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Abstract

The trade of bushmeat from rural areas to supply burgeoning cities is a major conservation and livelihood concern. Using a whole-city sampling strategy we mapped the distribution and numbers of meat outlets in the Kinshasa–Brazzaville metropolitan area, two neighboring capital cities in Central Africa. We show that both cities differ in the number and density of meat outlets, with more in Brazzaville per area sampled and inhabitants. The number of meat outlets is related to human population densities and primarily concentrated along the banks of the Congo River, in the more affluent areas of the cities. Across the two cities, roughly 22% of all sampled markets (50% in Brazzaville and 19% in Kinshasa) and 24% of all visited restaurants (24% in each city) were selling bushmeat during our survey. Despite the relatively low number of establishments offering bushmeat for sale, extrapolated to the entire area and population of both cities, we expect the overall amount of wild animal meat consumed per annum to be significantly high. We suggest that the supply of such numbers of wild animal meat will strongly impact the animal populations sourcing these cities. Our data also indicate that the number of domestic meat outlets may be adequate to supply urban dwellers with sufficient animal protein.

1. Introduction

Throughout sub-Saharan Africa, the meat of wild animals, wild meat or bushmeat, is a highly valuable non-timber forest product. In Central Africa alone, the trade of wild meat is estimated to be USD 1000–3000 million (Wilkie and Carpenter 1999). Such levels of extraction of terrestrial wildlife for food substantially exceeds sustainable offtake rates; the economic value being a short-term gain that will dwindle rapidly as wildlife populations are depleted (Coad *et al* 2019). In particular, the desire of families in towns and cities to eat bushmeat is a key factor driving overexploitation of wildlife in this region (Cowlishaw and Rowcliffe 2004, Wilkie *et al* 2005, Cronin *et al* 2015). Urban consumers of bushmeat live either in (a) provincial towns close to sources of wildlife where livestock production is uncommon and market access makes imported animal source foods unavailable or unaffordable, or (b) large metropolitan areas far from sources of wildlife where bushmeat is no longer a dietary necessity and more a cultural desire to connect to a rural past (Wilkie *et al* 2005).

In large metropolitan cities, consumers usually have the choice of several sources of domestic animal

protein but many opt for bushmeat for reasons other than its nutritional importance (Chausson *et al* 2019). City dwellers may eat bushmeat as a means of culturally re-connecting to their place of origin, where they or their parents consumed bushmeat (Luiselli *et al* 2017, 2018, 2019). Although consumers in some provincial towns (particularly isolated ones) may buy bushmeat because it is the cheaper meat and more readily available (Van Vliet *et al* 2010, Fargeot *et al* 2017), bushmeat in metropolitan cities is more of a luxury item and status symbol (Drury 2011, Ngoc and Wyatt 2013, Shairp *et al* 2016, Wilkie *et al* 2016). As a luxury commodity, city dwellers pay higher prices than rural consumers for the same animal. Urban consumer willingness to pay relatively high prices encourages rural hunters to increase the amount they take and the proportion they sell to gain income as well as food (de Merode *et al* 2004, Bennett *et al* 2007, Grande-Vega *et al* 2016). It also encourages non-local hunters to enter the market.

Africa's urban population is expected to more than triple over 40 years, from 395 million in 2010 to 1.339 billion in 2050, corresponding to 21% of the world's projected urban population (Güneralp *et al* 2017), and Africa has the fastest rate of urbanization in the world. Much of the increase in urban population is taking place in small- and medium-sized provincial towns in midlatitude Africa, as rural youth leave to seek a better life (Lwasa 2014).

Given the size and geographic extent of these rapidly growing metropolitan cities it is not surprising that there has been no comprehensive investigation of the number and distribution of sales outlets for bushmeat and alternative animal source foods within these. In this study, we documented the distribution and abundance of outlets selling animal source foods, including bushmeat, within Brazzaville, in the Republic of the Congo (ROC), and Kinshasa, in the Democratic Republic of the Congo (DRC)—two Central African capital cities separated by the Congo River, representing the third largest urban agglomeration on the African continent, behind Cairo and Lagos. Although bushmeat has been observed for sale in supermarkets on occasion, the main types of outlets that sell bushmeat are markets and restaurants. We therefore investigated a subsample of the markets and restaurants identified, to determine the proportion that openly offer bushmeat for sale.

2. The Kinshasa–Brazzaville metropolitan area

We surveyed sales outlets for animal source foods in Brazzaville, the capital of ROC, and in Kinshasa, the capital of DRC (figure 1). These are the largest cities in their respective countries and the closest capital cities in the world, separated only by the width of the Congo River (1.6 km), yet the cities differ substantially in population size and spatial extent.

Brazzaville is situated on the north bank of the Congo River and covers 263.9 km^2. In the absence of a regular and reliable national census, the population of the capital in 2018 has been estimated at around 2 million inhabitants (UNDESA 2014), comprising more than a third of the country's population. Population density in the city is close to 11 000 inhabitants per km^2 (Demographia 2019). Administratively, Brazzaville is one of twelve departments in ROC and is subdivided into nine arrondissements. Brazzaville was the capital of French Equatorial Africa during the French colonial period.

Kinshasa is situated on the south bank of the Congo River, in sight of Brazzaville. With an estimated population of 13 million inhabitants in 2018, Kinshasa is classified as a megacity and is predicted to become the largest city in Africa and the fourth largest in the world by 2050, with an expected population of 35 million (UNDESA 2014, Hoornweg and Pope 2017). Kinshasa is one of twenty-five provinces and has a total surface area of 9965 km^2 (African Development Bank 2019). Administratively, the province of Kinshasa is subdivided into twenty-four communes. The most heavily inhabited area of Kinshasa is close to the banks of the Congo River, where the population density is estimated at close to 20 000 inhabitants per km^2 (Demographia 2019). Kinshasa was known as Leopoldville during the Belgian colonial era.

Brazzaville and Kinshasa are the most important consumer centers in their respective countries, however there are significant differences in socioeconomic conditions between ROC and DRC. In 2017, income per capita in ROC was estimated at USD 1430, whereas it was estimated at USD 460 in DRC (The World Bank 2019). According to the GINI index, there are greater levels of inequality in ROC than in DRC, but inequality is apparent in both cities with vast differences in wealth between affluent and poorer areas.

3. Methods

3.1. Sampling

The total urban area covered in this study was 237.3 km^2 for Brazzaville and 476.3 km^2 for Kinshasa (figure 1). Sampling in each city was undertaken within 1 km^2 blocks. To calculate the ideal sample size of squares to be investigated in both cities, we used the sample size calculator in Qualtrics, a software for collecting and analyzing data for market research (Qualtrics 2018). We determined that a total of 60 1 km^2 squares would allow a coverage with 90% CI and a 10% margin of error.

We used ArcMap 10.3 to generate 20 and 40 random points across Brazzaville and Kinshasa, respectively, and to draw a 1 km radius circle around each point, ensuring that circles did not overlap. We then

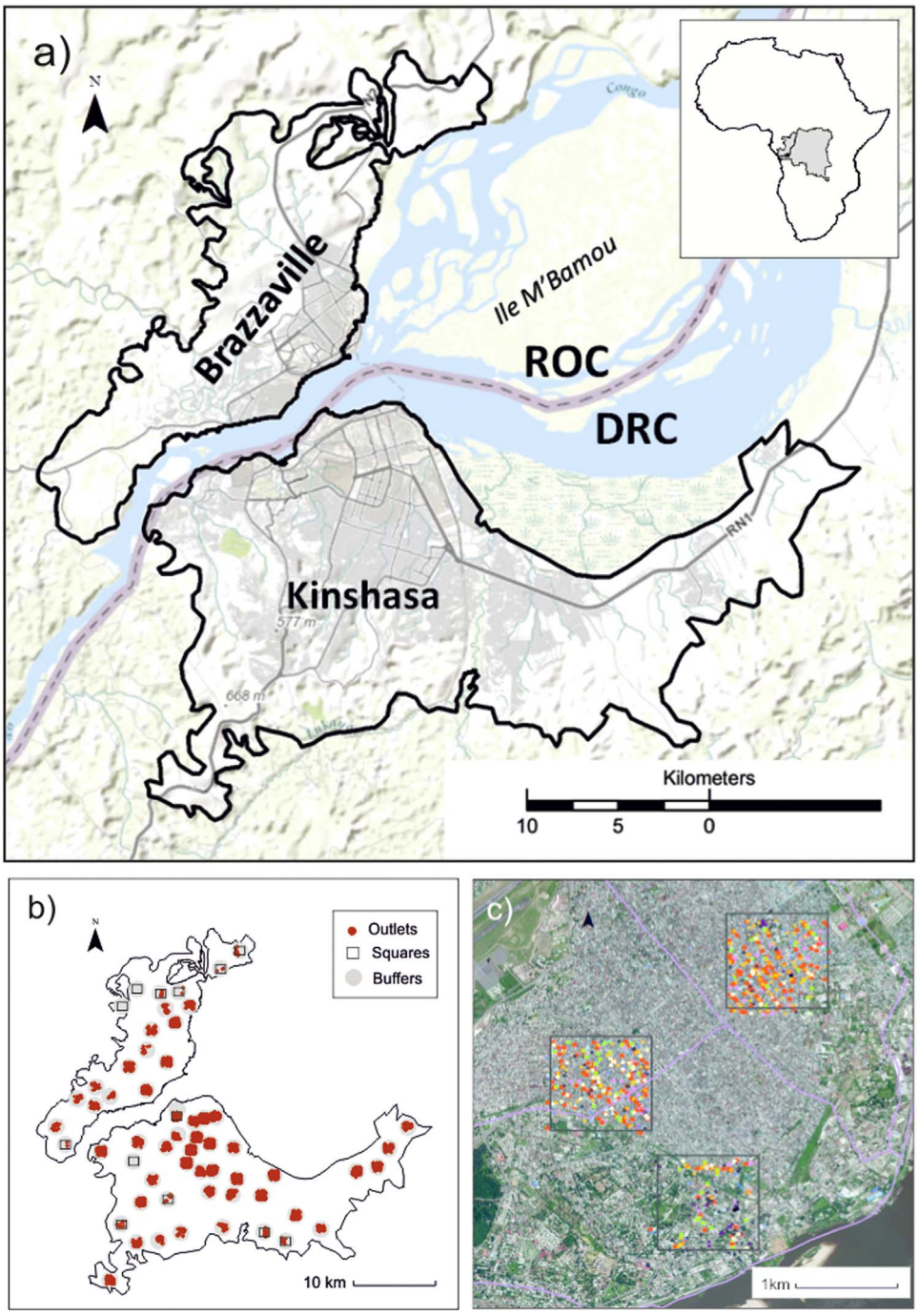

Figure 1. Study area. (a) Location of Brazzaville and Kinshasa cities. ROC = Republic of Congo; DRC = Democratic Republic of Congo. (b) Distribution of all outlets, sample squares and buffers used in this study. (c) Detail of the different outlets in Brazzaville, as an example of the mapping undertaken in this project.

converted the 1 km radius circles into 1 km^2 squares oriented North–South using the random point as the center.

We surveyed all 20 sample squares in Brazzaville, achieving a coverage of 8.43% of the delimited urban area. In Kinshasa, we visited all 40 sample squares, however two squares (3, 6) were sensitive sites not accessible to the survey team due to the presence of military roadblocks. We therefore achieved 7.98% coverage of the delimited urban area in Kinshasa.

3.2. Mapping meat outlets

A team of four research assistants was recruited in both Brazzaville and Kinshasa to undertake the fieldwork. These assistants were students from Marien Ngouabi University and the University of Kinshasa in Brazzaville and Kinshasa, respectively.

Before data collection commenced, research permissions were obtained in both cities from relevant central and local government departments, and the research assistants were trained in the data collection

Table 1. Definitions of outlets identified in this study.

Category	Definition
Formal restaurants	Permanent buildings with a separate kitchen and an area of tables where customers sit down to eat. A defining feature is that the restaurant has a name and often a menu, and the food is usually served by a waiter. We distinguished international restaurants as those mainly targeting the expatriate community.
Informal restaurants	More temporary structures, made from wood, corrugated metal or under an umbrella, with one or two tables. Food is either prepared off-site or in front of the customer. These restaurants do not have a name or a menu, but an array of dishes may be available for inspection. The person preparing the food also serves the customers.
Street meat vendors	Vendors whose merchandise can be easily transported but who return to sell at the same location on a regular basis, often with an umbrella or other temporary shelter, selling food that can be bought to take away. We recorded street vendors that sold cooked meats. Street vendors are located along roads and not in markets.
Butchers[a]	Locations where domestic animals (chicken, goat, sheep or cattle) are slaughtered and/or where domestic meat is sold fresh. These outlets can be formal, i.e. in permanent buildings, but most are informal (e.g. roadside stalls). Butchers may have only one animal, which they advertise before slaughtering to ensure all the meat is sold fresh.
Food shops	A shop that primarily sells non-perishable foods that are packaged in bottles, boxes, and cans; some also have bread and fresh produce. Many of the products sold are imported, but there are local goods too. These shops range from permanent buildings to temporary structures. They typically sell tins of sardines, corned beef etc.
Cold stores	These shops are permanent buildings with many freezers, sometimes walk-in freezers. They sell imported frozen meats and fish in bulk, and usually sell wholesale as well as directly to the public.
Markets	A market is a public place, usually designated by the government, where people sell a variety of goods on tables with some form of cover, such as a canopy or an umbrella. They range in size and can have hundreds of tables and sellers. Local and imported meats, vegetables, textiles and a variety of goods can be found in markets.

[a] In Brazzaville, the research assistants adopted a more liberal interpretation of the term 'butcher' and it has not been possible post hoc to identify exactly what was mapped. This category has been retained for analyses about meat outlet density and distribution in general but has been excluded from more specific analyses.

method and given a security briefing on the risks and how to stay safe whilst carrying out fieldwork in an urban environment.

The boundaries of each sample square were loaded into the application OsmAnd (OsmAnd 2019), which was installed on smartphones and tablets used by the research assistants to determine their exact location in real time and to ensure that all roads and paths within each square were mapped.

The application KoBoCollect was installed on mobile devices and a form created to enable the assistants to record specific points of interest (KoBoToolbox 2018). All food outlets (butchers, cold stores, food shops, formal restaurants, informal restaurants, markets, street meat vendors) that were known to sell (or could potentially sell) domestic and wild meat products were mapped (table 1).

The KoBoCollect form was used to record outlet type, establishment name and GPS coordinates, with data uploaded to the KoBoToolbox server at the end of each day. Audits were conducted in some squares to verify the accuracy of data collected.

In Brazzaville, the locations of outlets were mapped in all sample squares between May and July 2017. In Kinshasa, we mapped 16 of the selected squares in August 2017, with the remaining 24 squares visited between October 2017 and January 2018.

The assistants worked in teams of two and each square took 1.5 d to map on average. Repeat visits were made if the assistants had to curtail mapping due to security issues or the weather. The aim was to cover the entirety of each square, and tracklogs recorded in OsmAnd permitted assistants to identify areas that needed to be surveyed during revisits. The teams kept in regular communication with each other and the research supervisors via WhatsApp.

All data were downloaded from KoBoToolbox in Excel format.

3.3. Surveying markets and restaurants

A follow-up survey of mapped markets and restaurants in Brazzaville and Kinshasa was conducted almost one year later, in September and October 2018, to determine which markets and restaurants were openly selling bushmeat.

Due to heightened security concerns during the run up to elections in DRC, an assessment of the risks associated with returning to each commune in Kinshasa was conducted based on official recommendations and on-the-ground intelligence. Prioritizing the safety of the research assistants, 8 of the 38 sample squares in Kinshasa were excluded from further fieldwork. The same assessment was conducted in Brazzaville and 1 of the 20 squares was excluded.

Within the 19 retained squares in Brazzaville and the 30 retained squares in Kinshasa, we revisited all the markets identified during the mapping phase of the research. The GPS coordinates and name of each market were plotted in OsmAnd to enable the assistants to relocate them. The market survey was a one-time rapid observational exercise.

The research assistants worked in teams of two to note different observations as they walked through each market, including the types of meat available, the number of tables selling bushmeat and the different species for sale. If bushmeat was not observed, the

assistants made informal enquiries to determine whether it is ever sold at that market, and they also enquired about how often it is sold. The assistants recorded their observations in a KoBoCollect form at the end of their visit and indicated the size of each market based on an estimate of the total number of tables.

Due to time constraints, it was not possible to revisit every mapped restaurant; therefore, half of the retained squares were randomly selected using the random number function in Excel. All the restaurants in 9 squares in Brazzaville and 15 squares in Kinshasa were revisited, using GPS points and names in OsmAnd to relocate them. Given the time interval between the mapping exercise and the follow-up surveys, several markets and restaurants could not be located.

The restaurant survey involved a combination of observation and formal interview. The assistants moved around each square in pairs but visited the restaurants alone. After taking GPS coordinates in KoBoCollect and categorizing the restaurant according to a pre-defined list, the assistants then checked to see if the restaurant had a menu and if bushmeat was listed on the menu. They were also encouraged to observe their surroundings and ascertained whether bushmeat was being served or eaten.

The person in charge at the premises on the day of the survey was then approached for interview. Free, prior and informed consent was obtained before the interview began, with all research assistants having been trained in research ethics, following the guidance provided by the CITI Program on Human Subjects Research (CITI Program 2018).

The assistants asked whether or not the restaurant served bushmeat, how often bushmeat was served, how many customers the restaurant served per day and what proportion of those customers ordered bushmeat. Restaurants were classified as bushmeat restaurants if any of the following applied: (1) bushmeat was listed on the menu, (2) bushmeat was observed being served or eaten, (3) the sale of bushmeat at the restaurant was confirmed by the interviewee.

All the market and restaurant data were recorded in KoBoCollect, uploaded daily to the KoBoToolbox server and later downloaded in Excel format.

3.4. Population characteristics of sample squares

Human population densities for each sample square were obtained from the WorldPop project (WorldPop 2018). WorldPop produces high spatial resolution (1 ha) data on human population distributions and densities. We used population information from 2010 that originated from the AfriPop dataset, which is the most recent available dataset for ROC and DRC (Linard *et al* 2012). We calculated the population density for each sample square using the zonal statistic tool in ArcGIS 10.3.

3.5. Data analysis

We used an Analysis of Covariance (ANCOVA) to determine whether the two cities act as independent covariables for the number of outlets relative to human population density. We then employed Spearman correlation and linear regression analysis to establish the relationship between outlet numbers, human population density and city. Data were summarized using descriptive statistics and correlation coefficients (Pearson´s r, Spearman rho, r_s). All tests were performed in R (R Project 2018).

4. Results

4.1. Density and distribution of meat outlets

Within the 58 1 km^2 randomly located squares we counted a total of 5563 meat outlets (Brazzaville-1190; Kinshasa-4373)—butchers, cold stores, food shops, formal restaurants, informal restaurants, markets and street meat vendors (see supplementary table available online at stacks.iop.org/ERL/14/094002/mmedia for numbers of outlets per sample square). Table 2 details the descriptive statistics for each type of outlet, as well as the estimated number per 100 000 inhabitants based on population densities calculated for each 1 km^2 sample square. In both cities, food shops and street meat vendors, followed by informal restaurants, were the most common outlet types. In Brazzaville, butchers also appear to be relatively common, but this has been deemed a measurement error whereby the category 'butchers' was used erroneously, as explained in table 1. The data on butchers has been retained for the purpose of understanding the density and distribution of meat outlets in general.

Sampled squares contained 0–246 meat outlets in total in Brazzaville and 0–410 in Kinshasa, with distributions being positively skewed. A larger number of squares contained between 0 and 50 outlets, with fewer squares having more than 50 outlets. Although the numbers for particular outlet types were larger in Kinshasa, the relative proportion of different outlet types was similar in both cities, e.g. food shops were more common in all squares. The numbers of each outlet type detected in each sample square are mapped in figure 2 to show their relative distribution throughout each city. For all outlet types, higher densities were found closer to the Congo River, where it narrows after the Ile M'Bamou, in the southern arrondissements of Brazzaville and the northern communes of Kinshasa. This effect is particularly pronounced for formal restaurants in both cities, reflecting the concentration of commercial enterprises, government ministries and embassies, along with wealth, near the banks of the Congo River. In Kinshasa, markets and street meat vendors are found in higher

Table 2. Summary statistics of the numbers of different meat outlets recorded in Kinshasa (38 1 km^2 squares sampled) and Brazzaville (20 1 km^2 squares sampled) and the projected numbers of outlets per 100 000 inhabitants from estimated persons per 100 m × 100 m square (WorldPOP 2018) for each city.

	Outlet type Butchers	Cold stores	Food shops	Formal restaurants	Informal restaurants	Total restaurants	Bushmeat restaurants	Markets	Bushmeat markets	Street vendors	Total outlets
(a) Actual outlets counted in sample squares											
Kinshasa											
Mean	1.03	1.89	54.08	7.16	14.29	21.45	3.47	2.37	0.50	34.29	115.08
SD	1.82	3.31	55.42	9.48	18.08	26.08	4.49	4.28	0.82	40.21	111.53
Median	0	1	35.5	2	7	10	1	1	0	22	70
Min	0	0	0	0	0	0	0	0	0	0	0
Max	9	14	264	33	81	114	12	22	2	175	410
n	38	72	2055	272	543	815	52	90	8	1303	4373
Brazzaville											
Mean	9.90	1.25	26.75	4.20	5.80	10.00	2.00	0.35	0.50	11.25	59.50
SD	11.73	4.48	37.17	7.80	9.65	17.24	4.21	0.59	0.55	15.11	79.65
Median	6	0	10.5	1	2	4.5	0	0	0.5	4.5	26
Min	0	0	0	0	0	0	0	0	0	0	0
Max	40	20	132	26	35	61	13	2	1	47	246
n	198	25	535	84	116	200	18	7	3	225	1190
(b) Estimated number of outlets per 100 000 inhabitants in each city											
Kinshasa											
Mean	6.14	11.64	332.25	43.98	87.79	131.77	21.30	14.55	3.07	210.67	707.03
SD	11.06	20.34	340.47	58.23	111.07	160.24	27.56	26.32	5.02	247.03	685.20
Median	0.00	6.14	218.11	12.29	43.01	61.44	6.14	6.14	0.00	135.17	430.07
Min	0	0	0	0	0	0	0	0	0	0	0
Max	55.29	86.01	1621.98	202.75	497.65	700.40	73.73	135.17	12.29	1075.18	2518.99
Brazzaville											
Mean	60.82	7.68	164.35	25.80	35.63	61.44	12.29	2.15	0.000 03	69.12	365.56
SD	72.09	27.54	228.36	47.91	59.29	105.91	25.88	3.61	0.000 03	92.81	489.36
Median	36.86	0.00	64.51	6.14	12.29	27.65	0.00	0.00	0.000 03	27.65	159.74
Min	0	0	0	0	0	0	0	0	0	0	0
Max	245.76	122.88	810.99	159.74	215.04	374.78	79.87	12.29	0.000 06	288.76	1511.39

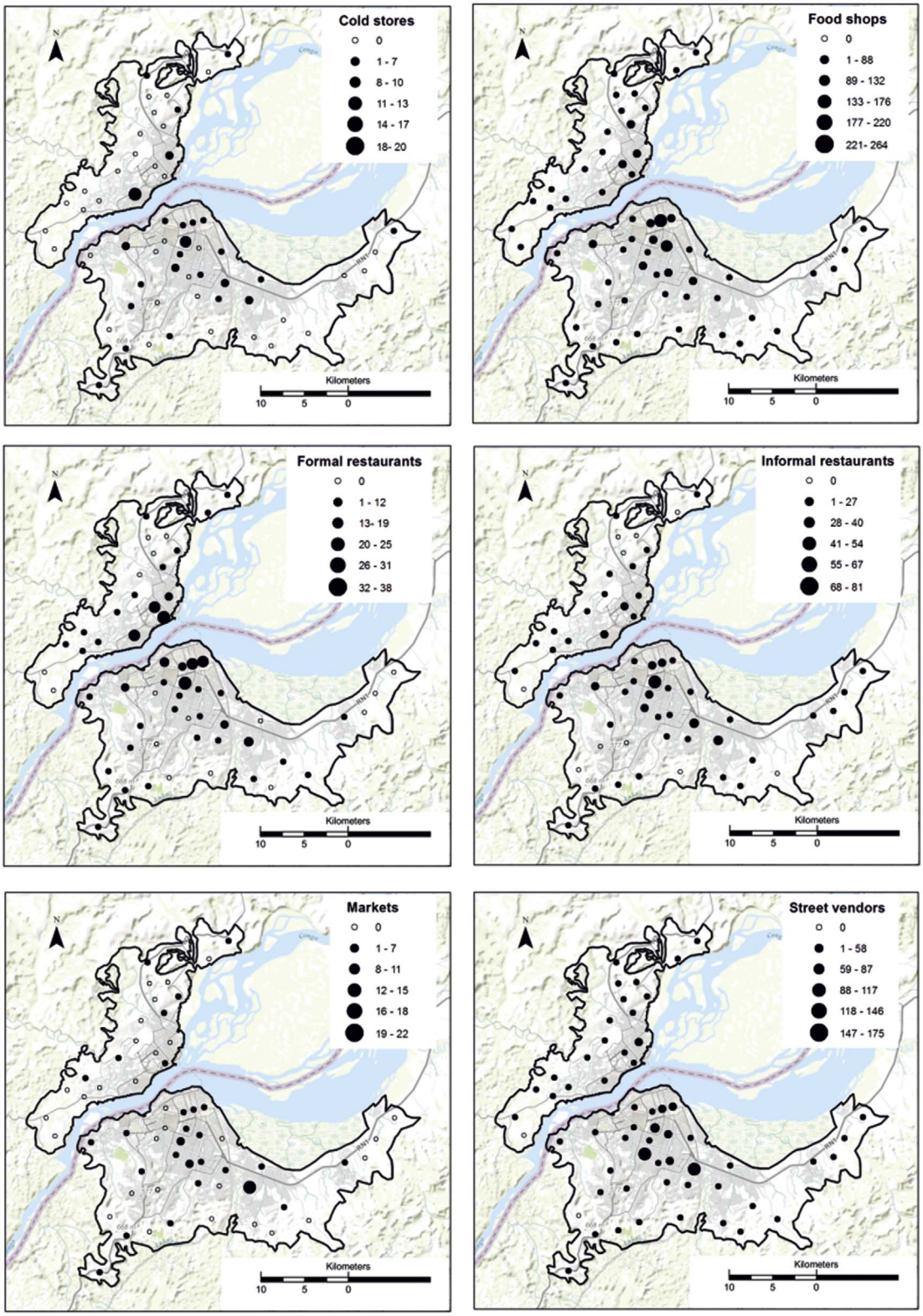

Figure 2. Distribution of numbers of outlets mapped throughout the Kinshasa–Brazzaville metropolitan area.

concentrations further south in more populous but less wealthy areas.

There was a significant positive correlation between the overall number of outlets and human population density, pop, in both cities combined ($r_s = 0.72$, $p < 0.001$) and the linear regression ($y = 0.40$ POP $+ 30.95$, $R^2 = 0.55$, $p < 0.0001$) explained 55% of the variance. ANCOVA results demonstrated that the addition of 'city' as an independent co-variable was not significant (model 1 (POP only) versus model 2 (POP * city): DF $= 1$, $F = 0.39, p = 0.53$).

Extrapolating from the outlet and population density data for each 1 km^2 sample square, we estimated

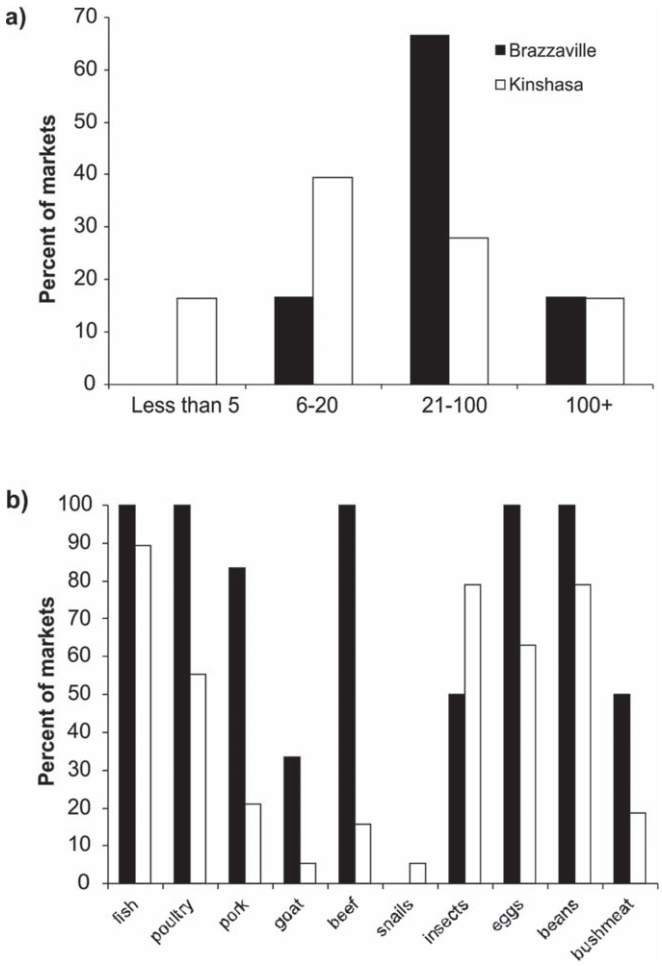

Figure 3. (a) Distribution of market sizes in Brazzaville and Kinshasa, given as the number of tables selling animal protein products. (b) Proportions of markets selling different meat types. Markets are identified as selling bushmeat if it is offered at least once per month. We also listed those markets that had bushmeat on offer on the day of the survey.

that there are approximately an average of 366 meat outlets per 100 000 inhabitants in Brazzaville and almost double—just over 700 per 100 000 inhabitants—in Kinshasa (table 2). Excluding butchers, there were higher numbers of outlets per 100 000 inhabitants estimated for all meat outlet types in Kinshasa when compared to Brazzaville (table 2). Data from the follow-up market and restaurant surveys suggest that there are, on average, around 12 bushmeat restaurants per 100 000 inhabitants in Brazzaville and 21 per 100 000 inhabitants in Kinshasa. For markets, there may be three bushmeat markets per 100 000 inhabitants in Kinshasa and less in Brazzaville. However, since markets are fewer in number and some large bushmeat markets in Brazzaville are known to have fallen outside the sample squares, a follow-up survey of all markets across the two cities is needed to verify these estimates.

4.2. Size and distribution of markets

We were able to locate a total of 49 markets in both cities (6 in Brazzaville and 43 in Kinshasa) within 21 squares (5 in Brazzaville and 16 in Kinshasa) during the follow-up surveys, which represents 86% of the markets originally identified in the 20 sample squares in Brazzaville and 48% of those in the 38 squares in Kinshasa. Within the 30 revisited squares in Kinshasa, 27 of the mapped markets could not be located; these markets may have disbanded, or this could indicate a degree of observer error during the mapping. Most Brazzaville markets ($n = 5$) had more than 20 tables selling a variety of food items (meats and vegetables), some including bushmeat. In Kinshasa, there was a greater proportion of smaller markets, with 17 of the 43 markets visited having between 6 and 20 tables (figure 3(a)). There was one market in Brazzaville and seven in Kinshasa that had more than 100 tables. Most (52%) of the revisited squares across both cities had only one market each, but one square, located in the commune of N'Djili in Kinshasa had 13 markets (27% of all markets located during the follow-up survey). In Kinshasa, 33 of the surveyed markets were open every day, with the remainders open every day except Sunday. In Brazzaville, the 6 surveyed markets were open every day.

Markets in both cities offered diverse types of animal meats for sale (figure 3(b)). Brazzaville markets

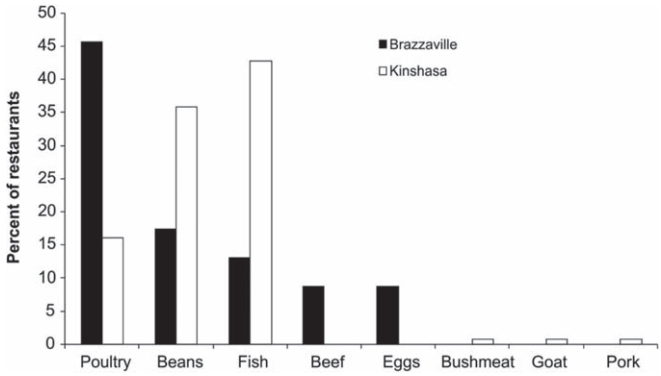

Figure 4. Responses given by interviewees about the most popular protein dishes available in Brazzaville and Kinshasa restaurants.

sold a larger selection of non-wildlife animal source foods than Kinshasa markets. In Brazzaville, three out of the six surveyed markets (50%) sold bushmeat, whereas eight (19%) of the 43 markets in Kinshasa sold it. The bushmeat markets identified were located in populous areas relatively close to the administrative centers of each city (Bacongo in Brazzaville; Lingwala, Kasa-Vubu and Ngiri–Ngiri in Kinshasa), as well as in areas towards the periphery (Madibou and Djiri in Brazzaville; Mont Ngafula in Kinshasa). Based on the observations of bushmeat during this one-time rapid market survey, the three markets that had it for sale on the day of the survey (one in Brazzaville and two in Kinshasa), were selling a variety of species. Monkey was available at all three markets, with porcupine, duiker, bush pig, pangolin, tortoise, cane rat, giant pouched rat and fruit bats seen for sale at one or more of the markets.

4.3. Types and distribution of restaurants

For the follow-up survey, we were able to locate 75 restaurants in the selected squares in Brazzaville and 213 in Kinshasa, and conduct interviews with staff at 46 and 131 of these restaurants, respectively. In Brazzaville, the restaurants were informal (60%), formal (28%) or very informal (12%). In Kinshasa, they were informal (46%), very informal (26%), formal (16%), private houses (8%), or international (2%). The most popular protein dishes served in the interviewed restaurants (figure 4) were poultry (49%), beans (19%) and fish (14%) in Brazzaville ($n = 43$), and fish (44%), beans (37%) and poultry (17%) in Kinshasa ($n = 127$).

Of the 75 restaurants revisited in Brazzaville, 18 (24.0%) confirmed that they sold bushmeat, with the assistants not recording bushmeat observations or bushmeat on the menu at any other restaurants. In Kinshasa, we determined that 52 restaurants out of the 213 (24.41%) revisited sold bushmeat—49 restaurants confirmed this with bushmeat observed at three other restaurants and seen on the menu at a fourth. Therefore, in Kinshasa, 49 restaurants were openly selling bushmeat, and 52 bushmeat restaurants were identified in total. Most restaurants that sold bushmeat were informal, very informal or a private house (78% in Brazzaville, 81% in Kinshasa). Restaurants offering bushmeat were found in four of the nine squares revisited for the restaurant survey in Brazzaville and 11 of the 15 squares revisited in Kinshasa. Clusters of bushmeat restaurants were found in populous inner-city areas close to the administrative centers of each city—Bacongo in Brazzaville and Ngiri–Ngiri, Kasa-Vubu, Lingwala and Bandalungwa in Kinshasa. There was also a cluster of bushmeat restaurants in the wealthy Gombe area, the administrative and commercial center of Kinshasa. In total, 24% of the surveyed restaurants in both cities were found to sell bushmeat, with two in Brazzaville and yhree in Kinshasa confirming that they sold bushmeat every day.

5. Discussion

The results of our study confirm that residents of Kinshasa and Brazzaville have reliable access to a range of animal source foods (e.g. beef, chicken, goat, fish and bushmeat) from a range of suppliers (e.g. markets, food shops and restaurants). Our data confirm prior research (Wilkie *et al* 2005) showing that domestically produced and imported animal source foods (primarily chicken and fish) provide city dwellers with almost all their dietary protein, and that bushmeat is sold irregularly by only a small percentage of vendors, and consumption of bushmeat is rare and is not likely to be a dietary necessity.

Typical of other cities in Africa, the most common outlet type was food shops. These small, often informal, grocery stores sell local and imported non-perishable foodstuffs such as tins of sardines and processed meats, and easy to store vegetables such as cassava and plantain to, primarily, low-income households. Unlike supermarkets that stock mainly high-price imported foods, including fresh fruit and vegetables, local food shops are crucial for the food security of most city dwellers. Research in poor neighborhoods in sub-Saharan African cities shows high levels of household

food insecurity and emphasizes the important role of informal food traders in meeting the needs of poor urban household (Crush and Riley 2017). Arguably, the growth of the supermarket system in urban areas, especially in the past decade, has economically undermined and spatially marginalized small food traders (Battersby and Watson 2018). There are a number of large, foreign-owned supermarkets in both Brazzaville and Kinshasa which were not captured in the mapping exercise but are increasingly the go-to food retailer for those on middle and high incomes, as well as the expatriate community.

Although we are aware that there are different factors that may affect outlet densities within a city (e.g. neighborhood wealth), our regression analysis clearly indicated that a positive correlation exists between human population density and the number of outlets recorded. Moreover, a larger proportion of outlets were found along the southern arrondissements of Brazzaville (Ouenze, Poto–Poto and Bacongo) and along the northern communes of Kinshasa (primarily Gombe, Barumbu and Lingwala). These areas are not only districts with the highest population densities in both cities, but also are higher-income compared to the more peri-urban areas. Wealth is clearly linked to better living conditions, including access to food as well as better health. In Kinshasa, for example, away from the areas highlighted, prevalence of malaria and anaemia is significantly higher (Ferrari *et al* 2016); a reflection of more socioeconomically deprived zones.

Both cities also have a large number of street vendors, providing a source of employment and income for many urban dwellers. As in other countries, this informal trade remains unaccounted and unrecognized in national economic statistics (Mitullah 2003). Street trade has in the past been viewed as an underground activity that undermines the formal economy resulting in conflicts with urban authorities over licensing, taxation, site of operation, sanitation and working conditions. Although we do not have any data on bushmeat sold by street vendors, we have observed that some of the myriad small meat sellers who roam night and day around bars, bus stops, churches and casinos do offer bushmeat. In several communes in the north and east of Kinshasa (Kingabwa, Masina, Lemba, Kinshasa, Lingwala, Limete) street vendors sell bushmeat, smoked or fresh, in small pieces or cooked (monkeys, snakes, bush pig, duiker and rodents). These patterns are likely to be similar in Brazzaville.

We showed there were clear differences in the types of restaurants found in Brazzaville and Kinshasa. The density of bushmeat restaurants in sampled squares did not correlate with population density, rather there were more bushmeat restaurants in rich than poor squares. Although the number of restaurants selling bushmeat seems relatively small, actual volumes consumed are still likely to be substantial in both cities, even without considering the amounts of bushmeat eaten by people buying directly from markets or other outlets. A quick calculation indicated that even if each person in Kinshasa and Brazzaville only eats 1 or 2 kg of bushmeat per year (data for urban consumers in Wilkie and Carpenter 1999) that would mean 15–30 million kilograms are consumed annually.

Given that urban demand for bushmeat is increasing rapidly, tackling this problem is an urgent priority requiring greater focus on social science research to compliment long-term ecological monitoring (Redman *et al* 2004). Understanding why people in metropolitan areas, such as Kinshasa–Brazzaville, consume wild meat is essential if we are to eliminate obstacles to creating policies that remove the need for these resources and promote the potential for other more abundant (and more affordable) animal protein sources to be available. Because food systems are complex entities, consisting of many different actors, their activities and interactions—the driving forces shaping these activities and the outcomes produced at the individual and system's level—food systems research must move towards an integrated approach for analysis and new ways to communicate this complexity outside the research domain.

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