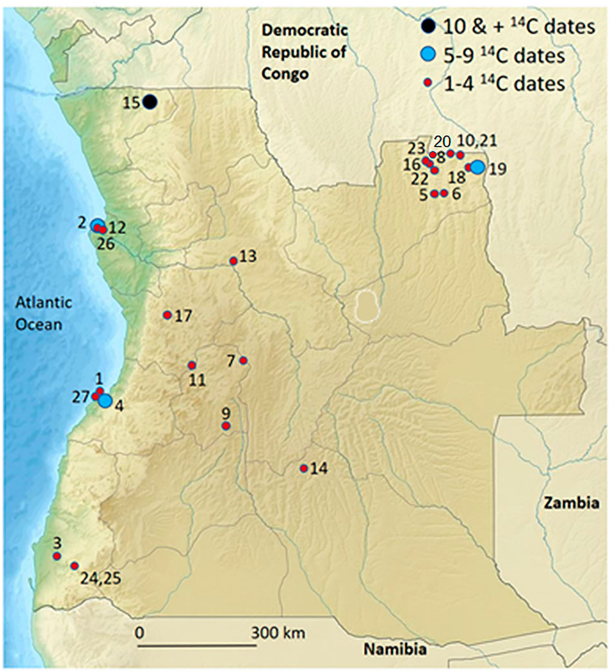


**Figure 2.6.** Excavated and radiocarbon-dated archaeological sites from Central Africa: Angola.

**Table 2.** Central Africa: Tier 3 and 4 sites, their Stone Age and 'Neolithic'/Iron Age numbers, their early and late components, and their associated radiocarbon dates.

| Country | Stone Age sites | Pottery sites | Early pottery components | Late pottery components | Early radiocarbon dates | Late radiocarbon dates |
|---|---|---|---|---|---|---|
| Cameroon | 2 | 23 | 25 | 10 | 188 | 69 |
| Central African Republic | 1 | 10 | 8 | 11 | 51 | 36 |
| Gabon | 4 | 9 | 10 | 10 | 45 | 24 |
| Equatorial Guinea | 1 | 2 | 1 | 2 | 10 | 23 |
| Congo-Brazzaville | 1 | 5 | 4 | 4 | 27 | 18 |
| Congo-Kinshasa | 5 | 17 | 13 | 17 | 43 | 122 |
| Angola | 2 | 2 | 1 | 2 | 3 | 22 |
| **Total** | **16** | **68** | **62** | **56** | **367** | **314** |

In Cameroon, Dibamba Yassa provided seven early and 36 late dates, meaning that about half of all the Late Iron Age dates from the country come from just a single site. In Table 2, columns 2 and 3 clearly show the bias towards investigating 'Neolithic' or Iron Age sites. Cameroon, especially, stands out for its over-representation of early versus late pottery sites (by a factor of ~2.5) with nearly four times (3.7) as many radiocarbon assays processed from the early period as from the later one; factoring in the fact that Dibamba Yassa dates count for half of the Late Iron Age dates in the country further increases the discrepancy.

Such a strong bias towards the Early Iron Age is not found in the Central African Republic, Gabon, Congo-Brazzaville and Congo-Kinshasa where the numbers of early and later sites are roughly equal (Table 2, columns 4 and 5). While in the Central African Republic the number of early and later dates is roughly similar, there are almost twice as many early rather than later dates in Gabon and Congo-Brazzaville (Table 2, columns 6 and 7). Congo-Kinshasa is the only country where there are more Late Iron Age dates (by a factor of 2.8). This is the result of a greater number of research questions that focused specifically on the Late Iron Age. The Tier 3 and 4 Late Iron Age sites investigated in this region include three from Bas-Congo (Kindoki, Ngongo Mbata and Tovo cave), two from the Inner Congo Basin (Bolondo and Iyonda), and the five cemeteries of Katanga (Kamilamba, Katongo, Kikulu, Malemba-Nkulu and Sanga).

Investigations along the Chad-Cameroon Export Pipeline project through southern Cameroon, produced the same dating bias. Of 302 recorded sites, several of them multi-component (Lavachery *et al.* 2008: 64, Table 4), 56 radiocarbon dates were obtained (Lavachery *et al.* 2008: 184, Appendix F): 33 from Stone Age components (10.9% of all the sites against only 5.3% of all the dates), 103 from 'Neolithic'/Early Iron Age components (34.1% of sites against 71.4% of the dates), and 156 from the Late Iron Age/Historical period (51.6% of sites against 23.2% of the dates).

Another example is, again, Dibamba-Yassa in Cameroon (de Saulieu *et al.* 2017b). The 43 dates from the hilltop here can be subdivided into four ceramic-chronological periods containing five pottery 'traditions' or groups. The 32 Late Iron Age dates are associated with 'traditions' A (N = 9), B (N = 14), which is younger than *c.* 600 cal. BP, and C (N = 9), which dates to *c.* 600–900 cal. BP. Another eight dates can be associated with Early Iron Age components, while five dates are from 'tradition' D features with dates falling in the range *c.* 1700–2000 cal. BP and three dates (one of them certainly contaminated) belong to ceramic 'tradition' E, which dates to *c.* 2400–2600 cal. BP; three dates cannot be associated to a 'tradition'. The ratio of the number of dates processed divided by the number of pits (the 'nd/np ratio') makes it clear that there was an unconscious bias towards dating the older features: 'A style' pottery from 108 pits has a nd/np ratio of 8.3%, 'B style' pottery from 52 features one of 26.9%, 'C style' pottery from 14 features one of 64.3%, 'D style' pottery from five pits one of 100% and finally 'E style' pottery from five pits one of 60%.

This research bias towards dating the early phase of the Early Iron Age and the 'Neolithic' was continued in 2018 when 68% of the samples chosen for dating were associated with Early Iron Age components in the Kongo Central province of Congo-Kinshasa (Clist *et al.* 2018a). Between 2012 and 2015, another project focused on the Kongo kingdom added 52 new radiocarbon dates, most of them from within the last 500 years (Clist *et al.* 2018b). In this project, both radiocarbon dating and typological dating of European-made artefacts were used together because many imported European artefacts such as glass beads or Portuguese *majolica* sherds of known age were recovered; their period of manufacture could be more precisely determined than would be possible with radiocarbon because the radiocarbon calibration curve for the last 500 years has so many fluctuations that affect its precision. Because of this, and even though there were several instances when wood charcoal was available, it was decided not to use radiocarbon dating.

Any post–AD 1500 archaeological site along the Atlantic coastline of Central Africa is thus likely to have fewer radiocarbon dates due to the use of foreign imports for dating; furthermore, researchers are reluctant to pay for radiocarbon dates that are likely to have large margins of error due to fluctuations in atmospheric radiocarbon during this period.

Such a situation exists for the Early and Late Iron Age sequences of the coast of Congo-Brazzaville and the Katanga region of Congo-Kinshasa where, after 400 BP, there is a sharp drop in the number of radiocarbon dates documented (de Maret 1992: 195–216). Unfortunately, this is the period when the Luba and Loango kingdoms were expanding and population sizes may have increased, although the population of Loango would have been also affected by the Atlantic slave trade (Miller 1988; Denbow 2014: 145–153); the eastern part of Congo-Kinshasa was not as subject to Atlantic slave raiding, although the possible impact of slave raiders possibly originating from the Indian Ocean coast of Africa is unknown. In the absence of imported European artefacts far from the Atlantic coast, several colleagues have processed an important number of carbon samples from the Late Iron Age at locations — such as in the Ngotto Reserve of the Central African Republic (Lupo *et al* 2018; Schmitt *et al* 2019) and pre–fifteenth-century Late Iron Age coastal sites like Dibamba Yassa in Cameroon (de Saulieu *et al* 2017), although an increased use of European imports would have limited the number of Late Iron Age radiocarbon dates.

Another type of temporal bias is the excessive use of pottery styles to associate cultural groups together in the absence of a robust cultural chronology based on radiocarbon dates. For instance, it is difficult to consider the 59 pottery styles from the Inner Congo Basin, 40 of them undated, with the 56 styles from west of the Congo River only two of which are undated (Clist *et al.* 2021a). Indeed, 68% of the pottery styles from the Inner Congo Basin are only dated through stylistic comparisons with just a few sites dated by radiocarbon (Seidensticker 2017; Seidensticker *et al.* 2021). This leads to a smaller radiocarbon corpus and a methodological difference between research carried out west and east of the Congo River.

## Bias 3 — The impact of forests and rivers on surveys

A careful analysis of the way in which most surveys have been conducted shows that modern roads were often used as survey transects through the equatorial forest west of the Congo River basin (e.g. Mbida Mindzié *et al.* 2001; Oslisly and Assoko Ndong 2006). Within the Congo River Basin, on the other hand, where roads are few, Manfred Eggert and Hans-Peter Wotzka followed rivers. They excavated sites located along the riverbanks or inside modern villages, with little work carried out inside the forest itself (Eggert 1983, 1984; Wotzka 1995; Seidensticker 2017). Such non-random sampling methods can lead to biased pictures of Iron Age settlement distribution in each area. A review of site finds along road construction projects in Cameroon and Gabon found that a mean of 0.5 sites per kilometre is common, with a maximum of 1.3 per kilometre (Table 3).

River surveys in Congo-Kinshasa, on the other hand, found many fewer sites, often with only 0.1 sites per kilometre (Table 3). The distance covered by river surveys was calculated from published maps (Wotzka 1995; Matonda Sakala *et al.* 2021). As river meanders were not tabulated (although these might one day be approximated: see Stølum 1996), the river distances used are minimum figures, making the site densities maximum numbers. Whatever the real length, the table shows that river surveys identified three to five *fewer* sites per kilometre than land surveys under the same rainforest conditions. It is significant that we get the same density of sites from the rivers of the Inner Congo Basin (Wotzka 1995) as from the Kasaï region more than 500 km to the south (Matonda Sakala *et al.* 2021). Comparison with land surveys, however, suggests that a large number of sites between the Inner Congo Basin's rivers, and along their banks, remain unidentified. Table 3 suggests a present site density of 0.1 sites per km using river surveys. This is a far cry from the figures in Table 1 where there were 1.4 excavated and dated sites per 100 km. Put another way, we can hypothesise that 98.6% of existing sites along rivers are not (yet) dated or in our catalogue.

## Bias 4 — Intra-site sampling

At the individual site level, radiocarbon samples are usually selected to strategically frame a stratigraphic sequence and rarely constitute a representative sample of all the occupation events at a site (Orton 2000). For example, one can distinguish between excavations in rock shelters or caves, which are often on limited surfaces but usually carried out down to the bedrock, from open air sites where fieldwork is more spatially extensive and rarely extends deep into the natural deposits. Such excavations may potentially miss deeper earlier occupations, especially Stone Age horizons. Many site chronologies in Central Africa (*c.* 94%) are based on fewer than ten radiocarbon determinations and approximately 55% of the time on only one (cf. Table 4). Sites of greater interest, aerial extent or heightened complexity are frequently dated more intensively. The wider implication is that summed probability plots of radiocarbon dates are in danger of being built from site records where the number of dates is not directly related simply to the density of human demographics (Williams 2012). Limiting ourselves to Tier 3 and 4 sites, which are usually multi-component locations, the regional mean is *c.* 9% for Tier 3 and *c.* 6% for Tier 4 sites, of which there are only 34. Taking into consideration Bias 1, these sites are mainly concentrated in the western part of Central Africa (Figures 2 and 10).

The peaks in the number of dates observed at a specific site may therefore not represent true demographic fluctuations. A recent American study used three methods to assess the local in-settlement demography — 61 radiocarbon dates, pottery accumulations and occupation areas. Twice it found that the various peaks were not in synch and once that they were only for the most recent cultural period (Ritchison 2020).

In Cameroon, the Dibamba-Yassa rescue excavations provide a similar example. They were conducted in 2008, covered over 80,000 m$^2$ (240 × 335 m) and identified 218 Early and Late Iron Age pits (de Saulieu *et al.* 2017b; de Saulieu 2020). As is often the case, no information about possible occupation of the surrounding areas is available. The site produced 43 new radiocarbon dates. Thirty-five belonged to the Late Iron Age (81% of the dates). Of these, nine were associated with pottery style A (from 108 pits), 14 with style B (52 pits) and nine with style C (14 pits and nine radiocarbon dates). Eight belonged to the Early Iron Age (19%), of which five were associated with pottery style D (from five pits) and three with style E (also from five pits). De Saulieu (2020) has argued that the number of houses in a village directly correlates with the number of pits, with one pit per household. In summary, although the global ratio between Early and Late Iron Age features is related to the number of radiocarbon dates, the dates are a function of the number of pits and do not directly approximate past demographics. They are rather a product of choices made by the archaeologists.

The main source of intra-site sampling bias is the relationship between the volume of cultural evidence left on a site, the sampling strategy used by the archaeologist to recover it and the number of radiocarbon dates processed. The number of dates in many cases is

**Table 3.** Central Africa: density of sites identified by way of surveyed transects.

| Number | Sites | Length in km | Site/ km | Reference |
|---|---|---|---|---|
| 1 | 11 | -100 | **0.1** | **Cameroon**, forest: Sangmelima-Mintom road (de Saulieu *et al.* 2015) |
| 2 | 15 | *c.* 150 | **0.1** | **Congo-Kinshasa**, forest: Lulonga River (Wotzka 1995) |
| 3 | 15 | *c.* 160 | **0.1** | **Congo-Kinshasa**, forest: Ikelemba River (Wotzka 1995) |
| 4 | 29 | *c.* 400 | **0.1** | **Congo-Kinshasa**, forest: Tshuapa River (Wotzka 1995) |
| 5 | 19 | *c.* 100 | **0.2** | **Congo-Kinshasa**, forest: Ruki River (Wotzka 1995) |
| 6 | 118 | 421 | **0.3** | **Cameroon** south, forest: pipeline Chad-Cameroon (Lavachery *et al.* 2005, 2008) |
| 7 | 184 | 489 | **0.4** | **Cameroon** north, wooded savanna: pipeline Chad-Cameroon (Lavachery *et al.* 2005, 2008) |
| 8 | 24 | 60 | **0.4** | **Gabon**, mostly savanna: Omboué-Iguela old road (Clist 1995b) |
| 9 | 119 | 248 | **0.5** | **Cameroon**, wooded savanna: Bertoua-Garoua-Boulaï road (Mbida *et al*. 2001) |
| 10 | 56 | 84 | **0.7** | **Gabon**, forest: Médoumane-Lalara road (Oslisly and Assoko Ndong 2006) |
| 11 | 168 | 178 | **0.9** | **Chad**, savanna: Chad-Cameroon pipeline (Lavachery *et al.* 2005, 2008) |
| 12 | 33 | 28 | **1.2** | **Gabon**, forest: Ofoubou Elf-Gabon road (Clist 1992) |
| 13 | 22 | 17 | **1.3** | **Gabon**, forest: Remboué River and British Gas oil exploitation roads and exploration platforms (Clist 1993) |
| 14 | 18 | *c.* 200 | **0.1** | **Congo-Kinshasa**, wooded savanna: Kasaï River (Matonda Sakala *et al* 2021) |
| 15 | 14 | *c.* 200 | **0.1** | **Congo-Kinshasa**, forest, Congo River (Livingstone-Smith *et al* 2017) |

therefore often not an infallible mirror image of the local demography (Orton 2000). Five further examples suggest that this is an overall regional trend:

1) at Nkométou in Cameroon, out of more than 128 features (pits) found along the two sides of the road, only a few were excavated. These produced nine radiocarbon dates (SOM 1). We have no information about how much further the settlement may have extended into the rainforest (Essomba 1992; Elouga 2001; Eggert 2002). The same situation applies to all sites found and test excavated along roads — their spatial extension into the dense surrounding vegetation remains unknown (Mbida Mindzié 2003);
2) at Ndindan, also in Cameroon, only 50% of the pits identified were studied, while 90% of the hilltop, especially its summit, was not surveyed or excavated (Mbida Mindzié 1996, 2002);
3) at Kango 5 in Gabon the entire hilltop was scraped by bulldozers to build a wood-processing factory, which entirely removed the rainforest along with the upper part of any prehistoric pits or other features that might have been present. Thirty-six features, grouped in two widely separated clusters, were then easily mapped. But limited funds enabled the excavation of only five 'Neolithic' and Early Iron Age pits at the site (Clist 2005a: 219, Figures 6–19; 216–229, 589–599). More interesting is the approximately 200-m-long stretch between the two clusters that was devoid of any pits. The southern cluster was dated to c. 2543 cal. BP (Beta-14825), c. 2342 cal. BP (Beta-17060) and c. 2242 cal. BP (Gif-6906), with another, seemingly slightly later, to the north dated to c. 1816 cal. BP (Lv-1519) and c. 2201 cal. BP (Arc-341). Since Beta-14825 falls into the 'Hallstatt plateau,' the four remaining later dates appear to relate to a single village that either extended over 6 hectares or had drifted to the north over time on the same hilltop (Clist 2021: 80–84);
4) archaeological study of three of the most important settlements of the Kongo kingdom —Mbanza Kongo (capital of the kingdom), Kindoki (capital of the Nsundi province) and Ngongo Mbata (main economic hub of the Mbata province) — show a continuous occupation over at least two centuries (Clist *et al.* 2018b). The capital, according to archives, possibly housed some 30,000 to 45,000 inhabitants (Thornton 2021: 208). The other two sites are only known through archaeological excavations. At Mbanza Kongo we have processed 20 radiocarbon dates (Clist *et al.* 2015a and SOM 1), with another 18 from Kindoki and 21 from Ngongo Mbata (SOM 1; contexts for the dates from Kindoki can be found in Clist *et al.* (2015b, 2018c) and about Ngongo Mbata in Clist *et al.* (2015c, 2018d)). Sampling

**Table 4.** Central Africa: country ratio of radiocarbon dates for Tier 1 (one date), Tier 2 (two to four dates), Tier 3 (five to nine dates) and Tier 4 sites (10 and more dates) (N = 601 sites).

| | Cameroon | Equatorial Guinea | Central African Republic | Gabon | Congo-Brazzaville | Congo-Kinshasa | Angola | Mean - six countries |
|---|---|---|---|---|---|---|---|---|
| Tier 1 | 48.1% | (50.0%) | 53.6% | 65.4% | 65.6% | 33.3% | 65.5% | 55.2% |
| Tier 2 | 32.3% | (12.5%) | 35.0% | 23.6% | 28.0% | 40.9% | 20.7% | 30.1% |
| Tier 3 | 12.1% | (0) | 9.3% | 6.3% | 4.3% | 11.8% | 10.4% | 9.1% |
| Tier 4 | 7.5% | (37.5%) | 2.1% | 4.7% | 2.1% | 14.0% | 3.4% | 5.6% |

was chosen with the aim of dating features, pits, iron-working areas and burials in cemeteries or sometimes inside churches as was the case at Mbanza Kongo and Ngongo Mbata. None of the contexts for these radiocarbon dates is related directly to demography; and

5) the Chad-Cameroon Export Pipeline project dissected the Ezezang site in Cameroon where both Stone Age and Iron Age locales were registered. Early in the study, ten features or pits and one pottery layer were noted. Of this 'sample,' only two pits (D and M) were excavated along with a trench that was opened to expose the pottery layer and the underlying lithic artefacts (Lavachery *et al.* 2008: 129–132; Gouem Gouem 2011: 401–403). While this effort is commendable, the excavators sadly note that, 'The site as a whole probably contains thousands of potsherds and stone fragments and several dozen pits' (Lavachery *et al.* 2008: 130; our translation). Although the excavated pottery seems to correctly relate to the time frame given by the five processed radiocarbon dates (see SOM 1), the pottery collected from the surface that is decorated with wooden roulettes must relate to another, later occupation that might be represented in some of the unexcavated pits that currently remain undated.

Rare examples also exist where fieldwork has striven to understand the total extension of the settlement before or during the excavations. We present two of them:

1) Oveng is an Early Iron Age shell midden in the rainforest of Gabon. It was excavated with funds from the London-based *Society of Antiquaries* and remains to this day the only shell midden studied north of the Congo River. The archaeologist was able to shovel test the entire hilltop, make a detailed map of the small hill and then randomly choose a 5% sample for excavation (Van Neer and Clist 1991; Clist 2005a: 541–588). This provided a representative sample of the ancient settlement and its major activity areas. It was found, for example, that rubbish was disposed of in only a few pits or was otherwise scattered on the hill slopes. This is one of only a small series of sites in Central Africa where it was possible to study most of an Early Iron Age village because of its relatively small size; and
2) the two Kongo kingdom towns of Kindoki and Ngongo Mbata in Congo-Kinshasa were not urbanised to the same extent as Mbanza Kongo in Angola. This made it possible to systematically field walk the spatial extension of each. A system of 1 × 1x1 metre units was then excavated every 50 metres to permit a better understanding of the internal structure of these cities, which are called *mbanza* in Kikongo. When needed, the units were extended. At Trench 83 at Ngongo Mbata, for example, 36 $m^2$ were opened down to a depth of 3 metres in order to study a single pit. At Kindoki, a 63-hectare town, 537 $m^2$ were excavated (Clist *et al.* 2018c). At Ngongo Mbata, this economic hub covered at least 68 hectares which were tested by way of 847.5 $m^2$ of excavation (Clist *et al.* 2018d). Even so, both projects only opened less than 1% of these ancient *mbanzas* while obtaining respectively 18 and 21 radiocarbon dates.

## Bias 5 — Ancient human factors skewing site carbon deposition

Different forms of past human activity can produce unequal amounts of datable archaeological carbon and other material due to variations in the amount of waste generated and the nature of the material left behind. For instance, the impact on deposition and preservation when changes in cultural practices such as when stone replaced wood or bone in tool manufacture or when changes in subsistence and settlement patterns occurred as nomadic foragers or herders transitioned to more settled farming settlements and the construction of more permanent structures. There have also been changes in building practices as houses constructed wholly from perishable materials such as grass or hides give way to wattle-and-daub or stone constructions extracted from hillsides or pits. Differences in depositional practices also took place as scattered hunting remains were deposited around or burned fireplaces as opposed to depositing marine shells in mounds (Van Neer and Clist 1991) or burying food and other waste in pits (Wotzka 1993). Different religious practices may also affect cultural deposition and preservation, such as when the deceased is buried in an open, unmarked area (Ribot *et al.* 2001) as opposed to individual graves organised into a cemetery (González-Ruibal *et al.* 2011, 2013; Eggert and Seidensticker 2016a; see also Wotzka 1993). Differences in soil chemistry also affect bone preservation, with bones deposited in more basic or alkaline soils with a higher pH — such as where ash from cooking fires has accumulated — more likely to be preserved (cf. pits at Nkang in Cameroon (Mbida Mindzié 1996) and Toubé 1 in Gabon (Assoko Ndong 2001). In contrast, those left in the more acidic soils of the tropical forest rapidly disappear (Clist 1997: Okala in Gabon, pH values of 4.6–5.7); shell middens are also good environments for preservation (Van Neer and Clist 1991: Oveng in Gabon, pH value of 8.3–8.5).

## Bias 6 — Multi-component sites

How a site is counted directly impacts our distribution maps and our inferences about past demographics. The Angondjé site in Gabon — site no. 256 in the Estuaire Province catalogue (Clist 2005a: 632–652, Appendix 1) — is a good example of such a multi-component site. The excavation, which was carried down to bedrock, identified six successive and widely separated components. The lowest one, a few centimetres above bedrock, contained Middle Stone Age flakes dated at the nearby site of Okala to *c.* 43,000 cal. BP (Figure 3). This was overlain by two Later Stone Age horizons, one of them dated to *c.* 11,500 cal. BP. The other was a 'Neolithic' episode belonging to the Okala Group — *c.* 2400–1900 cal. BP — which was attested by finds of isolated polished stone axes without pottery that were stratified under the base of the Late Iron Age layer; it preceded an Early Iron Age settlement belonging to the Oveng Group — *c.* 1900 cal. BP — identified on the hilltop with several pits. The main research interest at the site was its Late Iron Age Angondjé Group village with its deep pits dated to *c.* 680 and 840 cal. BP (Figure 3). The area excavated in this part of Angondjé did not yield evidence of the Stone Age use of the hill between the Middle and Later Stone Age periods. Even after *c.* 2400 cal. BP, the three pottery-using intervals at the site (the Okala, Oveng and Angondjé Groups) are separate. The Okala stone axes without evidence of a settlement, for instance, suggest that the hill was tilled for horticulture by a neighbouring village, perhaps even the Okala site found on a neighbouring hilltop. The two Oveng and Angondjé occupations are about 1000 years apart.

Other multi-component Tier 4 sites are listed in SOM 2, section 4.

If one of our objectives is to assess archaeologists' work rather than prehistoric activities or land use patterns, then such multi-component sites could be considered as a single occupation — otherwise, Angondjé represents six periods of activity.

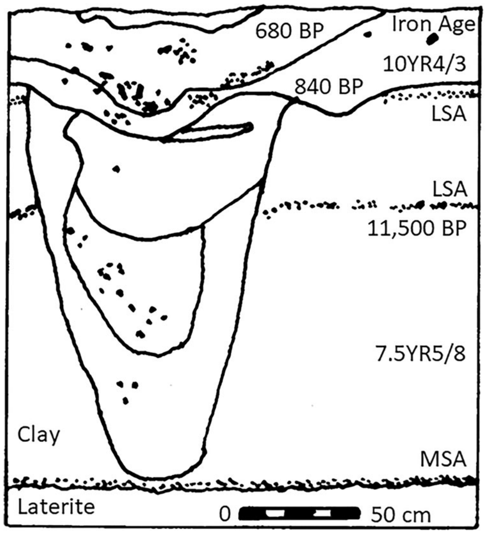


**Figure 3.** Angondjé multi-component site profile.

The Chad-Cameroon pipeline project chose to number sites without considering whether they were multi-component occupations: 118 sites are recorded in their ‘south’ Cameroon area, regardless of whether they are single component, double component or, occasionally, more (Lavachery *et al* 2008: 111 and Appendix D: 177–181). Working in Congo-Brazzaville, Denbow (2014: 61) discovered 204 sites with 295 cultural components: i.e. approximately 40%–50% of them were multi-component in nature.

Larger scale excavations will obviously result in better chronologies, especially if there are multiple occupations or when confronted with a large site. Often it is found that separate peaks in radiocarbon assays from the same site result from dating different or successive occupations.

We can develop this point by using the 34 Tier 4 sites from our catalogue (cf. SOM 2, section 4). We use the ‘Neolithic’/Early Iron Age Obobogo site profile to illustrate some of the issues with dating multi-component sites, especially when small-scale villages move around inside a confined local area (Figure 4a). We use the Late Iron Age Kindoki site to exemplify a typical single component site, in this case one continuously

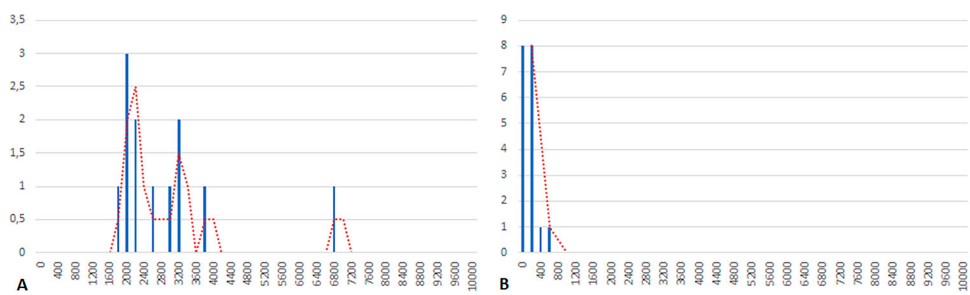


**Figure 4.** Distribution of radiocarbon dates at: a) a multi-component site (Obobogo, Cameroon) and b) a single component one (Kindoki, Congo-Kinshasa).

occupied for several centuries (Figure 4b). The distribution of Tier 4 settlements shows that open-air multi-component dominate the 23 sites in this group, followed by single component loci with six sites in Cameroon (Nya Zanga), three Kongo kingdom *mbanzas* and two cemeteries in Katanga in Congo-Kinshasa. Few Tier 4 locations are found in rock-shelters or caves: three are multi-component sites (Shum Laka in Cameroon; Nangara Komba in the Central African Republic; Matupi in Congo-Kinshasa); two are single component sites (Iroungou in Gabon and Tovo in Congo-Kinshasa); one is a cemetery where the deceased were deposited; and the last is a rock art site where a series of paintings were dated. Clearly, the number of dates from multi-component sites does not directly equate with their individual demographics.

## Bias 7 — Multiple dating of features

Along with intra-site sampling, some archaeologists have dated the same pit or feature with two or three assays. This was done for example at the Early Iron Age Campo site in Cameroon (Eggert and Seidensticker 2016) where 27 radiocarbon assays come from 17 features. Similarly, Denbow (2014: Table 4.1, dates 11 and 12; 15 and 16) used multiple dates for pit features at Lamba and Mvindu in Congo-Brazzaville to check the degree of deviation in age returned by wood charcoal and oil palm nuts during the early stage of his research in the region. Other researchers have relied on single dates, multiplying their number by the number of features excavated to confirm the site sequence. This was done at the Okala site in Gabon (Clist 1997), Ndindan (Mbida Mindzié 2002), Nkang in Cameroon (Mbida Mindzié *et al.* 2000) and the ancient economic hub of the Kongo kingdom at Ngongo Mbata (Clist *et al.* 2018d). Mbida Mindzié only once diverged from this rule, by processing three dates from pit no. 9 at Nkang because of the exceptional finds of *Musa* (banana) phytoliths and animal bones in its filling (see SOM 1, Lv-1942 to Lv-1944). Clist similarly dated pit no. 83 at Ngongo Mbata twice because of its large volume (26 $m^2$ and 3 m maximum depth or approximately 72 $m^3$ in volume) and the need to verify the speed of its infilling as suggested by the associated pottery that could be refitted through the layers.

A unique example of multiple dating is the Oliga pit (Cameroon) which has 12 dates that range over a 1000-year period (Essomba 1989: 44–48, 2004: 139–141; SOM 1). The excavator took the results as evidence of very old ironworking instead of the result of a series of filling episodes over time, none of them clearly linked to metallurgical activity (Clist 2012b, 2013).

Multiple dating of features will artificially increase the total number of dates from a site and thus artificially increase estimates of the local 'demography.' It has been argued that when such multiple radiocarbon dates are within the same age range, we can use the 'binPrep' function in 'rcarbon' to group them into 'bins' of 100 calendar years to overcome such 'investigator bias' (Seidensticker *et al.* 2021: 10). But what can we do when they are not in the same time range, such as at Koualessis in Gabon where there is a 1620-year time difference between two samples extracted from the same pit (Clist 1995a: 264, 277; SOM 1)? And on what grounds is the length of this range determined? By standard deviation? Or by ceramic typology or some other cultural measure? A better procedure may be to study the archive and the context of the dated features before deciding on 'binning' (see Bias 14). The 12 dated charcoal deposits from the single pit of Oliga cannot be considered on the same footing as a similar amount from several features obtained at Obobogo, a neighbouring suburb of Yaoundé in Cameroon (cf. SOM 1).

## Bias 8 — Post-depositional disturbances of excavated features

A more secure context for archaeological dates from later Holocene open-air sites comes from the ubiquitous pits found on them. The importance of post-depositional alterations of open-air sites is well-known, leading Daniel Cahen and Jan Moeyersons (Cahen 1976, 1978a, 1978b; Cahen and Moeyersons 1977) and Pierre de Maret to urge colleagues to 'stop the spits and find the pits' (de Maret 1995: 322). This led to what we have termed 'refuse pit archaeology'.

A doctoral study in Gabon incorporated a careful examination of pit profiles under an equatorial rainforest to isolate evidence of biotic post-depositional disturbances. Experiments were also conducted to understand how fast, and in what ways, abandoned refuse pits could be filled naturally. The experiments were conducted either on cleared land such as inside a village with a 1% slope, or under secondary forest similar to that on the periphery of a settlement (Clist 2005a: 179–185). These differing contexts could impact the quality of radiocarbon sampling, especially if earlier Later Stone Age charcoal and artefacts had intruded into the feature. This might possibly explain widely spaced dates in excavated features. Sometimes it is possible that charcoal from the older soil matrix may have been incorporated in the dating sample as well. The experiment found that over time a pit could acquire the characteristic profile illustrated here in Figure 5b. After only four days of heavy rain in March, the pit was half-filled. The water would then evaporate, creating a lateral fall from the side walls of between -30 and -100 cm of material, which was deposited as a silty layer at the bottom of the pit. A further week of rain led to the profile of Figure 5c, which then did not change much until further filling occurred until the trench was closed. Both profiles (Figures 5b and 5c) are well known from archaeological sites in Central Africa. Interesting sedimentological data were gathered and transport into the trench of eroding wood charcoal and small Later Stone Age artefacts by surface creep was also documented. If the surrounding soil matrix were older, this would result in

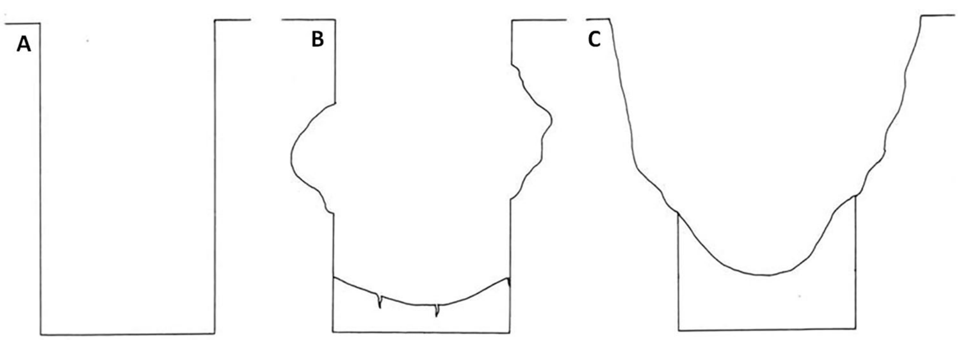


**Figure 5.** Profile evolution of a trench left opened on clear ground at Okala, Gabon (G1/G2 trench, 1 metre wide, Clist 2005a: 180).

older, natural charcoal being mixed in with the cultural charcoal. Other experimental trenches left opened under a secondary forest at the Oveng site were still only half filled four years later.

Further possible biotic and botanical post-depositional disturbances are illustrated in Figure 6.

The possible mixing of charcoals of differing periods within a single excavated pit is suggested by Figure 6a and its probable Later Stone Age charcoal documented in the surrounding clay on the left side of the profile. The situation is similar to that in Figure 3 where a Late Iron Age pit was dug through 'Neolithic'/Early Iron Age levels to Later Stone Age ones. Villagers can set up their pits — whatever their ancient usage may be — and partly or fully fill previous ones and thus potentially mix older charcoal into the more recent deposit. Sometimes, as at Okala in Gabon, this resulted in a possible 2000-year discrepancy when a Late Iron Age pit was dug into an earlier 'Neolithic' feature (Figure 6b). Figures 3, 5 and 6 nicely exemplify the problem of getting Later Stone Age, 'Neolithic' and Iron Age charcoals and artefacts mixed up in an excavated pit, leading to chronological and anthracological incoherence.

Such important knowledge about the post-depositional evolution of pits in the equatorial forest of northwestern Gabon must be confronted with similar observations coming from central Gabon where climate and vegetation, present and past, are strikingly different.

In the Lopé reserve, B. Peyrot made observations about the evolution of refuse pits. Figure 7 illustrates a different mechanism than on the Gabonese coast. As Oslisly (1992: 217, our translation) explains based on B. Peyrot's study:

> 'This situation is due to a chemical phenomenon of iron induration of the clays, a phenomenon that is part of the problem of iron mobility in the upper horizons of tropical soils. The figure explains the different stages of this process: [...] 1. This is the beginning of erosion through denudation of the surface. The stage of surface induration begins, by fixation of iron oxides by organic matter. 2. This stage sees the beginning of the inversion and reduction phase of the pit in relation to the initial level. Erosion of the sandy clay of the surrounding horizon accentuates this process. The remains were also uncovered and the clay on the dome hardened.'

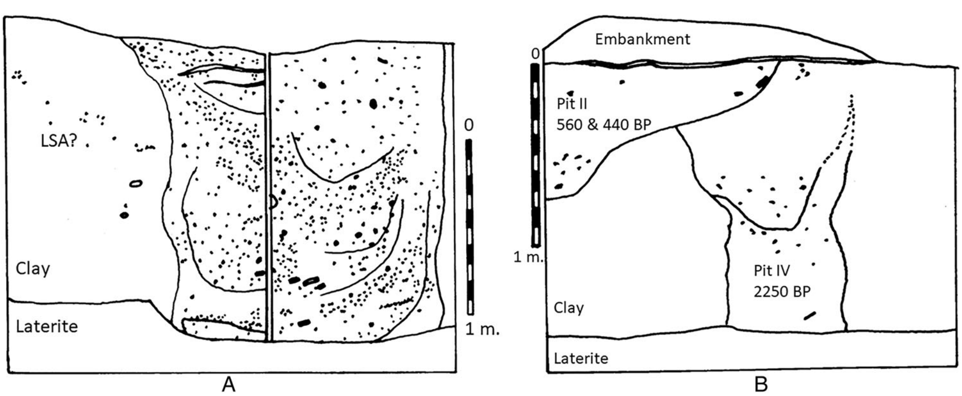


**Figure 6.** Feature profiles at Okala, Gabon (Clist 2005a): a) Feature XI. Each black dot is a charcoal fragment; b): Pits II (Late Iron Age) and IV ('Neolithic'/Early Iron Age).

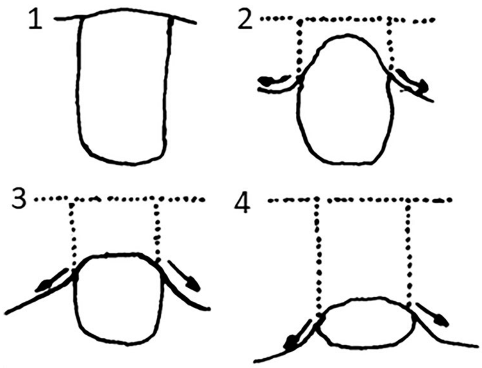


**Figure 7.** Evolution of a refuse pit in the savannas of the Lopé Reserve in central Gabon (Oslisly 1992: 218, based on an analysis by B. Peyrot).

The speed of this erosion was estimated to be about 1 metre per 1000 years. What is important here is the possibility that wood charcoal from previous fire episodes, both anthropogenic or natural in origin, can become incorporated in the developing dome of the eroding pit.

## Bias 9 — Variations in sea level along the coastlines

Since the end of the Pleistocene and throughout the Holocene, global sea levels have slowly increased, inundating and submerging thousands of square kilometres of coastline and probably hundreds of Stone Age coastal archaeological sites from Cameroon to Angola. For example, hunter-gatherer camp sites dating to *c.* 11,000 cal. BP could have been situated as far as 53 km off the coast of Libreville (Gabon). At *c.* 7500 cal. BP the beach was still around 25 km offshore (Clist 1995a: 55). Between *c.* 24,000 and 11,500 cal. BP when the ocean levels were 60 m or more lower, the island of Bioko (Equatorial Guinea) was linked to the continent near Mount Cameroon (Clist and de Maret 2021). In Congo-Brazzaville the coastline of Loango Bay is rapidly eroding, sometimes at a rate of 1.4 m a year (Denbow 2014: 34), while at Diosso, a rate varying from 0.4 to 3.3 m a year has been calculated (Sitou *et al.* 1996: 189). This is also documented in Congo-Kinshasa north of Muanda where the cliff retreats at an estimated rate of 1 m per year (Mwamba Nyembo 2007: 19). Such rapid coastal erosion was already noted in colonial times (Devroey and Vanderlinden 1933: 115). This likely accounts for the fact that only one prehistoric shell midden (Lac Tchitembo) was located by Denbow during archaeological surveys along this part of the Congo-Brazzaville coast, and this was because it was situated roughly 1 km back from the ocean around a saltwater lagoon. Others have likely been washed away or lie buried beneath the sea. Along the coast of Cabinda province (Angola) other submerged coastlines have been recorded (Ramos 1990: 426), but no datable charcoal associated with Middle or Later Stone Age stone assemblages has been found — perhaps because it rests many metres under the sea. The presence of underwater sites on this part of the coast is strongly suggested by a flint flake brought up by a coring at Djèno, south of Pointe Noire (5°06'S, 11°43'E, 35 m depth). Although Stone Age sites on land consist mainly of quartz, this offshore flake must be related to a submerged black flint layer in this area (Giresse and Cornen

1976: 10, Fig. 3, Profile 1144). The position of the artefact, and the chronology of known changes in the Atlantic Ocean sea-level, suggest that the flake is at least 9000 years old (P. Giresse, pers. comm. 22 May 2021). This further suggests that it probably comes from a Later Stone Age encampment invisible from any coastal survey. This intriguing discovery of evidence of underwater sites is similar to finds such as those at Doggerland in Europe's North Sea (Walker *et al.* 2020) and advocates that further evidence of human offshore settlements will be found in due course

## Bias 10 — Dating materials and artefacts can disappear through time

### *Charcoal*

Radiometric date distributions display exponential-like trends such that recent dates are more abundant while older dates decrease in number. This trend has been hypothesised to be due to the gradual destruction of datable materials from post-depositional processes such as erosion, dissolution and microbial action (Singh *et al.* 2012; Jaffé *et al.* 2013). The Gombe site in Kinshasa (Congo-Kinshasa) has, for example, a time gap or absence of carbon deposits from *c.* 27,000 to 15,000 BP (Cahen *et al.* 1983: 446–449). A similar gap has also been recorded in Congo-Brazzaville (Schwartz and Lanfranchi 1993: 31). Such gaps may have taphonomic causes.

At the regional level, such an absence is not visible in Central Africa during the Holocene (Figure 8). From *c.*10,000 cal. BP a 'background noise' from Stone Age hunter-gatherers is small, but consistently present. This is followed around *c.* 2800 cal. BP by megalith makers in the Central African Republic and by small, semi-sedentary villages elsewhere by people making and using pottery. This activity peaks *c.* 2300–1600 cal. BP. This is followed by a drop in dated settlements at *c.* 1500–1000 cal. BP that gives way to another increase *c.* 900–700 cal. BP and a final peak from *c.* 700 to 100 cal. BP. Within the Iron Age period a low number of radiocarbon dates from stone-using hunter-gatherer communities living in the forest is also likely to be embedded.

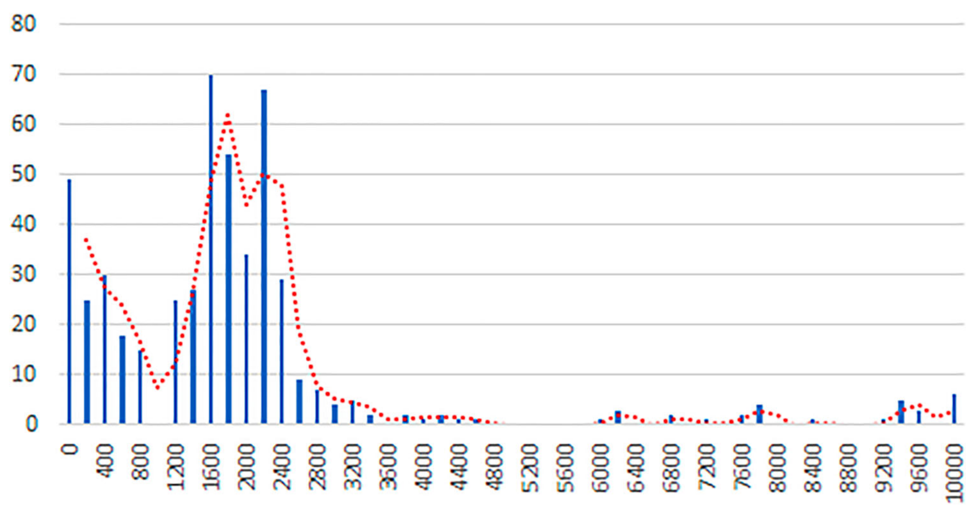


**Figure 8.** Holocene radiocarbon and TL dates from Central Africa presented in 200-year bins.

### *Pottery*

Pottery itself can disappear and it can do so fast. Kango 5, a 'Neolithic' and Early Iron Age site close to the Equator in Gabon and roughly 100 km southeast of Libreville, was discovered after the large and rather flat hilltop here was bulldozed to set up one of the compounds of SOGACEL (Société Gabonaise de Cellulose). This enabled the features, pits and formerly *in situ* artefact concentrations to be easily mapped (Clist 2005: 219). However, the pottery lying on the surface was subjected to the downpours of the equatorial climate for several years. As a result, it lost its coherence and slowly disintegrated and dissolved. This underscores the importance of conducting pit excavations where pottery is protected from corrosive agents.

### *Bone*

Animal and human bones from middens or burials disappear over time. The small Early Iron Age *c.* 1900–1500 BP cemeteries of Campo (Cameroon; Eggert and Seidensticker 2016a) and Nanda (Equatorial Guinea; González-Ruibal *et al.* 2011, 2013; Sánchez-Elipe Lorente 2015) have yielded no or only very small fragments of bone. Likewise, the much younger burials at Bolondo (Congo-Kinshasa), dated to *c.* 150 and *c.* 400 cal. BP, were all badly preserved but could still be used for specific research purposes (Wotzka 1995; Bleasdale *et al.* 2020), as were those recovered from Kindoki and Ngongo Mbata (Congo-Kinshasa) (Wang *et al.* 2020). At the cemetery of Kindoki, which developed between the seventeenth to early nineteenth centuries AD, the oldest burials had no bones preserved, but the later ones had most parts of their skeletons available for study (Polet 2018; Polet *et al.* 2018). The burials from Ngongo Mbata, the oldest Christian church in Congo-Kinshasa and in Central Africa as a whole, were also poorly preserved (Asti *et al.* 2020), while the few animal bones recovered from these Kongo kingdom cities hint at a fast decomposition rate over the 400 years since these open-air sites were abandoned (Linseele 2018). Similar findings are found all over Central Africa (Van Neer 2000).

## Bias 11 — Modern development of infrastructures

To locate or identify sites without soil erosion, one must make use of eroding riverbanks (Eggert 1983, 1993), construction projects like roads (Mbida Mindzié *et al.* 2001; Oslisly and Assoko Ndong 2006), pipelines (Lavachery *et al.* 2005, 2008; MacEachern 2010), urban development (Clist 1995a, 2005; de Saulieu *et al.* 2017b), water dams (Lavachery 2005, 2009a, 2009b; Arazi *et al.* 2011), onshore oil platforms and their associated clearings (Clist 1995a: 234–235), or extensive ploughing of the savanna such as occurred to remove the thick vegetation cover for eucalyptus plantations in Congo-Brazzaville (Denbow 2014). Following such projects, rescue archaeology has expanded most recently in Cameroon (e.g. Nlend Nlend 2022), Gabon (e.g. Oslisly 2017) and, less extensively, the Central African Republic (Ndanga 2008). The result is the destruction of a large part of the *in situ* archaeological evidence (Cameroon, see Oslisly 2014, 2017; Eggert and Seidensticker 2016a; de Saulieu *et al.* 2017b; Congo-Brazzaville, see Denbow 2012, 2014). For example, during 18 months in 1984–1985 the 'Sablières' site north of Libreville in

Gabon lost an estimated 135,000 $m^3$ of sand for building purposes (Peyrot *et al.* 1990: Fig. 3). The area impacted not only contained multiple Stone Age horizons, but also an important Iron Age cemetery of the Nandá group whose cemeteries are today only well known by their study on Corisco Island in Equatorial Guinea (González-Ruibal *et al.* 2011, 2013). Only a single tomb could be documented — many others were destroyed — as the dozens of intact pots displayed for sale to wealthy Gabonese and expatriates seen by the lead author can testify. This destruction has led to a deficit in radiocarbon dates from the 1400–900 cal. BP period.

In addition, many of the data obtained from these 'rescue archaeology' programs are not being made public but can often only be found in unpublished reports written for contractual reasons (Naffé *et al.* 2008). This prevents understanding of their cultural chronology or geographic context (for example, in Cameroon: Lavachery 2005, 2009a, 2009b; Arazi *et al.* 2011; Gouem Gouem 2019; and in the Central African Republic: Ndanga *et al.* 2013a, 2013b). A few rare counterexamples exist (e.g. Lavachery *et al.* 2005, 2008), but this situation is still all too common for many archaeological projects where data from fieldwork have now gone unexamined for years.

## Bias 12 —Ancient and recent environmental and natural factors

Past climates can impact present vegetation cover, as is illustrated by a study of the last 90,000 years carried out at Lake Bambili, Cameroon (Lézine *et al.* 2019) and other locations dating to the late Holocene (Maley *et al.* 2018; Giresse *et al.* 2020, 2023). Variation in food resource availability is closely linked to natural vegetation changes. One example of a climate-related movement of animals is the black rhinoceros (*Diceros bicornis*), a savanna-dwelling species (Duthé *et al.* 2020), dated to *c.* 7000 cal. BP at the Ntadi Yomba rock shelter in what is now the tropical forest of southern Congo-Brazzaville where it is no longer present (Van Neer and Lanfranchi 1985, 1986; Van Neer 1987). Ancient climate change may thus result in movements of human populations who, in turn, relied on game adapted to specific environments. This especially, but not exclusively, includes hunter-gatherers. Epidemics or inexplicable 'bad deaths' (deaths for unexplained reasons, maybe caused by a sorcerer) can further lower population density and the distribution of wild game, forcing people out of specific regions and creating an absence of available dating material (Thomas 1982; Pfeiffer 2020).

Soil formation processes also impact on the ability of archaeological surveys to locate Stone Age and Iron Age sites buried at varying depths in the soil. Unless severe soil erosion is present in savannas, as is the case for the central part of the Kongo Central province of Congo-Kinshasa (Clist *et al.* 2018a) or the Lopé Reserve in central Gabon (Oslisly 1992, 1995; Assoko Ndong 2001, 2002), surveys can miss — and thus not date — the oldest, more deeply buried, sites. The strategy must then involve methodologies such as the use of deep ploughing in Congo-Brazzaville (Denbow 2014: 55, 59–61), or systematic test units excavated down to at least one meter as done both there and in Congo-Kinshasa (Denbow 2012, 2014; Clist *et al.* 2018e). If earlier archaeological deposits are even more deeply buried, this could explain why almost no Later Stone Age, and no Middle Stone Age, remains were found in Denbow's surveys. In the rainforests the situation is different. In specific pedological contexts, such as the sands west of the Inkisi river in the western parts of Congo-Kinshasa, even Late Iron Age archaeological layers can be deeply buried, making them impossible to be identified by normal foot survey. For example, materials from the Kindoki site, which belongs to the seventeenth/eighteenth-century AD Kongo Group, are found between the surface and a depth of 80 cm below it (Clist *et al.* 2018e: 62, Fig. 9.1). One fourteenth-century settlement is buried at a depth of 50 to 60 cm (Clist *et al.* 2018c: 138, Fig. 11.7). This bias has also been documented for the upper levels of the site of Kayes in Congo-Brazzaville, where the top 30–40 cm of deposit covering the Early Iron Age archaeological level were sterile sand; the occupation horizon and refuse middens were only encountered below this, from 50 to 100 cm below surface (Denbow 2014: 82, Table 5.2; 116–117, Figs 6.8 and 6.9). At Iyonda (Congo-Kinshasa), Wotzka preliminarily describes thousands of features found buried under colluvium, but identified by geomagnetic survey, coring and excavation (Neumann *et al.* 2022: 5). Sheet erosion can also obscure the presence of pits: ' … it was by scraping the surface to release a half-buried lip potsherd we found a pit hidden by a layer of rubble' (Assoko Ndong 2001: 175, with reference to the Lopé 2 site, Gabon).

## Bias 13 — Past settlement density and land use

Ancient land use patterns must also have been different from region to region and period to period, leading to the production of varying volumes of carbon. Using nineteenth/twentieth-century demographic studies as a reminder of this bias is useful. In the Bas-Congo province of colonial Belgian Congo, north of the Congo River, the so-called *Cartes de Territoire* of the 1950s located all the villages present. A multi-proxy analysis by H. Nicolaï (1961) shows clusters of villages and their differing densities as they relate to the topography and soils (his map no. 1), and population density (his map no. 2). Along a 140 km southwest to northeast transect, population density went from less than 1 inhabitant per $km^2$ to over 30 per $km^2$ as villages, often found in clusters, went from being 5 km apart in the northeast to over 10 km apart in the southwest, with the intervening lands being uninhabited. Similar information can be gleaned from a 1947 Belgian Congo map that illustrates the demography at the time (available online at http://www.kaowarsom.be/documents/ATLAS/107.jpg). Most areas had figures of less than 1 to 2 inhabitants per square kilometre. Anthropological registers in the rainforests of southern Cameroon, Congo-Brazzaville, Gabon and western and central Congo-Kinshasa record between 0.5 to 7 inhabitants per $km^2$ (Sautter 1966; Podlewski 1973; Fournier and Sasson 1983; Bley and Pagezy 2000). Specifically, in southeastern Cameroon, northern Congo-Brazzaville and Gabon the figures average about 1 inhabitant per $km^2$, while in other regions the numbers can be as high as five inhabitants per $km^2$ in southern Congo-Brazzaville, four to eight inhabitants per $km^2$ in southern and southwest Cameroon, and six inhabitants per $km^2$ in the Mbandaka province of Congo-Kinshasa (Sautter 1966). In Gabon the density slowly increased from 1.4 in 1906 to 3.8 inhabitants per $km^2$ in 1993. The mean size of the population per settlement was 136 villagers, with a variation from 60 in Ogooué-Maritime province to 261 in Estuaire province (Clist 2005a: 83–88). Vansina proposed a similar figure for Central Africa, with villages ranging from *c.* 50 to 325 inhabitants, with a mean of around 100 (Vansina 1990: 320, note 21; see also Bley and Pagezy 2000). To feed such populations would have required a horticultural space of approximately 4 km$^2$ (Pourtier 1989: 199–201). Where swidden (slash-and-burn) horticulture is dominant, men must fell and burn trees every five to seven years to clear new land and produce ash for fertiliser. When soil fertility declines, weeds proliferate and new plots are opened to let women develop their agricultural parcels, thereby creating successive patches of secondary forest (Allan 1965; Pourtier 1989: 194–207). It is possible that pre-colonial population density may have been higher but was reduced due to the various diseases introduced in the nineteenth century by European explorers (Pourtier 1989).

Clusters of villages as described by Nicolaï in Congo-Kinshasa also existed in prehistory. A recent study by Clist in the same country suggests that the Early Iron Age villages of the Kay Ladio Group in Bas Congo were clustered into ancient *vicinages* or small groups of villages that were well separated from each other (Clist 2021; for the notion of *vicinages* see Vansina 2004: 223–224). Such settlement clustering created voids in occupation that left some areas unoccupied. Anthropogenic carbon was not deposited in these locales, so there are no Iron Age dates. A similar settlement strategy, with gaps between *vicinages*, has also been found in prehistoric Europe (Naudinot *et al.* 2014) and could be a widespread pattern.

A systematic survey around the Iguela lagoon south of Port-Gentil in Gabon identified 28 archaeological sites, with a surprising number belonging to the Stone Age (23), most likely the Later Stone Age, but only five Iron Age sites, mostly dating to the Late Iron Age according to their pottery (Louis and Clist 1994: 76). This is the opposite of what was expected: a greater number of Late Iron Age sites along with a few Early Iron Age settlements. One possible explanation is that some of the Stone Age occurrences were left by stone-using hunter-collectors living during the Iron Age, another is that the sites are linked to land use patterns when Iron Age peoples did not significantly occupy this particular stretch of the Gabonese coast.

Two other projects studied the spatial distribution of archaeological sites according to their chronology and using a similar protocol, one in the coastal Estuary area of Gabon (Clist 2005a: 83–88) and the other on the Loango coast of Congo-Brazzaville (Denbow 2012: 402; 2014: 59–75). The Stone Age period is better represented in Gabon, but this is probably because a higher rate of natural erosion laid bare deeper layers of the soil after modern deforestation and because several excavations in Gabon were conducted down to bedrock, exposing Later and Middle Stone Age artefacts. During the 'Neolithic' and the Iron Age, there is an identical increase of Early Iron Age to Late Iron Age sites, suggesting increasing population size over time. However, a careful look at the pottery groups or traditions shows some major differences. In Gabon, for instance, after the pre-metallurgy sites of the Okala group, a small number of metallurgical settlements belonging to the Oveng group appear. In Congo-Brazzaville a roughly similar relationship between pre- and post-metallurgical sites exists from the 'Ceramic Late Stone Age' to the Herringbone Group sites. We conclude that the number of sites is always a better indication of ancient demography than the number of radiocarbon dates.

## Bias 14 — Context issues of radiocarbon dates

An initial assessment of data quality and reliability should be done prior to any in-depth analysis. Are the radiocarbon dates truly associated to anthropogenic activities or to the specific activity we want to date? If so, is there enough cultural material or artefacts to have them logically assigned to the correct cultural phase based on age range? Is the reference collection large enough (the 'shoe box' syndrome) or correctly published (see Bias 18)? When bulk-sampling was carried out before Accelerator Mass Spectrometry (henceforth AMS) dating became readily available, how concentrated was the charcoal in the archaeological layer or feature (see below for discussion of the 'Waterbolk DCA range')? To determine the nature of the relationship between the charcoal collected and the activities to be dated requires lengthy and tedious cross-checking of published documentation and its precision (cf. Wotzka 2006: 273–274, 288).

The possibility that dates have been wrongly associated with archaeological materials certainly exists. We mention three from recent publications in Gabon (Garcin *et al.* 2018; de Saulieu *et al.* 2021; Seidensticker *et al.* 2021). Two are from the Otoumbi 2 site where wood charcoal was extracted from an old termite mound that was excavated because it was mistakenly thought to be an iron smelting furnace (Beta-14834 and Gif-7130 in Clist 1989: 83). The proof that it was a termite mound only came later (Clist 2005a: 776–777) with the new interpretation published about ten years ago (Clist 2012b: 77). Another common problem is the incorporation in some catalogues of wood charcoal that only dates other wood charcoal, or charred palm nuts that only date other carbonised palm nuts, without any certainty of them having been produced by human activity (e.g. a series of dates from Fay 1997; Morin-Rivat *et al.* 2014, 2016; Bourland et al. 2015; Morin-Rivat 2017). An incorrect linkage between a radiocarbon date and cultural material with which it is presumed to be associated may also occur, such as with the well-known Later Stone Age date from Nsongezi rock shelter in Uganda (M-1113) which for years was wrongly associated with the 'Urewe Early Iron Age Industry' (Clist 1987: 45–46). A similar correction was made in the dating of Spaced Curvilinear ceramics from the Madingo-Kayes site in Congo-Brazzaville. The initial dates of *c.* 1900–1500 cal. BP were obtained from scattered charcoal fragments that may have been disturbed because the site was located on the edge of a borrow pit. Later AMS dating from a single-component horizon from Area A at Lac Ndembo more accurately dated these Spaced Curvilinear Wares to *c.* 1300–1200 cal. BP (Denbow 2012: 400–401; Denbow 2014: 57–58, 122, 124). At Mosumu in Equatorial Guinea, excavations at this open-air site went through clayey soils down to local 'bedrock' that was less than two metres deep (Marti 2003). Eighteen radiocarbon dates were processed. No potsherds were found even though the chronology of the calibrated dates runs from *c.* 34,600 to *c.* 1480 cal. BP (cf. SOM 1).

These few examples are evidence that one must always check the association between the dates and the artefacts back to the original papers. This would have identified the Nsongezi rock shelter and Otoumbi 2 problems. Our examination of recently published radiocarbon date catalogues has convinced us that such necessary and lengthy processing was not, or was not fully, carried out (see the radiocarbon catalogues in Garcin *et al.* 2018; de Saulieu *et al.* 2021; Seidensticker *et al.* 2021).

Probably the most important activity after cross-checking the literature is to determine the degree of association between the material dated and the cultural remains that it attempts to date: i.e., the *degree of certainty in association* or DCA (Waterbolk 1971: 15–16; cf. Denbow, above). This should be compulsory for both bulk sampling and AMS dating. Following the four stage DCA protocol proposed by Waterbolk (1971), de Maret (1978) added a fifth, namely 'possibility'. This DCA scale was put to use for the Urewe 'Tradition' (Clist 1987), the *Cibadates* radiocarbon database (Sarrazin 1987; Clist and Lanfranchi 1990) and a later PhD dissertation (Clist 2005a). The five stages or protocols are as follows:

1) absolute certainty that the archaeological object itself provided the dated material (e.g., *Elaeis guineensis* carbonised endocarps, or potsherds used for thermoluminescence or AMS dating);
2) a good probability that there is a direct functional relationship between the dated organic material and the archaeological material (e.g. the dated material and pottery come from the same pit and, preferably, the same levels (Mbida Mindzié *et al.* 2000: Fig. 3) or from an important concentration of artefacts with charcoal in one or several contiguous 10 cm spits (e.g. the Carboneras Group layer at the Carboneras site in Equatorial Guinea; Clist and de Maret 2021: Fig. 7));
3) when there is no direct functional relationship between the dated material and the archaeological material, but the quantity, size and concentration of the dated fragments suggest a direct functional relationship exists between the dated material and the archaeological material (e.g. the Lukula site in Congo-Kinshasa; Hubau *et al.* 2014);
4) there is a reasonable probability of a direct functional relations, as in point 3 above, but the fragments are small and scattered (e.g. the Epona 2 site, Gabon; Oslisly 1992: 156); and
5) there is a possibility of a relationship (added to Waterbolk 1971 by de Maret 1978), as in point 4 above, but the fragments come from the same depth as the archaeological material, though in an undifferentiated deposit (e.g. the Mosumu site, Equatorial Guinea; Mercader and Martí 2003).

An online pdf formatted file is available on the Society of Africanist Archaeologists (SAfA) web site explaining the problem of context for radiocarbon dates (https://safarchaeology.org/resources/Documents/Stratigraphic Context Tutorial English.pdf).

## Bias 15 — Size of the radiocarbon dates corpus and sub-regional radiocarbon date profiles

For a given geographical sub-set, Wotzka (2006: 272–273) suggests that we need over 100 radiocarbon dates before even the major trends of variability in past settlement intensity over space and time are adequately reflected:

> 'as long as no all too selective approaches are followed, systematically favouring certain time periods to the detriment of others in terms of collection and submission of samples for dating'.

However, some authors working with large corpuses, as in Europe, have argued for a minimum of 200 to 500 radiocarbon dates (Williams 2012). For southeast France, which incorporates the Languedoc-Roussillon, Provence-Alpes-Côte d'Azur and Rhône-Alpes regions, 3507 dates were put together from a total surface of 102,474 km$^2$ in order to discuss the Holocene demography of the past *c.* 10,000 years, i.e. roughly 35 dates per century or one date per 29 km$^2$ (Berger *et al* 2019). Another example comes from Rapa Nui (Easter Island) in the Pacific Ocean where on a 164 km$^2$ island 201 radiocarbon dates were available to discuss the ancient demography or 1.2 dates per km$^2$ (DiNapoli *et al* 2021). Similar numbers are likely to be the minimum needed for Central Africa before a broader and more reliable perspective on the cultural chronology of the region can be developed (Wotzka 2006). The best-known region of southern Cameroon, which is three times the surface area of southeast France, has only 443 Holocene radiocarbon dates, or four dates per century (cf. SOM 1); even if we restrict our survey to the last 3000 years, there are just 407 dates, or 13 dates per century, or slightly over four dates to cover the same area as the French case which has 35 dates per hundred years.

We have tested smaller areas of Central Africa to evaluate when a given corpus of dates gives a stable profile using our 17 sub-regional test cases, six of them divisions of southern Cameroon (SOM 2, section 3). The importance of sample size — and of the geographical differences — is crystal clear:

> *Cameroon* 1. Grassfields: 34 dates (incoherent curve); 2. Central: 104 dates (V-shaped curve); 3. East: 84 dates (incoherent curve); 4. Southwest: 115 dates (incoherent curve); 5. South: 67 dates (incoherent curve); 6. West: 73 dates (incoherent curve);
>
> *Central African Republic* 7. Northwest: 128 dates (continuous curve); 8. Southwest: 105 dates (L-shaped curve);
>
> *Gabon* 9. Northwest and Corisco island (which is part of Equatorial Guinea): 73 dates (incoherent curve); 10. Central: 70 dates (incoherent curve); 11. Southeast: 27 dates (incoherent curve);
>
> *Congo-Brazzaville* 12. Coastal: 48 dates (incoherent curve); 13. South-Central: 58 dates (L-shaped curve); 14. North: 35 dates (incoherent curve); and
>
> *Congo-Kinshasa* 15. Lower Congo: 128 dates (U-shaped curve); 16. Inner Congo Basin: 125 dates (U-shaped curve); 17. South-East: 66 dates (L-shaped curve).

The illustration of the corpora (SOM 2, section 3) only provides coherent date profiles for cases 2, 7, 8, 13, 15, 16 and 17, i.e. seven out of 17 instances. The result confirms that the better series have more than 100 dates (numbers 2, 7, 8, 15 and 16 above), as was suggested by Wotzka (2006) long ago. Sometimes for smaller samples of from 58 to 78 assays significant results can be suggested (cases 13 and 17), but this is probably due to better strategies during fieldwalking and the elimination or reduction of impact from Biases 1 and 2. Furthermore, even with over 100 dates, sometimes the profile is not coherent enough (case 4). These results restrict discussions if one uses radiocarbon dates to infer demographic histories to just five sectors of Central Africa, which are isolated one from the other: central Cameroon (N = 104), the northwestern Central African Republic (N = 128), southwestern Central African Republic (N = 105), western or Lower Congo-Brazzaville (N = 128) and the Inner Congo Basin region of Congo-Kinshasa

(N = 125). These five sectors correlate partly to where the data are heavily concentrated due to Bias 1 (Figure 2). However, using the number of a minimum series of 200 dates as proposed by Williams (2012), even these sectors could not be retained. The best profiles from our sample are either V- or U-shaped (cases 2, 15 and 16), continuous (case 7) or L-shaped (cases 8, 13 and 17). The profile type found does not correlate with the environment: cases 2, 8 and 16 are in the rainforest, cases 13, 15, and 17 in wooded savanna on the periphery of the rainforest and case 7 in the savannas of the Central African Republic. No regional picture emerges, but rather a series of local trajectories, at best.

Looking into the national series which are aggregates of the local ones discussed above (SOM 2, section 2), we identify a heterogeneous situation in contradiction with the conclusion of recent studies. One L-shaped profile, based on a regular uptake of carbon samples dated, is present in the Central African Republic (233 dates younger than 10,000 cal. BP) and the outline of another is present in Angola (59 dates). A V-shaped profile, exhibiting a decline then a low number of dated carbon samples between two maxima, exists for Cameroon (505 dates), Gabon (252 dates), Congo-Brazzaville (165 dates, but note that the south-central region of the country exhibits an L-shaped profile) and Congo-Kinshasa (410 dates, but note that the southeast of the country exhibits an L-shaped profile). The timing of the decline differs from one country to the other: in Cameroon, Gabon and Congo-Kinshasa after 1600 cal. BP, but in Congo-Brazzaville only after 1400 cal. BP. The low levels of carbon dated are at *c.* 1000–1200 cal. BP in Cameroon and Congo-Brazzaville, but 1200–1400 cal. BP in Gabon and Congo-Kinshasa. There thus seems to exist a relationship between savannas and L-shaped radiocarbon profiles and between the rainforest and V-shaped profiles, although exceptions exist, i.e. southern Congo-Brazzaville and western Congo-Kinshasa, both of them located in wooded savanna environments, exhibit L-shaped and V-shaped profiles.

Such V-shaped profiles exist in other parts of the world where they are called a 'peak and bust radiocarbon profile' or the 'Neolithic Demographic Transition' (NDT) and are not explained by epidemics. A rise in radiocarbon dates always seems to be followed by a decreasing number of assays amongst Neolithic communities, or a strong 'peak' is followed by a 'bust' (Guerrero *et al.* 2008; Kohler *et al.* 2008; Shennan *et al.* 2013; Lesure *et al.* 2014; Timpson *et al.* 2014; Porčić *et al.* 2016, 2021). The development of such a new Neolithic subsistence strategy implies an increase in fertility. With a population growth of between 1% and 2%, more carbon is deposited, leading to a peak in radiocarbon dates. A few centuries later, a second stage of NDT mortality (death rate) catches up with fertility (birth rate) and population growth decreases, the amount of carbon deposited drops and the graphic declines develop. Colledge *et al.* (2019) propose that these declines are due to an agricultural crisis. A further double peak of radiocarbon dates has been observed in the Neolithic of the Balkans by Porčić *et al.* (2021), who explain the first as marking the arrival of the original Neolithic population (immigration) which they associate with improved fertility caused by the NDT and a growth rate of between 1.14% and 2.36%. The following decline could then represent people moving on to new lands, perhaps as soil fertility decreased. The second peak is then seen as evidence of a return to a normal growth rate, estimated to be between 1.76% and 1.92%, caused by higher fertility in rates in the remaining population.

But all these discussions rely on a robust radiocarbon corpus that is as yet unavailable in Central Africa.

## Bias 16 — Old wood effect and the Hallstatt plateau

The problem of ‘old-growth wood’ dating has long been recognised. Wood in the Saharan and Sahel regions of West Africa was sometimes used centuries after the death of the tree (Killick 1987: 29–30, 2004: 102; Killick *et al.* 1988). As a result, the lead author has previously suggested that wood identification of dated charcoal be compulsory (Clist 1987: 40). This is also why Denbow (2014: 56–58) ran separate radiocarbon tests from both wood charcoal and oil palm nuts from some of the same features in Congo-Brazzaville to determine whether the wood charcoal might have come from the heartwood of old trees.

Interaction with botanists has recently hinted that the old wood effect is of negligible interest in a rainforest environment. In the forests of Central Africa, it has been estimated that between two and ten trees per hectare are lost each year from an average cover of 426 trees per hectare (Lewis *et al.* 2013: 6, Fig. 3). The initial stock is completely renewed over a period of 50 to 100 years (Galbraith *et al.* 2013: 3–4, Table 1). The decomposition period of the necro-mass in the Amazon Forest is a maximum of 13 years and often less than ten (Brienen *et al.* 2015: Table 2). In the African equatorial and sub-equatorial domain, most dead trees do not last long as their wood decomposes quickly. This is contrary to the Sahara and Sahel. However, the ‘old wood’ problem could still pertain to charcoal, which can last longer. A similar issue might also crop up in the future in the more southerly parts of the region (Angola, southern Congo-Kinshasa, Zambia) where large numbers of baobab trees (*Adansonia digitata*) grow that are well known for their long lifespan, which can last from several centuries to well over 1000 years (Wickens 1982; Patrut *et al.* 2010, 2015). While such trees may not often be selected for firewood because of their porosity, anthracological identification of prehistoric charcoal selected for dating may need to be added to the research protocols operating in the southern parts of our region. Another issue from neighbouring northern Botswana involves removing presumed charcoal-temper from Early Iron Age ceramics for radiocarbon dating. Kinahan (2013) argues that since the charcoal was added by the potter to the clay as temper, it should be the preferred material used to date the vessels. But Okavango Delta clays mainly form when channel systems become moribund and turn to peat that is created by decaying organic matter from the reed and papyrus beds that cover this wetland. This is combined with stream-borne sediments which then desiccate and accumulates as clay deposits. The now dry organic matter burns and the charcoal formed is dispersed in the clay, which then includes old carbon dating back to the onset of island formation 1000–100,000 years ago. If the potter chooses to add extra charcoal to the clay as temper this will be mixed with the naturally occurring carbon from the formation of the clay. Since it is impossible to estimate the elapsed time between wood death, charcoal production and its use by potters, this compromises the value of using charcoal recovered from such potsherds for radiocarbon determinations (Denbow and Wilmsen 2023).

The so-called “Hallstatt plateau” refers to a period when calibration of a *c.* 2550–2400 bp date will systematically fall anywhere between 2700 and 2350 cal. BP. Obviously, this is a poor resolution for archaeologists interested in discussing the expansion of iron metallurgy or the first villages in Central Africa (Clist 2013; Eggert 2014b). During the Holocene, other such periods exist (e.g. 4550–4400 bp). In SOM 1, the acronym HP

(Hallstatt plateau) has been added to dates where needed. Such assays are few in number and do not affect too much the two topics discussed here. It has been demonstrated that using a combination of radiocarbon dating, along with osteological, stratigraphic and typological information, it is possible to overcome or minimise the Hallstatt plateau handicap (Rose *et al.* 2022). Archaeometric dating of the remains of clay smelting furnaces can also resolve the problem presented by the 1650–1950 AD plateau (Herve et al. 2023).

## Bias 17 — Materials dated

It is important to record the type of material dated as precision depends on it. Samples that have been radiocarbon-dated since the inception of the method include charcoal, wood, twigs, seeds, bones, shells, leather, peat, lake mud, soil, hair, pottery, pollen, phytoliths, wall paintings, corals, blood residues, fabrics, paper or parchment, resins and water, among others. Our radiocarbon catalogue identifies a number of archaeological materials (see SOM 1). Wood charcoal represents the majority of the material dated, followed in Central Africa by palm nuts (*Elaeis guineensis*). Other material includes mangrove shells, bivalves from freshwater and ocean shell middens, bush candle nuts (*Canarium schweinfurthii*) and bulk carbon of organic matter. Some are better than others. The differing quality for dating of animal bone, human bone and wood has been discussed by Pawełczyk *et al.* (2022). Another study briefly examined the use of ostrich eggshell, mollusc shells and bone (Wright 2017: 307–311). Care must be taken when dating marine shell since the effects of the marine carbon reservoir must be corrected for on the normally calibrated date (Kennett *et al.* 1997; Bezerra *et al.* 2000; Reimer and Reimer 2006; Soares and Martins 2009). Shell middens are found along the Atlantic Ocean coastline from Cameroon to Angola and also along the lower parts of rivers like the Sanaga in Cameroon or in Congo-Brazzaville and Congo-Kinshasa. When using this material, care must be taken to measure the local reservoir effect. This requires more time and funds by double dating the shells and nearby collected wood charcoal and/or *Elaeis guineensis* nuts. This was done when studying the shell middens of the Mondah bight in Gabon, revealing that dates from *Arca senilis* shells were 100 to 200 years older than those on charcoal or *Elaeis* nuts (Van Neer and Clist 1991). A marine carbon correction applied to a single marine shell specimen dated from Lac Tchitembo in Congo-Brazzaville resulted in a date that was 300 to 400 years younger than the original BP date; here, however, there were no preserved palm or *Elaeis* nuts that could be used to cross-check this (Denbow 2014: 58).

To be able to distinguish the best material for radiocarbon dating, a comparison was conducted between charred seeds, wood charcoal and wood and bone from Neolithic deposits excavated in Belgium of known age (Jadin 1999: Fig. 6.1–7): charred seeds were the most precise, followed by charcoal. For the most accurate dating results, cereal grains, fruits and seeds that reflect growth in a single vegetative season are preferred (Nowak *et al.* 2017). In Central Africa, such samples are still rare due to a lack of on-site water sieving and flotation. Another difficulty impacting the accuracy of dating that is rarely discussed is found in Wright (2017: 311–312). Here, artefact storage under the non-controlled humidity conditions often found on the African continent can potentially lead to the slow development of micro-organisms on badly curated artefacts and ecofacts.

## Bias 18 — Availability and quality of pottery analysis

Another major issue, one that does not impact the use of dates for ancient demographics but does affect local social and cultural analysis, concerns assays obtained from features without any pottery, such as iron smelting furnaces (e.g. Lopé 10 in Gabon; Clist 2005a: 774), or too few decorated potsherds to get to a convincing cultural association (e.g. Oyem 2 in Gabon; Clist 1989: 82, Fig. 12). This can lead to an inflation in the number of cultural groups with dates of uncertain association. Several cases exist where the pottery was never published (e.g. the Gabonese Early Iron Age Moanda iron furnaces: Digombe *et al.* 1985, 1988) or incorrectly described (e.g., the Gabonese Otoumbi Group pottery: Oslisly 1992: 231–245). This leads us to the question of the availability and quality of pottery analyses and the existence or development of robust pottery sequences.

Complete sequences from the earliest pottery to historical times are found in only the following five areas:

Figure 9, no. 1 around the Gabon estuary and on the island of Corisco in Equatorial Guinea (*c.* 2800–200 cal. BP: Clist 1995a, 2005a; Sánchez-Elipe Lorente 2015);

Figure 9, no. 2 in the Middle Ogooué river area, Gabon (*c.* 2800–200 cal. BP: Assoko Ndong 2001, 2002, 2003; Oslisly 1992);

Figure 9, no. 3 in the Inner Congo Basin of Congo-Kinshasa and Congo-Brazzaville (*c.* 2400–200 cal. BP: Eggert 1984, 1987, 1995; Wotzka 1995, Seidensticker 2016, 2017);

Figure 9, no. 4 along the Upemba River and in Katanga, Congo-Kinshasa (*c.* 1600–400 cal. BP: Anciaux de Faveaux and de Maret 1980, 1984; de Maret 1985a, 1991, 1992); and

Figure 9, no. 5 in the western Central African Republic, around Bouar (*c.* 3500–200 cal. BP: Zangato 1999, 2000, 2007).

Interesting but incomplete pottery sequences are to be found in two areas:

Figure 9, no. 6 around the Kouilou river in Congo-Brazzaville (*c.* 2500–1200 cal. BP: Denbow 2014); and

Figure 9, no. 7 in the Lower-Congo area of Congo-Kinshasa (*c.* 2300–200 cal. BP: de Maret 1990; Clist 2018; Clist *et al.* 2018b; Clist *et al.* 2018f).

Partial pottery sequences exist from specific excavated sites of the Iron Age, namely:

Figure 9, no. 8 from southern Congo-Brazzaville (*c.* 2000–200 cal. BP: Pinçon 1988, 1991a, 1991b; Pinçon and Dechamps 1991; Pinçon *et al.* 1995; Dupré and Pinçon 1997; Nikis 2018a, 2018b, 2018c, 2018d);

Figure 9, no. 9 in southwestern Cameroon at Campo (Eggert and Seidensticker 2016a), near Douala (de Saulieu *et al.* 2017b), near the border with Gabon (de Saulieu *et al.* 2015) and along the coast (Oslisly 2006; Oslisly *et al.* 2006; Meister 2008, 2010; Meister and Eggert 2008);

Figure 9, no. 10 in central Cameroon in and around Yaoundé (Mbida Mindzié 1996, 2002; Mbida Mindzié *et al.* 2000); and

Figure 9, no. 11 in the Central African Republic in the Ngotto Nature Reserve (Lupo *et al.* 2018, 2021; Schmitt *et al.* 2019).

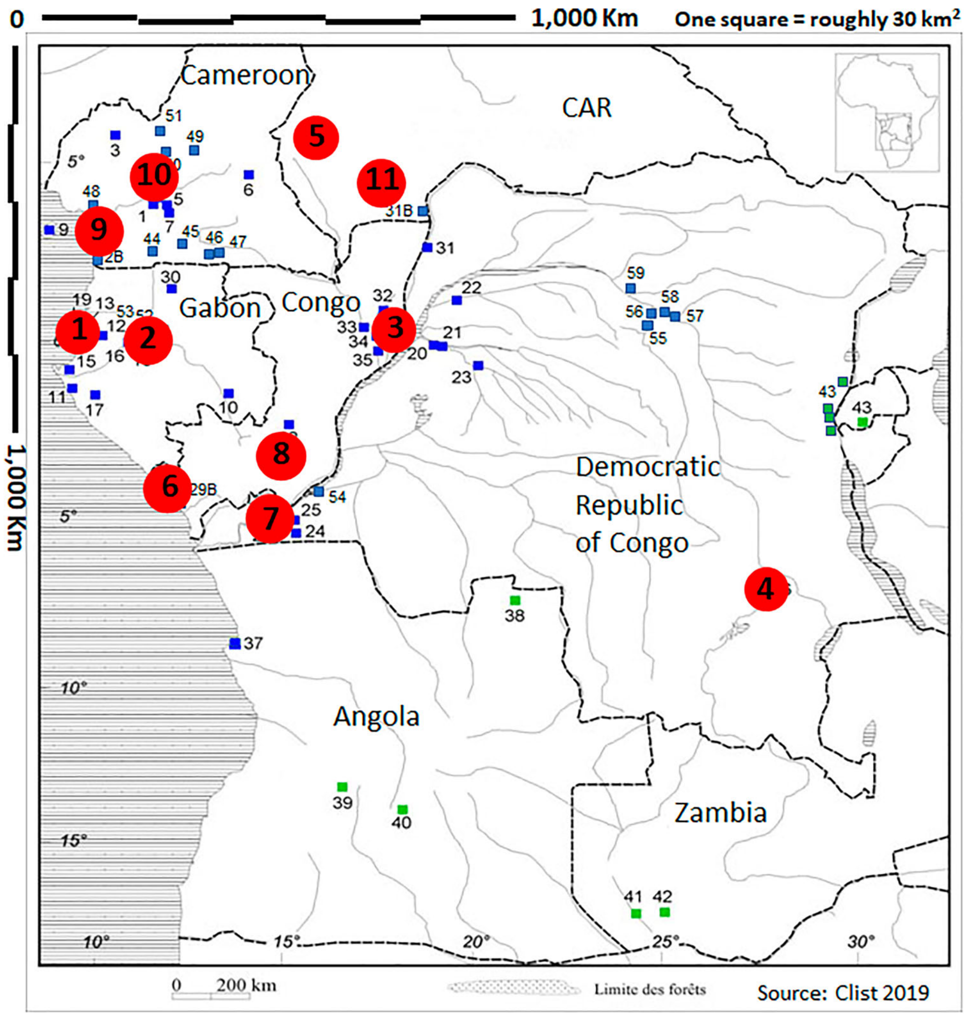


**Figure 9.** Location map of the cultural sequences in Central Africa - Blue squares, dated archaeological sites pre-2000 cal BP.

We are far from having adequate data for all the pottery groups known from public and grey (unpublished MA and PhD theses) literature (Clist *et al.* 2021a). This hampers a good understanding of past social processes, especially those relating to a probable Bantu-speaker expansion through the equatorial forest (Eggert 2016: 84–85), and of the reliability of all the radiocarbon dates obtained thus far (Clist *et al.* 2021b).

One example is compelling: the Obobogo Group or Tradition from Cameroon, probably one of the most cited pottery groups in the region since the Obobogo site 1980-1983 excavations, has yet to be fully described and published; part of the needed information can only be found in unpublished MA (Claes 1985, 1992) and PhD theses (Mbida Mindzié 1996; Clist 2005a: 721–740 and its Appendix 5; Nlend Nlend 2014: 231–261). Most, if not all, the inferences drawn rely on a superficial understanding of this pottery tradition. The same can be said of other 'traditions' from Cameroon to Congo-Kinshasa (Clist *et al.* 2021a). There exists a confusion leading to a multiplication of heterogenous entities for varying reasons. These include:

1) considering on an equal footing fully described pottery assemblages, part of a 'pottery group', with others published without any good description (e.g. Clist *et al.* 2019a: Kitala Group in Congo-Kinshasa versus Oslisly 2006: Malongo Group in Cameroon);
2) keeping distinguishing groups when they are known to be one and the same (e.g. Okala and Epona groups in Gabon which must be understood as a single Okala Group; Clist 1988, 1995a, 1997, 2005a); and
3) misunderstanding a new and single Kongo Group, made up of common pottery types [A to C-types] associated with another probably produced for the Kongo kingdom's élite [D-type] (Clist *et al.* 2018f), with four distinct Late Iron Age groups (Seidensticker *et al.* 2021).

Apart from the Bouar area in the Central African Republic located in an Adamawa-Ubanguian language zone, and the Batalimo-Maluba group along the Ubangui in a border zone, all the other pottery groups are deeply situated in modern Bantu-speaking territory.

## Bias 19 — Quality of specific dating laboratories

Using the same laboratory is recommended as long one has confidence in it. This helps to reduce the possibility of differing quality in the instruments and the protocols used. Thus Jadin (1999: Fig. 6.1–8), when working on the European Danubian Neolithic which was known then to extend from 6300–6000 BC, showed that differing results came from nine distinct laboratories. The most accurate were Oxford (OxA, United Kingdom), Leuven (Lv, Belgium), Berlin (Bln, Germany), Groningen (GrN, Netherlands), Kiel (KN, Germany) and Utrecht (Utc, Netherlands). The laboratories producing dates that were widely spread out were Gif-sur-Yvette (Gif, France), Hanover (Hv, Germany) and Lyon (Ly, France). Today, the main authors of the present study make use on a regular basis of Poznań (Poz, Poland), Beta Analytic (Beta, United States) and the Brussels' Royal Cultural Heritage Institute (RICH, Belgium) radiocarbon laboratories, Poznań being the cheapest.

The Hanover laboratory came to the forefront of discussions about Central Africa when Eggert (1987: 132) suggested that it had a systematic bias. He claimed that it provided dates that he felt were too early for his Inner Congo Basin research project, sometimes with discrepancies of 500 years. There was indeed a problem at the laboratory. As described by its director, the laboratory acknowledged that dates had been aged by 'contamination of the acetylene used as counting gas with recent and/or fossil carbon by the lithium used for its preparation' (Geyh 1990: 321).

A re-evaluation of the 161 Hanover dates from Central African sites, as well as from Rwanda and Burundi, is ongoing by Bernard Clist and Pierre de Maret. The main finding is that most of them fit the local cultural sequences developed during the last 40 years. The provisional conclusion is that any dubious result must first be explained by the local excavation context, not by *a priori* citing the problem encountered by Hanover.

This said, we do have evidence of dating differences between some laboratories. Eggert (1987: 132–133) was the first to outline such inaccuracies when he discussed the chronology of the Imbonga group, the earliest pottery group in the Inner Congo Basin. At Isaka in Congo-Kinshasa the same charcoal sample was subdivided and sent to both the Hanover and Groningen laboratories. This resulted in a major difference, with the Hanover date being older by 545 years. Clist later sent the same sample, subdivided four times, to Gif-sur-Yvette and to a different laboratory; three times the subdivided portion was also sent to Beta Analytic. Another time an *Anadara senilis* mangrove shell sent to the Archéolabs facility in France (Clist 2005a: 132). Gif-sur-Yvette always dated older (Table 5).

Eggert also sent to differing laboratories charcoal samples from different depths of the same pit (Table 6). In addition, three charcoal samples processed by Hanover from the same pit at Imbonga found a 730-year difference between them (-40 cm, Hv-12614 *c.* 2665 bp; – 80 cm, Hv-12207 *c.* 2860 bp; -100 cm, Hv-11575 *c.* 2130 bp). While the upper two dates overlap at Imbonga, the deepest sample is too young. At Wafanya, four samples were dated from the same 83/16 feature (spit 5, Hv-12612 *c.* 3305 bp and KI-2365-01 *c.* 280 bp; spit 6, Hv-12611 *c.* 2695 bp; spit 8, Hv-12613 *c.* 1920bp).

Important chronological differences also appear between the Kiel and Groningen laboratories. At Bamanya, the means of three charcoal samples from the same feature have a 220-year difference (83/1-V; KI-2361 *c.* 640 bp; GrN-13077 *c.* 440 bp; KI-2360 *c.* 420 bp). At Baringa, three more samples from the same feature (85/1) were dated with a 300-year difference (KI-2431 *c.* 950 bp; GrN-14002 *c.* 710 bp; KI-2430 c.650 bp). At Isaka-Elinga, one feature was dated by three samples sent to three different laboratories (Hv-12626 *c.* 1895bp; GrN-13076 *c.* 1450 bp; KN-4206 *c.* 1590 bp) with the result that there was 445 years between Hanover and Groningen, 405 years between Hanover and Kiel, and 140 years between Groningen and Kiel. Two features from the Bolondo site were also dated three times with the following results: (83/2, KN-4203 *c.* 230 bp; Hv-12618 *c.* 1175 bp; Hv-12619 *c.* 1195 bp), (83/1, Hv-12624 *c.*1725bp; Hv-12625 *c.* 915 bp; GrN-13078 c.660 bp).

During his surveys and excavations along rivers in the Congo, Eggert ran 27 radiocarbon dates from 13 features (Seidensticker 2017: 516–518). As with the Hanover series

**Table 5.** Radiocarbon dates processed for the same sample by M. Eggert and B. Clist.

| Site | Laboratory number | Date (bp) | Laboratory number | Date (bp) | Difference |
|---|---|---|---|---|---|
| Isaka, 83/104 | GrN-13076 | 1450 ± 45 | Hv-12626 | 1895 ± 65 | +545 |
| Otoumbi 1 | Beta-14835 | 1740 ± 60 | Gif-6908 | 1860 ± 60 | +120 |
| Sablières | Beta-14828 | 5950 ± 70 | Gif-6907 | 6450 ± 80 | +500 |
| Okala 1 | Beta-46142 | 39,690 ± 670 | Gif-9378 | >40,000 | ≥310 |
| Oveng 1 | Arc-343 | 1900 ± 50 | Gif-8151 | 2210 ± 40 | +310 |

**Table 6.** Radiocarbon dates processed for M. Eggert in the Inner Congo Basin.

| Site | Laboratory number and depth (cm) | Date (bp) | Laboratory number and depth (cm) | Date (bp) | Difference |
|---|---|---|---|---|---|
| Bokuma 83/1 | KI-2363, -256 | 2260 ± 60 | Hv-12627, -214 | 3485 ± 220 | +1225 |
| Bokele, 81/1 | GrN-13583, -15 | 2290 ± 60 | Hv-11573, - 40 | 1850 ± 120 | -440 |
| Longa 81/1 | GrN-13586, -40 | 500 ± 90 | Hv-11571, -50 | 730 ± 75 | +230 |

**Table 7.** Radiocarbon dates processed for M. Eggert along the Sangha River.

| Site | Laboratory number | Date (bp) | Laboratory number | Date (bp) | Difference |
|---|---|---|---|---|---|
| Maluba, 85/1-3-1 | GrN-13584 | 1670 ± 110 | KI-2444 | 1930 ± 120 | +260 |
| Maluba, 85/1-3-2 | GrN-13585 | 1990 ± 60 | KI-2445 | 2140 ± 200 | +150 |
| Maluba, 85/1-4-3 | Poz-62102 | 580 ± 30 | Poz-62103 | 810 ± 80 | +230 |
| Pikunda 87/1 | KI-2891 | 600 ± 75 | KI-2877 | 1980 ± 100 | +1380 |
| Munda 87/1-0-1 | KI-2883 | 870 ± 180 | KI-2882 | 1110 ± 110 | +240 |
| Munda, 87/3 | KI-2889 | 1650 ± 80 | KI-2890 | 1680 ± 90 | +30 |
| Munda, 87/2-1-1 | KI-2885 | 1800 ± 80 | KI-2887 | 2020 ± 180 | +220 |
| Munda, 87/2-1-3 | KI-2876 | 1980 ± 41 | KI-2888 | 1990 ± 65 | +10 |

from the early 1980s, the results from the Groningen and Kiel laboratories show similar discrepancies for the same features (Table 7). Two assays show Kiel dating older than Groningen, while two dates from Poznań have a 230-year difference. Five different times the same pit was processed twice at Kiel: twice the difference in dating was negligible (Munda 87/3 and Munda 87/2-1-3), twice it was important (Munda 87/1-0-1 and Munda 87/2-1-1) and once it was very important (Pikunda 87/1) (Table 7). A pit from Munda was dated four times at Kiel (87/2-1-1), with a difference of 220 years between the samples (KI-2885 *c.* 1800bp; KI-2886 *c.* 1910bp; KI-2881 *c.* 1990bp; KI-2887 *c.* 2020bp).

Other examples could be put forward. The deviations were significant enough that in the 1980s it was felt there was evidence of a technical problem at the Hanover laboratory that possibly impacted the accuracy of its dates for samples from Congo-Kinshasa, Cameroon, Rwanda and Burundi. The comparison with the more recent results from the Inner Congo Basin illustrates that the same 'problem' occurred with the Groningen and Kiel laboratories.

The observation that the Hanover dates seem to 'fit' the local cultural sequences in other parts of Congo-Kinshasa, Cameroon and the Great Lakes area of East Africa suggests that the 'problem' was, and still is, a contextual one.

## Bias 20 — Accelerator Mass Spectrometry versus bulk sampling

In the 1950s and 1960s, radiometric analysis was carried out with Gas Proportional Counters, which were superseded by Liquid Scintillation Counting (henceforth LSC) after 1970. Since the late 1970s, AMS has become a standard tool (Hedges 1987). In its early stages it was too expensive for research budgets and laboratories like Beta Analytic (USA) would propose using either classic or AMS dating: in 1994 a conventional radiometric service cost US$245 while an AMS date was US$560; today one can get an AMS date for just €270 or US$285! Before the advent of AMS, archaeologists had to gather a maximum amount of charcoal in order to get the needed minimum weight of material. This is where the degree of association between the charcoal dated and the artefacts with which it was assumed to be associated was vital. Careful stratigraphic analysis of the context was needed to understand how the materials came to rest where they were found. Although with AMS only a very small particle of charcoal or other organic material is sufficient, its association with the historic event being studied remains crucial. The technique in use for bulk sampling is also important. David Wright has called our attention to the danger of using 'legacy data' (Wright 2017: 307), which combine dates for a single event produced by varying AMS and LSC laboratory techniques.

## Bias 21 — Using legacy dates and the available literature

Apart from collecting and combining radiocarbon dates related to our own research questions (e.g. Sarrazin 1987; Clist and Lanfranchi 1990), we had to regularly consult a number of issues of *Archaeometry* and *Radiocarbon* published up to the late 1990s to locate date series produced by a variety of radiocarbon laboratories. These dates were supplemented by those from articles in the *Journal of African History* for the continent as a whole (Fagan 1961, 1963, 1965, 1966) and later regional series covering West Africa (Willett 1971; Flight 1973; Calvocoressi and David 1979; Sutton 1982; McIntosh and McIntosh 1986), Central Africa (de Maret *et al.* 1977; de Maret 1982, 1985b), East Africa (Sutton 1972; Maggs 1977; Mgomezulu 1981; Robertshaw 1984; Sinclair 1991) and southern Africa (Hall and Vogel 1980; Parkington and Hall 1987; Maggs and Whitelaw 1991; Mitchell and Whitelaw 2005). These were enhanced for Central Africa by national lists, especially the first catalogue published as early as 1985 for Congo-Brazzaville (Kouyoumontzakis *et al.* 1985; see also Lanfranchi and Manima-Moubouha 1984); others were later developed for Cameroon (Delneuf *et al.* 1998) and Gabon (Digombe *et al.* 1985; Clist 1995a: 259–280). These lists have provided us with our basic information.

To circumvent biases such as Bias 14 we needed to examine all the published data since ‘the reality is that obtaining legacy dates and verifying their accuracy require[s] legwork and knowledge of what separates a good date from a bad one’ (Wright 2017: 312) or, more directly expressed,

> “It is a sheer waste of precious time tracing obscure literature, comparing contradictory publications, trying to find out about sample materials and delta $^{13}$C values or hunting after geographical coordinates of remote sites” (Wotzka 2006: 288).

While the archives from *Radiocarbon* are freely available online thanks to the University of Arizona (https://repository.arizona.edu/handle/10150/635035), there is no bibliography for eastern and southern Africa that can compare to the one created for Central Africa to document the Cibadates radiocarbon database that is still being continually updated (http://www.african-archaeology.net/biblio/index.html).

In the future, one can hope that an *African Radiocarbon Database* will become available online and that it will be built to first class standards with an associated bibliography of all archaeological references. Our colleagues will then have a thoroughly screened tool that will enable them to save time by not having to do tedious documentation for new research projects.

## Bias 22 — Illustrations and graphics

Maps created to illustrate the locations of archaeological sites can sometimes give a false impression of good sampling. For example, the dots used in Garcin *et al.* (2018) have a diameter of 25 km and tend to fill up the map. The same is true for many other maps (cf. Oslisly *et al.* 2013; de Saulieu *et al.* 2021; Seidensticker *et al.* 2021). A comparison with our maps (Figure 2) lead to an unambiguous conclusion — ours better illustrate not only the concentration of research, but also the vast areas of Central Africa that remain unknown.

## Bias 23 — Psychological aspects of academic research

Three aspects that are often overlooked, even though they impact academic work, are the '*mere exposure effect*', the '*hindsight bias*' and the '*confirmation bias*'. Since the 1990s, the statement that there is a gap in our radiocarbon series that is explained by a decrease in population has often been accepted without any deeper investigation. Its repetition developed a *cognitive ease*. This has led to a feeling of familiarity, with the result that the belief is thought to be true without questioning or debating the underlying facts (Kahneman 2011: 62, 66–67). It is also known as the *confirmation bias*, i.e. the tendency to search for, interpret, favour and recall information in a way that confirms or supports one's prior beliefs or values (Kahnemann 2011: 80–81). Proponents of a radiocarbon date 'hiatus' supporting a 'population crash' in Central Africa have, over the years, combed the data to find similar cases without fact-checking each new occurrence. The Kalahari Debate between Wilmsen, Denbow, Lee and DeVore is another well-known example of such a controversy and has produced more than 600 papers and books dealing directly with the issue. Three principal articles, all published in *Current Anthropology* in 1990/91, lie at the core of the debate, with Elphick's (1977) book and Denbow's (1984) book chapter perhaps presaging some of its major elements (Solway and Lee 1990: 209–246; Wilmsen and Denbow 1990: 489–524; Lee and Guenther 1991: 593–40). '*Hindsight bias*' adds another fascinating element to the '*mere exposure effect*'. Today, some colleagues will believe that they were the first to suggest that a regional epidemic was the cause of the decrease in the number of dates after *c.* 1500 BP, forgetting that they were at first very cautious because the suggestion was based on feeble evidence from only a few areas. The tendency to revise the history of one's past beliefs in the light of modern data can produce a robust cognitive (de)illusion (Kahneman 2011: 202–203).

## Bias 24 — Deficits in Africanising archaeological research

The small number of studied sites is, of course, linked to the small number of archaeologists who have worked in Equatorial Africa since the 1980s from Europe and North America and the small number of research programs they have been able to carry out in spite of difficult physiographic, political and financial circumstances (de Maret 1990). In 1985, only ten archaeologists and historians were active in Central Africa (Clist 1986: 228). A regional 1989 survey based on a questionnaire sent to all the existing laboratories in Central Africa and Zambia still produced dire results (Clist and Lanfranchi 1989). The best funded laboratory in the region — in Gabon — did not have an annual budget exceeding 2500 euros (~US$2683) between 1985 and 1992. In 1990, only 12 archaeologists were active in the region, both nationals of Central African countries and expatriates (Lanfranchi 1990: 504). More recently, although the number of African PhDs has slowly increased, in their newly found positions at local universities they have often found it difficult or impossible to secure national funds for research or to care for archaeological collections and develop laboratories (Eggert and Seidensticker 2016b; Marliac 2006, 2016). Perusing the archaeological bibliography for Central

Africa at http://www.african-archaeology.net/biblio/index.html, one finds 13 PhD holders in Cameroon, seven in Gabon, seven in Congo-Kinshasa, five in the Central African Republic, four in Congo-Brazzaville, three in Angola, and none in Equatorial Guinea for a total of 39 or 6.5 per country (excluding Equatorial Guinea and São Tomé and Príncipe), several of whom are now deceased.

Another unsettling factor is the social and political instability that impacts many areas, with ongoing civil strife in the English-speaking zone of Cameroon, intermittent war-like conditions in eastern Congo-Kinshasa, ongoing civil war in the Central African Republic and the long civil war in Angola between 1975 and 2006.

Low-budget archaeological research projects linked to urban development in and around at least the various capital cities could lead to robust cultural sequences if they were properly supervised by local archaeologists. Additionally, where the numbers permit it, more construction programs could be overseen by indigenous scholars for preventive and rescue archaeology purposes. But so far, this is not the case. In order for this specific bias to disappear, there needs to be increased financial support at the national level through ministries of culture (museums, collection curation and public outreach) and scientific research (field and laboratory work). This can be boosted by external schemes such as the African Chronometric Dating Fund started in 2022 by the Society of Africanist Archaeologists to pay for radiocarbon dating of samples collected by young African PhD candidates and African archaeologists (https://safarchaeology.org/African-Chronometric-Dating-Fund-2022-23).

## Discussion as a conclusion

In 1981, the late Nicholas David (1981) published the 'state of the art' for archaeology in Central Africa, though it also nibbled slightly at the Sahel. He identified two major flaws in research at that time, namely: 1) the small and restricted nature of most excavations, which yielded only enough stone or pottery for typological analysis, but were too small to produce adequate samples for good archaeobotanical or archaeozoological studies (David 1981: 44); and 2) the fact that regional sequences were inadequate because 'our pinprick excavations may have penetrated quite atypical portions of the prehistoric anatomy' (David 1981: 46). Similarly, only a few years ago, Eggert (2014a: 199) described the state of archaeological research in the region as being a drop in the bucket.

As we have repeatedly shown, it is problematic to engage in wide-scale regional syntheses without first considering the twenty-four underlying research biases that have impacted, and are still impacting, the developing radiocarbon catalogue. The focus of this study has been to examine the robustness and comprehensiveness of the radiocarbon date corpus from Central Africa, which covers over 50,000 years from the earliest Maboué 5 site in Gabon, dated to ≥57,100 bp. We have assessed 1764 radiocarbon and thermoluminescence dates from 601 archaeological sites, documenting them by looking systematically into their original publications. While a full and accurate listing of radiocarbon dates has still to be developed to be set up on the Internet, we have found too many dates that are wrongly or poorly documented in secondary publications because archaeologists have not consulted the primary research.

As discussed in Bias 15, we feel that a minimum of 70 dates is needed for any sub-area before even an educated hypothesis can be safely made and the data provide graphic evidence to suggest that over 100 dates are required before a stable picture of past events in a region can be discussed with confidence. Such a density of Holocene dates is currently only available from five isolated sectors of Central Africa, central Cameroon (N = 104), the northwestern (N = 128) and southwestern (N = 105) parts of the Central African Republic, western or Lower Congo (N = 128) and Inner Congo Basin of Congo–Kinshasa (N = 125).

Before taking for granted the conclusions of colleagues, a full re-evaluation of the data is needed that would include an exhaustive new review of the labels that have been taped to the finds. Probably our greatest surprise came when we mapped the excavated and radiocarbon-dated sites for seven countries in the region. Given our joint long-term experience in Central African archaeology, we never thought that our research was so spatially concentrated, leaving huge spaces unexplored. This is especially clear from the map locating Tier 3 and 4 sites with a minimum of five radiocarbon dates, when looking for instance at the data for the Central African Republic, Congo-Brazzaville and Congo-Kinshasa (Figure 10). Angola and Equatorial Guinea are considered separately due to the present poor development of their research results.

We have outlined how diverse research strategies have been employed to find and then study archaeological sites by investigators from a number of countries and research backgrounds. This has led to biased sampling of the evidence when the entire region is considered. River surveys, for example, probably under-represent the density of ancient settlements when compared to land surveys. And even land surveys in the equatorial forests west of the Congo River are spotty because they have focused on cleared lands where features and artefacts can be more easily be identified (Cameroon, Gabon, Equatorial Guinea, Congo-Brazzaville). Many sites have been found along roads, but others were also found where large construction projects such as power plants, water dams or industrial-scale wood processing have created clearings or excavations. In the savannas of Gabon, the coast of Congo-Brazzaville and the western portions of Congo-Kinshasa, many sites were identified by foot surveys that focused on highly eroded areas and hill slopes (central Gabon, the Congo-Brazzaville coast, Bas-Congo) where the remains of ancient living floors were exposed on the slopes. Other excavations were limited to 'refuse pit archaeology'. Many field research programs in Central Africa have also involved rescue archaeology.

As we found in our study, Early Iron Age sites have clearly been over-sampled when compared to those from the Later Iron Age. This explains the larger number of radiocarbon dates for this period when compared to the last centuries of the Iron Age. Nonetheless, we do find clear rises and falls in the amount of carbon retrieved and dated that might be indicative of changing demographic trajectories — but, if so, only acceptably in limited parts of the region — and not in as drastic a fashion as some recent publications suggest. In our opinion, one must still be cautious about attributing a too direct relationship between numbers of radiocarbon dates processed and changes in palaeodemography, as suggested by Ritchison (2020) about a site in Georgia in the southeastern United States or by DiNapoli *et al.* (2021) for Rapa Nui.

At the site level, all excavations only opened parts of a settlement. This results in another type of sampling bias when the relationship between the sample and the original

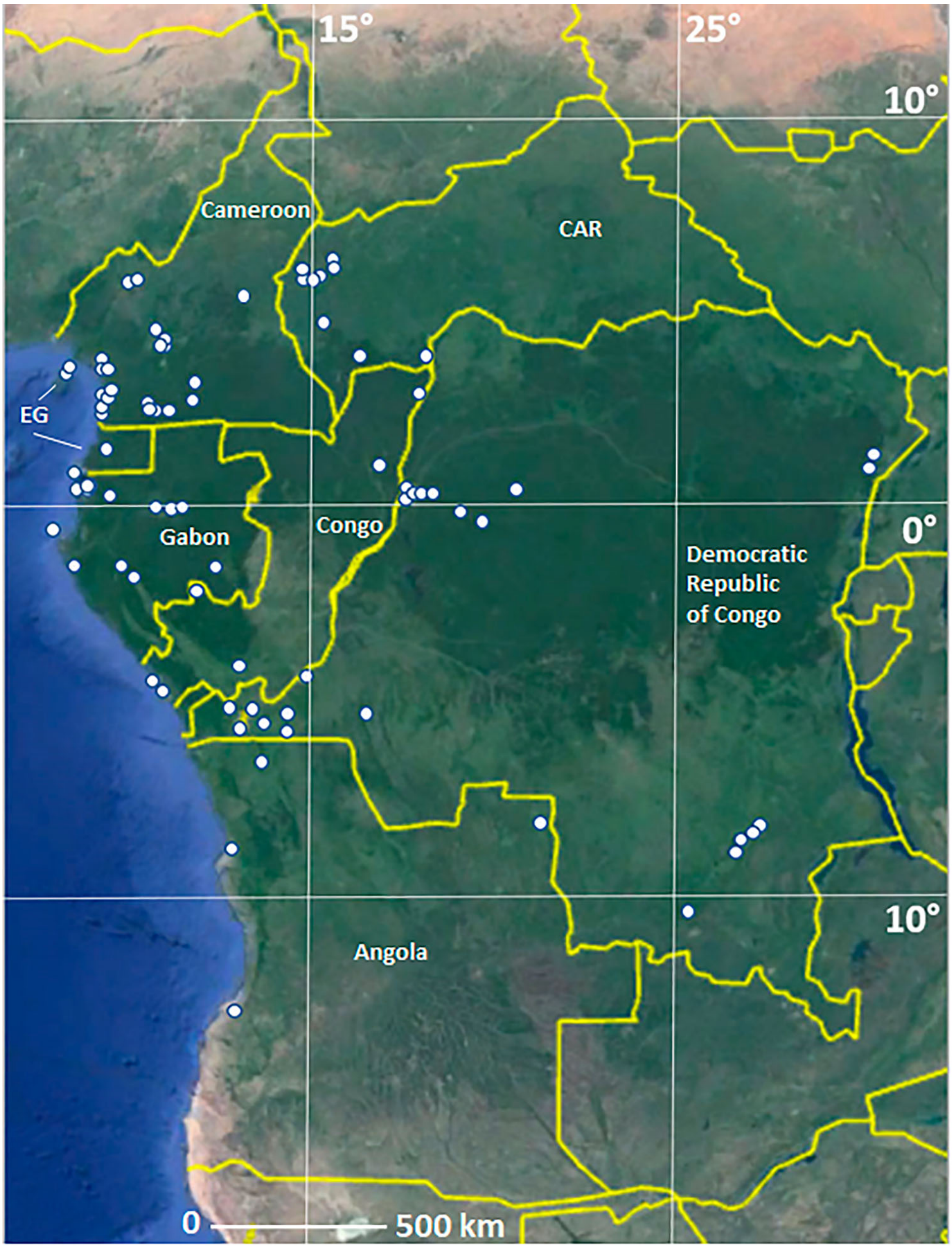


**Figure 10.** Central Africa: Tier 3 and 4 excavated and dated sites.

population is inadequate. As already noted nearly 40 years ago (Clist 1986: 228–229) wider-scale strategies for settlement archaeology must be developed that overcome the 'pinprick or telephone booth excavations' criticised by David (1981). This is needed so that we can add more anthropology to our syntheses (cf. Denbow 1999). Yet wider-scale, more intensive excavations to determine settlement layout have only been carried out on a few rare sites by Pierre de Maret in Cameroon, Bernard Clist in

Gabon and Jim Denbow in Congo-Brazzaville, although recent fieldwork by Hans-Peter Wotzka at Iyonda and Bolondo in Congo-Kinshasa is also promising (Neumann *et al.* 2022).

Our paper further highlights how pottery studies are still limited in number and how, in the majority of cases, ceramic descriptions are not detailed enough to permit regional comparisons. In most instances, clay or metallurgical analyses that would permit better identification of exchange or trade networks are only in their early stages, as shown by Nikis (2018) or Tsoupra and Clist (Tsoupra *et al.* 2022). New and higher quality fieldwork is now being undertaken by, among a few others, Wotzka (see first results in, for example, Bleasdale *et al.* 2020; Neumann *et al.* 2022). These studies should include on-site sampling oriented towards systematic botanical recovery, especially given the vast unchartered territories that we illustrate on our maps. New work should be done in conjunction with the development of locally based resources and the encouragement of local interest in national heritage.

To summarise, the spatially spotty nature of present research, the very low density of sites across the region, the fact that 85% of our dates come from isolated test excavations and the limited number of dates in our radiocarbon catalogue which covers more than 50,000 years set limits to the representativeness of our sampling strategies. When combined with the inadequate overall quality of pottery descriptions that prevent long-distance connections between pottery traditions to be made, and the near absence of archaeobotanical, zooarchaeological or metallurgical analyses, any regional synthesis of the late Holocene in Central Africa must rest on shaky foundations. But as we show, there are some meaningful results to build upon, as well as new and fascinating research questions to answer. From a two waves expansion model of horticulturalist communities through Central Africa *c.* 3500–3000 cal. BP in the 1990s, recent research on pottery styles has instead shown further discontinuities every 500 years or so. This could suggest a more intricate scenario of successive waves of incoming people leading to the coexistence of some technological groups (Clist 2021). In the last 40 years, our understanding of the inner complexity of these waves also suggests that several parts of the region were avoided for centuries, creating an irregular pattern of land use by a cultural mosaic outlined by the radiocarbon dates. The data further suggest that this movement was undertaken by small-scale shifting horticulturalists living in modest settlements, likely with limited impact on their environment and low numbers of people.

Our findings propose that the number of radiocarbon dates in Central Africa is a better indicator of the effort that an archaeologist has put into understanding a settlement than it is of ancient demographics. Furthermore, we strongly advocate more and better local research facilities in each country which, at present, are almost non-existent. In short, we need to help Africanise the archaeology of Central Africa to take full advantage of the skills and knowledge of our indigenous colleagues while at the same time working to decolonise our understandings of the African past.

Hopefully, with more research, we can begin the difficult task of connecting the Iron Age sequences from Central Africa with those from southern and eastern Africa, especially in co-operation with other disciplines such as linguistics and genetics. This will help us to further unravel the complex and diverse history of the expansion of Bantu-speaking peoples in Sub-Saharan Africa.

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