



Short communication

Synthesising bushmeat research effort in West and Central Africa: A new regional database



G. Taylor^{a,1}, J.P.W. Scharlemann^{b,c,*}, M. Rowcliffe^d, N. Kumpel^d, M.B.J. Harfoot^c, J.E. Fa^e, R. Melisch^f, E.J. Milner-Gulland^g, S. Bhagwat^a, K.A. Abernethy^{h,i}, A.S. Ajonina^j, L. Albrechtsen^k, S. Allebone-Webb^g, E. Brown^l, D. Brugiere^m, C. Clarkⁿ, M. Colell^o, G. Cowlshaw^d, D. Crookes^{g,p}, E. De Merode^d, J. Dupain^{l,q,r}, T. East^g, D. Edderai^s, P. Elkan^{ag}, D. Gill^{g,t}, E. Greengrass^t, C. Hodgkinson^t, O. Ilambu^u, P. Jeanmart^v, J. Juste^w, J.M. Linder^x, D.W. Macdonald^k, A.J. Noss^y, P.U. Okorie^z, V.J.J. Okouyi^{aa}, S. Pailler^{ab}, J.R. Poulsenⁿ, M. Riddell^{ac}, J. Schleicher^{ac,ad}, B. Schulte-Herbrüggen^{ad,c}, M. Starkey^{ad}, N. van Vliet^{ae}, C. Whitham^g, A.S. Willcox^{af}, D.S. Wilkie^{ag}, J.H. Wright^{d,g}, L.M. Coad^{ac,*}

^a School of Geography and the Environment, University of Oxford, South Parks Road, Oxford OX1 3QY, UK

^b School of Life Sciences, University of Sussex, Brighton BN1 9QG, UK

^c United Nations Environment Programme World Conservation Monitoring Centre, 219 Huntingdon Road, Cambridge CB3 0DL, UK

^d Institute of Zoology, Zoological Society of London, Regent's Park, London NW1 4RW, UK

^e Durrell Wildlife Conservation Trust, Les Augrès Manor, Trinity, Jersey JE3 5BP, Channel Islands, UK

^f TRAFFIC International, 219A Huntingdon Road, Cambridge CB3 0DL, UK

^g Division of Biology, Imperial College London, Silwood Park Campus, Ascot, Berkshire SL5 7PY, UK

^h African Forest Ecology Group, School of Natural Sciences, University of Stirling, Stirling FK9 4LA, UK

ⁱ Institut de Recherche en Ecologie Tropicale, CENAREST, BP 842, Libreville, Gabon

^j Department of Environmental Science, University of Buea, Cameroon

^k Wildlife Conservation Research Unit (WildCRU), University of Oxford, Tubney House, Abingdon Road, Abingdon OX13 5QL, UK

^l Wildlife Conservation Society, Okapi Faunal Reserve, The Democratic Republic of Congo

^m SECA-BRLI Consulting Company, 1105 av P. Mendes-France, BP 4001, 30001 Nîmes cedex, France

ⁿ Nicholas School of the Environment, Duke University, P.O. Box 90328, Durham, NC 27709, USA

^o Department of Psychiatry and Clinical Psychobiology, Faculty of Psychology, Campus Mundet, University of Barcelona, 08036 Barcelona, Spain

^p Department of Economics, University of Pretoria, Private bag X20, Hatfield 0028, South Africa

^q Center for Research and Conservation, Royal Zoological Society of Antwerp, Koningin Astridplein 26, 2018 Antwerp, Belgium

^r African Wildlife Foundation, Boulevard du 30 juin No. 2515, Immeuble AFORIA, B.P. 2396, Gombe, Kinshasa, The Democratic Republic of Congo

^s Projet Développement d'Alternatives au Braconnage en Afrique Centrale, BP 2572, Yaounde, Cameroon

^t Fauna and Flora International, Jupiter House, Station Road, Cambridge CB1 2JD, UK

^u WWF Central Africa Regional Programme Office (CARPO), 4, Av. Sergeant Moke, (Concession SAFRICAS), Commune de Ngaliema, Kinshasa, The Democratic Republic of Congo

^v Precious Woods Gabon, BP 2262 Quartier Batterie IV, Libreville, Gabon

^w Estación Biológica de Doñana, Consejo Superior de Investigaciones Científicas, Apdo 1056, 41013 Sevilla, Spain

^x Department of Sociology and Anthropology, James Madison University, MSC 7501, Harrisonburg, VA 22807, USA

^y Department of Geography, University of Florida, 3141 Turlington Hall, P.O. Box 117315, Gainesville, FL 32611-7315, USA

^z Department of Animal and Environmental Biology, Imo State University, P.M.B. 2000, Owerri, Imo State, Nigeria

^{aa} Institut de Recherches sur l'Écologie Tropicale, BP 13354, Gabon

^{ab} Economics Department, Clark University, 950 Main St., Worcester, MA 01610, USA

^{ac} Environmental Change Institute, School of Geography, University of Oxford, Oxford OX1 3QY, UK

* Corresponding authors at: School of Life Sciences, University of Sussex, Brighton BN1 9QG, UK. Tel.: +44 (0)1273 873502 (J.P.W. Scharlemann). Environmental Change Institute, School of Geography, University of Oxford, Oxford OX1 3QY, UK. Tel.: +44 (0)1223 363835 (L.M. Coad).

E-mail addresses: gemma.taylor.14@ucl.ac.uk (G. Taylor), j.scharlemann@sussex.ac.uk (J.P.W. Scharlemann), Marcus.Rowcliffe@ioz.ac.uk (M. Rowcliffe), noelle.kumpel@zsl.org (N. Kumpel), Mike.Harfoot@unep-wcmc.org (M.B.J. Harfoot), John.Fa@durrell.org (J.E. Fa), Roland.Melisch@wwf.de (R. Melisch), e.j.milner-gulland@imperial.ac.uk (E.J. Milner-Gulland), shonil.bhagwat@open.ac.uk (S. Bhagwat), k.a.abernethy@stir.ac.uk (K.A. Abernethy), saajonina@yahoo.com (A.S. Ajonina), lise.albrechtsen@gmail.com (L. Albrechtsen), alleboneweb@yahoo.co.uk (S. Allebone-Webb), Ellen@proforest.net (E. Brown), dmc_brugiere@yahoo.fr (D. Brugiere), connie.j.clark@duke.edu (C. Clark), mcolell@ub.edu (M. Colell), Guy.Cowlshaw@ioz.ac.uk (G. Cowlshaw), d_crookes@hotmail.com (D. Crookes), emmanuel@gorilla.cd (E. De Merode), jdupain@awf.org (J. Dupain), tamsyneast@gmail.com (T. East), davidedderai@hotmail.fr (D. Edderai), pelkan@uuplus.com (P. Elkan), David.Gill@fauna-flora.org (D. Gill), ejgreengrass@yahoo.co.uk (E. Greengrass), Chloe.Hodgkinson@fauna-flora.org (C. Hodgkinson), oilambu@wwfcarpo.org (O. Ilambu), philippe.jeanmart@preciouswoods.com (P. Jeanmart), juste@ebd.csic.es (J. Juste), linderjm@jmu.edu (J.M. Linder), david.macdonald@zoo.ox.ac.uk (D.W. Macdonald), andrew.noss@scbbs-bo.com (A.J. Noss), puokorie@yahoo.com (P.U. Okorie), okouyi_joseph@yahoo.fr (V.J.J. Okouyi), sharonpailler@gmail.com (S. Pailler), jpoulsen@duke.edu (J.R. Poulsen), mike.riddell@brdt.org (M. Riddell), schleicher.judith@gmail.com (J. Schleicher), bjorn.schulte-herbruggen@su.se (B. Schulte-Herbrüggen), malcolm.starkey@thebiodiversityconsultancy.com (M. Starkey), vanvlietnathalie@yahoo.com (N. van Vliet), charlotte.whitham@gmail.com (C. Whitham), awillcox@ufl.edu (A.S. Willcox), dwilkie@wcs.org (D.S. Wilkie), juliet.wright@ioz.ac.uk (J.H. Wright), lauren.coad@ouce.ox.ac.uk (L.M. Coad).

¹ Current address: University College London, Gower Street, London WC1E 6BT, UK.

^{ad} Department of Geography, University of Cambridge, Downing Place, Cambridge CB2 3EN, UK

^{ae} Center for International Forestry Research, Jalan CIFOR, Situ Gede, Sindang Barang, Bogor (Barat) 16115, Indonesia

^{af} Department of Forestry, Wildlife and Fisheries, University of Tennessee, 274 Ellington Plant Sciences Building, Knoxville, TN 37996, USA

^{ag} Wildlife Conservation Society, 2300 Southern Boulevard, Bronx, New York, NY 10460, USA

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ABSTRACT

Unsustainable hunting threatens both biodiversity and local livelihoods. Despite high levels of research effort focused on understanding the dynamics of bushmeat trade and consumption, current research is largely site specific. Without synthesis and quantitative analysis of available case studies, the national and regional characteristics of bushmeat trade and consumption remain largely speculative, impeding efforts to inform national and regional policy on bushmeat trade. Here we describe the structure and content of the West and Central African bushmeat database which holds quantitative data on bushmeat sales, consumption and offtake for 177 species from 275 sites across 11 countries in two regions, spanning three decades of research. Despite this wealth of available data, we found important biases in research effort. The majority of studies in West and Central Africa have collected market data, which although providing a useful record of bushmeat sales, are limited in their ability to track changes in hunting offtake. In addition, few data exist for West Africa, and few studies have tracked changes over time, using repeat sampling. With new initiatives in the regions to track bushmeat hunting, this database represents an opportunity to synthesise current and future data on bushmeat hunting, consumption and trade in West and Central Africa, identify gaps in current understanding, and systematically target future monitoring efforts.

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1. Introduction

In tropical forests worldwide, hunting of wild animals provides an important source of food and income for many rural peoples (Milner-Gulland and Bennett, 2003; Abernethy et al., 2013). In West and Central Africa in particular, present hunting levels are considered unsustainable for many large-bodied fauna, driven largely by the demands of the burgeoning human population (Abernethy et al., 2013). The loss of wildlife in these forests will not only be detrimental to biological diversity and ecosystem integrity, but will also affect people's livelihoods (Nasi et al., 2011), their ability to eat recommended levels of dietary protein, and their health and well-being (Arnold et al., 2011; Golden et al., 2011).

Despite a wealth of studies documenting offtake, consumption and trade of wild meat in tropical forests across Africa since the 1960s (e.g. Asibey, 1966), most studies have targeted small harvest areas, often around single sites, over short time periods (but see Fa et al., 2002). While such studies provide valuable site-level data, information on bushmeat use on larger scales and over longer time periods is currently lacking.

Comparing and combining results at national or regional scales can aid identification of spatial and temporal patterns and outliers in bushmeat use, and where time-series data are available, can be used to track changes in bushmeat use, and to calculate proxy indicators of faunal depletion or ecological change such as mean body mass of prey (Jerozolinski and Peres, 2003). Such information could assist decision-makers to develop evidence-based conservation strategies (van Vliet et al., 2012). To date, studies employing systematic literature reviews have determined regional bushmeat offtake trends within the Congo Basin (Wilkie and Carpenter, 1999) or compared offtake between continental forest regions (Fa et al., 2002, 2005). While these studies demonstrate the potential for meta-analyses to illustrate regional trends in bushmeat use, they have been limited by the availability of raw data from published studies (<40 sites).

Nations that are Parties to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the Convention on Biological Diversity (CBD) are required to comply with recommendations, resolutions and decisions related to

'bushmeat' issues, such as building databases and providing knowledge about bushmeat harvest, trade and use. In particular, the CBD 11th Conference of Parties explicitly called for the development of '...appropriate monitoring systems of bushmeat harvest and trade [that] should be based on an integration of traditional, indigenous and scientific knowledge' (Decision XI/25, CBD, 2012). To begin to address these calls, we have developed a database to collate published, quantitative datasets on bushmeat use.

We decided to focus on West and Central African bushmeat because initial literature searches yielded substantially more information from West and Central Africa than from other regions, and the authors have built professional networks in the region. We present initial results on quantitative research effort into offtake, consumption and market sales of bushmeat over 30 years, and the spatial and temporal extent of these data. We ask the following questions of the database: (1) How many quantitative studies of bushmeat use exist in West and Central African, and how has research effort varied through time? (2) Where geographically have the majority of studies occurred? (3) What types of data have been collected? (4) What levels of sampling effort have been employed at each site? (5) Which species are represented within the current studies?

We discuss research gaps, and potential applications of the database, and propose plans to make the database an open-access resource for the conservation community.

2. Methods

2.1. Definition and geographic scope

We used the term "bushmeat hunting" as defined by the CBD's Liaison Group on Bushmeat as 'the harvesting of wild animals in tropical and sub-tropical countries for food and for non-food purposes, including for medicinal use' (CBD, 2012). However, following Nasi et al. (2008) we also excluded insects, crustaceans, molluscs and fish from our definition.

Our study region included all 10 Central African countries in the Central African Forests Commission (COMIFAC www.comifac.org)

and all countries within the Economic Community of West African States (ECOWAS www.ecowas.int).

2.2. Literature search and e-mail campaign

A search for data sources was conducted between June 2012 and June 2013. We searched scientific bibliographic databases, thesis archives, specialist, academic search engines and conservation NGO websites ([Supplementary Table A.1](#)) using relevant keywords and secondary terms in English, French and Spanish ([Supplementary Table A.2](#)). In addition, we contacted a number of conservation and development organisations, and posted on appropriate email lists, stating our project goals and asking for further contacts and/or any quantitative raw data ([Supplementary Table A.3](#)); many organisations then sent our request to their contact lists. This ‘snowball’ sampling technique (Noy, 2008) identified additional unpublished data sources.

2.3. Data inclusion criteria

Datasets were included if they: (1) provided a quantitative measure of bushmeat offtake, consumption and/or market availability/sales; (2) used non-biased data collection methods (e.g. recorded all species and hunting returns, not just mammals, or more specifically primates) and systematically sampled settlements/hunters to prevent selection bias; (3) identified carcasses to the species level (for exceptions see [Supplementary Table A.4](#)) and (4) recorded either the number of carcasses or the total biomass (kg). In cases where data were only partially provided, we requested additional information from the authors.

2.4. Data extraction and database terminology

We extracted the required data from all sources that matched the above inclusion criteria and stored the data in a purpose-built

Microsoft Access database (2010). The structure of the database with the main data tables is summarised below ([Fig. 1](#)).

- **Source** refers to the source of the data, either a scientific publication, NGO report or raw data.
- **Site** captures information about the location where data were collected. The ‘Site’ table holds the geographic coordinates of the site as well as information on site characteristics (e.g. country, settlement type, population size).
- **Sample** refers to the data of a specific type (market, consumption or offtake, see below) collected over a specific delimited time period at a specific site. The ‘Sample’ table holds data on the dates of the sample, the data type and the sampling methods and effort. To avoid pseudo-replication of samples that were published in multiple sources (e.g. in a PhD thesis and a published paper), we only included the sample once, from the earliest published source.
- **Harvest data** refers to the meat hunted, offered/sold or consumed. The ‘Harvest Data’ table holds data on the number of whole carcasses or biomass of each species recorded for each sample. Using data on adult body mass from the PanTHERIA database (Jones et al., 2009) and published data on carcass biomass (Fa and Purvis, 1997) we converted between the number of carcasses and biomass.
- **Data type** refers to one of three different data types: ‘Market’ data collected on the number/biomass of each taxon offered or sold at a market (not including individual shops, restaurants or chop bars). ‘Consumption’ data collected on the number/biomass of each taxon consumed by a household for set recall periods (i.e. 24 h, 3 days), either from data-sheets, diaries or memory. ‘Offtake’ refers to the number/biomass of each taxon caught by a hunter or household.

A full list of references, sites and samples stored in the database on March 2014 is provided in [Supplementary Table A.5](#).

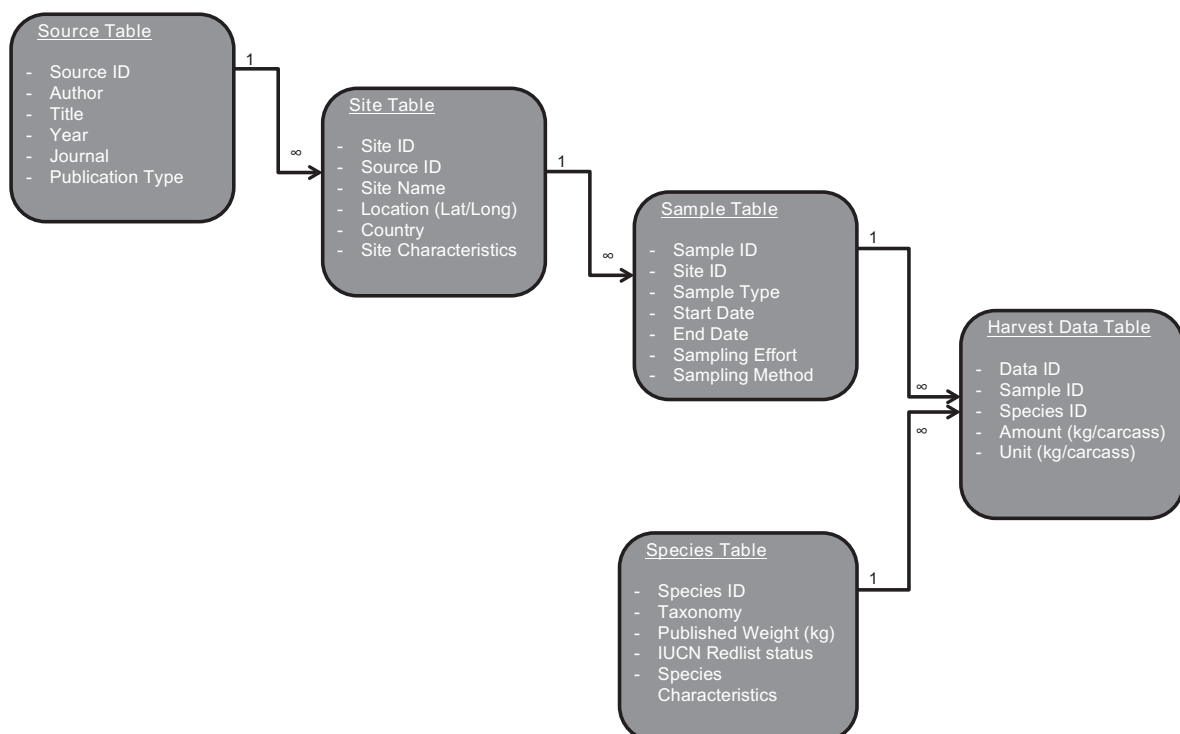


Fig. 1. Schematic diagram of the West and Central African bushmeat database. Arrows indicate the connections by which information from different tables can be linked. Asterisks highlight multiple data columns.

3. Results

3.1. Data types, sites and samples

The March 2014 version of the database holds data from 67 sources, which have collected 311 samples at 275 sites. The majority of sources (36 or 54%) were published scientific papers, 15 (22%) academic theses, 8 (12%) NGO reports, 7 (10%) raw data sets, from which data have been published, and one unpublished raw dataset. Although the earliest samples were collected in 1981, the majority (81%) of samples, for which exact dates are known, were collected between 2001 and 2011 (Fig. 2).

3.2. Geographical distribution of research effort

Research effort has focussed on Central Africa, with data available in six of 10 countries (248 samples), compared to West Africa, with data in five of 15 countries (63 samples; Fig. 3, data in Supplementary Table A.5). Surveyed sites were concentrated in the Cross-Sanaga region of Nigeria and Cameroon, where Fa et al. (2006) collected market data at 86 sites.

3.3. Type of data collected

The proportion of data types (market, consumption and offtake) sampled was similar across regions (Supplementary Fig. A.1 and Table A.6) with market samples being the most common (79.3% and 53.6%, in West and Central Africa, respectively), followed by offtake (17.5%, 23.0%) and consumption (3.2%, 23.4%). Only two consumption samples were collected in West Africa at two sites in Liberia (Fig. 3d). Carcasses were either reported as biomass (in kg) (17% of samples) or as number of individual carcasses (83%).

3.4. Time series

For samples for which the exact dates of collection were known ($n = 272$ samples) the mean sampling effort in days was 161 ± 10 days. Market and offtake data tended to be collected over longer periods of time (173 ± 14 days and 152 ± 22 days, respectively) compared to samples of consumption (98 ± 11 days).

Forty-eight sites (4 West, 44 Central Africa) have been surveyed more than once. For half of these (2 West, 22 Central), two different data types were collected (e.g. the site had a market survey and a

consumption survey). Repeat samples of the same data type at the same site in different years, which would permit time-series analyses, have been collected at 24 sites (Fig. 3a). Two of these sites were located in West Africa (Ghana and Cote d'Ivoire) and 22 in Central Africa (Cameroon, Equatorial Guinea, Gabon, Democratic Republic of Congo and Republic of Congo). These repeat samples were of all three study types (offtake, market or consumption) with a mean of 3.8 repeat samples per site (range: 2–15 repeat samples).

Samples were collected during all months of the year, however sampling intensity was 6.0 to 1.7 times higher between August and January compared to February and July for West and Central Africa, respectively (Supplementary Fig. A.2).

3.5. Species represented in the database

A total of 177 species from 25 orders have been recorded in the database, 134 (76%) of these were mammals (Table 1; species list in Supplementary Table A.7). Although the majority of species in the database are classified by the IUCN Red List (IUCN 2014) as Least Concern (62%), 17.3% (31 species including reptiles) are classified as threatened (i.e. either Critically Endangered, Endangered or Vulnerable). The database contains a statistically significantly greater proportion of threatened species than are occurring in the 5 West and 6 Central African countries (26 threatened of 159 species in the database vs. 256 of 2392 species of mammal, bird and amphibian recorded in the IUCN Red List; χ^2 goodness of fit test, $\chi^2 = 9.83$, $df = 1$, p -value = 0.002. Reptiles were not included in the χ^2 goodness of fit test, as they are not yet fully assessed in the IUCN Red List).

4. Discussion

Conservation practise and policy have often been criticised for not being based on empirical evidence (Sutherland et al., 2004). The West and Central African Bushmeat database has been created with the aim of synthesising all quantitative bushmeat studies in the region, and providing a resource for analysing trends in bushmeat harvest, consumption and trade at the national and regional level.

Despite the large number of sources identified, we suspect that further datasets exist, but are not currently publicly available. The majority of identified datasets were published in peer-reviewed journals or as academic theses online. However, many NGO and

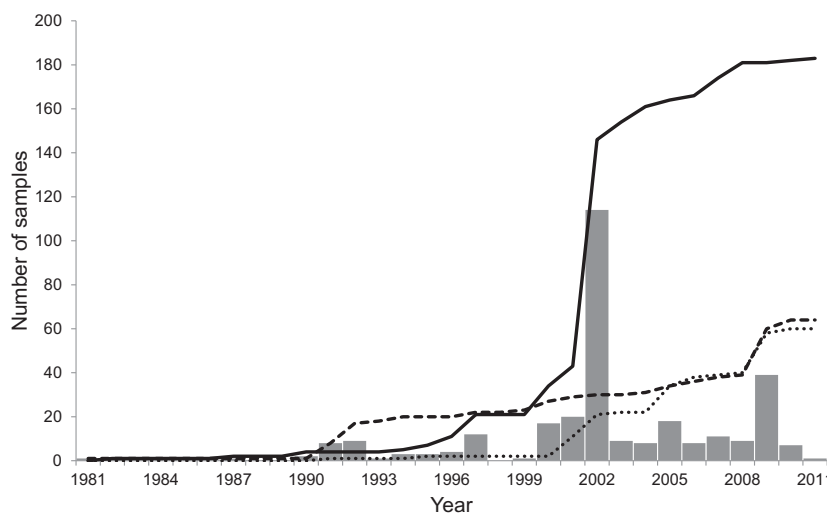


Fig. 2. Cumulative number of samples of bushmeat consumption (dotted), market trade (solid) and hunter offtake (dashed) over the last three decades, as currently recorded in the database. Bars show the start year for each sample. The large increase in market studies in 2002 reflects the survey of 86 markets in the Cross-Sanga region of Cameroon and Nigeria by Fa et al. (2006).

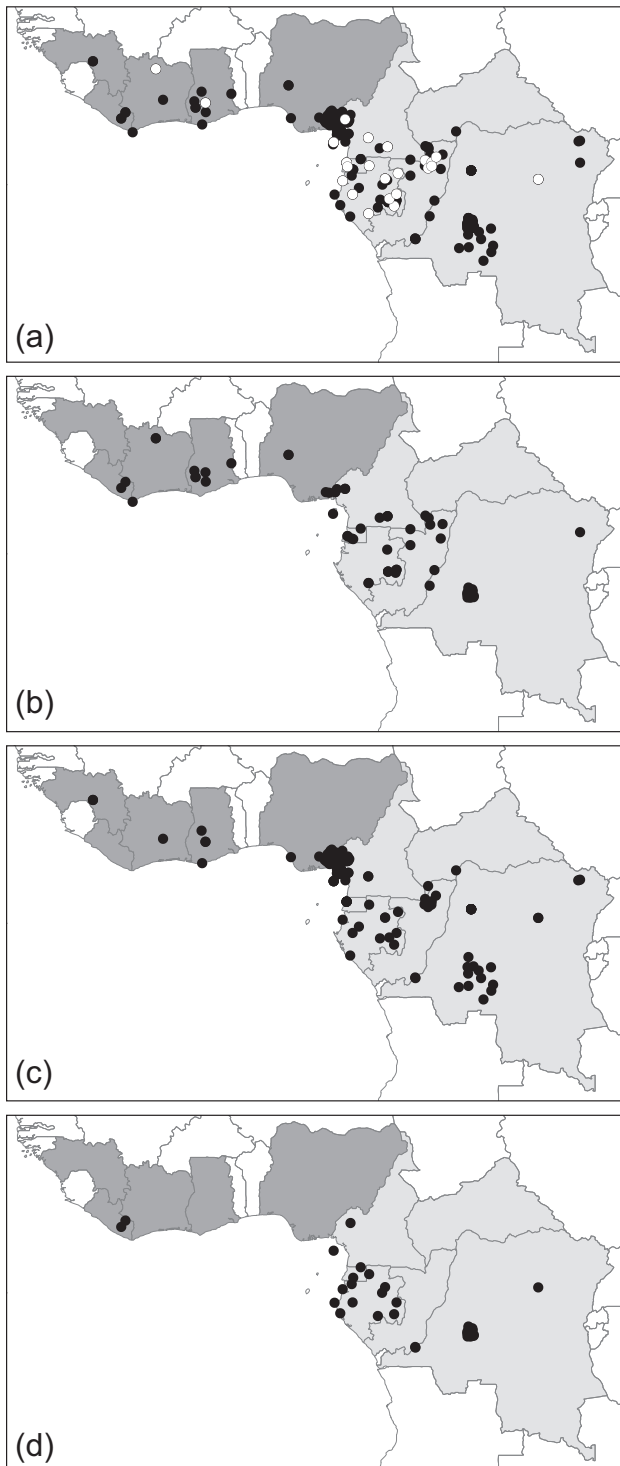


Fig. 3. Distribution of samples across West and Central Africa by data type. (a) Total with time series sites highlighted (white circle) (b) Offtake data (c) Market data (d) Consumption data. West African countries shown in dark grey ($n = 6$) and Central African countries in light grey ($n = 5$).

government technical reports with valuable site-specific information are published internally or on NGO websites, and often remain undetected. Studies included in this database were also most likely to have been published in the last decade. Although this probably reflects a genuine increase in research effort, it may also partly reflect an increase in online publication of student theses and technical reports, which would previously have been published only as hardcopies and therefore may not have been found by this study.

Further, our search method, asking contacts, might have affected the bias towards more recent publications. Many older reports are only available in-country or directly from the authors, and we would ask that anyone who knows of any datasets that may have been overlooked by this study contact the corresponding authors. In the medium to long term we envisage that the database will be developed to function as a live, public repository for both published and unpublished datasets of bushmeat offtake, trade and consumption to allow near real-time, comprehensive information on bushmeat to be made available to decision makers.

Market data were the most commonly collected data type, possibly reflecting the relative ease with which information can be collected at bushmeat markets. Although market data offer a pragmatic way of assessing minimal extraction levels at large scales, studies of urban markets fail to provide an accurate picture of off-take levels and sustainability (Ling and Milner-Gulland, 2006). Trends in species composition of bushmeat in markets may not reflect the wildlife community in the surrounding area as offtake will vary with changes in hunting effort, technologies, and size of hunting catchments. In comparison, few data are currently available on bushmeat consumption and consumer choices, especially in West Africa where data on bushmeat consumption were only available for Liberia. Consumer demand, as indicated by consumption, is potentially a critical aspect to monitor, since we expect changes in demand to be a key determinant of future hunting and trade efforts and ultimately sustainable resource use (van Vliet et al., 2010). This highlights a need for increasing research efforts on consumption studies and the need to better understand consumers' preferences.

Birds and reptiles are likely underrepresented in bushmeat studies and therefore in our database. Although we only included studies which stated that they reported all species hunted, sold or consumed, often overall household offtake of birds and reptiles is likely underestimated by studies of hunter bag counts as these taxa are also harvested by small children or by women during other livelihoods activities, such as agriculture. Further, invertebrate harvest is often not recorded by "wild meat" researchers. Nevertheless, these taxa are an important source of protein and are likely impacted by hunting, and future research needs to acknowledge the importance of these taxa and the limitations of current sampling methods.

A geographical bias also exists, with more sites surveyed in Central Africa than in West Africa, and disproportionate focus on certain countries within Central Africa (Gabon, Equatorial Guinea, Cameroon and Nigeria). This may partly reflect the accessibility of the research sites, as well as the interests of research institutions and donor organisations, and that of the lead authors. It may also reflect a focus on areas perceived to be experiencing higher bushmeat hunting and trade intensities, and hence higher levels of threat. West Africa has already lost much of its original tropical forest and has suffered much higher hunting intensities than the less fragmented Central African forests (Schulte-Herbrüggen et al., 2013). The general perception is that West Africa is now in a 'post-depletion' phase, having already lost larger wildlife species

Table 1

The number of orders and species in the database for the four most common taxa: mammals, birds, amphibians and reptiles. Also shown are the number of threatened species classified as Critically Endangered (CR), Endangered (EN) and Vulnerable (VU) in the IUCN Red List (IUCN, 2014).

	Number of orders	Number of species	Number of threatened species (CR/EN/VU)
Mammalia	12	134	4/5/14
Aves	9	24	0/0/2
Amphibia	1	1	0/0/1
Reptilia	3	18	2/1/2

from most of the region (Cowlshaw et al., 2005). However, this perception is a generalisation that probably masks considerable variation in patterns of depletion, trade and consumption within this region. Data from a wider geographical range of sites would be desirable, including more and less depleted areas in both West and Central Africa.

Hunting sustainability cannot be inferred from static data (Coad et al., 2013), but of the sites identified in this study, only 9% had repeat samples of the same data type. Few studies have therefore been able to track changes in hunting consumption or offtakes over time (but see Poulsen et al., 2009; Coad et al., 2013; Gill et al., 2012). To address this problem, a more systematically selected and regularly monitored set of sites would be desirable, spanning a range of current depletion levels and contextual socio-economic circumstances in both regions. Researchers should capitalise on the wealth of baseline data presented in this database and resample sites to increase our knowledge of how and why bushmeat use changes over time. Regional monitoring systems are being developed; an example is the *Système de suivi de la filière viande de brousse en Afrique Centrale (SYVBAC)*, a monitoring framework being developed to operate under the Central African Forests Observatory (van Vliet et al., 2010). SYVBAC aims to collect data at systematically selected sites across Central Africa and develop key indicators to track bushmeat offtake, trade and consumption; impacts of bushmeat hunting on wildlife populations, and ultimately the sustainability of current hunting levels. The database presented here could be a valuable tool to inform the development, implementation and review stages of such monitoring projects.

The West and Central African bushmeat database is the first attempt at collating published quantitative data on bushmeat offtake, trade and consumption. The database continues to evolve and we welcome further contributions. Based on our collation as of March 2014 and preliminary analyses of bushmeat data for West and Central Africa, we suggest the following priorities for bushmeat research and policy that would be facilitated by this database:

- Investigate the drivers of bushmeat use, consumption and sales at national and regional levels by undertaking a meta-analysis of existing studies.
- Develop indicators for measuring bushmeat use and sustainability, designed to inform national and regional policy on bushmeat hunting. Indicators should be scientifically robust, and the data required for the indicators should be practically feasible to collect.
- Use these indicators to map regional hotspots of unsustainability.
- Identify knowledge gaps and future research priorities for bushmeat. The studies collated in this database provide an overview of past research effort in West and Central Africa. However, they were originally collected as individual studies, rather than undertaken with one overriding research goal in mind. This database can now function as an evolving baseline for bushmeat research, enabling researchers, in collaboration with conservation practitioners, to take stock and identify the key questions for future bushmeat research.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <http://dx.doi.org/10.1016/j.biocon.2014.11.001>.

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