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Examining the international bushmeat traffic in Belgium: A threat to conservation and public health

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ABSTRACT

The carriage of bushmeat into the European Union is an infringement of EU Animal Health and Wildlife Trade legislation and poses a threat to biodiversity and public health. To explore the nature and scale of the international bushmeat trade, seized leaking luggage and passengers arriving at Brussels Zaventem airport from sub-Saharan Africa between 2017 and 2018 were searched for "meat" (bushmeat and livestock) by border control authorities. Visual identification, radiography and genetic analysis were applied to derive information from seized specimens, including at least ten CITES-listed species. We estimate that an average of 3.9 t of bushmeat is smuggled monthly through Brussels. The average consignment of meat seized per passenger was 2.8 kg and 4 kg of bushmeat or domestic livestock meat, respectively. The international trafficking of bushmeat is evidently active, yet penalties are rarely enforced; hence we provide suggestions to simplify law enforcement procedures.

1. Introduction

Bushmeat is meat derived from wildlife, including all wild, terrestrial or semi-terrestrial animal species [18]. Although wildlife has been hunted for thousands of years, the increase in human population density, infrastructure and access to forest areas is promoting unsustainable levels of bushmeat harvesting, threatening the survival of many wildlife populations [6,7]. Overhunting has the potential to cause local or global extinctions, while also affecting non-target species, species interactions and ecosystem structure and function [6]. There is therefore a need to understand trade dynamics and to reduce pressures on targeted populations. The movement of animal products and close interactions between humans and wildlife also enables the spread of zoonoses and emergence of novel infectious diseases [23,27]. The international movement of illegal meat products which bypass standard regulatory procedures therefore threatens animal and human health through the introduction of pathogens.

In accordance with European Union (EU) Animal Health legislation, the import of personal consignments of meat from third countries into the EU is prohibited (Regulation (EC) 206/2009 and consolidated version, repealed by Regulation (EU) 2019/2122 and consolidated version in 2019). Restrictions on non-commercial imports of products of

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animal origin are considered safeguarding measures, aiming to prevent the introduction of animal and zoonotic diseases and pests into the EU. Importation of bushmeat could also be an infringement of EU Wildlife Trade legislation (Regulation (EC) 338/97 on the protection of species of wild fauna and flora by regulating trade therein, with the most recent amended form in Regulation (EU) 2021/2280) where annex-listed species are brought to the EU illegally. There is currently no general established practise of seizing illegal meat, ensuring investigation of alleged offenses and securing evidence for prosecution through combined enforcement of these regulations, offering support to the perception that importing bushmeat, even from endangered species, can be a low risk, high reward practice [21,24]. While EU Wildlife Trade legislation is generally associated with potentially high national penalties in the case of infringement, the EU Animal Health legislation is still currently not. Factually however, bushmeat from protected species cannot always be visually distinguished from livestock meat. The nature and scale of illegal meat imports, including bushmeat, into the EU is currently unknown as published research offering quantitative evidence is scarce. This is due, in part, to the illegal nature of the practice, meanwhile the concerned Animal Health legislation limits the ability to access and search these products. Evidence of illegal meat entering Europe through commercial flights to Paris and Switzerland has been previously uncovered [9,31] and it is likely that substantial volumes of bushmeat and other animal products are entering undetected through other EU airports. Moreover, once on EU territory, such meat products can be diffused freely throughout the entire EU market.

We describe here an exploration of the nature and scale of the international bushmeat trade in Belgium over a 2-year period from 2017 to 2018. Selected incoming flights from sub-Saharan Africa were intercepted by border control authorities at Brussels Zaventem airport, where all passengers and seized leaking luggage were searched for both bushmeat and domestic livestock meat. Through the systematic inspection of passengers, this study aims to estimate the overall volume of illegal meat entering and transiting through Belgium via commercial flights from Africa. Given the substantial and deleterious impacts associated with the unsustainable and unregulated trade of bushmeat on affected ecosystems, biodiversity and public health, we offer suggestions for active intervention by border control authorities including enhanced surveillance efforts, implementation of stricter penalties and awareness-raising among passengers aimed at discouraging involvement in the illegal importing of meat, with a special focus on bushmeat.

2. Methods

2.1. Passenger screening and sample collection

Support from Brussels-National airport (Zaventem) border control authorities, Inspection Service of the Federal Public Service Health, Food Chain Safety and Environment and the Federal Agency for the Safety of the Food Chain (FASFC) was secured for this study. Between January 2017 and October 2018, flights arriving in Brussels Zaventem from sub-Saharan Africa between 0500 and 0900 h were subjected to special passenger baggage compliance checks ('BACON' actions), in addition to the routine checks. 17 BACON actions were undertaken in 2017 and 9 in 2018 in this airport. During these actions, all passengers were subjected to a thorough inspection of their luggage. Targeted or opportunistic seizures from other passengers during the study period collected by authorities were also included. In addition, leaking luggage isolated during transfer between connecting flights was investigated and any meat products identified were included. Information recorded at the airport was for the *i*th port of origin, number of passengers in the flights from this destination (c_i), number of passengers checked (n_i) and the weight of bushmeat carried by the *j*th passenger (k_{ij}). The estimated weight of meat imported during this period from a given country was calculated by.

$$K_i = c_i \sum k_{ij} \Big/ n_i$$

and the total weight imported across all routes searched is the sum of the country-specific weights. All meat samples were sealed in plastic bags, numbered and placed in a sealed plastic drum for transport to the Faculty of Veterinary Medicine at the University of Liège. The seizures were visually inspected at the university's necropsy room under strict biosecurity safeguards. Bushmeat, livestock and undetermined meat were sampled for genetic analysis while meat with bones was radiographed (Fig. 1).

2.2. Species identification

A total of 194 tissue samples derived from BACON actions and leaking luggage were preserved in 90% ethanol and sent to Laboratoire Evolution et Diversité Biologique at the Université Paul Sabatier Toulouse III (France) for expert DNA-typing based on four mitochondrial genes following Gaubert et al. [14]. Final molecular identification was reached through a consensus-based approach after blasting the nucleotide sequences on DNABUSHMEAT [14] or NCBI [4] when percentages of similarity with the query were below established thresholds [14] (see Supplementary Information, Appendix 1 for expanded protocol).

2.3. Radiographic examination

All specimens seized containing bones were x-rayed at the Medical Imaging Department of the Faculty of Veterinary Medicine from the University of Liège using a direct x-ray machine with flat panel detector. The specimens were kept in sealed plastic bags for biosafety and the equipment was fully disinfected after use. The radiographs were examined by a board-certified radiologist (V.B.) to identify the anatomical region of the specimen, whether the animal was an adult or juvenile and to identify any bullets present or other indications of interest such as fractures as a result of trapping.

3. Results

3.1. Seizure quantity and condition

A total of 1,013,754 passengers from sub-Saharan Africa across 4887 flights arrived at Brussels Zaventem airport between January 2017 and October 2018 (Supplementary Information, Table S1).

Passengers from 1% of these flights were systematically searched (BACON actions) for the carriage of meat. During the study period, a total of 687 kg of meat was found across 173 seizures involving BACON actions (402.8 kg), leaking luggage and opportunistic collection. The quantity of meat derived from livestock (Supplementary Information, Table S2) and bushmeat (Supplementary Information, Table S3) seized per passenger was recorded in conjunction with the flight information and was used to estimate the total import rates. Based on our findings, it is estimated that a total of 80,381.20 kg of bushmeat transited through Brussels airport over the course of the survey (Table 1), equating to 3876.42 kg of bushmeat arriving in, or transiting through, the airport on a monthly basis. It is important to note that not all passengers landing in Brussels necessarily departed here, therefore our calculation is an estimate of the volume of bushmeat exiting and transiting via Brussels airport. Additionally, due to the limited BACON actions performed and therefore sample size, the estimated volume is associated with a large margin of error across the study period.

The average consignment of bushmeat carried by a passenger was 2.8 kg (SD 2.8 kg) with the largest individual consignment being 13 kg. This compares to an average quantity of 4 kg (SD 4.5 kg) and maximum of 32 kg for livestock meat. The Democratic Republic of Congo (DRC) appeared to be the main source of bushmeat based on the percentage of passengers carrying bushmeat (Table 1), although this may be biased

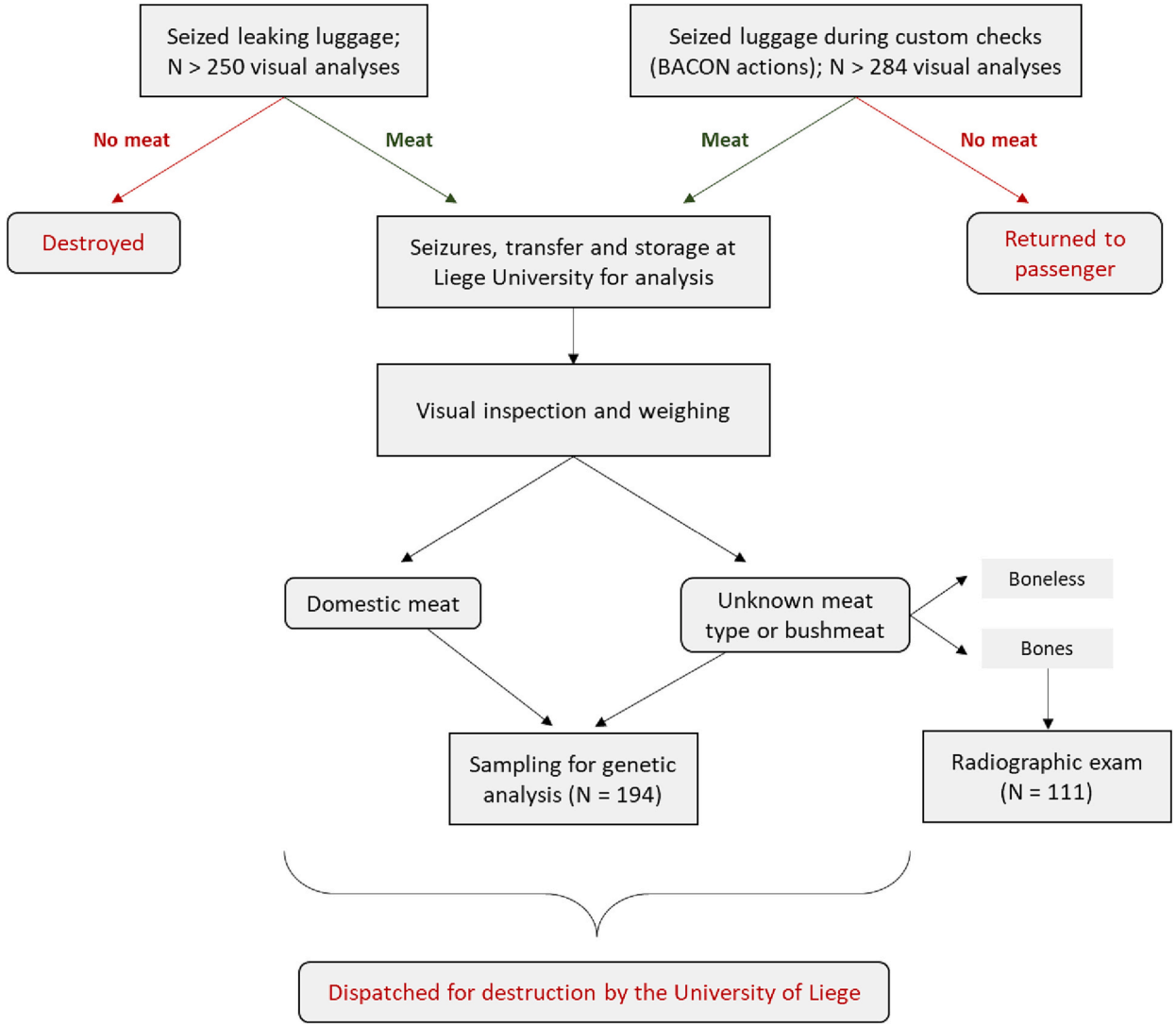

Fig. 1. The illegal meat selection and sampling process implemented by border control authorities at Brussels Zaventem airport during the 2017–2018 survey.

Table 1
Summary of the estimated total rates of bushmeat import arriving from sub-Saharan African departure points at Brussels Zaventem airport between January 2017 and October 2018.

Country	Number of passengers carrying bushmeat	Number of passengers checked*	Percentage of passengers carrying bushmeat*	Estimation of the number of passengers carrying bushmeat^	Mean (kg) of the volume of bushmeat carried per passenger	Std. Deviation of the mean	Estimated volume in kg imported (95% confidence interval)
Burkina Faso	1	34	2.94%	34.53	1.35	0.21	46.61 (±7.32)
Burundi	1	25	4.00%	751.16	4.00	.	3004.64
Cameroon	2	41	4.88%	6658.98	3.66	3.91	24,342.55
DRC#	3	42	7.14%	4412.29	1.93	1.68	8510.86 (±7417.98)
Ethiopia	1	20	5.00%	3400.10	3.50	.	11,900.35
Ivory Coast	1	20	5.00%	4301.05	2.83	2.42	12,171.97 (±10,429.06)
Nigeria	1	25	4.00%	NA	4.00	.	NA
Togo	3	78	3.85%	3617.77	5.64	4.47	20,404.22 (±16,168.24)
TOTAL							**80,381.20 (±60,036.69)**

* The percentage of passengers carrying bushmeat (number of passengers carrying bushmeat versus number of passengers checked) was determined on the following luggage surveillance days: 16/5/17, 30/5/17, 3/6/2017, 20/6/2017, 4/7/2017 and 1/8/17.
^ During the study period (January 2017 to October 2018).
# Democratic Republic of Congo.

based on flight routes targeted by BACON actions. Meanwhile, Togo provided the greatest average quantity of bushmeat per seizure; however, this may have been influenced by one particularly large (12 kg) seizure. All consignments except livestock imports from Uganda averaged 6 kg or less. Similarities were observed between the supplier countries for livestock meat and bushmeat, with the DRC (19% and 28%), Cameroon (12% and 25%) and Togo (10% and 22%) consistently supplying the largest proportions of livestock meat and bushmeat (Supplementary Information, Fig. S1).

The proportion of bushmeat seized by African country-of-origin was calculated (Fig. 2a) and compared with bushmeat seizures in Paris (Fig. 2b) and Switzerland (Fig. 2c), demonstrating similarities in the distribution of origin countries with a concentration mainly around regions of West and Central Africa.

3.2. Bushmeat species

The 194 samples collected during the 2017–2018 study which were subjected to DNA analysis included 100 from leaking luggage, 85 from passengers (BACON actions) and 9 from opportunistic seizures. Among the carcasses and meat items sampled, 62 were a priori identified as livestock and 46 as bushmeat (in this case, with no species-level identification) – representing 11 taxa – whereas 86 (59% of the samples) were of unknown identity (Supplementary Information, Fig. S2). The genetic identification returned 113 livestock, 75 wild and 6 unsolved samples (Supplementary Information, Table S4 and Fig. S3), distributed into 27 (bushmeat) and seven (livestock meat) species-level taxa. Respectively, 38.4% and 58.1% of the 86 samples without taxonomic attribution were genetically assigned to bushmeat and livestock species. Error rates between bushmeat and livestock meat identification varied from 6.5% (livestock meat wrongly identified as bushmeat) to 10.9% (bushmeat wrongly identified as livestock meat). Overall, 90.2% of the original identifications were refined by DNA-typing (16.0% were corrected and 74.2% were improved; Fig. 3 and Supplementary Information, Fig. S4). The seized bushmeat distributed into seven orders of vertebrates, dominated by Rodentia (rodents; $N = 27$), Cetartiodactyla (antelopes and pigs; $N = 19$) and Pholidota (pangolins; $N = 15$) (Figs. 3 and 4). Three species represented almost half of the sampled seizures: the African brush-tailed porcupine (*Atherurus africanus*; $N = 12$), the greater cane rat (*Thryonomys swinderianus*; $N = 10$) and the white-bellied pangolin (*Phataginus tricuspis*; N = 15).

3.3. Radiographic examination

A total of 111 x-rays were taken, from which 94 were relevant (example provided in Supplementary Information, Fig. S5). It was determined that 30% and 56% of the animals radiographed were adults and juveniles respectively, while 14% could not be determined. Most of the pangolins (8 out of 12) and rodents (29 out of 38) were juveniles, while all primates were adults. Bullets were found in 19% of the samples x-rayed.

4. Discussion

4.1. Scale of illegal meat imports arriving in Belgium

Through systematic assessment of incoming commercial passenger flights, our study estimated that approximately 3876 kg of bushmeat is entering Europe through Brussels Zaventem airport each month. Although the estimated volume is small (see below) and potentially associated with a large margin of error, it clearly shows that there is a demand for bushmeat in Europe. In comparison with previous studies, the mean weight of bushmeat per passenger appears to be greater than that found in Switzerland [31], but less than was seen in France [9]. However, in terms of overall volume, Chaber et al. [9] reported that an estimated five tonnes of bushmeat was transiting through Paris Roissy-Charles de Gaulle airport per week, which is five times greater than the almost four tonnes per month transiting through Brussels Zaventem. Chaber et al. [9] suggested bushmeat imported into Paris, with an average consignment weight ten times higher than seen in Belgium, was likely for commercial purposes, therefore implying the bushmeat carried by passengers entering or transiting through Brussels was intended for personal consumption. However, given the luxury bushmeat market in Europe, even small consignments could still prove lucrative if sold commercially [9]. An enquiry in the "Matongé" quarter of Brussels revealed that some shops indeed sold bushmeat, at a luxury price, while not displayed transparently because the practice is known to be illegal by the venders [15]. Moreover, Wood et al. [31] have suggested Brussels airport may be a major hub for the distribution of bushmeat from Africa to Europe. This is also reflected in our findings, where most of the leaking luggage assessed with intact tags was transiting to other European countries, largely to Paris, followed by Geneva and Madrid.

Since the study conducted by Chaber et al. [9] on the international bushmeat trade from West and Central Africa to Europe carried out in 2008 in Paris, EU regulations governing the import of personal consignments of meat were strengthened. However, despite these regulations, our findings demonstrate persistence of the international traffic. Flights arriving from sub-Saharan Africa were targeted through border control authorities on the basis of airport origin due to the predominance of the bushmeat trade in these regions; therefore, randomisation of flights was not employed, possibly overvaluing some flights while undervaluing others. Our study was therefore unable to capture the scale

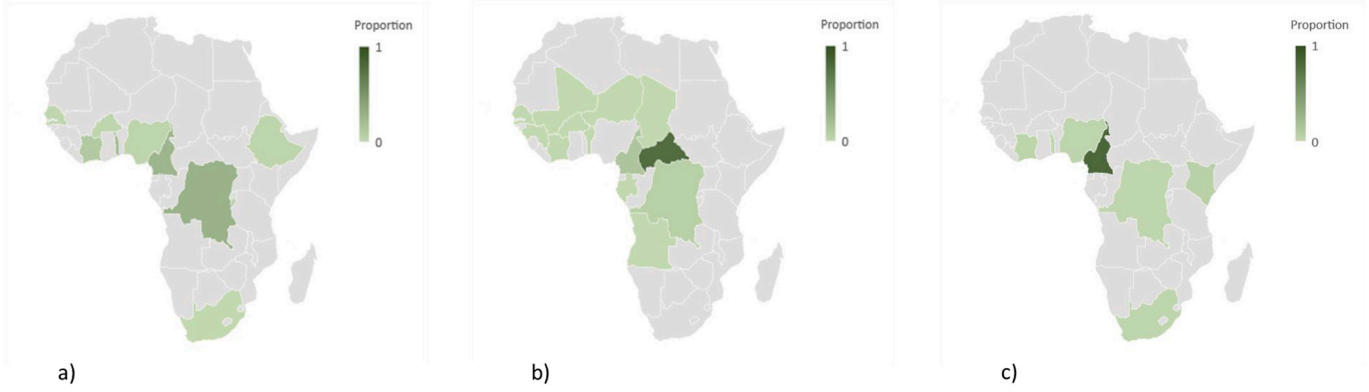

Fig. 2. Origin of bushmeat (by weight) carried by passengers travelling to a) Belgium, b) Paris and c) Switzerland on flights originating from African departure points. Increasing colour intensity represents the proportion of the total quantity of bushmeat seized originating from these regions. Seizures of bushmeat reported in Paris (b) were from passengers travelling on Air France flights arriving at Roissy-Charles de Gaulle airport from Central and West Africa in June 2008 [9]. Similarly, Swiss customs (c) seized bushmeat products transiting through two airports, Zürich Flughafen and Genève Aéroport, between 2011 and 2013 [31].

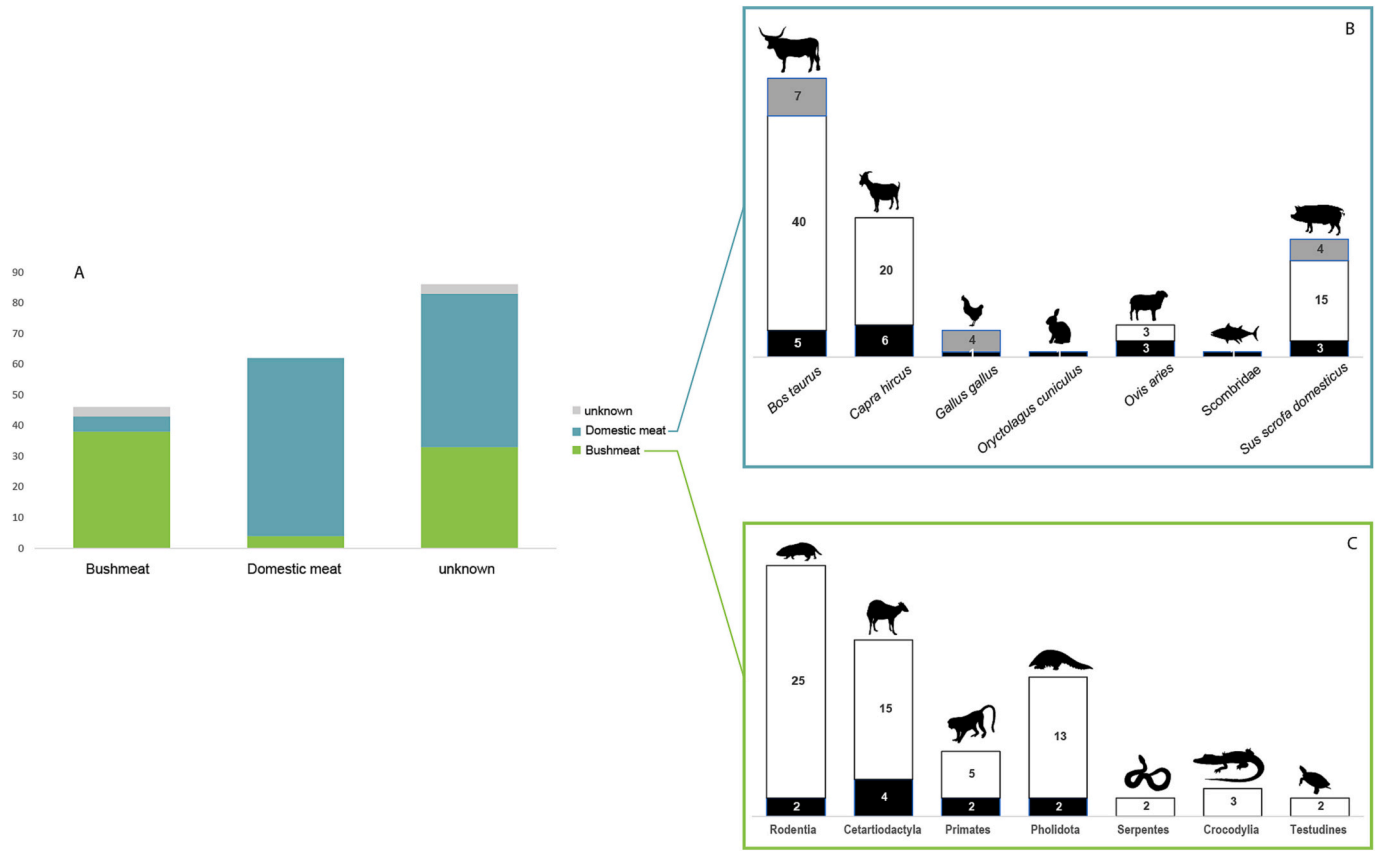

Fig. 3. DNA-typing refinement across samples (A) and taxa (B-C) as applied to the genetic samples taken from flight seizures at Brussels Zaventem airport. A) Genetic re-assignment of sample types from a priori identifications (x-axis); B and C) Taxonomic representation – per species (domestic meat; B) and orders (bushmeat; C) – of the corrections (black area) and improvements (white area) of the seizure samples supported by the DNA-typing approach. Grey areas represent correct a priori identifications (B). Numbers correspond to the sample sizes.

of illegal imports of animal products from other regions prevalent in the wildlife and bushmeat trade, such as Asia. In our study, based on the percentage of passengers carrying bushmeat, the predominant countries from which bushmeat was imported were DRC, Ivory Coast, Ethiopia and Cameroon, echoing findings presented in previous studies [9,31]. Flight path limitations may explain why the distribution of origin countries was narrower than what was found in previous studies where, for example, a significant proportion of bushmeat products arriving in Paris originated from the Central African Republic (CAR; [9]), yet there are no direct flights from CAR to Belgium. Nevertheless, it is apparent that most bushmeat is being imported from known hotspots of trade activity in West and Central Africa [13,33]. A pan-European study is required to estimate the full scale of illegal bushmeat trafficking to Europe, the routes used, the associated risks for biodiversity and health, and the new measures needed to limit this import and its risks.

4.2. Public health concern

One of the emerging issues associated with the illegal movement of bushmeat is the potential for the spread of zoonoses and other pathogens of public health concern [19,27]. Seized bushmeat specimens in this study were not tested for pathogens, however previous studies have detected the presence of viruses including Monkeypox, Ebola and Henipavirus in bushmeat [23,27,29], meanwhile retrovirus and herpesvirus DNA have been detected in non-human primates illegally imported into the United States [27]. Unsanitary conditions, poor hygiene and unregulated handling procedures associated with bushmeat preparation and transport also promote bacterial contamination. However, the way in which a product is processed can reduce the likelihood of contamination, where for example smoked bushmeat is less likely to contain detectable pathogens than raw meat [22]. Evidence of food-borne bacteria in bushmeat carcasses, such as Listeria associated with pangolin, primate, crocodile, duiker and greater cane rat transported internationally, have the potential to cause illness if consumed [8]. The illegal importation of domestic meat products also carries significant risks which could threaten local livestock industries, economies and human health [32]. Diseases of concern carried by these products may include foot and mouth disease, African swine fever, classical swine fever and swine vesicular disease [26,32]. The major African swine fever outbreak in Belgium between 2018 and 2020 highlights the severity of such an incursion [5]. Bushmeat could potentially also be the source of new pathogens different from those already known in livestock. It is important for authorities to mitigate the potential public health risks, particularly from high-risk taxa [30], through confiscation of illegal meat products and appropriate analysis of all meat samples collected.

4.3. Accurate species identification through DNA-typing and conservation implications

DNA-typing proved critical in determining the taxonomic identity of seized meat, refining more than 90% of the original identifications. Such value is much greater than those reported in recent studies from West and Central Africa (43–57%; [11,16]), likely because of a European context affected by limitations in custom officer's taxonomic expertise, the processing or degradation of the bushmeat items and passengers' non-willingness to declare products. The taxonomic spectrum of the 27 bushmeat species seized appeared correlated with that of local African marketplaces, with Rodentia and Cetartiodactyla being the most

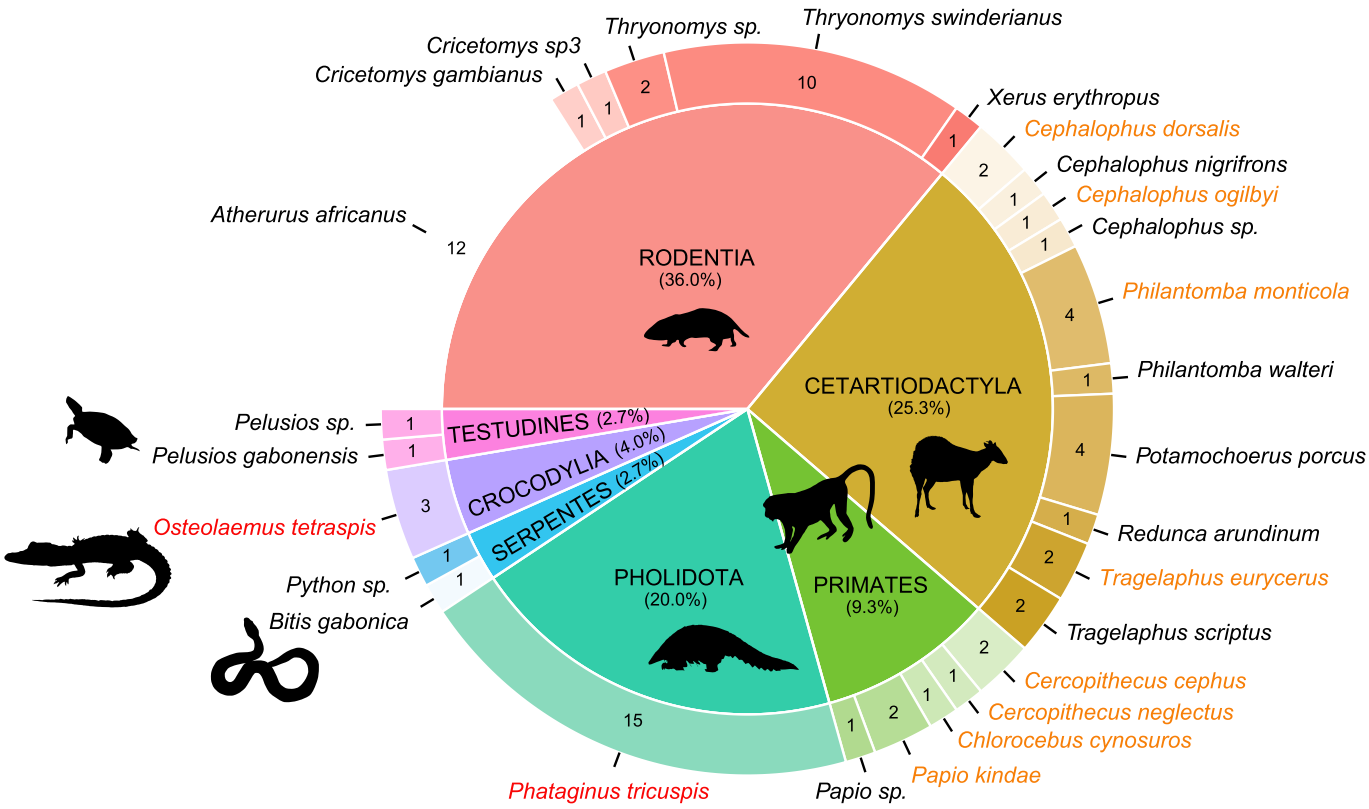

Fig. 4. Pie-Donut chart representing the DNA-typing taxonomic assignment of the bushmeat species seized from flights originating from sub-Saharan Africa to Brussels Zaventem airport. In capitals (pie), taxonomic orders with their respective contributions (in brackets) relative to the total number of genetic samples. In the donut, the 27 species-level taxa genetically identified, together with their sample sizes. Species in red and orange are listed on the Appendices I and II of the CITES, respectively. The Pie-Donut chart was built using *webr* package in R. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

represented taxa [25].

Among the bushmeat specimens seized were ten CITES-listed species (Appendices I and II) with implied trade restrictions. CITES-listed samples represented 17% of all typed samples and 44% of bushmeat samples, slightly higher than seizures identified in Paris (39%; [9]) and in Switzerland (35%; [31]). The presence of CITES-listed species infringes EU wildlife trade legislation (Regulation (EC) 338/97), which should be of immediate concern to CITES, and may suggest a lack of enforcement. Furthermore, none of these species were correctly identified visually, necessitating the input of DNA-typing in tracing the wildlife trade, notably for Appendix I species including the white-bellied pangolin (*P. tricuspis*) and the African dwarf crocodile (*O. tetraspis*).

Meanwhile, non-CITES-listed species may also be of concern if not protected from overhunting promoted by international demand. Radiological analysis revealed a large proportion of specimens were juveniles, similar to previous studies [12,20], even though logically adult animals should be the main targets for hunters due to their larger body size. Possible reasons for this include ease of capture, high demand for bushmeat or depleted adult populations [12], where these characteristics are important to understand from a conservation perspective.

4.4. *Legislative requirements and recommendations to mitigate the illegal movement of meat in Europe*

Enhanced surveillance and legislative enforcement are required to monitor the illegal movement of meat, as the penalties are currently minimal and rarely enforced while the financial reward for importing bushmeat is potentially high [9]. The movement of CITES-listed species is of particular concern, where the penalty for transporting these specimens without appropriate certificates is a fine of up to 50,000EUR with possible imprisonment for up to 5 years in Belgium (Art 5, CITES law, 1981). Regulations need to be tailored towards enabling border control authorities to implement interventions along the supply chain, seize meat products and to promptly commence the prosecution of potential CITES infringements, even before species or CITES confirmation, to deter future trafficking attempts. However, as seized meat is typically incinerated at airports, prosecution evidence is lost and the likelihood of penalty enforcement is low [9]. During the study, it was evident that customs officers required, and often requested, additional training to identify infringements and so enforce CITES, as inaccuracy and error rate in morphological identification were high. Regarding the protection of overhunted species not yet included in the CITES list, these concerns should be taken into account in regular re-evaluation of CITES categories and in collaboration with CBD (Convention on Biological Diversity), particularly with regards to Target 5 of the Kunming-Montreal Global Biodiversity Framework [10], and with programmes such as the Sustainable Wildlife Management Programme developed by a consortium of international and national organizations to improve regulation of wildlife hunting and reduce the demand for wild meat in African countries [28].

We propose here a further simplification of control and law enforcement procedures by requiring all incoming passengers to complete a declaration card upon entry to the EU, similar to the Incoming Passenger Card issued for international visitors to Australia. Australian biosecurity laws under the Migration Act (*Migration Act 1958* and the *Migration Regulations 1994*) require all passengers travelling to Australia to declare any food, animal materials or plant products they may be carrying in order to prevent serious pests or diseases entering Australia [2]. This system would negate the need for authorities to immediately identify meat samples. Instead, giving false information on this card

could incur a heavy fine, directly enforceable by border control authorities. These samples should subsequently be subjected to DNA-typing for accurate species identification and issuance of appropriate penalties. Air transport companies should be actively involved in the fight against wildlife trafficking by distributing these declaration cards to passengers and projecting a short video explaining the penalties associated with providing false information to authorities. While implementing these suggestions may take some time, we believe that such a simplified system will assist in capturing more illegal trade activity and ultimately reduce the flow of illegal meat and wildlife products into the EU. In the meantime, the immediate focus should involve interventions which allow stricter enforcement of EU Animal Health and Wildlife Trade regulations with enhanced disciplinary action for offenders.

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CRediT authorship contribution statement

Anne-Lise Chaber: Conceptualization, Methodology, Investigation, Funding acquisition, Writing – original draft, Writing – review & editing. **Georgia Kate Moloney:** Writing – original draft, Visualization, Writing – review & editing. **Veronique Renault:** Methodology, Investigation, Writing – review & editing. **Sandrella Morrison-Lanjouw:** Writing – review & editing. **Mutien Garigliany:** Methodology, Investigation, Writing – review & editing. **Lucette Flandroy:** Investigation, Writing – review & editing. **Daniel Pires:** Formal analysis, Investigation, Writing – review & editing. **Valeria Busoni:** Investigation, Resources, Writing – review & editing. **Claude Saegerman:** Methodology, Investigation, Validation, Funding acquisition, Project administration, Writing – review & editing. **Philippe Gaubert:** Methodology, Investigation, Formal analysis, Visualization, Data curation, Funding acquisition, Resources, Supervision, Writing – review & editing.

Declaration of Competing Interest

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

Data availability

Supplementary Information has been provided with the submission of this manuscript. Additional data is confidential and therefore cannot be shared.

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