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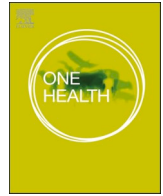
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Is social media the new wet market? Social media platforms facilitate the online sale of bushmeat in West Africa

Georgia Kate Moloney^{a,*}, Koffi Jules Gossé^b, Sery Gonedelé-Bi^b, Philippe Gaubert^{c,d}, Anne-Lise Chaber^{a,e}

^a School of Animal and Veterinary Sciences, University of Adelaide, Roseworthy Campus, SA 5371, Australia

^b Laboratoire de Biotechnologie, Agriculture et Valorisation des Ressources Biologiques, UFR Biosciences, Université Félix Houphouët-Boigny d'Abidjan-Cocody, 22 BP 582, Abidjan 22, Cote d'Ivoire

^c Laboratoire Evolution et Diversité Biologique (EDB), IRD/CNRS/UPS, Université Toulouse III Paul Sabatier – Bâtiment 4R1, 118 route de Narbonne, 31062 Toulouse cedex 9, France

^d Centro Interdisciplinar de Investigação Marinha e Ambiental (CIIMAR), Universidade do Porto, Terminal de Cruzeiros do Porto de Leixões, Av. General Norton de Matos, s/n, 4450-208 Porto, Portugal

^e Global One Health Alliance Pty Ltd, West Lakes Shore, SA 5021, Australia

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ABSTRACT

Social media provides a platform for wildlife crime syndicates to access a global consumer-driven market. Whilst studies have uncovered the online trade in wildlife, the availability of wild meat (bushmeat) has not been assessed. To investigate the sale of wild meat online, we analysed 563 posts published between 2018 and 2022 from six West African Facebook pages selected using predetermined search criteria. Across 1511 images and 18 videos, we visually identified 25 bushmeat species-level taxa including mammals (six Rodentia, five Artiodactyla, three Carnivora, two Pholidota, one Primate, two Lagomorpha, one Hyracoidea), birds (three Galliformes) and reptiles (two Squamata), predominately advertised as smoked (63%) or fresh (30%) whole carcasses or portions. Among the species identified, 16% feature a status of concern on the International Union for Conservation of Nature (IUCN) Red List (Near Threatened to Endangered), 16% are listed on the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES; Appendix I and II) and 24% are either fully or partially protected by local legislation. Images were commonly used as propaganda rather than to display inventory, where additional taxa protected from game hunting in West Africa, such as hornbill, were exclusively listed in captions. The advertisement of these protected and vulnerable species on the surface web indicates weak local and international legislative enforcement. Comparatively, when the same search criteria were applied to the deep web browser Tor no results were generated, reinforcing the idea that bushmeat vendors have no need to hide their activities online. Despite local and international trade restrictions, the taxa advertised feature similarities with bushmeat seizures reported in Europe, alluding to the interconnectedness of the trade facilitated by social media. We conclude that enhanced policy enforcement is essential to combat the online sale of bushmeat and mitigate the potential biodiversity and public health impacts.

1. Introduction

The wild meat trade poses a threat to species conservation, public health and national and global biosecurity [1,2]. Wild meat traditionally refers to meat obtained from wild, non-domesticated animals and is associated with local cultures and diets [3]. The modern wild meat trade is considered to be one of the main threats to species biodiversity in the tropics as it contributes to population declines (including local species

extinctions) and disruption to ecological functions [4]. Biodiversity loss results in the loss of ecosystem services required to sustain human and animal life, while increased contact at the human-wildlife interface enhances exposure to harmful pathogens. Wildlife trade activity has consequently been associated with human disease outbreaks, such as the emergence of Human Immunodeficiency Virus (HIV) in association with the consumption of non-human primate meat [1]. Previous estimates have suggested that wild meat in Central Africa (commonly referred to

* Corresponding author at: The University of Adelaide, Roseworthy Campus, School of Animal and Veterinary Sciences, Adelaide, SA 5371, Australia.

E-mail address: georgia.moloney@adelaide.edu.au (G.K. Moloney).

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as 'bushmeat') is being harvested at six times the sustainable rate of these tropical forests, placing a major strain on wild populations [5]. Similar trends have been documented across West Africa, another known hotspot of wild meat trade activity, where wildlife resources are being rapidly depleted and have even disappeared from some areas [5]. The now unsustainable harvesting of wild meat is likely associated with the globalisation of the trade, as evidenced through reported seizures of

African wild meat imported into Europe and the United States [6–10], supported by a modern interconnected digital society. The internet serves as a convenient medium for the promotion, sale and distribution of wildlife and thus facilitates widespread accessibility to wildlife products [2,11].

Social media platforms expedite the widespread sharing of information and have previously been implicated in the illegal wildlife

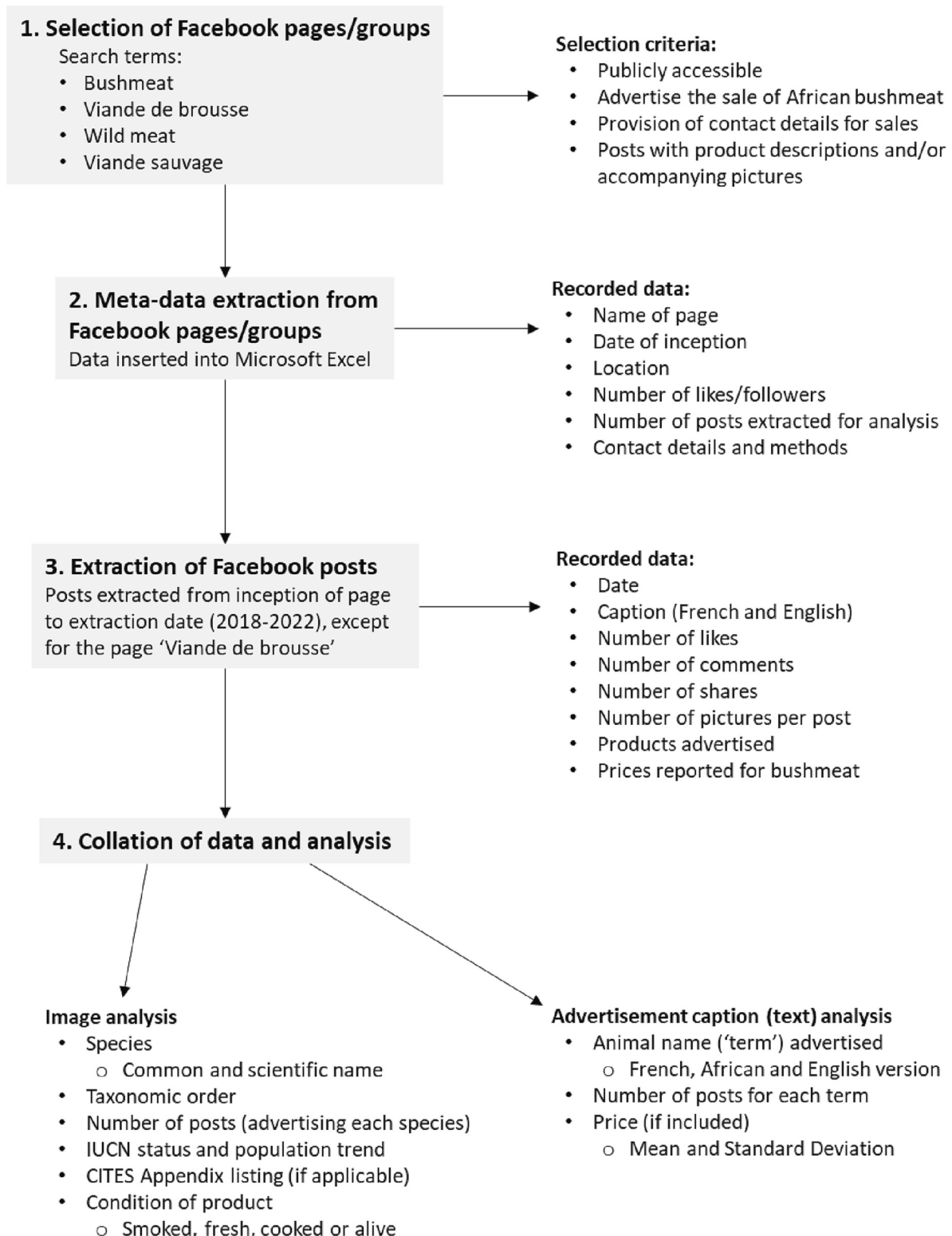


Fig. 1. Methodology and data extraction flowchart.

distribution chain [12–14], however their role in the African wild meat trade specifically has not yet been investigated. The advertisement of wildlife products through social media enables suppliers to reach a broader global community and connect effortlessly with consumers [15]. The facilitation of a wider distribution network enables increased volumes of wildlife products to be traded worldwide. This in turn enhances the public health, biosecurity and conservation implications associated with the wildlife trade. Facebook is ranked as the most widely used social media platform globally, accommodating 2.9 billion monthly active users, and therefore serves as an ideal medium for the promotion of wild meat products [16]. Therefore, the aim of this study was to first identify the presence or absence of African wild meat for sale on the surface web (through Facebook) and the deep web (via the private browser Tor) for comparison. French and English language and bushmeat terminology was used to capture all regions of Africa. Publicly discoverable and accessible pages or groups on Facebook dedicated to the sale of wild meat were then assessed based on ease of access, ability to engage with consumers, diversity of species advertised and prices listed. A comprehensive analysis of all wild meat available through social media and volume of meat traded is beyond the scope of this investigation. As this study focuses on the trade of wild meat from Africa, the term bushmeat is used throughout the manuscript.

2. Materials and methods

The methodology was guided by the approach developed by Stringham et al. [17] for internet-based wildlife trade surveillance. The social media platform Facebook was investigated for bushmeat advertisements using the broad search terms ‘bushmeat’, ‘viande de brousse’, ‘wild meat’ or ‘viande sauvage’. The private web browser Tor (The Onion Router), which enables anonymous browsing on the internet (encrypts user data and hides the IP address), was also investigated using the same search criteria to serve as a comparison. Tor is readily accessible and is legal in most countries, including Australia. The search was undertaken in Adelaide, Australia without the use of a virtual private network (VPN). Publicly accessible Facebook pages or groups explicitly advertising the sale of African bushmeat (including images of bushmeat and advertisement captions) with accessible contact details were included. Pages were excluded if no contact method was provided, or if the page posted images infrequently with no context (i.e. it was not clear if the products pictured were for sale). Meta-data was extracted from each Facebook page and each post (Fig. 1) between April 29th and May 16th 2022. One page, ‘Viandes de brousse’, posted daily and often repetitively and thus featured a significantly larger number of posts, hence only a subset (from 1st January to 31st December 2021) was included to provide a snapshot of advertisements through a calendar year. Screenshots of all posts were captured and archived for reference.

Bushmeat taxa were reported based on both the advertisement caption description and visual identification from featured images and videos, where possible. Identification of bushmeat species in images was confirmed by bushmeat experts (SGB, KJG, PG) with reference to Kingdon et al. [18]. Specimens that could not be identified to any taxonomic level ($n = 31$) have been excluded from the image analysis. Posts exclusively containing domestic, aquatic or agricultural species, such as chickens or goats, were also excluded. However, posts containing a combination of domestic or agricultural animals and bushmeat specimens were included. The number of individuals identified in each image was recorded where possible, however proved largely inconsistent and unreliable across advertisements. Exploratory analysis was performed to investigate trends in taxonomy and advertisement frequency through time. Data analysis and visualisation was conducted in R (v3.3.0) [19] using the packages tidy (v1.3.1) [20], dplyr (v1.0.6) [21] and ggplot2 (v3.3.6) [22].

3. Results

3.1. Overview

French and English terminology was used to capture all African regions, where West and Central Africa in particular have previously been identified as hotspots of bushmeat trade activity [23,24]. Consequently, we identified six public Facebook pages advertising the sale of bushmeat, all originating from West Africa (Côte d’Ivoire $n = 5$, Nigeria $n = 1$). These pages were discovered using the terminology ‘bushmeat’ or ‘viande de brousse’ and selected in-line with the inclusion criteria. The terms ‘wild meat’ or ‘viande sauvage’ generated no suitable results as although pages featuring wild meat emerged, none were advertising these products for sale (i.e. no provision of contact details, prices or product description). Similarly, Tor generated no results for the search terms explored. The Facebook pages selected attracted between 100 and 19,100 followers and a cumulative 21,590 ‘likes’. Five of the six pages specifically directed customers to the end-to-end encrypted private messaging service ‘WhatsApp’ as the preferred method of communication. Alternative channels of communication included publicly commenting on posts or sending a private message via Facebook Messenger, however vendors would then typically redirect these customers to WhatsApp. A total of 563 posts published between 2018 and 2022 were analysed. There were some discrepancies between the images and advertisement caption descriptions, hence these datasets have been explored separately.

3.2. Image analysis and species identification

We visually identified 25 bushmeat species across 1511 images and 18 videos associated with the 563 posts analysed (Table 1). Identifiable species were distributed across 10 taxonomic orders, covering mammals (Rodentia ($n = 6$), Artiodactyla ($n = 5$), Carnivora ($n = 3$), Pholidota ($n = 2$), Lagomorpha ($n = 2$), Primates ($n = 1$), Hyracoidea ($n = 1$)), birds (Galliformes ($n = 3$)) and reptiles (Squamata ($n = 2$)). Several specimens of duiker (*P. maxwelli* or *C. dorsalis*) and pangolin (*P. tricuspis* or *P. tetradactyla*) could not be clearly distinguished, hence have been listed separately (Table 1). Some specimens were only identifiable to the genus level, including *Cercopithecus* spp. and *Python* spp. Specimens belonging to the orders Galliformes (‘guineafowl’ and ‘partridge’; $n = 2$), Artiodactyla (‘antelope’ and ‘gazelle’; $n = 2$), Lagomorpha ($n = 1$), Primates ($n = 1$), Rodentia ($n = 1$), Chiroptera ($n = 1$), Crocrodilia ($n = 1$), Squamata ($n = 1$) and Testudines ($n = 1$) could not be classified to a more specific taxonomic level. Other taxa were unrecognisable due to constraints imposed by image limitations.

Four of the 25 identifiable species (16%) are recognised as a conservation concern based on the IUCN Red List and are listed as Near Threatened (*Cephalophus dorsalis*, *Perodicticus potto*), Vulnerable (*Phataginus tetradactyla*) or Endangered (*Phataginus tricuspis*) [25]. Four species (16%) and two additional taxa are CITES listed in these regions, three in Appendix I (*Phataginus tetradactyla*, *Phataginus tricuspis* and crocodile) and three in Appendix II (*Cephalophus dorsalis*, *Varanus niloticus* and *Python* spp.) [26]. Rodentia was the most frequently identified taxa based on number of posts, where the greater cane rat (*Thryonomys swinderianus*), also locally known as ‘agouti’, was the most frequently advertised species (41% of posts), followed by the brush-tailed porcupine (*Atherurus africanus*; 13%) and the giant pouched rat (*Cricetomys gambianus*; 6%). Bushmeat products were advertised in various conditions: 63% smoked, 30% fresh, 4% cooked and 2% alive. Domestic species featured alongside bushmeat included chickens (*Gallus gallus*; $n = 31$), goats (*Capra hircus*; $n = 14$), sheep (*Ovis aries*; $n = 1$), ducks (species not identified; $n = 2$) and pigs (*Sus Scrofa domesticus*; $n = 1$).

We observed an overall annual trend in the sale of bushmeat, with an increased number of posts and variety of orders being advertised during the dry season (November–March) in comparison with the wet season (April–October) (Fig. 2).

Table 1

Species visually identified in images posted between 2018 and 2022 across six West African Facebook pages advertising the sale of bushmeat, with their associated national (Ivorian law), international (CITES) and global (IUCN) trade or conservation status.

Taxonomy	Order	Posts	IUCN ¹	Trend ²	CITES ³	National status ⁴
Aves						
<i>Francolinus bicalcaratus</i>	Galliformes	6	LC	↓		Authorised hunting
Guineafowl ⁵	Galliformes	16				Authorised hunting
<i>Numida meleagris</i>	Galliformes	58	LC	Stable		Authorised hunting
Partridge ⁵	Galliformes	8				Authorised hunting
<i>Pternistis bicalcaratus</i>	Galliformes	28	LC	↓		Authorised hunting
Mammalia						
<i>Anomalurus pelii</i>	Rodentia	1	LC	↓		
Antelope ⁵	Artiodactyla	2				
<i>Atherurus africanus</i>	Rodentia	122	LC	Unknown		Authorised hunting
Bat ⁵	Chiroptera	1				
<i>Cephalophus dorsalis</i>	Artiodactyla	12	NT	↓	II	
<i>Cercopithecus</i> spp. ⁵	Primates	1				
<i>Civettictis civetta</i>	Carnivora	15	LC	Unknown		
<i>Cricetomys gambianus</i>	Rodentia	60	LC	Stable		
<i>Crossarchus obscurus</i>	Carnivora	6	LC	Unknown		
<i>Dendrohyrax dorsalis</i>	Hyracoidea	1	LC	Unknown		
Gazelle ⁵	Artiodactyla	1				
Hare ⁵	Lagomorpha	1				
<i>Hystrix cristata</i>	Rodentia	3	LC	Unknown		Authorised hunting
<i>Lepus victoriae</i>	Lagomorpha	6	LC	Stable		
<i>Nandinia binotata</i>	Carnivora	18	LC	Unknown		Partially protected
<i>Neotragus pygmaeus</i>	Artiodactyla	2	LC	↓		Fully protected
<i>Oryctolagus cuniculus</i>	Lagomorpha	4				
<i>P. maxwelli</i> or <i>C. dorsalis</i>	Artiodactyla	20	LC/NT	↓		
<i>P. tricuspis</i> or <i>P. tetradactyla</i>	Pholidota	6	VU/EN	↓	I	
<i>Perodicticus potto</i>	Primates	2	NT	↓		Fully protected
<i>Phataginus tetradactyla</i>	Pholidota	5	VU	↓	I	Partially protected
<i>Phataginus tricuspis</i>	Pholidota	17	EN	↓	I	Partially protected
<i>Philantomba maxwellii</i>	Artiodactyla	20	LC	↓		Authorised hunting
<i>Potamochoerus porcus</i>	Artiodactyla	8	LC	↓		Partially protected
Squirrel ⁵	Rodentia	9				Authorised hunting
<i>Thryonomys swinderianus</i>	Rodentia	385	LC	Unknown		Authorised hunting
<i>Tragelaphus scriptus</i>	Artiodactyla	5	LC	Stable		Authorised hunting
<i>Xerus erythropus</i>	Rodentia	1	LC	Stable		
Reptilia						
<i>Bitis arietans</i>	Squamata	4	LC	Stable		
Crocodile ⁵	Crocodylia	1			I ⁶	Fully protected
<i>Python</i> spp.	Squamata	22			II	Partially protected
Tortoise ⁵	Testudines	14				
<i>Varanus niloticus</i>	Squamata	20	LC	Stable	II	

¹ International Union for Conservation of Nature (IUCN) Red List of Threatened Species [25]; species classified as Least Concern (LC), Near Threatened (NT), Vulnerable (VU), or Endangered (EN)

² Population trends determined by the IUCN [25].

³ Convention on International Trade in Endangered Species of Wild Fauna and Flora Appendices [26].

⁴ Ivorian law (Law No. 94-442 of August 16, 1994 amending Law No. 65-255 of August 4, 1965). Fully protected: species prohibited from hunting or capture (including their young or eggs), except to holders of scientific permits in line with the limits of the permit. Partially protected: animals may be hunted or captured by those with an authorised hunting or capture license in line with the limits of the permit. Authorised hunting: species may be hunted by customary users, small game and special sports permits within the general hunting latitudes authorised under law.

⁵ Unable to be identified to the species level.

⁶ All populations in the Central and West African regions are CITES Appendix I listed [27].

3.3. Advertisement caption analysis

A total of 30 animals advertised as bushmeat were recorded (Table 2), where some species such as hornbill were listed but not pictured. The bushmeat taxonomic orders described in captions included Rodentia ($n = 7$), Artiodactyla ($n = 5$), Carnivora ($n = 4$), Squamata ($n = 3$), Primates ($n = 2$), Galliformes ($n = 2$), Lagomorpha ($n = 1$), Bucerotiformes ($n = 1$), Chiroptera ($n = 1$), Crocodylia ($n = 1$), Hyracoidea ($n = 1$), Pholidota ($n = 1$) and Testudines ($n = 1$). Rodentia and Artiodactyla were the most frequently represented taxa based on number of posts, where ‘agouti’ (cane rat; 58% posts), ‘h risson’ (mostly porcupines, but possibly hedgehogs too; 34% posts), ‘biche’ (antelope; 29% posts) and ‘rat’ (usually the Gambian rat; 18% posts) were the most popular bushmeat options advertised. ‘Porc africain’ described in two

posts was excluded as it was unclear whether this referred to wild or domesticated pigs. Aquatic and domestic animals advertised alongside bushmeat included chickens (including ‘African chicken’ and layers, $n = 69$), rabbits ($n = 11$), sheep ($n = 8$), ducks ($n = 7$), fish ($n = 6$), turkeys ($n = 4$), quail ($n = 2$), cows ($n = 1$), frogs ($n = 1$) and shrimp ($n = 1$).

The proportion of bushmeat taxa traded (as a proportion of posts) is comparable with previous studies evaluating the market in West Africa, but also features similarities with seizures reported in the international European illegal bushmeat trade originating from Africa (Fig. 3). Rodentia and Artiodactyla were consistently the most popular taxa. Lagomorpha, Hyracoidea, Galliformes, Chiroptera and Bucerotiformes were documented in the local and online trade, however were reportedly not seized internationally.

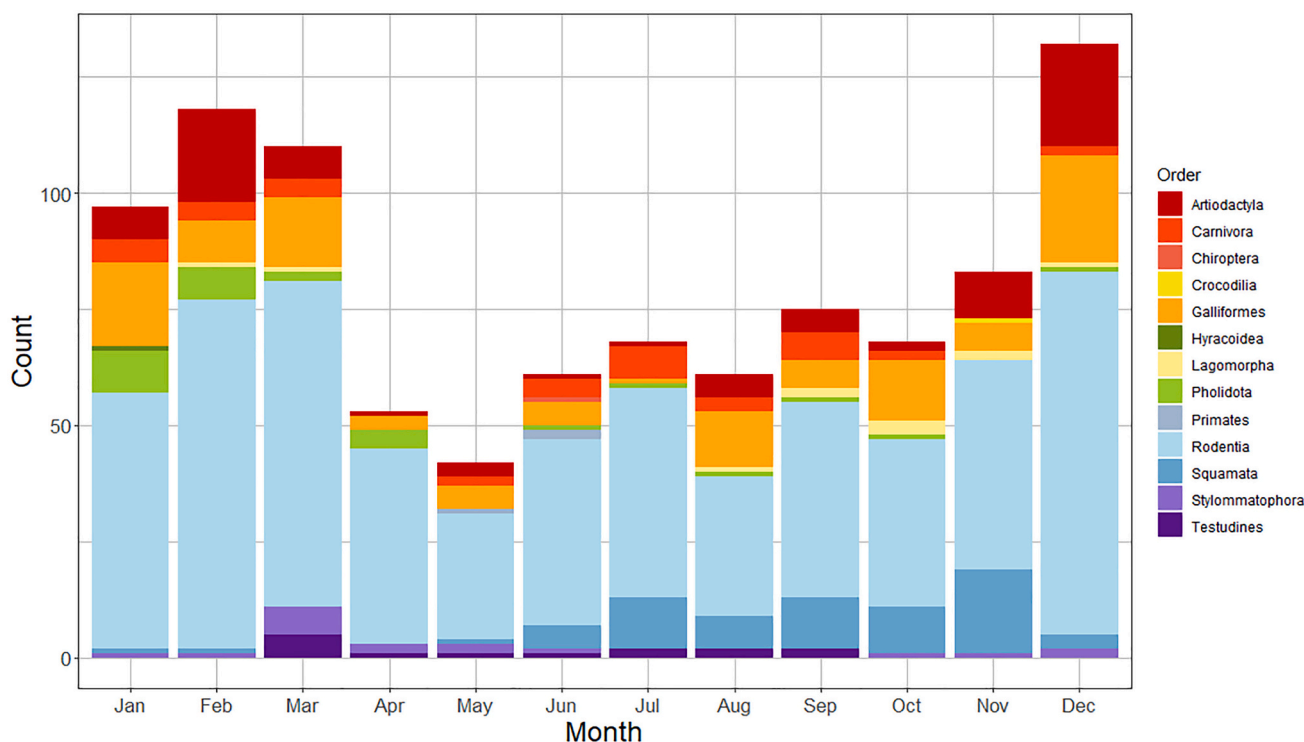


Fig. 2. Annual bushmeat sale trends for the 13 taxonomic orders identified within images posted on Facebook between 2018 and 2022. Each ‘count’ represents a post in which an animal classified within that taxonomic order was identified. Many posts contained multiple species and were therefore included within each count.

Table 2

Descriptive terms listed in advertisement captions posted between 2018 and 2022 across six Facebook pages promoting the sale of bushmeat. The number of posts wherein that product was advertised is inclusive across all six pages. The mean price and standard deviation in Central African CFA franc (FCFA) were derived across all six pages and represent the price for a whole carcass (unless otherwise specified). The mean price in euros (€) is also presented, based on the conversion rate as of October 7th 2022.

Terminology	Taxonomic correspondence	Order	Number of posts	Mean price (FCFA)	SD (FCFA)	Mean price (€)
Agouti	<i>Thryonomys swinderianus</i>	Rodentia	329	16,475	4291.96	25.10
Akpani	Megachiroptera	Chiroptera	4	1000		1.52
Antilope (or Gazelle)	Bovidae	Artiodactyla	6			
Biche	Bovidae	Artiodactyla	163	28,130	3717.40	42.86
Biche rouge	<i>Cephalophus</i> spp.	Artiodactyla	1	30,000		45.71
Biche royale	<i>Neotragus pygmaeus</i>	Artiodactyla	5	13,571	975.90	20.68
Calao	Bucerotidae	Bucerotiformes	2			
Chat de brousse	Small carnivorans	Carnivora	40	14,182	981.65	21.61
Chat huant	<i>Nandinia binotata</i>	Carnivora	4			
Civette	<i>Civettictis civetta</i>	Carnivora	11	24,286	1889.82	37.00
Crocodile	Crocodylidae	Crocodylia	2	87,500	0	133.31
Écureuil	Sciuridae	Rodentia	43	3374	332.66	5.14
Écureuil volant	Anomaluridae	Rodentia	1			
Hérisson	<i>Atherurus africanus</i>	Rodentia	191	21,691	2930.51	33.05
Lièvre	<i>Lepus</i> spp.	Lagomorpha	32	6636	744.68	10.11
Mangouste	Herpestidae	Carnivora	29	6982	4190.72	10.64
Pangolin	<i>Phataginus</i> spp.	Pholidota	21	17,750	3336.67	27.04
Paresseux	<i>Perodicticus potto</i>	Primates	2			
Perdrix	Pavoninae	Galliformes	73	3517	736.44	5.36
Phacochère	<i>Phacochoerus africanus</i>	Artiodactyla	34	72,500 (whole) 14,450 (leg)	0 1300.64	110.46 (whole) 22.02 (leg)
Pintade de brousse	Numididae	Galliformes	75	7734	5737.16	11.78
Porc épïc	<i>Hystrix cristata</i>	Rodentia	15	47,667	22,250.00	72.62
Python	<i>Python</i> spp.	Squamata	39	9333 (1-2 kg)	887.63	14.22 (1-2 kg)
Rat	Murinae	Rodentia	104	4770	743.04	7.27
Rat palmiste	<i>Cricetomys</i> spp.	Rodentia	30	4667	449.87	7.11
Singe	Primates	Primates	3	25,000	0	38.09
Tortue	Testudines	Testudines	14	9000	0	13.71
Varan	Varanidae	Squamata	40	25,714	4423.96	39.18
Vipère	Viperidae	Squamata	45	22,500	849.84	34.28
Woya	Procaviidae	Hyracoidea	16	12,167	1457.74	18.54

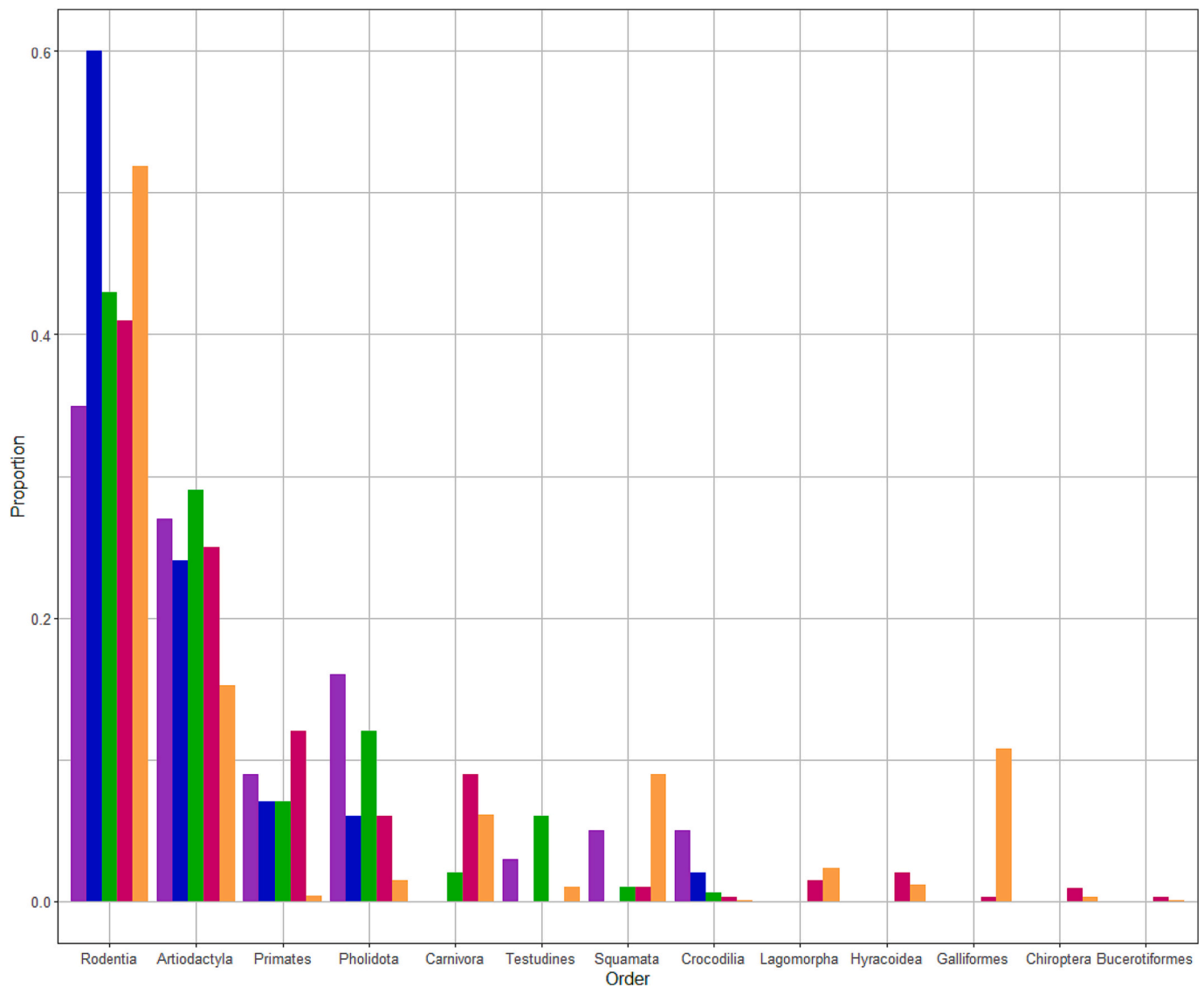


Fig. 3. Comparison of the proportion of bushmeat ordines (vertebrates only) advertised in captions across the six Facebook pages from West Africa (orange; based on number of posts, derived from Table 2) with taxa traded in the local West African marketplace (pink; based on molecular identification [28]). Proportion of bushmeat ordines reportedly seized in Europe, based on number of specimens identified in Belgium (purple [29]), France (blue [6]) and Switzerland (green [10]), have also been included. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

4. Discussion

4.1. Ease of access

Our findings confirm bushmeat trade activity is occurring through Facebook and support the role of social media in facilitating the illegal wildlife trade. Thousands of individuals ‘liked’ or ‘followed’ the pages reviewed, alluding to a widespread network of consumers openly supporting this online trade. The availability of pages advertising bushmeat highlights inadequate enforcement of Facebook’s own *Community Standards and Commerce Policies*, which specifies that listings must not promote the sale or trade of animals or animal products, including parts of endangered or threatened animals, raw meat or carcasses [30]. While limited search terms were explored, the basic descriptors selected were used to demonstrate the accessibility and transparency of bushmeat advertisements available online. We acknowledge that this did not enable a comprehensive analysis of all bushmeat activity occurring through social media and may negate the promotion of single species or forbidden mammals, however the results reaffirm that bushmeat vendors are comfortable advertising their products on public platforms. In

comparison, no results were generated using the deep web browser Tor suggesting bushmeat vendors have no need to hide their activities online, despite fears that increased awareness and regulation would drive the illegal wildlife trade to the dark web [31]. The authors further acknowledge that the pages selected for analysis do not represent all bushmeat advertised through Facebook, but provide an insight into the online trade.

Social media not only provides a platform for the advertisement of bushmeat, but also facilitates anonymous communication and transactions between local and international parties [32]. Five of the six pages directed customers to the end-to-end encrypted messaging service ‘WhatsApp’, where previous reports have supported a preference for the private application [12,13]. The shift from public pages to private encrypted messaging applications contributes to the challenges associated with tracing and regulating the trade. Machine learning algorithms have been previously implemented to enable real-time monitoring of social media content [11]; however, most suppliers advertise their products and connect with consumers using strategies such as this which are designed to evade detection [17]. The use of the internet and social media therefore not only facilitates the trade by generating public

interest in bushmeat content, but also aids in concealing illicit activities through directing customers to private communications for transactions.

4.2. Diversity of species

Analysis of the taxa advertised through images and advertisement captions posted from 2018 to 2022 closely aligns with those traded in bushmeat marketplaces in West and Central Africa [33,34]. As all six pages were created in West Africa, it is assumed that the products were sourced in these regions. Local market trends favour mammals, where mammals also dominated the online trade with respect to the number of posts and diversity of species traded [35]. Previous studies support the popularity of Rodentia and Artiodactyla in the bushmeat trade [28,33], which is likely due to their reproductive strategies and ability to inhabit land influenced by human disturbance [36,37]. Endemic rodent species including the greater cane rat (*Thryonomys swinderianus*), brush-tailed porcupine (*Atherurus africanus*) and the giant pouched rat (*Cricetomys gambianus*) dominated the online market both visually and through advertisement captions. Among the 25 species-level taxa identified (Table 1), 16% (four species) are listed in CITES Appendix I or II [26], 16% feature a conservation status of concern (Near Threatened to Endangered) [25] and 24% (six species) are either fully or partially protected by the Ivorian law (Law No. 94-442 of August 16, 1994 amending Law No. 65-255 of August 4, 1965). The presence of these vulnerable species in the online trade despite violation of relevant national laws [38,39] suggests vendors prioritise financial gain over sustainable wildlife management. Whilst the volume of specimens traded was unable to be assessed, the presence of these species in the online marketplace and the potential conservation and public health implications warrants further investigation.

Trends in species advertisements throughout a calendar year were graphically represented (Fig. 2) to determine if there was an association between advertisement frequency and month. There appeared to be an overall annual trend in the sale of bushmeat, with an increased frequency of posts and variety of orders identified in the dry season (November–March) compared with the wet season (April–October). Previous studies have also reported a significant increase in bushmeat activity during the dry season [40–42], likely associated with favourable environmental conditions (i.e. minimal forest undergrowth [37]) and animal behaviours (i.e. increased animal density around water sources [40]) which enhance visibility and accessibility for hunters. Whilst the number of advertisements assessed is limited, the taxa and trends identified provides an indication of bushmeat activity through Facebook, which reflects local bushmeat marketplaces and hunting practices.

4.3. International sale trends

The ease of access to online bushmeat sales and comparable species trends noted in European seizures of African bushmeat suggests social media could be facilitating the international trade. Seizures of illegal bushmeat imported from West and Central Africa (including Côte d'Ivoire and Nigeria) via international airports in Belgium, France and Switzerland have been reported [6,10,29], supporting speculation of a luxury market for African bushmeat in Europe [43]. The taxonomic orders identified within our study and previous studies of the bushmeat trade in West Africa [28] closely resemble those reported in European seizures (Fig. 3), with Rodentia and Artiodactyla being the most popular taxonomic orders trafficked based on proportion of specimens seized. Whilst our study did not represent all species seized, our ability to accurately identify species was limited by images provided by vendors whereas other studies were supported by DNA analysis [6,10,29]. The orders Lagomorpha, Hyracoidea, Galliformes, Chiroptera and Bucerotiformes were exclusively documented in the bushmeat trade in West Africa (both online and local marketplaces) and not in European seizure reports cited, potentially suggesting these animals are less popular or valuable in the international market.

Six taxa (including all Crocodiles and *Python* spp.) identified in this study are CITES listed in West African regions and are therefore restricted in the international trade [26,27]. Additionally, of the species visually identified for sale on a Nigerian Facebook page, the brush-tailed porcupine (*Atherurus africanus*) and white-bellied pangolin (*Phataginus tricuspis*) are listed in the first schedule of the *Endangered Species (Control of International Trade and Traffic) Act*, meaning these animals are absolutely prohibited from the international trade except in exceptional circumstances [44]. Whilst vendors do not specify where their products can be sent, accessibility to these pages even without a VPN and similarities between the products advertised and those seized in Europe suggests international clients are likely. Despite the trade restrictions, vendors continue to supply the European bushmeat market as it is considered to be a low-risk, high-reward practise [45], supporting a lack of legislative enforcement. The prices reported per kilogram in the French market [6] are notably higher than in the local trade [46] and are often even higher than the price of a whole carcass advertised online (Table 2), providing financial incentive for the international trade. The globalisation of the bushmeat trade is not only a concern for species conservation, but also presents a major public health risk, where previous studies have demonstrated the detection of infectious organisms in imported [9,47] and locally acquired African bushmeat [48,49]. In addition to the human health risks posed by the unregulated movement of meat, pest and disease transmission mechanisms threaten livestock health, international trade, native wildlife populations and ecosystem health in importing countries [1]. Therefore, online sale trends should be monitored closely in order to better understand and regulate the international trade to limit biodiversity loss and disease outbreaks.

4.4. Limitations

Image quality and advertisement transparency provided key limitations in our research. The images analysed did not capture the complete variety or volume of products available and there is no indication as to the quantity of wildlife hunted, therefore we can only comment on the relative proportion of each bushmeat taxa available on the online market. However, it was often difficult to classify bushmeat to a specific taxonomic level based on the images provided, even where text descriptions were available, resulting in 10 taxa (29%) being unable to be identified to the species level. Additionally, 111 posts provided inadequate information or poor-quality images which prevented the identification of at least one species, which is a known limitation when assessing the trade through these platforms [17]. Many of the images posted were also either re-used (i.e. the same image was used across multiple posts) or not authentic (i.e. derived from the internet), therefore introducing bias to our assessment of species diversity. As the purpose of the images was to attract the attention of customers, not all species listed in advertisement captions were pictured, generating discrepancies in the data. As we were aware of the use of images primarily as a marketing tool, we also analysed the promotion of products through advertisement captions (text) as we believe this to be more accurate representation of the species available for sale. Enquiring customers were directed to encrypted messaging services such as WhatsApp for private untraceable transactions, therefore we were unable to access information regarding the number of customers who have purchased bushmeat and the quantity of animals sold. However, this paper does not aim to assess the volume of the online trade. As we were unable to access this data, it also cannot be confirmed that all sales are going ahead, or that the products are sold as advertised (i.e. vendors may substitute domestic products for bushmeat, which could only be confirmed by DNA analysis [50], or sales may be fraudulent). While the evidence compiled does not explicitly link the African bushmeat trade to the international market, our study supports the role of social media in facilitating wildlife trade activity and should serve as a warning for both customs authorities and consumers.

5. Conclusion

Social media is being used as a platform for the modern bushmeat trade, where our study provides a preliminary indication of bushmeat trade activity currently occurring through Facebook. The species identified closely align with local West African bushmeat market trends and correspond to products seized internationally, however limitations in the data provided prevent a comprehensive analysis of the impact of the Facebook pages discovered. Whilst there are some provisions in place to target wildlife content posted online, the ease of access to Facebook pages advertising bushmeat demonstrates that stricter policy guidelines and enforcement is pertinent to combat the online sale of wildlife through social media. The globalisation of the bushmeat trade facilitated by social media poses a threat to human, animal and environmental health alike due to the pressure placed on targeted species and their habitats, contributing to the emergence and spread of pathogens. We recommend further investigation into the impact of social media in the facilitation of the bushmeat trade and enhanced regulation of social media content to discourage the exploitation of threatened species and protect biosecurity and public health.

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CRedit authorship contribution statement

Georgia Kate Moloney: Conceptualization, Methodology, Data curation, Formal analysis, Investigation, Visualization, Writing – original draft. **Koffi Jules Gossé:** Data curation, Visualization, Writing – review & editing. **Sery Gonedelé-Bi:** Data curation, Visualization, Writing – review & editing. **Philippe Gaubert:** Data curation, Visualization, Writing – review & editing. **Anne-Lise Chaber:** Conceptualization, Funding acquisition, Supervision, Writing – review & editing.

Declaration of Competing Interest

The authors declare there are no conflicts of interest in this project.

Data availability

Data will be made available on request.

References

- [1] W.B. Karesh, R. Cook, E.L. Bennett, J. Newcomb, Wildlife trade and global disease emergence, *Emerg. Infect. Dis.* 11 (2005) 1000–1002, <https://doi.org/10.3201/eid1107.050194>.
- [2] A. Lavorgna, Wildlife trafficking in the internet age, *Crime Sci.* 3 (2014) 1–12, <https://doi.org/10.1186/s40163-014-0005-2>.
- [3] D.S. Wilkie, M. Wieland, H. Boulet, S. Le Bel, N. van Vliet, D. Cornelis, V. BriacWarnon, R. Nasi, J.E. Fa, Eating and conserving bushmeat in Africa, *Afr. J. Ecol.* 54 (2016) 402–414, <https://doi.org/10.1111/aje.12392>.
- [4] R.D. Harrison, Emptying the forests: hunting and the extirpation of wildlife from tropical nature reserves, *BioScience* 61 (2011) 919–924, <https://doi.org/10.1525/bio.2011.61.11.11>.
- [5] E.L. Bennet, Is there a link between wild meat and food security? *Conserv. Biol.* 16 (2002) 590–592, <https://doi.org/10.1046/j.1523-1739.2002.01637.x>.
- [6] A.L. Chaber, S. Allebone-Webb, Y. Lignereux, A.A. Cunningham, J.M. Rowcliffe, The scale of illegal meat importation from Africa to Europe via Paris, *Conserv. Lett.* 3 (2010) 317–323, <https://doi.org/10.1111/j.1755-263X.2010.00121.x>.
- [7] S. Gombeer, C. Nebesse, P. Musaba, S. Ngoy, M. Peeters, A. Vanderheyden, K. Manganck, N. Smitz, F. Geers, S. Van Den Heuvel, T. Backeljau, M. De Meyer, E. Verheyen, Exploring the bushmeat market in Brussels, Belgium: a clandestine luxury business, *Biodivers. Conserv.* 30 (2020) 55–66, <https://doi.org/10.1007/s10531-020-02074-7>.
- [8] D. Schoder, A. Strauß, K. Szakmary-Brändle, B. Stessl, S. Schlager, M. Wagner, Prevalence of major foodborne pathogens in food confiscated from air passenger luggage, *Int. J. Food Microbiol.* 209 (2015) 3–12, <https://doi.org/10.1016/j.ijfoodmicro.2014.08.010>.
- [9] K.M. Smith, S.J. Anthony, W.M. Switzer, J.H. Epstein, T. Seimon, H. Jia, M. D. Sanchez, T.T. Huynh, G.G. Galland, S.E. Shapiro, Zoonotic viruses associated with illegally imported wildlife products, *PLoS One* 7 (2012), e29505, <https://doi.org/10.1371/journal.pone.0029505>.
- [10] K.L. Wood, T. Bruno, M. Nadja, K. Adelgunde, Report to CITES: CITES-listed species at risk from illegal trafficking in bushmeat; results of a 2012 study in Switzerland's International Airports. https://www.zora.uzh.ch/id/eprint/111850/1/tengwood_report_to_cites.pdf, 2014.
- [11] Q. Xu, J. Li, M. Cai, T.K. Mackey, Use of machine learning to detect wildlife product promotion and sales on twitter, *Front. Big Data.* 2 (2019) 28, <https://doi.org/10.3389/fdata.2019.00028>.
- [12] W.X. Chiok, S. Chng, Trading faces: Live Bird Trade on Facebook in Singapore, *TRAFFIC Report*. https://www.traffic.org/site/assets/files/16465/trading_faces-dec2021.pdf, December 2021, 2021 (accessed 14 July 2022).
- [13] K. Krishnasamy, S. Stoner, Trading Faces: A Rapid Assessment on the Use of Facebook to Trade Wildlife in Peninsular Malaysia, *TRAFFIC Report*. <https://www.traffic.org/site/assets/files/2434/trading-faces-facebook-malaysia.pdf>, March 2016, 2016 (accessed 14 July 2022).
- [14] M. Phassaraudomsak, K. Krishnasamy, S.C.L. Chng, Trading Faces: Online Trade of Helmeted and other Hornbill Species on Facebook in Thailand, *TRAFFIC Report*. <https://www.traffic.org/site/assets/files/12381/trading-faces-helmeted-hornbill-final.pdf>, August 2019, 2019 (accessed 14 July 2022).
- [15] J. Guan, L. Xu, Deadly Messaging: Illegal Ivory Trade in China's Social Media. <https://www.traffic.org/site/assets/files/10442/deadly-messaging.pdf>, 2015.
- [16] A. Lua, 20 Top Social Media Sites to Consider for Your Brand in 2022. <https://buffer.com/library/social-media-sites/>, 2022 (accessed 7 July 2022).
- [17] O.C. Stringham, A. Toomes, A.M. Kanishka, L. Mitchell, S. Heinrich, J.V. Ross, P. Cassey, A guide to using the internet to monitor and quantify the wildlife trade, *Conserv. Biol.* 35 (2020) 1130–1139, <https://doi.org/10.1111/cobi.13675>.
- [18] J. Kingdon, *The Kingdon Field Guide to African Mammals*, second ed., Bloomsbury Publishing, London, 2015.
- [19] R Core Team, R Foundation for Statistical Computing Version 3.3.0., Vienna, Austria. <https://www.R-project.org/>, 2022.
- [20] H. Wickham, tidy: Tidy Messy Data, R Package Version 1.3.1. <https://CRAN.R-project.org/package=tidy>, 2021.
- [21] H. Wickham, R. François, L. Henry, K. Müller, dplyr: A Grammar of Data Manipulation, R Package Version 1.0.6. <https://CRAN.R-project.org/package=dplyr>, 2021.
- [22] H. Wickham, ggplot2: Elegant Graphics for Data Analysis Version 3.3.6, Springer-Verlag, New York, 2016. <https://ggplot2.tidyverse.org>.
- [23] J.E. Fa, J.H. Wright, S.M. Funk, A.L. Marquez, J. Olivero, M.A. Farfan, F. Guio, L. Mayet, D. Malekani, C.H. Louzolo, R. Mwinyihali, D.S. Wilkie, M. Wieland, Mapping the availability of bushmeat for consumption in Central African cities, *Environ. Res. Lett.* 14 (2019), e094002, <https://doi.org/10.1088/1748-9326/ab36fa>.
- [24] S. Ziegler, J.E. Fa, C. Wohlfart, B. Streit, S. Jacob, M. Wegmann, Mapping Bushmeat hunting pressure in Central Africa, *Biotropica*. 48 (2016) 405–412, <https://doi.org/10.1111/btp.12286>.
- [25] IUCN, The IUCN Red List of Threatened Species Version 2021–3. <https://www.iucnredlist.org>, 2021.
- [26] CITES, Appendices. <https://cites.org/eng/app/appendices.php>, 2022 (accessed 30 June 2022).
- [27] D.P. Mallon, M. Hoffmann, P.J.K. McGowan, An IUCN Situation Analysis of Terrestrial and Freshwater Fauna in West and Central Africa. <https://portals.iucn.org/library/sites/library/files/documents/SSC-OP-054.pdf>, 2015 (accessed 19 July 2022).
- [28] K.J. Gossé, S. Gonedele Bi, F. Justy, A.L. Chaber, P. Gaubert, DNA-typing surveillance of the bushmeat trade in Côte d'Ivoire: a multi-faceted tool for wildlife management in West Africa, *Conserv. Genet.* 23 (2022) 1073–1088, <https://doi.org/10.1007/s10592-022-01474-2>.
- [29] A.L. Chaber, P. Gaubert, H. Green, M. Garigliani, V. Renault, V. Busoni, M. Dieudonné, C. Saegerman, Report on the illegal importation of meat, including bushmeat, seized at Zaventem airport - 2017/2018, in: *Dead or alive: towards a sustainable wildlife trade*, *One World One Health recommendations*, Brussels, 3–4 December 2019, 2019 <https://www.biodiversity.be/4859/>.

- [30] Meta, Prohibited Content: Animals and Animal Products. https://www.facebook.com/policies_center/commerce/animals, 2022 (accessed 29 June 2022).
- [31] J.R. Harrison, D.L. Roberts, J. Hernandez-Castro, Assessing the extent and nature of wildlife trade on the dark web, *Conserv. Biol.* 30 (2016) 900–904, <https://doi.org/10.1111/cobi.12707>.
- [32] International fund for animal welfare (IFAW), Caught in the web: wildlife trade on the internet. https://dljyxxz9imt9yb.cloudfront.net/resource/680/attachment/original/Report_2005_Caught_in_the_web_UK.pdf, 2005 (accessed 21 July 2022).
- [33] S. Gonedelé Bi, I. Kone, J.C.K. Bene, E.A. Bitty, K.A. Yao, B.A. Kouassi, P. Gaubert, Bushmeat hunting around a remnant coastal rainforest in cote d'Ivoire, *Oryx*. 51 (2017) 418–427, <https://doi.org/10.1017/S0030605315001453>.
- [34] C.M. Mbutu, B.S. Nguemwo, Species in bushmeat trade: in Cameroon and the Republic of the Congo, TRAFFIC Report. <https://www.traffic.org/site/assets/files/16648/caf-bushmeat-vdec-final-07-01-2021.pdf>, 2021 (accessed 24 July 2022).
- [35] F. Petrozzi, G. Amori, D. Franco, P. Gaubert, N. Pacini, E.A. Enian, G.C. Akani, E. Politano, L. Luiselli, Ecology of the bushmeat trade in west and Central Africa, *Trop. Ecol.* 57 (2016) 547–559.
- [36] S. Gonedelé Bi, B. Kramoko, J.C.K. Bené, I. Koné, L. Luiselli, P. Gaubert, Year-round longitudinal monitoring of a bushmeat market in Central-Western Côte d'Ivoire: implication for wildlife conservation, *J. Nat. Conserv.* 70 (2022) 126297, <https://doi.org/10.1016/j.jnc.2022.126297>.
- [37] J. McNamara, M. Rowcliffe, G. Cowlshaw, J.S. Alexander, Y. Ntiama-Baidu, A. Brenya, E.J. Milner-Gulland, Characterising wildlife trade market supply-demand dynamics, *PLoS One* 11 (2016), e0162972, <https://doi.org/10.1371/journal.pone.0162972>.
- [38] A.O. Dindé, A.J. Mobio, A.G. Konan, G. Fokou, K. Yao, E.L.J.C. Esso, A. Fantodji, M. Koussémon, B. Bonfoh, Response to the Ebola-related bushmeat consumption ban in rural Côte d'Ivoire, *Agric. Food Secur.* 6 (2017) 28, <https://doi.org/10.1186/s40066-017-0105-9>.
- [39] Endangered Species Act 1985 (NG). <http://lawsfnigeria.placng.org/laws/E9.pdf#:~:text=ENDANGERED%2%A0SPECIES%2%A0%28CONTROL%2%A0OF%2%A0INTERNATIONAL%2%A0TRADE%2%A0AND%2%A0TRAFFIC%29%2%A0ACT,An%2%A0Act%2%A0to%2%A0provide%2%A0for%2%A0the%2%A0conservation%2%A0and%2%A0management%2%A0of%2%A0Nigeria%27s%2%A0wild%2%A0life%2%A0and%2%A0the%2%A0protection%2%A0of%2%A0some%2%A0of%2%A0her%2%A0endangered%2%A0species%2%A0in%2%A0danger%2%A0of%2%A0extinction%2%A0as%2%A0a%2%A0result%2%A0of%2%A0over%28%80%90exploitation%2C%2%A0as%2%A0required%2%A0under%2%A0certain%2%A0internat>
- [40] K.A. Alexander, J.K. Blackburn, M.E. Vandewalle, R. Pesapane, E.K. Baipoledi, P. H. Elzer, Buffalo, bush meat, and the zoonotic threat of brucellosis in Botswana, *PLoS One* 7 (2012), e32842, <https://doi.org/10.1371/journal.pone.0032842>.
- [41] C. Fargeot, N. Drouet-Hoguet, S. Le Bel, The role of bushmeat in urban household consumption: insights from Bangui, the capital city of the Central African Republic, *Bois For. Trop.* 332 (2017) 31–42, <https://doi.org/10.19182/bft2017.332.a3133>.
- [42] A. Nuno, N. Bunnefeld, L.C. Naiman, E.J. Milner-Gulland, A novel approach to assessing the prevalence and drivers of illegal Bushmeat hunting in the Serengeti, *Conserv. Biol.* 27 (2013) 1355–1365, <https://doi.org/10.1111/cobi.12124>.
- [43] S. Gombeer, C. Nebesse, P. Musaba, S. Ngoy, M. Peeters, A. Vanderheyden, K. Meganck, N. Smitz, F. Geers, S. Van Den Heuvel, T. Backeljauf, M. De Meyer, E. Verheyen, Exploring the bushmeat market in Brussels, Belgium: a clandestine luxury business, *Biodivers. Conserv.* 30 (2020) 55–66, <https://doi.org/10.1007/s10531-020-02074-7>.
- [44] Endangered Species (Control of International Trade and Traffic Act, NG. <http://faolex.fao.org/docs/pdf/nig18379.pdf>, 1985 (accessed 24 July 2022).
- [45] A.O. Brown, G.J. Frankham, L. Bond, B.H. Stuart, R.N. Johnson, M. Ueland, An overview of risk investment in the transnational illegal wildlife trade from stakeholder perspectives, *WIREs Forensic Sci.* 3 (2020), e1397, <https://doi.org/10.1002/wfs2.1397>.
- [46] A.S. Willcox, D.M. Nambu, Wildlife hunting practices and bushmeat dynamics of the Banyangi and Mbo people of Southwestern Cameroon, *Biol. Conserv.* 134 (2007) 251–261, <https://doi.org/10.1016/j.biocon.2006.08.016>.
- [47] A.L. Chaber, A. Cunningham, Public health risks from illegally imported African bushmeat and smoked fish, *EcoHealth* 13 (2016) 135–138, <https://doi.org/10.1007/s10393-015-1065-9>.
- [48] C.S. Peros, R. Dasgupta, P. Kumar, B.A. Johnson, Bushmeat, wet markets, and the risks of pandemics: exploring the nexus through systematic review of scientific disclosures, *Environ. Sci. Pol.* 124 (2021) 1–11, <https://doi.org/10.1016/j.envsci.2021.05.025>.
- [49] N. Van Vliet, A.P. Antunes, P.D.A.L. Constantino, J. Gómez, D. Santos-Fita, E. Sartoretto, Frameworks regulating hunting for meat in tropical countries leave the sector in the limbo, *Front. Ecol. Evol.* 7 (2019) 280, <https://doi.org/10.3389/fevo.2019.00280>.
- [50] P. Gaubert, F. Njiokou, A. Olayemi, P. Pagani, S. Dufour, E. Danquah, M.E. K. Nutsuakor, G. Ngua, A.D. Missou, P.A. Tedesco, R. Darnat, A. Antunes, Bushmeat genetics: setting up a reference framework for the DNA typing of African forest bushmeat, *Mol. Ecol. Resour.* 15 (2015) 633–651, <https://doi.org/10.1111/1755-0998.12334>.