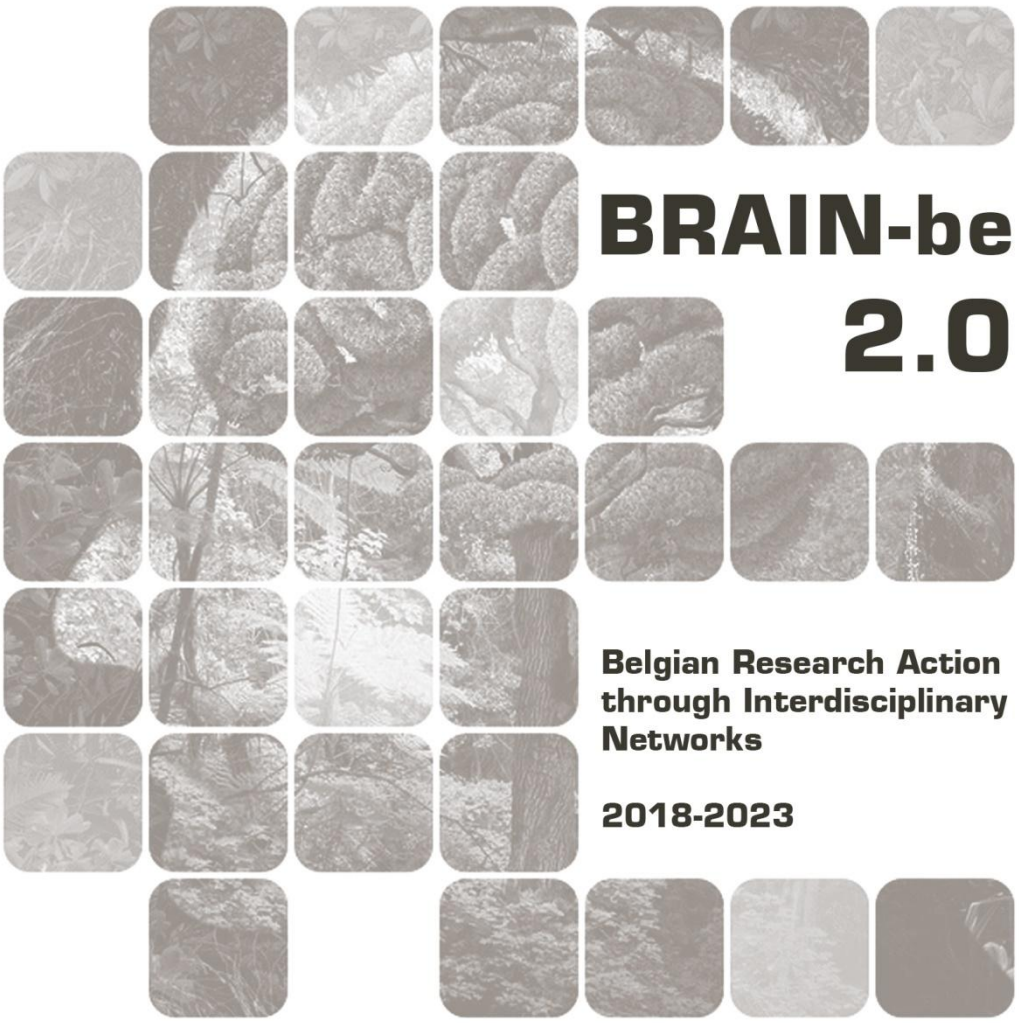

INTERCEPT

Monitoring the trade of exotic animals, wild meat and the pathogens they carry

Pillar 3: Federal societal challenges

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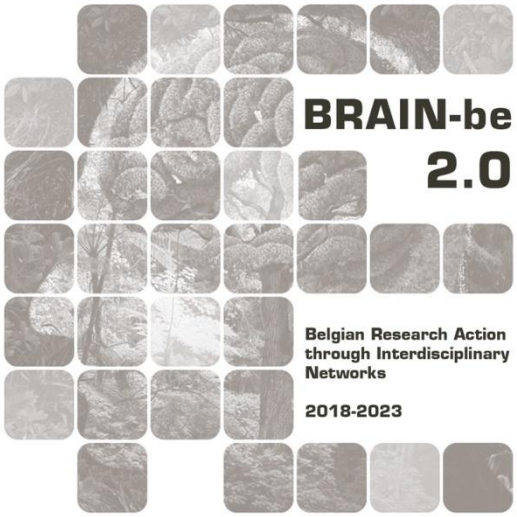

NETWORK PROJECT

INTERCEPT

Monitoring the trade of exotic animals, wild meat and the pathogens they carry

Contract - B2/ 223 / P3 / INTERCEPT

FINAL REPORT

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ABSTRACT

Context

Animals and animal products are imported on a daily basis into Belgium, some legally, some illegally. In Belgium, several government agencies at the federal level are competent to control and document the legal and illegal import of meat, animal products and wildlife and exotic pets. Each agency, however, currently works within its own framework and collects data tailored to its specific needs. A vital part of the action plan towards the fight against illegal import of exotic animals and wild meat, especially with the aim to reduce the risk of importing and spreading zoonotic pathogens, is to obtain a scientific evaluation of the scale and risks of the exotic animal and wild meat trade based on an integrated data collection.

Objectives

INTERCEPT aimed to develop a sustainable workflow for monitoring the import of exotic animals and wild meat into Belgium and its associated health risks. This entailed: mapping the pathways, agencies and existing data sources involved in this trade; designing and building a prototype centralised database with user-friendly data-entry tools; establishing and field-testing standardised protocols for sample and data collection (for both biological researchers and non-researchers); establishing and validating laboratory protocols for DNA-barcoding-based species identification and for unbiased metagenomic pathogen detection; using these to characterise the taxonomic diversity of intercepted meat and the pathogens it carries; and translating all findings into concrete recommendations for decision-support, disseminated to policymakers and stakeholders through dedicated workshops.

Conclusions

The project mapped the full landscape of Belgian import-control agencies and their data sources, identifying substantial fragmentation and formulating source-specific recommendations for harmonisation and digitisation. Building on this, a prototype centralised database was developed, demonstrating that integrating these sources is technically feasible, though challenged by lack of data harmonisation. We provide a roadmap toward a future harmonised, interoperable and ultimately FAIR database.

Standardised meat sampling and laboratory protocols for animal species identification and pathogen detection were established, tested and disseminated. Applying these, 637 meat specimens were sampled during 28 Baggage Control and 8 luggage-destruction actions (August 2023–December 2024); 569 were identified to species level, of which 24.6% were confirmed as wild meat spanning at least 25 species (17 CITES-listed). Unbiased metagenomic screening of 35 sample pools detected viruses in 88.6%, and viruses of veterinary or zoonotic concern in 74.3% of the pools, including five WOAH-listed pathogens (African swine fever, avian influenza, Newcastle disease, infectious bronchitis, Peste des petits ruminants). Domestic meat, carried a higher prevalence of these well-characterised pathogens, while the wild-meat virome remains comparatively under-characterised.

The final roadmap towards sustainable monitoring of the import of exotic animals, wild meat and the pathogens they carry is presented to the FPS Health.

Keywords: wildlife trade; wild meat; domestic animal meat; biodiversity; database; DNA barcoding; veterinary diseases; zoonotic disease surveillance; metagenomics

1. INTRODUCTION

Wild meat is an important food source in many regions of the world. Especially where meat from domesticated animals is scarce or expensive, it often represents the primary or only source of animal protein (Swamy and Pinedo-Vasquez 2014; Wilkie et al. 2016). In such areas, the wild meat trade also generates income by providing cash through trade (Nasi et al. 2008; Brown and Marks 2008). In addition, hunting and the consumption of wild meat are integral parts of the cultural heritage of many communities and extends to the expatriate urban elite who consider it a delicacy and a way to maintain links with a traditional lifestyle (Cawthorn and Hoffman 2015; Ichikawa et al. 2016). This taste preference and desire to retain cultural ties has generated an international market for wild meat, with widespread organised trade networks feeding this international demand (Chaber et al. 2010). There is no reliable information on the scale of the international wild meat trade, yet there is growing evidence that the amount of bushmeat imported in Europe is substantial (Chaber et al. 2010; Falk et al. 2013). Recent reports estimate that each month an average of 3.7 tonnes of wild meat is being imported into Belgium through Brussels Airport (Chaber et al. 2020) and demonstrate that a clandestine market for wild meat exists in Brussels (Gombeer et al. 2021). The trade in exotic animals for pets is a centuries old practice, but the globalisation and liberalisation of the market make it difficult to monitor this phenomenon, especially its hidden sides, the illegal and unregulated wildlife trade (UNEP, 2017).

While the legal trade is regulated by the United Nations Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which concerns about 5950 animal species, the illegal wildlife trade involves the illegal smuggling, poaching, capture, collection or trade of endangered species and protected wildlife (Fukushima et al., 2020). The unregulated wildlife trade also concerns the commercial trade of non-domesticated animals raised in captivity or extracted from their natural environment, but it is not subject to any legal or regulatory framework (UNODC, 2020; UNEP, 2017). The legal trade of CITES-listed species is being monitored, yet establishing the traceability for other exotic wildlife in Belgium is difficult as official data characterising the trade are scarce and anecdotal. TRACES (Trade Control and Expert System) monitors and provides data on the import, export and intra-EU trade of live animals. The database focuses on the monitoring of trade flows for sanitary purposes (TRACES webpage), yet does not collect comprehensive biodiversity-oriented and detailed taxonomic data (Biondo, 2017).

There are several reasons why the (illegal) import of exotic animals and wild meat into Belgium is a matter of concern. For example, studies on the import of wild meat conducted at European airports

identified multiple species that are listed as vulnerable or critically endangered on the International Union for Conservation of Nature's (IUCN) Red List or that are protected under the CITES regulation (Chaber et al., 2010; Wood et al., 2014; Falk et al., 2013; Chaber et al., 2020).

Another cause for concern is the health risk that the uncontrolled importation of exotic animals poses to public health, livestock, and local biodiversity in destination countries through the transmission of exotic infectious diseases. An estimated 60 to 75 % of the emerging infectious diseases in humans are of zoonotic origin (Bair-Brake et al. 2014; Cawthorn and Hoffman 2015; Smith et al. 2012; Wood et al. 2014). Animal-borne pathogens that otherwise would remain secluded to wildlife in their natural environment may find a way to susceptible human populations via wildlife hunting, the processing and consumption of wild meat and the wild meat trade. For example, there is solid scientific evidence that Ebola, the human/simian immunodeficiency viruses that cause AIDS, the monkeypox virus and more recently SARS-CoV and SARS-CoV-2 have repeatedly emerged by transmission from animals to humans through wild meat related activities (Kurpiers et al., 2015; Lytra et al. 2021, Gryseels et al. 2020; Keele et al., 2006; Chen et al., 1997; D'arc et al., 2015; Ayouba et al., 2013). In addition, the unhygienic butchering, storage and transport conditions often result in (superficial) contamination with bacteria of which some are associated with foodborne illnesses, e.g. *Salmonella* spp*., Listeria monocytogenes* and *Staphylococcus aureus* (Schoder et al. 2015, Rodríguez-Lázaro et al. 2015, Beutlich et al. 2015, Jansen et al. 2019, Chaber & Cunningham 2016). While smoking the meat for preservation and transport may decrease the transmission potential, several studies report that also fresh/raw wild meat is imported into Europe and the US (Wood et al. 2014; Falk et al. 2013; Smith et al. 2012; Marris 2006), increasing the infection risk.

2. STATE OF THE ART AND OBJECTIVES

State of the art

In Belgium, several government agencies at the federal level are competent to enforce international, European and Belgian laws aimed at preventing the illegal import of wildlife, banning the importation of meat (products) by passengers, addressing the illegal trade in exotic animals for the pet trade, avoiding the introduction of invasive alien species and the import of transmittable animal diseases. Each agency, however, currently works within its own framework and collects data tailored to its own needs. In addition, data from controls and confiscations are not routinely recorded. At present for example, intercepted illegally imported wild meat is seized and destroyed without gathering any information on its origin, the species or the eventual pathogens present. For Belgium, no systematic records exist on the importation of exotic animals, except when it concerns the legal trade of CITES-listed species and data available through TRACES. There is also no systematic database on the scale of the international trade in wild meat, except the estimate that 3.7 tonnes are illegally imported every month (Chaber *et al.*, 2020). Belgium is also an important hub for international transport via ships, trains and postal services, yet to date there is little information on the use of these routes for the import of exotic wildlife and derived products.

Objectives

The aim of the project INTERCEPT was to develop a fully operational and robust data collection workflow for the efficient, safe and sustainable monitoring of the import of exotic animals and wild meat into Belgium and of the associated health risks. To guarantee the quality of the information collected over time by participating agencies and different laboratories, the protocols will be based on well-established scientific methods which have already proven their usefulness and reliability in this context.

To summarise the current knowledge on the international trade in exotic animals and wild meat, on the scale, mode and diversity of the import into Belgium, as well as on the various state-of-the-art methods to collect data and analyse biological samples, a comprehensive **literature review** of scientific papers and reports published by NGOs and governmental institutes will be conducted.

We aimed to **design a database** that will centralise all data related to the import of wild meat, exotic and animals and the possible associated pathogens and will eventually provide the basis to efficiently monitor the import of exotic animals and wild meat. Via a connected on-line tool the federal governmental officers from customs, FAVV, Sciensano and RBINS would ideally be able to enter data on e.g. the number, volume, taxonomic identity and possible associated pathogens of the intercepted exotic animals and wild meat directly into the database. When developing the database and data-entry tools, the insights from the literature study will be taken into account, the user-friendliness of data entry will be maximised and throughout the duration of the project the data-entry modalities will be further optimised according to the needs and suggestions of the agents and inspectors in the field. The goal of the project is to centralise all data allowing different levels of access to enter or retrieve information depending on the needs and jurisdictions of the different federal agencies, taking into account the available regulations regarding the acquisition, storage and usage of sensitive and personal data.

We will organise several **workshops** with all partners and advisors at different stages of the project to discuss needs, issues and concerns in order to continuously optimise and fine-tune the database and protocols to be used in the field.

We will establish **field protocols** of how to identify exotic animals and wild meat, how to document the confiscated material using photographs, how to safely take samples suited for molecular analyses of both species identification and pathogen detection, how to safely dispose of the carcasses, or how to keep live exotic animals while awaiting approval for import.

We will next **train officers in the field** to perform these field protocols and to enter the data in the database.

The **laboratory protocols for the species-level identification** of the traded animals and meat samples will be established based on DNA-based methods that are widely accepted in forensic investigations (e.g. Tobe and Linacre, 2010; Gaubert et al*.,* 2015). Similarly for the **analysis of the pathogens**, standard pathogen detection protocols will be gathered. The protocols for the laboratory analyses will

be extensively tested to assure continuity of the acquired data over time and across different laboratories. The analyses of the species-identification of the traded species and the detected pathogens that were found, will lead to an updated **risk assessment of the import of exotic animals and domestic and wild meat** into Belgium.

After performing trial runs of the entire workflow from interception to DNA-based species identification and pathogen detection, a final **workshop** will be organised to discuss the findings, and provide an opportunity for all the stakeholders to provide feedback on the protocols, workflow and database. Based on these findings and feedback, the **finalised workflow** (the optimised field protocols and lab protocols, the database and its entry tools) will be established and presented to the federal government and the relevant governmental agencies.

3. METHODOLOGY

WP 1: Exploring the current situation and future needs.

Task 1.1: Literature review.

Scientific peer-reviewed literature

A scoping literature review was carried out on 2023-02-16 according to the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR; Tricco 2018). Titles, abstracts and keywords (topic) in the Web of Science Core Collection published between 2013-01-01 and 2023-02-16 were searched with the Boolean search string TS=((import OR imports OR imported OR trade) AND (eu OR europe* OR belgi* OR brussels OR antwerp) AND (meat OR wildmeat OR gamemeat OR bushmeat OR (animal AND product*) OR egg OR eggs OR caviar OR milk OR dairy OR (wild AND animal*) OR (exotic AND animal*) OR pet OR pets OR fish OR shark* OR ray OR rays OR amphibia* OR frog OR reptil* OR bird* OR mammal*)). Because of this review's special focus on Belgium, the search terms included 'belgi*', covering both 'Belgium' and 'Belgian' and 'Brussels', the capital with nearby the country's main airport (Brussels Airport). We may have missed a few extra results that only mention other points of entry into Belgium. However, including search terms for other potentially import entry points such as 'Antwerp', Belgium's second largest metropolitan region with the country's main port, did not result in any additional search results. The search terms 'fish', 'shark*' and 'ray'/'rays', 'amphibia*', 'reptil*' , 'bird*', and 'mammal*' cover the main vertebrate classes. The term 'frog' was used in addition to 'amphibia*' to include search results on frog legs, meat that is not always named 'meat', but can even be legally imported into the EU from third countries in personal luggage. Including the search terms 'wildmeat' or 'gamemeat' did not result in any additional search results, in contrast to the inclusion of the search term 'bushmeat' (2 additional results). The final search returned 2,251 results, filtered to 2,181 after removing duplicates and reports in languages other than English, Dutch or French. We further filtered the list of manuscripts by screening titles, abstracts and key words for eligibility. Search results on actively imported vertebrate animals, their meat, eggs or dairy products and/or associated risks (including invertebrate ectoparasites) from outside the European Union into the European Union in modern times were retained. Associated risks were restricted to those that can propagate further once introduced, such as pathogens/parasites or live (invasive) animals.

The information from the scientific peer-reviewed literature review will be used in our scientific manuscript about the pathogen detections in passenger-imported meat products and the risks of this importation route.

Task 1.2: Bilateral discussions with all involved federal agencies and stakeholders

We carried out bilateral discussions via 1-3 hour live or on-line meetings with the following agencies and entities:

- TRAFFIC (NGO tackling the illegal wildlife trade), brainstorm on current situation of wildlife trafficking and agencies involved. Present: Stephanie von Meibom, Magdalena Norwisz, Sophie Gryseels, Laura Cuypers, Erik Verheyen. 15/02/2023.
- CITES unit of FPS Public Health. Present: Elke Malfait, Sarah Van Staen, Sophie Gryseels, Laura Cuypers, Erik Verheyen. 21/02/2023
- Federal Agency of the Safety of the Food Chain (FASFC), DG Control, central service for Import, Export and Notifications. Present: Xavier Pattigny, Rixta Lycklama A Nijeholt (DG control) & Perrine Godart from FASFC, Sophie Gryseels, Laura Cuypers. 22/03/2023
- Institute for Nature and Forest research (INBO), brainstorm on carcass and sample collection management and whether introduced animals are monitored by INBO. Present: Emily Veltjen (INBO), Sophie Gryseels, Laura Cuypers, Erik Verheyen. 28/04/2023.
- FASFC border control post Zaventem. Present: Benedikte Verstreken & Joris Parmentier from FASFC; Sophie Gryseels, Laura Cuypers, Erik Verheyen. 22/05/2023
- Customs (Operations, Central Component, Non-Fiscal unit). Present: Bart Coessens, Patrick Versluys, Delphine Lejeune, Sophie Gryseels, Laura Cuypers, Erik Verheyen. 14/04/2023.
- Customs (Operations, Central Component, Non-Fiscal unit), new contact person: Ioan Mihai Szalo. Present: Ioan Mihai Szalo, Sophie Gryseels, Laura Cuypers. 27/11/2023.
- SANIPORT (FPS Public Health). Present: Nyota Kalimira, Maud Istasse, Elke Malfait, Sophie Gryseels, Erik Verheyen, Laura Cuypers. 02/06/2023.
- FASFC National Investigation Unit (NIU). Present: Yves Martin, Sophie Gryseels, Laura Cuypers. 28/11/2023.
- Customs, Risk Management Unit. Anaëlle Tilborg, Sophie Gryseels, Erik Verheyen, Laura Cuypers. 07/06/2023.
- Visit to Natuurhulpcentrum Oudsbergen (wildlife rescue center, including confiscated trafficked exotic animals). Present: Frederik Thoelen, Laura Cuypers, Sophie Gryseels, Erik Verheyen, Sophie Philtjens. 11/01/2024.
- FASFC: TRACES data responsibles. Present: Rixta Nijeholt, Peter Gysegom, Hadewich Lempens, Lies Adriaenssen, Jellen T'jaeckx, Laura Cuypers, Sophie Gryseels, Erik Verheyen. 02/02/2024
- Centre for IT & IP Law (CITIP), KU Leuven. Present: Nathalie Bertels, Maud Istasse, Laura Cuypers, Sophie Gryseels, Erik Verheyen. 22/03/2024.
- Visit Cargo (Brussels Airport) and FASFC border control post Zaventem. 03/04/2024
- Instituut voor de Overheid (KU Leuven). Present: Joep Crompvoets, Laura Cuypers, Sophie Gryseels, Paola Burelli, Peter De Maeght (FPS Health). 08/07/2024

- Instituut voor de Overheid (KU Leuven). Present: Frankie Schram, Laura Cuypers, Sophie Gryseels, Paola Burelli, Erik Verheyen, Peter De Maeght (FPS Health). 28/08/24 + 10/09/24

These meetings enabled us to create a roadmap of the pathways that wild meat and exotic animals are legally and illegally imported into Belgium, at which paths are controls by relevant authorities carried out (how frequently, what is targeted?) and where, how and which data is stored, and how to further access the existing data, and what legislative protections allow for data-sharing or not. To complement information for this roadmap, we interviewed various agents and officers of FASFC, customs and SANIPORT during their work at airport control actions, to gage at their first hand of experience of how controls are conducted, how they record the data where the data is sent to. We performed these non-structured qualitative interviews during the "BaCon" actions (bi-monthly luggage controls of selected flights) and the "leaky luggage"actions (destruction of leaking and perceived unsanitary luggage, conducted every 6-8 weeks) during which we were present (see below).

Task 1.3: Workshops.

Workshop 1

We organized a first workshop with stakeholders on May 31st 2024. We invited three external expert speakers: Justine Guiny from the NGO TRAFFIC, researcher on environmental law Farah Bouquelle (UGhent) and anthropologist studying wild meat consumption Sandrella Morrison-Lanjouw (Utrecht University). We next presented the preliminary results of INTERCEPT thus far, and next invited all speakers and expert stakeholders for a panel discussion. Forty-six people from 20 different organisation registered and participated. The program can be found in Figure 1 and the participant list in Table 1. Notes about the workshop are in the Results section.

Figure 2.1. Program of the workshop on the scale and risks of import of animals and animal products we organized at RBINS on 31/05/2024, and pictures taken during the workshop.

Table 1. List of 46 participants from 20 different organisations to our workshop on animal product importations.

Name	Organisation
Ioan Szalo	Customs
Barbora Krizova	DG Environment
Sophie Azam	DG Environment
Audrey VELDEMAN	FAVV/AFSCA
Aurélie Vandermeulen	FAVV/AFSCA
Benedikte Verstreken	FAVV/AFSCA
Jessie Vandyck	FAVV/AFSCA
Laurien Bets	FAVV/AFSCA
Maude Lebrun	FAVV/AFSCA
Peter Gysegom	FAVV/AFSCA
Pieter-Jan Swijsen	FAVV/AFSCA
Rixta Lycklama à Nijeholt	FAVV/AFSCA
Xavier Patigny	FAVV/AFSCA
Catarina Santiago	Federation of Veterinarians of Europe
Gonçalo Oliveira Portela	Federation of Veterinarians of Europe
Christiaan Ceusters	FOD VVVL - CITES
Elke Malfait	FOD VVVL - CITES
Miet Van Looy	FOD VVVL - CITES

Maud Istasse	FPS Health
Peter Demaeght	FPS Health
Lieze Rouffaer	Ghent University
Inge Dedding	Netherlands Food and Consumer Product Safety Authority
Jane reniers	NSSIAS
Brigitte Segers	RBINS
Erik Verheyen	RBINS
Francis Strobbe	RBINS
Laura Cuypers	RBINS
Léa Fourchault	RBINS
Paola Burelli	RBINS
Samuel Vanden Abeele	RBINS
Sophie Gryseels	RBINS
Thierry Backeljau	RBINS
Jan Van den Berghe	Rechtbank van eerste aanleg Gent
Fanny KRATZ	Royal Museum for Central Africa
Nathalie Smitz	Royal Museum for Central Africa
Nyota Kalimira	Saniport
David Fretin	Sciensano
Maud Papageorges	Sciensano
Michèle Driesen	Sciensano
Sanne Terryn	Sciensano
Justine Guiny	TRAFFIC
Mare Geraerts	University of Antwerp
Farah Bouquelle	University of Ghent
Sandrella Morrison-Lanjouw	University of Utrecht
Caroline Abid	Wildlife Conservation Society
Valeria Colombo	WOAH
Divija Jata	Belgian Biodiversity Platform
Barbara Soto-Largo	DG ENV F3
Selby Zuma	Ecology Africa Foundation
Frederik Mahieu	FOD Financiën - Douane en Accijnzen - OPS CC Niet-Fiscale Materies
Sarah Van Staen	FOD VVVL - CITES
Ilaria Di Silvestre	IFAW
Karin Breugelmans	RBINS
Kelle Moreau	RBINS (CITES Scientific comittee)
Jon Garcia	TRAFFIC
Nicola Okes	TRAFFIC
Alexia Dimopoulos	ULB
Emily Patterson	University of Leicester
Samuel Akpan	Wageningen University
Arnaud Goessens	Wildlife Conservation Society

Workshop 2

We organised a second workshop together with the FPS Health (Maud Istasse and Peter Demaeght) and WWF France (Lorélie Escot) on the illegal importation of wild meat on 12/12/2024. This workshop was also part of a multidisciplinary and interministerial task force that is working on a Belgian action plan to improve legislation on wild meat imports. It was held at the conference rooms of the Galileo building (where FPS Health is housed). There were expert presentations (incl. about INTERCEPT) as

well as presentations from stakeholders in airport organisation and control agencies, and break-out sessions that allowed for in-depth discussion on postulated problems. The program can be found in Figure 2.

Agenda workshop on the illegal importation of wild meat

12/12/2024

MORNING SESSION - Auditorium Hâlsa (00.A1 - groundfloor)

9.15 - 9.45	***Registration and coffee***	
9.45 – 9.50	*Opening speech by the Chair*	***Sophie Gryseels**, Royal Belgian Institute of Natural Sciences and coordinator of INTERCEPT*
9.50 – 9.55	*Welcome speech*	***Pierre Kerkhofs**, Director general, DG ENV, FPS Health, Food Chain Safety and Environment*
PART ONE: SETTING THE SCENE		
9.55 – 10.10	*Setting the scene: overview of the scale and characteristics of the illegal wild meat trade*	***Justine Guiny**, Senior Policy Manager, TRAFFIC* & ***Lorélie Escot**, Head of the "Illegal wildlife trade & Human-wildlife coexistence" Programme, WWF France*
10.10 - 10.20	*The Belgian draft action plan to combat the illegal importation and consumption of wild meat: an overview*	***Maud Istasse**, DG ENV, FPS Health, Food Chain Safety and Environment & pilot of the Belgian Task Force on Sustainable Wildlife Trade*
10.20 – 10.55	*"Action de la douane française pour lutter contre l'introduction de produits carnés dans les bagages voyageurs"* - Action from French customs to combat the introduction of meat products in passenger's luggage*	***Benjamin Baud**, Chef du Bureau "Restriction et sécurisation des échanges", Direction générale des douanes et droits indirects, Customs, France*
	"Initiatives menées auprès des compagnies aériennes et des autorités étrangères" - Initiatives taken with airlines and foreign authorities*	***Morgan Verin**, Chef de programme "Facilitation, Direction générale de l'aviation civile / Directorat of civil aviation", France*
	These two presentations will be in French, with an interpretation provided in English	
PART TWO: IMPORTATION ANALYSIS ROUTES		
10.55 - 11.00	*What actions are foreseen at the Belgian level?*	***Peter Demaeght**, DG ENV, FPS Health, Food Chain Safety and Environment*
11.00 - 11.25	*The scale of exotic (wild) meat import into Belgium: Findings from the INTERCEPT project*	***Laura Cuypers**, Royal Belgian Institute of Natural Sciences*
11.25 - 11.35	*Q&A*	
11.35 - 11.55	***Coffee break***	
PART THREE: HEALTH RISKS		
11.55 - 12.00	*What actions are foreseen at Belgian level?*	***Peter Demaeght**, DG ENV, FPS Health, Food Chain Safety and Environment*
12.00 - 12.25	*Diverse pathogens detected in animals involved in the wild meat trade: implications for public health*	***Sophie Gryseels**, Royal Belgian Institute of Natural Sciences*
12.25 - 12.35	*Q&A*	
PART FOUR: COLLABORATION WITH THE PRIVATE SECTOR		
12.35 - 12.50	*Private sector engagement against the illegal wild meat trade: the example of Air France in raising-awareness and communicating towards its staff and clients*	***Marie-Pierre Pernet**, Sustainable Development Manager, Air France*
12.50 - 13.00	*Q&A*	
13.00 - 14.00	***Lunch break***	

1

Agenda workshop on the illegal importation of wild meat

12/12/2024

AFTERNOON SESSION - Auditorium Hâlsa (00.A1) & breakout groups in rooms GAL 01.C5 (Muhlt), GAL 01.C6 (Dhana), GAL 01.D3 (Gelykheid)

BREAKOUT SESSIONS	
Presentation of the breakout sessions by the chair	***Sophie Gryseels**, Royal Belgian Institute for Natural Sciences and coordinator of INTERCEPT*
Breakout sessions	
Coffee break	
REPORTING	
Report on breakout group one: Knowledge, data collection and research	***Laura Cuypers**, facilitator, Royal Belgian Institute for Natural Sciences and coordinator of INTERCEPT*
Q&A	
Report on breakout group two: Control & enforcement	***Elke Malfait**, facilitator, Senior expert Enforcement, CITES, DG ENV, FPS Health, Food Chain Safety and Environment*
Q&A	
Report on breakout group three: Collaboration with the private sector	***Lorélie Escot**, facilitator, Head of the « Illegal wildlife trade & Human-wildlife coexistence Programme», WWF France*
Q&A	
Wrap up & closure by the Chair	***Sophie Gryseels**, Royal Belgian Institute for Natural Sciences and coordinator of INTERCEPT*
CLOSURE OF THE WORKSHOP	

Figure 2.2. Program and pictures of the workshop co-organized with FPS Health and WWF France on wild meat trafficking.

WP 2: Coordination, project management and reporting.

Task 2.1: Coordination and project management.

We carried out regular informal meetings between RBINS coordination team and partners at Sciensano, RMCA and UAntwerp.

We held seven project management and coordination meetings between project coordination team (RBINS) Maud Istasse and, FPS Public Health (31/04/23, 13/10/23, 24/11/23, 23/02/24, 05/06/24, 18/11/24, 25/02/2025).

The core group of the follow-up committee met on the following days:

- 10/11/22 core meeting 1
- 24/04/23 core meeting 2
- 23/01/24 core meeting 3
- 19/03/24 core meeting 4
- 16/09/25 core meeting 5

The presentations and reports of the meetings can be found in the project's google drive folder.

WP 3: Building a centralised database.

Task 3.1: Compiling the existing data from the different federal databases.

Through bilateral discussions of WP1 and interviews during field actions, we have compiled a list of currently existing databases containing information on imported animals and animal products from third countries into Belgium. Obtaining relevant data from these databases has proven challenging due to legal data-sharing reasons at EU-level, rigid hierarchical structures to go through to officially request data, database unfriendly ways the data is stored and therefore substantial effort that is needed (by agencies and authorities) to compile data. Nevertheless, we received the most important data:

- a datadump from the Traces database of animal products (or commodities containing animal products) arriving via commercial shipments into Belgium from representative agents of the Federal Agency for Safety of the Food Chain (FASFC) between (01/01/2020 - 22/11/2024), as an excel list.
- a datadump of all confiscated meat and animal products from passengers' luggages at Brussels airport (from BaCon actions and regular individual controls), from FASFC officers at the Zaventem Border Control post (2012-2024).
- All CITES infringements (2017-2021, EU-TWIX) and legal imports (2020-2022, Trade db) of animal products imported in Belgium, from the publicly available CITES database.
- Small consignments control register illegal imports low value consignments (01/03/2024 - 31/12/2024)

We provide more details about these data sources in the Results section.

Task 3.2: Designing a centralised database with user-friendly data-entry tools.

A designated data engineer, Paola Burelli, was hired to design and fill in the centralised database, under supervision of Francis Strobbe (RBINS, FedOSC). The database was chosen to be scripted in Oracle via an Apex environment, as are other databases hosted at RBINS. The database can be accessed by registered users at: https://apext.rbins.be/data/r/ws_intercept/

A substantial data-cleaning effort was required before the collected records could be entered into the database. P. Burelli, L. Cuypers and an intern Luca Zorzetto spend several months cleaning up existing data the multiple agencies (and our own laboratory data) and sources from which the data came from. Although Traces data were mostlyy recorded in the Traces database in a consistent way, data from FAFSC was presented in non-database spreadsheets with inconsistent formatting conventions. As such, we standardised each field prior to integration. E.g. dates were converted to a single format, country and flight designations were harmonised against standard reference lists (e.g. ISO country codes, IATA flight numbers), animal species names were reconciled to a single accepted taxonomy (resolving synonyms), and quantitative fields such as weight were converted to consistent units. This harmonisation step was essential to allow accurate querying, aggregation and cross-referencing of records within the integrated database, but took up much more time than previously anticipated.

WP 4: Establishing procedures for in-field data and sample collection.

Task 4.1: Establishing procedures for data collection in the field.

Data collection in the field was organized during dedicated control “BaCon” actions by Customs and FASFC, and leaking luggage destruction actions by Saniport (see Results section for details on the modi operandi).

We first joined a BaCon and a leaky luggage action without actively recording data of the intercepted animal products or sampling, but noting the actual procedures in reality. This enabled us to design a protocol for standardized data and sample collection during control actions of luggage or other shipments. This protocol was revised and optimized during the first control actions we and a variety of colleagues from RBINS, RMSCA, University of Antwerp and Sciensano participated in, who all provided feedback. We further discussed with FASFC staff on how to link our samples to their data records.

An overview of the procedure for meat sampling and data collection in the field can be found in Figure 3.

We provide the complete protocols at our INTERCEPT on-line repository as they are >20 pages long. The preliminary draft protocols, as they were in use in 2023, can be found here: Initial draft protocols.

The finalized “Standard Operational Procedures” (SOPs) can be found here: Final Protocols – SOPs. This includes the protocols for sampling meat by experienced researchers, as well as the protocol for for non-researchers.

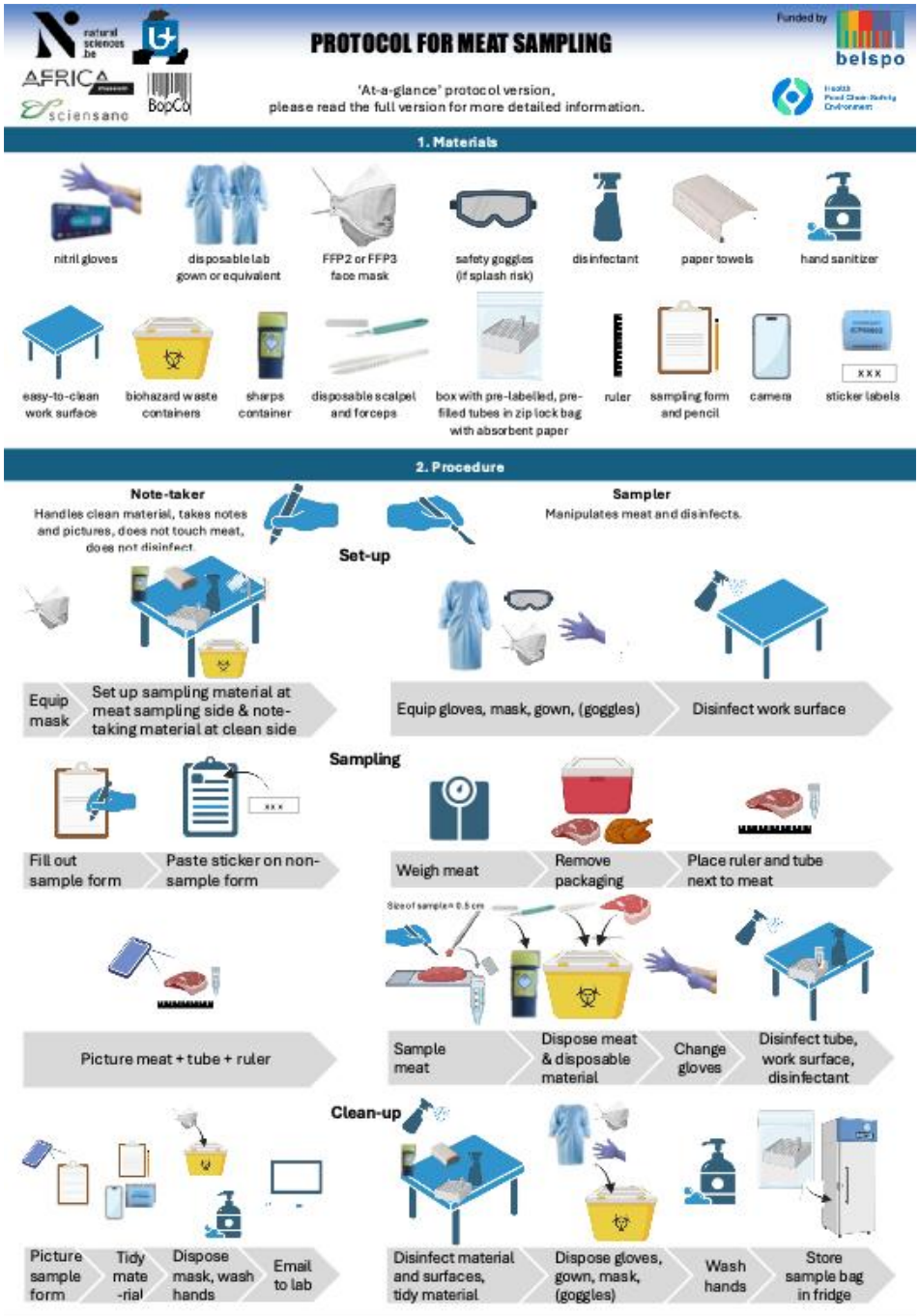

Figure 2.3. "At-a-glance" overview of the sampling and data recording procedure for sampling meat that is confiscated by (border) control agents. The full protocol can be found here.

Task 4.2: Collecting biological samples and long-term storage in biobank.

Animal samples from meat or animal carcasses were collected from all confiscated meat/carcasses derived from terrestrial vertebrates (i.e. mammals, birds, reptiles and amphibians; fish were excluded) intercepted during control actions in which all or most of the luggage on a given flight was inspected by Customs, FASFC and, where relevant, CITES officers. We targeted all terrestrial vertebrate meat encountered without discriminating between suspected domestic and suspected wild meat. If mulitple specimens (individual animal carcasses or meat pieces) were present in a package, we sampled only one specimen. Three samples were taken of each sampled specimen, of which two were stored without medium and one in ethanol. Samples were transported in a coolbox with icepacks

For BaCon actions, Customs officers first flagged passenger luggage for inspection, either following scanner detection, manual search after random selection, or selection on suspicion. Once a package was opened by Customs, a FASFC agent inspected its contents (see Results section for the outcomes of this inspection) and set aside any package found to contain meat for sampling by the project team, following the sampling procedures described in Task 4.1. The same procedure was followed for leaking-luggage actions, where packages were instead set aside by Saniport officials.

In total, 637 specimens were sampled during 28 BaCon actions and 8 luggage-destruction actions carried out between August 2023 and December 2024. Data recorded on the sample sheet (Figure 3) were:

- Sample ID
- Date
- Control type (BaCon or Leaking luggage destruction)
- Flight number(s)
- Departure city
- Transit city
- Regional information
- Package weight (kg)
- Suspected animal species/type (domestic or wild)
- Condition of the meat (raw, cooked, processed…)
- Remarks

Staal ID Échantillon	Datum Date	Controle type de côntrole	Vluchtnummer(s) Numéro(s) de vol	Vluchtstad Ville de départ	Transitstad Ville de transit	Regionale info Informations régionales	Pakketgewicht Poids du colis (kg)	Vermoedelijke diersoort/type Espèce/type d'animal présumé	Vleesstaat État de la viande	Opmerkingen Remarques
ICP00646										
ICP00647										
ICP00648										
ICP00649										
ICP00650										

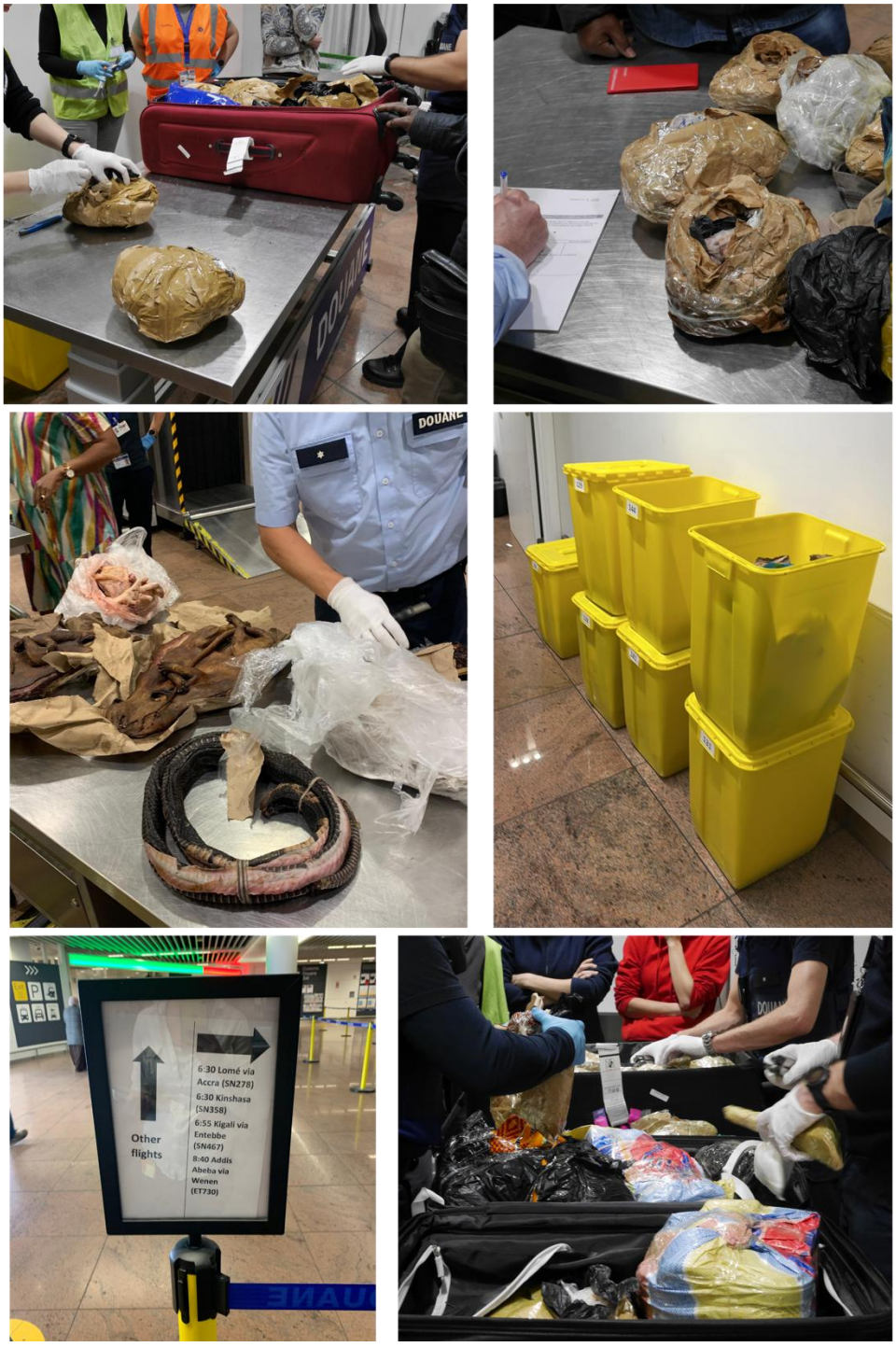

Figure 2.4. Customs and FASFC officials carrying out controls during a BaCon action.

Figure 2.5. INTERCEPT researchers taking samples of intercepted meat during BaCon actions.

Figure 2.6. Sampling meat during a leaking luggage destruction action.

WP 5: Establishing and testing laboratory procedures for species identification.

Task 5.1: Establishing laboratory procedures for DNA-based species identification & Task 5.2: Testing the laboratory procedures on biological samples collected in WP4.

We compiled the current state-of-the-art practices for DNA-based species identification, in particular of meat samples, and wrote a SOP for DNA-based identification of these types of samples (led by partner RMCA-BopCo), which is available in SOP meat sampling and molecular species identification INTERCEPT.docx. In brief, samples were further dissected into smaller pieces which were subjected to DNA extraction using the Macherey-Nagel NucleoSpin Tissue Kit, following the manufacturer's standard protocol. The digestion time varied according to tissue consistency, ranging from approximately 3 hours to overnight incubation. Final DNA elution was performed in 80 µL of the provided elution buffer.

The choice of target gene fragments for PCR amplification is based on the field identification reported on the ***Sample Information form***. Specific primers were selected to amplify DNA from domestic animals, wildlife species, and birds (Table 3).

Table 2. Primer combinations used within the framework of the INTERCEPT project

Primer	Gene region	Direction	Sequence	Reference
LCO1490	MT-CO1	Forward	GGTCAACAAATCATAAAGATATTGG	Folmer *et al.,* 1994
HCO2198	MT-CO1	Reverse	TAAACTTCAGGGTGACCAAAAAATCA	Folmer *et al.,* 1994
BirdF1	MT-CO1	Forward	TTCTCCAACCACAAAGACATTGGCAC	Hebert *et al*., 2004
BirdR1	MT-CO1	Reverse	ACGTGGGAGATAATTCCAAATCCTG	Hebert *et al*., 2004
bush-COIF	MT-CO1	Forward	CACAAACCACAAAGAYATYGG	Gaubert *et al*., 2015
bush-COIR	MT-CO1	Reverse	TCAGGGTGTCCAAARAAYCA	Gaubert *et al*., 2015
bush-12SF	MT-RNR1	Forward	GGGATTAGATACCCCACTATGC	Gaubert *et al*., 2015
bush-12SR	MT-RNR1	Reverse	GTGACGGGCGGTGTGT	Gaubert *et al*., 2015
bush-16SF	MT-RNR2	Forward	CGCCTGTTTACCAAAAACATC	Gaubert *et al*., 2015
bush-16SR	MT-RNR2	Reverse	AATCGTTGAACAAACGAACC	Gaubert *et al*., 2015
ND2-L5216	MT-ND2	Forward	RGAKGAGAARGCYAGGATYTTKCG	Sorenson *et al*., 1998
ND2-H5766	MT-ND2	Reverse	AGATATTGGAACWTTATATTTTATTTTTGG	Sorenson *et al*., 1998
L14723	MT-CYB	Forward	ACCAATGACATGAAAAATCATCGTT	Bradley *et al*., 2001
H15915	MT-CYB	Reverse	TCTCCATTTCTGGTTTACAAGAC	Bradley *et al*., 2001

An initial PCR run was performed using the most commonly referenced gene fragments available on GenBank. Amplification results were visualized on a 1.3% agarose gel stained with MidoriGreen Direct and observed under UV light. If amplification failed for a given fragment, an alternative primer pair was tested, as outlined in the decision tree (Figure 2).

Successful PCR products were purified and bidirectionally sequenced to ensure complete coverage and quality control by Macrogen (Amsterdam). The resulting sequences were checked for stop codons, trimmed, and assembled into overlapping consensus sequences using Geneious Prime v.2019.2.3. Consensus sequences were then compared against the GenBank reference database using BLAST (Altschul et al., 1990).

If BLAST analysis did not yield a high similarity match or if DNA identification remained ambiguous, a Neighbor-Joining (NJ) phylogenetic analysis (Tamura–Nei model, 1000 bootstrap replicates) was performed using all available sequences for the corresponding gene region from GenBank, and from BOLD if the COI gene was targeted, restricted to members of the relevant family or genus.

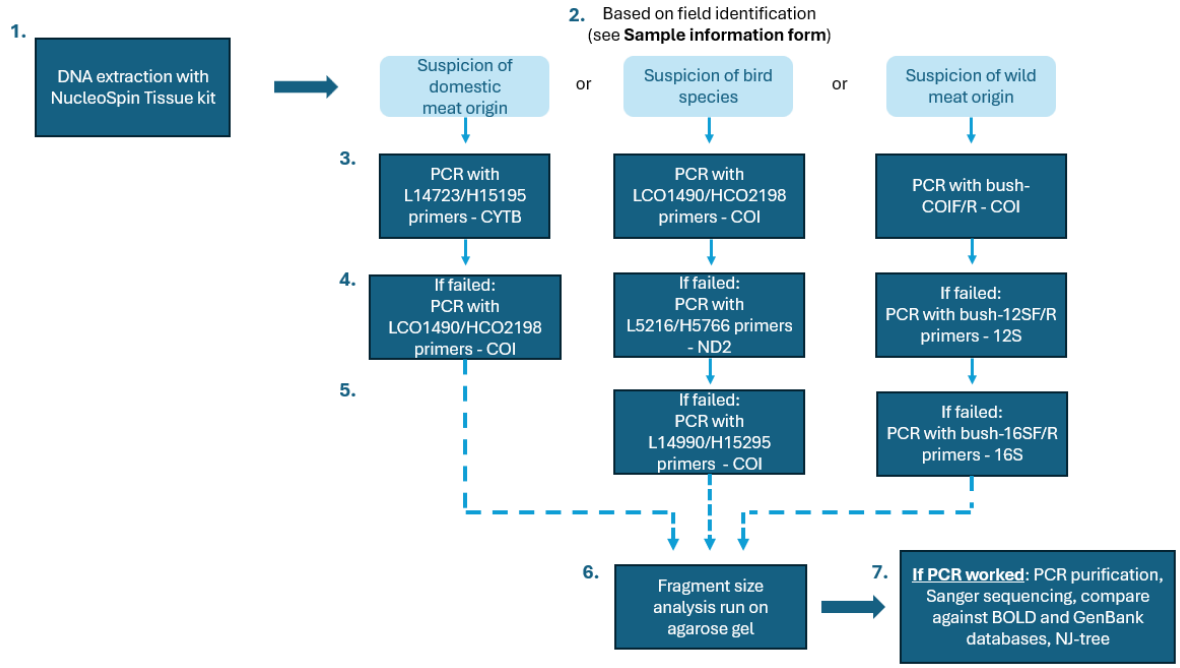

Figure 4. Decision tree showing the selection of primer combinations used for PCR amplification to identify seized meat samples within the framework of the INTERCEPT project.

WP 6: Establishing and testing laboratory procedures for pathogen detection.

Task 6.1: Establishing laboratory procedures for pathogen detection & Testing the laboratory procedures on samples collected in WP4

We first tested all DNA extracts from WP5 for the presence of orthopoxiruses (which among others includes mpox virus) using a quantitative mulitplex PCR as described in (Schroeder and Nitsche 2010) that targets all known orthopoxviruses.

To verify the presence of all possible viruses, we next performed RNA extraction and DNA extractions on pools of samples and subjected the samples for metagenomic shotgun sequencing. We based on the protocols established in (Geraerts *et al.* 2025) and carried this out for the INTERCEPT meat samples. In brief, RNA was extracted of most collected specimens using the Nucleospin Total RNA extraction kit (Machery -Nagel), using the manufacturer's instructions apart from the addition of beta-mercaptoethanol during lysis. The quantity of the RNA in the extracts was measured by Qubit. In case of too low quantity, RNA extraction was re-attempted and the new RNA extract was pooled with the old RNA extract and concentrated using the RNeasy MinElute Cleanup Kit (Qiagen). This process was re-iterated if necessary. For some samples, no RNA extract with detectable RNA via Qubit measurement was obtained, and these were not included in further analyses.

Four to five RNA extracts (with detectable RNA quantity) of samples from the same or similar animal species and origin of the passenger's flight were then pooled and concentrated and cleaned using the RNeasy MinElute Cleanup Kit (Qiagen), after adjusting their concentrations to be equimolar. The DNA extracts from the corresponding samples were then also pooled and concentrated and cleaned using the DNA Clean & Concentrator-5' kit (Zymo). The RNA and DNA extract pools were subsequently sent to Novogene company for library preparation (followed by cDNA generation for the RNA extracts), depletion of mouse/rat/human rRNA and shotgun sequencing (PE150) at Novogene's NextSeq Illumina sequencer, at targeted depth of 10Gb for DNA and 12Gb for RNA.

The bioinformatic pipeline followed the procedure described in (Geraerts *et al.* 2025). In bried, reads were next trimmed based on quality by Trimmomatic. Host reads were filtered by mapping to host genomic datasets (if not available for a particular host species, the closest related host species of which the genome was available was used). Host-filtered reads were next *de novo* assembled using metaSPAdes (Nurk *et al.* 2017). The resulting contigs were blasted using blastn against the entire nucleotide database of GenBank. Hits were subsequently filtered to contain only viruses of which the families have at least one member that is known to infect vertebrates. All alignments between contig query and blastn hit sequence were manually verified and false positive hits were filtered. Each detected virus was further annotated with its WOAH listing status (listed / not listed / unknown) and a literature-based zoonotic and veterinary concern level (high / medium / low / no concern / unknown-uncharacterised).

4. SCIENTIFIC RESULTS AND RECOMMENDATIONS

4.1. How are wild meat and exotic animals imported into Belgium and how is this import monitored?

4.1.1. Preface

In December 2019 the Federal Public Service Health, Food Chain Safety and Environment and the Belgian Biodiversity Platform organised the workshop "Dead or alive: towards a sustainable wildlife trade – One World One Health recommendations". This workshop resulted in the establishment of the 'Sustainable Wildlife Trade' National Task Force with an interministerial mandate in 2020, which drafted a national action plan for the sustainable trade in exotic animals. Both the workshop and the draft action plan call for continuous data collection on the import of animals and animal products, and their centralization into reliable and transparent databases. A recommendation which was echoed at

the "Workshop on the illegal importation of wild meat" organised in December 2024 by the Belgian Federal Public Service Health, Food Chain Safety and Environment, the Royal Institute of Natural Sciences, WWF France and TRAFFIC.

This recommendation stems from the fact that currently a database that centralises data on the import of animals and animal products from different import pathways does not exist on the European, Belgian or regional level. This makes it difficult for stakeholders (policy makers, researchers, but also the involved administrations and agencies) to gain a comprehensive overview of what is imported and to assess the scale; the associated risks for human, veterinary and environmental health; and their evolution.

As we have observed during our INTERCEPT research project (co-funded by the Federal Public Service Health, Food Chain Safety and Environment and the Belgian Science Policy Office), data about the import of animals and animal products from third countries into Belgium are now scattered among the different federal administrations and agencies. While performing their specific roles, these administrations and agencies each collect their own data for their own purposes. Joint collection or sharing of data between these administrations/agencies follow protocols or cooperation agreements, but is limited and does not result in joint databases that are jointly curated. Within administrations/agencies data can be shared more easily, but even so data and associated unit-specific insights often remain scattered over the different units.

4.1.2. Map of the current situation: the role and modus operandi of involved (federal) agencies

Animals and animal products are imported into Belgium from third countries via different pathways. We can distinguish between animals and animal products entering through personal luggage, non-commercial shipments and commercial shipments. A summary overview of the pathways, how they are controlled and where the monitoring data is stored, is provided in the overview below.

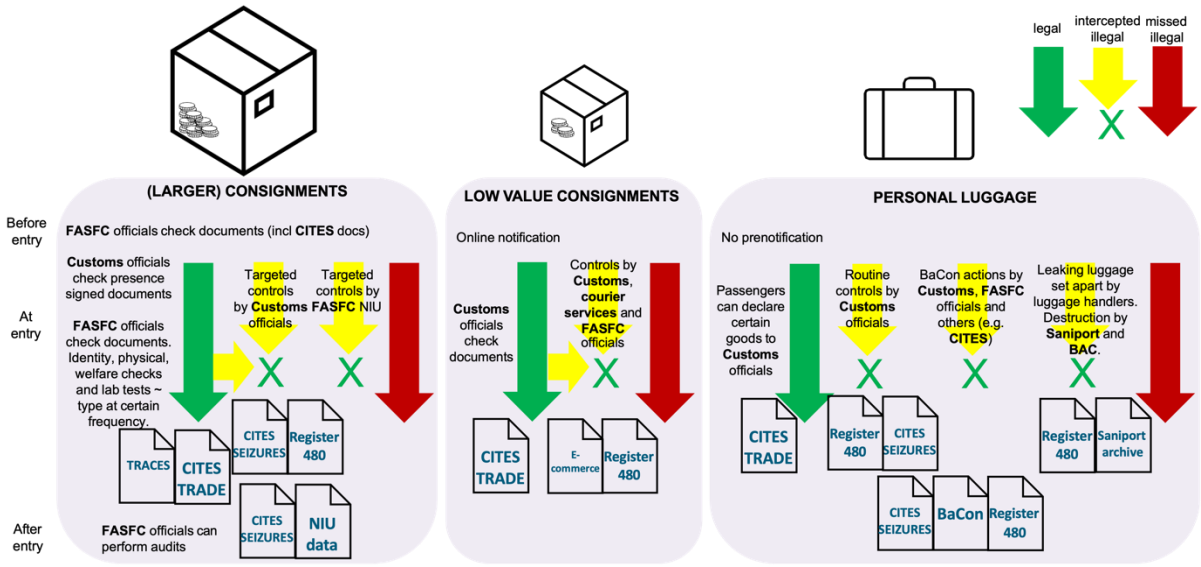

Figure 4.1.. Overview of the different pathways through which animals and animal products are imported into Belgium in legal and illegal ways, where and when controls happen by which agency, and how the monitoring data of the controls are stored.

Personal luggage

With few exceptions, it is not permitted to travel with animal products into Belgium from third countries. One notable exception does allow the import of up to 20 kg of eviscerated fish (or one fish exceeding 20 kg). Up to five pet dogs, cats or ferrets can also travel with their owners from third countries with certain documents. Depending on the third country, these pets should be presented to Customs at entry or not. Other pets can also enter from third countries if their import application is approved by the FASFC.

Illegally imported animals and animal products in personal luggage are intercepted during routine Customs controls, BaCon actions and leaking luggage destruction. If live animals are intercepted, FASFC officials are notified and suitable shelters are found within their network.

BaCon actions

'BaCon' or 'Baggage Control' actions focus on sanitary infractions and are organised on a regular basis at several points of entry: Brussels Airport (2 days/month); Brussels South Charleroi Airport (every two months); Ostend-Bruges International Airport, Liège Airport and Antwerp International Airport (during the summer months only); and Brussels-South railway station. They are organised by FASFC and Customs officials, but officials from other authorities such as the CITES Unit and the Federal Agency for Medicines and Health Products sometimes assist during the controls for infractions for which they are the competent authority.

During the course of this study the actions in Brussels Airport were held on mornings of week days. Specific flights are preselected by a Customs official, generally about five per morning. Most (>70%) of these departed from a range of African countries (Angola, Burundi, Cameroon, DRC, Ethiopia, Ghana, Liberia, Mauritius, Rwanda, Sierra Leone, Togo, Uganda) and about a quarter of them departed from Asian countries (Israel, Turkey, UAE and mostly China). During the control, the aim is to check all passengers from these flights.

The passengers are first redirected from their baggage carousel to a control queue. Generally their checked luggage then passes through a scanner and only if anything suspicious is noticed on this scan by a Customs official, the passenger's luggage is opened by a Customs official. In some cases passenger's luggage is opened without passing through the scanner first to speed up the passenger flow. If a sanitary infraction is noticed by Customs and FASFC officials, the passenger's ID is copied and a Dutch form 'Bewijs van inbeslagname van bederfbare goederen ingevoerd in de baggage' is filled in. This form serves as proof and consent that the passenger's goods are confiscated and will be destroyed. The passenger's name, passport number, nationality, the flight origin, the flight number and the date are recorded, as well as a description of the goods, their quantity in kg and the number of the recipient they are stored in for destruction. The forms are later digitised by Customs and FASFC officials. If a passenger is travelling with goods that are allowed as such (e.g. fish), but that exceed the permitted quantity (>20 kg) or are contaminated, those goods are destroyed in their entirety. After

the control the waste recipients with confiscated goods are transported to a cold room where they are picked up for destruction.

If there is a suspicion the confiscated good could be a species on one of the appendices of the European Council Regulation (EC) No 338/97 on the protection of species of wild fauna and flora by regulating trade therein (which includes CITES-protected species), a picture is taken and a CITES official is notified. CITES officials then ask external experts to identify the goods based on the picture. The waste recipients with these kind of goods are marked, so they can be kept for a longer time in the cold room before destruction (awaiting identification).

Leaking luggage destruction

When luggage handlers encounter leaking luggage, this piece of luggage is brought to a first cool room. From there it is picked up by the BAC waste management team and transported to a different cool cell in the airport container park. Once every 5-6 weeks these pieces of luggage are taken from their cool cell and brought to a central warehouse for destruction together with some pieces of luggage flagged for destruction by Customs officials which were not stored in dedicated waste recipients. That morning or the morning following after, the pieces of leaking luggage are opened by an external waste company team. They are assisted by BAC waste management and notes are made by two Saniport officials. They record a description of the goods, their quantity and the waste recipient. If a tag is still attached to the piece of luggage, the airline company and flight number or individual tag number are recorded as well. However, for quite a number of pieces of luggage this tag has been lost or is no longer readable. The form 'Attest van vernietiging/Attestation de destruction' is then signed off by BAC waste management and Customs. It is not digitised.

Commercial shipments

Commercial shipments of animals and animal products should be prenotified by the sender. They create a 'Common Health Entry Document' or CHED file in the European Commission's online platform 'TRAde Control and expert System (New Technology)' or TRACES(NT). This file e.g. contains information about the country of origin, the destination, a description and quantity of the goods, and attachments such as sanitary certifications or CITES permits if required. Before import the contents of the CHED file are checked by FASFC officials.

At import, the goods need to be reported at Customs. Customs officials check if the Customs declaration, the CHED file and any other certificates/permits required for that type of goods are present and signed in the PLDA ('PaperLess Douane en Accijnzen/PaperLess Douanes et Accices') application. If the paperwork is in order, the CHED file is 'released'. When a CHED file is 'refused', the animal/animal product is returned, destroyed or its documents are regularised. In the future, most of the document checks will take place in a more automated fashion when PLDA will be linked more directly to TRACES via the 'EU Customs Single Window Certificates Exchange System' (EU CSW-CERTEX). Live animals (including invertebrates) are physically checked at entry by veterinarians at Border Control Posts. Physical checks of animal products are usually only performed if there is a doubt about the documents or as part of targeted controls on goods with specific nomenclature codes indicated by the central Risk Management Office. These controls can be based on selection profiles

and risk signals (coming e.g. from the Rapid Alert System for Food and Feed). The Risk Management Office currently employs three officials working specifically on sanitary measures. In addition, risk analysists are also active in certain local entities such as the port of Antwerp and the airport of Liège. Controls can also take place based on mutual agreements with competent authorities as laid out in national operation plans.

Furthermore, audits (mainly for enterprises) are performed a few months after import and the FASFC National Investigation Unit (NIU) conducts additional controls and special investigations. These investigations can be based on leads from their FASFC colleagues, but also from various partners and other sources. Moreover, they act as liaisons in matters involving other countries, prosecutors etc. Additional controls by NIU on wild animals are rare, but recently there have been multiple controls on domestic live animals such as goats, sheep, dogs (concerning rabies) and horses (concerning Equine Infectious Anemia).

Non-commercial shipments

Non-commercial shipments from third countries enter Belgium through postal services and logistics companies (often those located at major logistics hubs such as airports and seaports). These shipments should be notified online prior to entry. Customs officials can deny entry to Belgium based on the type of goods and some shipments are checked. There is no systematic control specifically for animals or animal products, but FASFC officials are notified in case of sanitary infringements.

4.2. Existing databases

Here we outline which data from the monitoring of legally and illegally imported animals and animal products is recorded, how is it stored, in which databases and to whom these databases are accessible. We also provide recommendations for improving efficiency, additional or different data that needs to be recorded, improving traceability, data harmonisation and standardisation, and across-database interoperability and interlinkage possibilities.

4.2.1. CITES Unit databases

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) regulates the international trade in the animal and plant species listed in its appendices. In Belgium, this convention is implemented through Council Regulation (EC) No 338/97 on the protection of species of wild fauna and flora by regulating trade therein, which also protects some additional non-CITES species. The Belgian management authority which collects data on their legal and illegal import is the CITES Unit of the Federal Public Service Health, Food Chain Safety and Environment (Directorate General Environment).

4.2.1.1. Data on legal imports (CITES Trade Database)

Data from the legal trade stems from issued import and (re-)export permits and certificates. However, as quantities mentioned on these documents may deviate from actual import quantities, these quantities are further investigated by the Belgian CITES Unit to curate the data accordingly. Once a year the data on the import from and export to third countries from the previous year is compiled into a report and sent to the United Nations Environment Programme World Conservation Monitoring

Centre (UNEP-WCMC). On behalf of the CITES Secretariat, the UNEP-WCMC compiles this data from CITES Management Authorities around the world and makes it available through the CITES Trade Database at https://trade.cites.org/. While data quality checks are conducted by the UNEP-WCMC, discrepancies between import and export quantities remain present as not all CITES Management Authorities curate their data to the same extent that e.g. the Belgian CITES Unit does. While the data submitted by other CITES Management Authorities can include data on animal (products) seized during illegal import, this is not the case for most countries including Belgium.

The public CITES Trade Database contains the following data:

- A unique identifier ('Id')
- The year
- Animal taxon[1] information up to species level ('Taxon' (usually containing species information), 'Genus', 'Family', 'Order', 'Class') and the corresponding CITES Appendix ('Appendix')
- Transport information ('Importer', 'Exporter', 'Origin') and the corresponding anonymised certificate identifiers ('Import.permit.RandomID', 'Export.permit.RandomID', 'Origin.permit.RandomID')
- 'Reporter.type' indicating if the data came from the importer or exporter
- Quantities ('quantity', 'unit')
- Descriptions ('term', 'purpose', 'source')

An English guide document is available on the database website to better understand the database and the complexities of its data. For example, this guide document also explains the anonymisation process of the certificate numbers during downloads. To enable smooth linkage with other data sources like TRACES NT (see section 1.2), we recommend the Belgian database to also include (a) field(s) for identifiers of those data sources (e.g. TRACES references).

4.1.1.2 Data on illegal imports (EU-TWIX)

The Belgian CITES Unit also gathers data on illegally imported animal (product)s listed on EC No 338/97. These animals or products can be seized during controls in which they themselves participate or during controls performed by other authorities after which they are contacted. Like for the data on the legal imports, the data on these illegal imports are compiled and fed into a European-level database on a yearly basis. The Europe Trade in Wildlife Information eXchange (EU-TWIX) database was developed by the Belgian Federal Police and TRAFFIC with the advice of the Belgian CITES Unit and Customs authorities. Access to this database is restricted. Publicly accessible reports providing an overview of the seizures are published by the NGO TRAFFIC. However, this stepwise process does result in a delayed publication. The reports are typically only available about 1.5 years later, e.g. the report on the 2022 data was only published in the spring of 2024. Data extracts can be requested and

[1]Taxon: a group of living things used in biological classification or taxonomy. Taxa can be high-level groupings like 'animals' (Kindom: Animalia), but also low-level groupings like 'eastern black rhinoceros' (Subspecies: *Diceros bicornis michaeli*).

the Belgian CITES Unit kindly shared their 2017-2021 Belgian import data with us in a reduced form (reduced number of columns and animal product types).

The EU-TWIX database contains the following data (fields indicated with * were included in the reduced version shared with us):

- The file number*
- The date*
- Taxon information up to species level ('Kingdom'*, 'Class'*, 'Order'*, 'Family'*, 'Genus'*, 'Species'*, 'Common Names'*) and the corresponding CITES Appendix and EU Annex ('CITES App.'*, 'EU Annex'*)
- Transport information ('Country of origin'*, 'Direction of trade'*, 'Country of export'* with the corresponding 'Country of export ISO', 'Intermediate country 1'* with the corresponding 'Intermediate country 1 ISO'* through 'Intermediate country 4'* with the corresponding 'Intermediate country 4 ISO'*, 'Country of destination'* with the corresponding 'Country of destination ISO'*, 'mode of transport', 'transport details')
- The reporting country*
- Quantities ('No. of specimens'*, 'Units (medicinals only)'*, 'Mass'*, 'Unit of measurement'*)
- Animal/product descriptions ('Description'*, 'Source'*, 'Purpose'*, 'Value', 'Sex', 'Marking', 'Marking ID')
- Seizure information ('agency', 'type of seizure', 'type of location', 'location', 'CITES documentation offence', 'other CITES offence', 'other offence', 'Method of concealment 1', 'Method of concealment 2', 'Detection method', 'Detection method aid', 'Disposal of specimens', 'Remarks')
- Offender and prosecution information ('no. of offenders', 'nationality of offender', 'occupation', 'role', 'sex of offender', 'status of prosecution', 'prosecution start', 'prosecution end', 'primary sentence', 'secondary sentence', 'imprisonment', 'fine', 'law under which charges brought', 'sentence comments')

Like for the legal import data, we recommend the Belgian CITES database (from which this data is compiled for EU-TWIX) to add one or more fields to house identifiers from other data sources (e.g. Register 480) concerning the same data entry to enable smooth linkage.

4.2.2. TRACES NT

TRAde Control and Expert System New Technology (TRACES NT) is the European Commission's platform for sanitary and phytosanitary certifications required for the importation of animals, animal products, food and feed of non-animal origin and plants into the European Union, as well as the intra-EU trade and EU exports of animals and certain animal products. It is the successor of the decommissioned 'TRACES Classic' platform and is a component of the Information Management System for Official Controls (IMSOC; see (EU) 2017/625 and (EU) 2019/1715). During the INTERCEPT project, Belgian Customs used the PaperLess Douane en Accijnzen/PaperLess Douanes et Accises (PLDA) application to access TRACES NT to check if the CHED file and accompanying documents are available and signed upon import. However, under the EU Customs Single Window Certificates

Exchange System (EU CSW-CERTEX), the goods clearance process and associated data exchanges is being streamlined. This centralised system should better interconnect the import, export and transit systems of all European Union Member States with non-Customs systems that manage other formalities. In order to exchange data with the EU CSW-CERTEX system, PLDA-Import is being replaced by the Import Declaration Management System (IDMS).

Within the online TRACES platform, Common Health Entry Documents (CHEDs) are used to pre-notify and control the import of animals and animal products from third countries. For imports of live animal CHED-A files are employed, while CHED-P files are employed for imports of animal products. An overview of the data fields in these files along with some explanatory notes can be found in Annex II of (EU) 2019/1715. Within the INTERCEPT project it was not possible to gain direct access to TRACES as Article 36 of (EU) 2019/1715 does not permit access to persons/entities who have not contributed to the processing, production or transmission of data, information or documents in TRACES, or who are not involved in the placing on the market or movement concerned, do not have access to such data, information or documents. However, data extracts were requested via TRACES.Belgium@favv-afsca.be and included the following data:

CHED-A:

- Identifiers ('I.2. CHED reference', 'I.3. Local reference')
- Taxon information ('I.31. Species', 'I.31. Commodities EPPO Code')
- Transport information ('I.31. Commodities Country of origin', 'I.11. Country of origin ISO Code', 'I.12. Administrative Region of Origin', 'I.13. Means of transport before BCP/storage', 'I.13. Means of transport before BCP/storage Identifier of means of transport')
- Quantities
- Animal descriptions ('I.18. Goods certified as', 'I.31. Commodities')
- Control information ('II.3. Documentary Check Results', 'II.4. Identity Check', 'II.4. Identity Check Results', 'II.5. Physical Check', 'II.5. Physical Check Results', 'II.5. Total number of animals checked', 'II.6. Laboratory Tests', 'II.6. Laboratory Tests Motivation', 'II.6. Laboratory Tests Results', 'II.6. Laboratory Tests Name', 'II.7. Welfare Check', 'II.7. Welfare Check Results', 'II.8. Impact of the transport on animals Number of dead animals', 'II.8. Impact of the transport on animals Number of unfit animals', 'II.8. Impact of the transport on animals Number of birth or abortion', 'II.12. Acceptable for internal market', 'II.16. Not acceptable measure selection', 'II.17. Reason for Refusal', 'II.21. Decision date', 'II.21. Decision date year')

CHED-P:

- Identifiers ('I.2. CHED reference', 'I.3. Local reference')
- Taxon information ('I.31. Commodities Latin Name', 'I.31. Commodities EPPO Code')
- Transport information ('I.31. Commodities Country of origin', 'I.11. Country of origin ISO Code', 'I.13. Means of transport before BCP/storage', 'I.13. Means of transport before BCP/storage Identifier of means of transport', 'I.14. Country of dispatch ISO Code', 'I.16. Transport conditions')

- Quantities ('I.34 Net Weight (kg)', 'I.34 Total Gross Weight (kg)', 'I.32 Number of packages')
- Animal product descriptions ('I.18. Goods certified as', 'I.31. Commodities', 'I.31. Product Type')
- Control information ('I.19. Conformity of the goods', 'II.3. Documentary Check Results', 'II.4. Identity Check', 'II.4. Identity Check Results', 'II.5. Physical Check', 'II.5. Physical Check Results', 'II.5. No physical checks reason', 'II.6. Laboratory Tests', 'II.6. Laboratory Tests Motivation', 'II.6. Laboratory Tests Results', 'II.6. Laboratory Tests Name', 'II.12. Acceptable for internal market', 'II.16. Not acceptable measure selection', 'II.17. Reason for Refusal', 'II.21. Decision date', 'II.21. Decision date year')

A major drawback of the data contained in TRACES NT is that the reliability of its contents is to a large extent dependent on the declaration of the notifier. That errors are introduced is for example evident in cases where the declared net weight is 0, but the total gross weight is high, the product is unlikely to be transported in a net weight close to 0, and its CN code is not one for which net weight is an optional field (e.g. certain fishery products for human consumption with total gross weights over a tonne). There are also instances where the declared animal species does not correspond to the Combined Nomenclature (CN) code (e.g. a genus of krill combined with a CN code reserved for fish products). Generally, taxonomic information is often limited, though some types of goods are affected worse than others. For example, while an animal species is reported for about half of the live animals imports, this is only the case for about 1.5% of goods certified as 'animal feedingstuff' (no taxon information for about 14% and only class or higher level information for 68%). Furthermore, if detailed taxonomic information is provided, it is often not straightforward for customs officials to verify it on sight.

Another drawback is that the most precise product description consists of the CN code, a code which is mostly designed to levy duties. In absence of precise taxonomic information in I.31 fields, CN codes are therefore often unhelpful for further clarification as these codes can cover broad groups of animals. Moreover, while in general separate CN codes exist for live animals in contrast to animal products, this is not the case for aquatic invertebrates including molluscs and crustaceans. This raises concerns as several crustaceans are listed as Invasive Alien Species (IAS) of Union Concern (see (EU) 1143/2014).

While e.g. health certificates can be selected as a document type when uploading accompanying documents, this is not the case for CITES certificates. As a result these certificates end up in the large category 'Other', which (in the absence of a universal CITES certificate number format) makes it very challenging to extract CITES certificate numbers from the field 'I.9. Accompanying documents Number' hindering correct links with CITES Trade data. (However, note that while the CITES certificate numbers are included in the CITES Trade data, they are anonymised when downloaded from the publicly available database.)

We therefore make the following recommendations:

Advocate for internal checks in TRACES that avoid easily checkable mistakes, such as zero weights and contradictory CN codes and taxonomic information. For example, for the latter hierarchical drop-down lists for I.31 fields which are linked to certain CN codes could be established. Moreover, the introduction of drop-down lists would also reduce the amount of typos in these fields.

- Advocate for separate CN codes for all live animals, including aquatic invertebrates and especially for taxa that raise additional concerns such as crustaceans listed as IAS of Union Concern.
- Investigate the possibility to add CITES certificates as (a) document type(s) in 'I.9. Accompanying documents Document Type'.

4.2.3. FASFC data

The Federal Agency for the Safety of the Food Chain (FASFC) monitors the food chain and is responsible for the assessment and management of risks that may be harmful to the health of consumers as well as the health of animals (and plants). During their activities FASFC officials make use of the European IMSOC components, including TRACES NT (see 1.2), the Animal Disease Information System (ADIS) and iRASFF, which implements Rapid Alert System for Food and Feed (RASFF) and Administrative Assistance and Cooperation Network (AAC; a part of the Alert and Cooperation Network, ACN) procedures. Most of these components are used to communicate with officials from other Member States on non-compliances and health risks. ADIS is a disease management tool to register and document evolving situations of important infectious animal diseases. iRASFF is used to communicate about non-compliances with possible health risk (e.g. the detection of pathogens or contaminants in goods, non-compliance with labelling and traceability,…). The full tool is only available to competent authorities such as FASFC and the European Commission. However, summary information from 2020 onwards is available to the public through the interactive online database RASFF Window (https://webgate.ec.europa.eu/rasff-window/screen/search). AAC is used to communicate about non-compliances that concern any potential violations that do not present a risk requiring notification in RASFF and facilitates investigations. Another part of the ACN, the FFN is used to communicate and collaborate about suspicions of fraud. Yearly reports of the information shared through the ACN network are compiled by the Directorate-General Health and Food Safety (DG SANTE) of the European Commission.

During various controls, FASFC officials also generate valuable data which does not end up in one of these European systems. Relevant examples include data gathered by the National Investigation Unit (NIU), data from the Baggage Control (BaCon) actions and data from the small consignments controls.

4.2.3.1. Baggage Control register

BAggage CONtrol or BaCon actions focus on sanitary infractions in air and train passenger luggage. They are organised on a regular basis at the international airports and the Brussels-South railway station by Customs and FASFC. Officials from other authorities such as the CITES Unit and the Federal Agency for Medicines and Health Products sometimes advise during the controls for infractions for which they are the competent authority.

The aim is to check the luggage of all passengers from preselected routes and the documentation of all live (companion) animals. For the former only non-compliant animal products are registered, while for the latter both compliant and non-compliant live animals are registered. The data generated during these controls is recorded on paper. Afterwards it is digitised by FASFC officials and stored in Excel spreadsheets. Access to these spreadsheets is restricted. However, limited information is publicly available in the FASFC year reports and data extracts can be requested. FASFC kindly shared their data with us from the beginning of the actions in 2012 up until 2024. Over the years the data format has evolved frequently, but in 2024 the data included:

- The date
- Control information (control site, passenger number (a serial number for the date-site combination), compliance, reason of non-compliance, specification of non-compliance, CITES suspicion)
- Product category (animals, animal products) and description (for live animals this corresponds to taxon information at species level, e.g. dog or cat)
- Transport information (flight number, flight origin)
- Quantities and units (kg, pieces, animals)

A first major drawback of the BaCon data is that the control effort is only very minimally recorded. While it's good that the number of offenders and the preselected flights (time, flight number, flight origin, remark) are recorded (in a separate sheet), these preselected flights do not correspond perfectly to the actually controlled flights. Due to delays or cancellations some flights may not be checked and other flights may be added to compensate. While the aim is to check all passengers of the preselected flights, due to circumstances (e.g. several planes arriving at the same time) this is not always possible. Although recording the number of passengers controlled and their flights would require an additional official to participate in the controls, this would be worthwhile, as the lack of such data currently prevents an appropriate estimate of imports and their evolution over time. To further increase the data value for pathogen risk analyses, adding records of animal product states (e.g. raw, partially raw, cooked through, prepared, industrially processed) is recommended.

A second major drawback is the lack of taxonomic information. Animal product descriptions are currently usually limited to broad categories such as 'meat' or 'fish'. While a 100% accurate determination of the concerned animal species on the field by officials based on morphological identification is not achievable, this should not hinder recording relevant information which could be recorded, in certain instances e.g. terms like 'bird' or 'hoofed mammal' could be recorded, even without additional training of officials. Likewise, passenger species declarations cannot be considered fully accurate, but including this information would be a great improvement over the current situation and provide valuable insights. Moreover, taxonomic identifications could be added for goods for which expert (morphology and/or DNA-based) advice was obtained after controls to confirm or rule out CITES infringements.

A third major drawback is the fact that only data from joint BaCon actions are included in this register, while other data on the same import pathway collected by different agencies exist, but are not

registered in a similar way. Harmonisation with data from luggage destructions would be achievable, but appears less straightforward at present (see section 1.5). However, including data from routine baggage checks by customs officials in this register or a register with harmonised data fields appears straightforward as their data are at present initially recorded on the same paper destruction forms. Currently the data from the joint BaCon actions is also digitised separately by FASFC and Customs officials. Data sharing after entry by a single agency (whether or not alternating) would therefore not only increase harmonisation, but also reduce the joint work load. Digital entry on site (e.g. on easy-to-clean tablets) rather than digitisation of paper records can further reduce the workload. In that case, the validity of the digital signatures and the provision of passenger copies could prove minor hurdles that should be taken into account. Digital entry through an app could also provide an opportunity to easily link specimens with pictures, though a sufficiently large storage capacity should be foreseen.

A positive development in the BaCon data over the years, has been the introduction of fixed entry values for certain fields like the reason of non-compliance and flight origin. The latter field, however, currently contains export countries, sometimes followed by export cities, sometimes followed by transit countries and/or cities. It could thus be improved further by splitting the cities from the countries and the transit countries/cities from the export countries/cities into four data fields (export country, export city, transit country and transit city). Ideally these export/transit cities and countries would be linked, so only cities with airports in the specified countries are accepted or vice versa. Ideally, the current product specification field would also be split into a field only containing product specifications and a comment field for additional comments or observations.

We therefore make the following recommendations:

- Record control efforts, including the total number of controlled passengers and their flights, allowing the BaCon data to develop from a record of illegal import detections into a data source that allows to estimate the scale and evolution of these illegal imports more adequately.
- Record animal product states (e.g. raw, partially raw, cooked through, prepared, industrially processed).
- Include taxonomic information to the extent to which it is possible based on morphological identification on the field, passenger knowledge and/or post-control expert identifications.
- Split the product specification field into a product specification and comment field and split the flight origin field into four fields (cities vs. countries, export vs. transit), while linking the cities with the countries.
- Avoid separate data entry by FASFC and Customs officials to reduce the joint work load of officials. Investigate if digital entry on site of the destruction forms could further reduce the workload.
- Investigate the possibility to combine the BaCon data with other passenger luggage data such as the routine customs luggage check data and luggage destructions data.

4.2.3.2. Small consignment control register

FASFC officials perform controls for sanitary infringements on selected e-commerce and private packages after presentation by customs or courier services. The proportion of consignments that is checked is unknown, but considered to be very low. Data on non-complying packages is recorded in Excel spreadsheets. Access to these spreadsheets is restricted. However, limited information is publicly available in the FASFC year reports and data extracts can be requested. Since March 2024 a common template is used by both the border control post in Zaventem and Liège. The data fields include:

- The file number
- The (Air Waybill) date
- Control information (control site, control reason, control date, illicit trade suspicion, remarks, status, completion date, FASFC sample number, the responsible official)
- Transport information (Air Waybill number; the sender and the country of the sender; contact information of the courier service and receiver; the type of import (B/C2B/C) and if B/C2B if the operator database BOOD code is correct; the reason(s) for, specification(s) of and legislation relevant to the non-compliance; if the consignment should have been reported in TRACES and the CHED file number; the measures, measure and destruction number, regulation measures and period, detainment reason and if the consignment was accepted)
- Quantities and units (kg or pieces)
- Product description (name and type)

The main drawbacks of the small consignment control register are largely the same as those of the Baggage Control register and pertain to the registration of the control effort, the lack of taxonomic and product processing state information, and the lack of integration with other data on the same import pathway. We therefore make the following recommendations:

- Investigate the possibility to add control information to enable estimations of scales, risks and their evolution. For example, relevant numbers to take into account are the total number of imported consignments, the proportion checked by customs/courier services and the proportion presented to FASFC due to the presence of animal products. Moreover, these numbers should take into account different control strategies if applicable. For example, if the proportion of consignments checked differs for different variables (product categories, export countries,…), these numbers should be split per strategy.
- Record taxonomic information (at present to some extent hidden in product descriptions in certain cases) and animal product states (e.g. raw, partially raw, cooked through, prepared, industrially processed).

4.2.4. Customs data

Customs (GAC&E- General Administration of Customs and Excise, FPS Finance) control the flow of goods at external borders. In order to perform these controls they have access to several databases. For example, as mentioned in section 1.2, Belgian Customs have access to TRACES NT via PLDA/IDMS. Another European database that is accessed via IDMS is the H7 dataset, the ‘super reduced dataset’

for low-value consignments. Unlike products imported in bulk from third countries, third country consignments valued under €150 are currently typically exempt from customs duties. These low-value consignments do need to be declared, but much less info is required compared to the standard declaration in TRACES NT. However, certain commodity codes (including animal and animal product codes) are excluded from this reduced declaration.

Infractions of various natures (including sanitary infractions) encountered during controls are recorded in the 'Register 480'. However, further details such as the extent to which different data is currently digitised and centralised, and the exact data fields, are not clear to us.

Due to the restricted nature of the data, we are unable to formulate specific recommendations. However, as mentioned in section 1.3 increased sharing, harmonisation and linkage with FASFC data would help to valorise the data and in some cases avoid double data digitisation efforts. Importantly, it would also help to avoid the entry of duplicates into a centralised database.

4.2.5. Saniport data

Saniport (FPS Health, Food Chain Safety and Environment) is the sanitary policy of international traffic, ensuring the public health of passengers and crew of aircrafts and ships. Amongst other tasks, Saniport officials record the contents of luggage set aside by luggage handlers for sanitary reasons (mostly leaking) at Brussels Airport. This takes place during luggage destruction actions organised by the Waste Management unit of Brussels Airport Company (BAC) and with help of an external waste company who open the luggage. While currently paper destruction attestation forms are filled in on paper and not digitised afterwards, an app is under development for digital entry. The paper forms are shared with Customs and include fields for:

- The (destruction action) date
- Product description
- Transport information (flight number and airline)
- Quantity (kg)

Unfortunately the weight in kg is currently just a crude estimate as no scales are present on site. We therefore recommend to base the weight records on actual weight measurements, ideally separately for each product (category). Eventually, we recommend to implement a scale on the site.

The current digitisation development offers opportunities to introduce dropdown menus or fixed clickable content with internal links and additional data fields, resulting in increased data value and reduced downstream data curation efforts. We recommend the following additional fields:

- **Airline**. The airline is already recorded in a shared flight number and airline data field in the absence of a flight number, but is better recorded in a separate data field. Ideally this could be filled in automatically based on the entered flight number, while still allowing the possibility to enter data in the absence of a flight number.
- **Personal tag numbers**. These are already recorded in the flight number and airline field in the absence of a flight number, but are better recorded in a separate data field. They may also be

useful to record even when the flight number is known in cases where it could be relevant to maintain a link to the passenger, e.g. if it would be decided to keep track of (potential) CITES infringements. In other cases where a link to the passenger might not provide any specific advantages, there seems no need to record the personal tag number if a flight number is available.

- **Country, city and airport codes** (each separate for export and transit). Airport codes might be easier to decipher from luggage tags than cities and certainly countries. They could be automatically suggested based on the flight number and automatically suggest the city and country.
- **Flight date.** Typically only the control date is currently recorded on which luggage from a span of about five to six weeks is destroyed.
- **Product category.** This product category would ideally be harmonised with the product categories in FASFC's BaCon data field for reason of non-compliance (e.g. meat, fish dairy,…), while the already existing product description data field could encompass less fixed product description as is the case for the BaCon's product specification data field (e.g.; 'dried sausage', 'steak', 'whole carcass', '5 legs',…)
- **Product state.** For relevant product categories it would be informative to add animal product processing states if still recognisable (e.g. raw, partially raw, cooked through, prepared, industrially processed).
- **Taxon.** While sometimes challenging due to (incipient) decomposition, it would be relevant to add taxonomic information to the extent to which it is possible (e.g. bird, chicken, monkey, (hoofed) mammal, snake, reptile,..)
- **Compliance**. For estimations, it is very valuable that both compliant and non-compliant products are already recorded. However, currently no distinction is made between compliant and non-compliant products. Including this information is not straightforward as it requires knowledge for which training is needed. However, it would allow better integration with BaCon and routine luggage control data and could provide extra information to inform risk-based flight/passenger selection for these controls.
- **Remarks**. A comment field can include relevant additional information and observations. Some examples include:
    - 'wrapped in newspaper from country X', indicating a country of origin in case it deviates from the export country or the export country is not known
    - 'packed with cool packs', indicating cooled transport, or 'packed with water', indicating potential live transport in case of e.g. whole fish or amphibians (in which case FASFC officials could be notified as is the case for still living animals)
    - 'CITES suspicion' with additional details, in which case CITES officials could be notified

If the main limitation to adding some of the additional fields would be the slightly longer time required for destruction actions on site (e.g. due to increased costs for engaging the external waste management personnel), it could also be possible to add some of the information after the actions based on pictures linked to the data entries. While inevitably demanding some extra time on site

and/or after the actions, the additional data would make the collected data more valuable, improving the possibility of integration with other passenger luggage data, scale and risk estimates and use for risk-based controls. All of which would make the already invested effort more worthwhile.

As the proportion of luggage without tags is large, we also recommend investigating how the proportion of luggage with tags can be increased in collaboration with the luggage handlers, Brussels Airport Company and/or others in the luggage destruction chain to further increase the data value.

In short, we recommend to:

- Base the weight records on actual weight measurements for each product (category).
- While switching to digital entry, introduce additional fields and dropdown menus/fixed clickable content with internal checks.
- Investigate with actors along the chain how to increase the proportion of luggage with tags.

4.3. The current INTERCEPT centralised database prototype

4.3.1. Data model

The INTERCEPT prototype database was built incrementally, as data from the different sources described in 4.2. became available throughout the project (while not all data became available). Rather than starting from a single, upfront database design, its underlying data model therefore grew organically: tables and relationships were added source by source as each new data extract (TRACES NT, the CITES Trade Database and EU-TWIX, the BaCon and small consignment control registers, Customs Register 480, Saniport data, and the INTERCEPT sampling and laboratory data itself) was integrated. Figure 4.3.1. shows the resulting entity-relationship diagram of the current prototype: distinct clusters of interlinked tables correspond to the different original data sources, connected wherever a meaningful link between them could be established (e.g. through shared flight numbers, dates or identifiers).

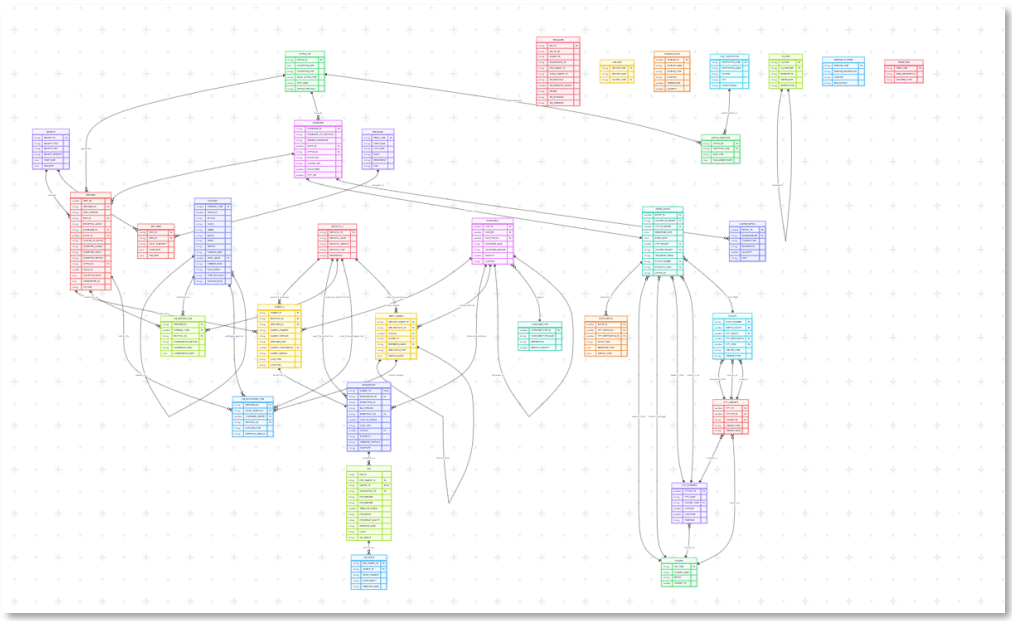

Figure 4.3.1. Entity-relationship diagram of the current INTERCEPT prototype database. Colour-coded clusters correspond to tables originating from the different data sources described in 4.2, linked together wherever a meaningful connection between them could be established.

Figure 4.3.2. illustrates this in more detail for the data model built around meat intercepted from personal-luggage: a.o. flights, their component route segments, the found specimens, field notes and our laboratory data. These are each represented by dedicated tables, linked so that a single record can be traced from an intercepted item back to the flight and route on which it travelled.

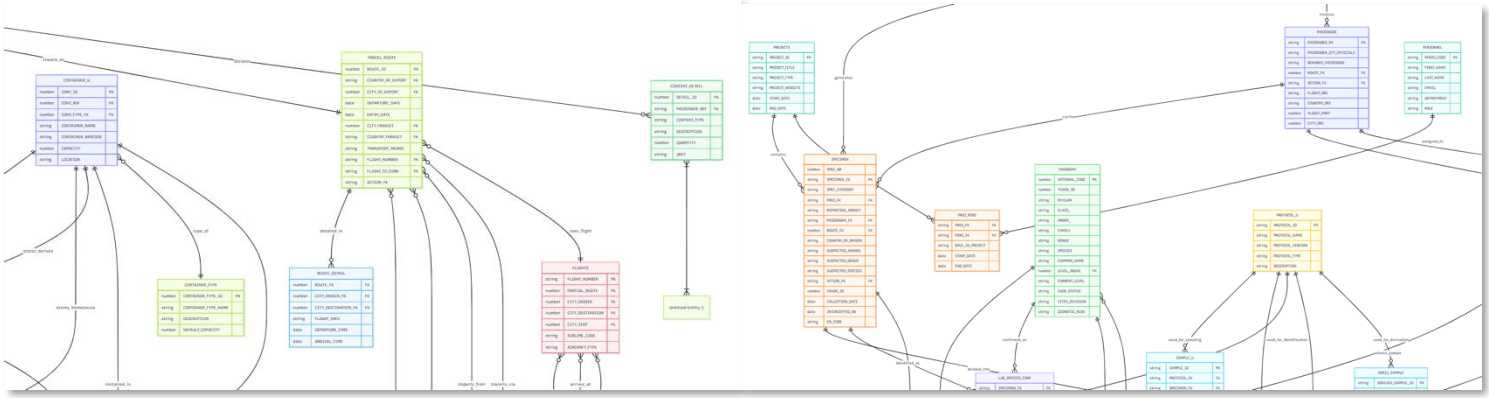

Figure 4.3.2.. Detail of the data model built around personal-luggage-related meat specimens.

4.3.2. Data sources

Of the nine data sources identified as relevant to the import of animals and animal products into Belgium (Table 2), five could ultimately be obtained and integrated into the INTERCEPT prototype database, each covering a different period: TRACES NT (legal imports, larger consignments; 01/01/2020–22/11/2024), the small consignments control register (illegal imports, low-value consignments; 01/03/2024–31/12/2024), the BaCon control register (illegal imports in passenger luggage, compiled by FASFC as Excel spreadsheets; 2012–2024), the CITES Trade Database (legal CITES imports; 2020–2022) and EU-TWIX (illegal CITES imports, shared with us in a reduced form; 2017–2021), alongside the project's own INTERCEPT data: meat specimens sampled by the project team during BaCon and leaking-luggage-destruction actions, with species identity determined by DNA barcoding, collected between 2023 and 2024.

The remaining four sources could not be included. The H7 dataset (the 'super reduced' declaration used for legal low-value consignments, accessed by Customs via IDMS), Customs' Register 480 (illegal imports detected during various Customs controls) and the data held by FASFC's National Investigation Unit (NIU) were all not made accessible to the project team. This is due to a combination of lack of clarity on whether the agencies are legally allowed to share this data with researchers and lack of staff time (or motivation to allocate staff time) to investigate the legality properly. As noted in 4.2.4, the restricted nature of the Register 480 data from customs in particular meant we were unable to obtain an extract or formulate source-specific recommendations for it. Saniport's data on illegal imports in passenger luggage (see 4.2.5.) is a distinct case: rather than an access restriction, this reflects the fact that Saniport's destruction attestation forms are currently still recorded on paper and have not yet been digitised, so no dataset yet exists to share. However, a digital entry app is reportedly under development by Saniport, which would make a major improvement.

Table 2. Overview of data sources of monitored imported animals and animal products (see 4.2.) and whether they could be included in the INTERCEPT database or not. Six of 9 listed data sources (counting CITES as one source, split into legal/illegal) were included in the INTERCEPT prototype database; 4 were not — H7, Register 480 and NIU data due to restricted access, Saniport data because it is still paper-only and not yet digitised.

Data source	Description	Coverage period / status	Included in INTERCEPT database?
TRACES NT (FASFC)	Legal imports (larger) consignments	01/01/2020 – 22/11/2024	**Yes**
H7 (Customs)	Super reduced dataset for legal low-value consignments	/	**No**
Small consignments control register (FASFC)	Illegal imports, low-value consignments	01/03/2024 – 31/12/2024	**Yes**
BaCon control register (FASFC)	Illegal imports in passenger luggage (FASFC Excel data)	2012 – 2024	**Yes**
Saniport data	Illegal imports in passenger luggage	/ (not yet digitised)	**No**
INTERCEPT data (RBINS, RMCA)	Own field notes and laboratory data of sampled meat during BaCon & leaking-luggage actions	2023 – 2024	**Yes**
CITES database – legal imports (FPS Health)	Legal CITES imports (CITES Trade Database)	2020 – 2022	**Yes**
CITES database – illegal imports (EU-TWIX)	Illegal CITES imports (EU-TWIX, reduced set of animal products)	2017 – 2021	**Yes**
Customs register 480 (Customs)	Illegal imports detected during various controls	/	**No**
NIU data (FASFC)	Illegal imports	/	**No**

4.3.3. Current database features and additional future possibilities

The prototype database was implemented in Oracle, using Oracle Application Express (APEX) as its combined backend development environment and web-based user interface. The database's user interface offers a set of pre-built, interactive report pages tailored to different needs, including a general overview, overviews enriched with flight or country details, a view linking specimens to their laboratory test results, a full data export view, and a curated view showing only a relevant subset of columns (Figure 4.4.3.). Without needing any SQL knowledge, users can show or hide columns, apply filters or facets -- for example restricting a view to a chosen data source and set of years (Figure 5) -- group records by chosen fields with automatic subtotals (a 'control break'), and toggle between tabular and chart views of the same underlying data. This flexibility allows the same underlying dataset to serve very different purposes, from a detailed record-level audit trail to a quick aggregate overview, without requiring a custom query for each.

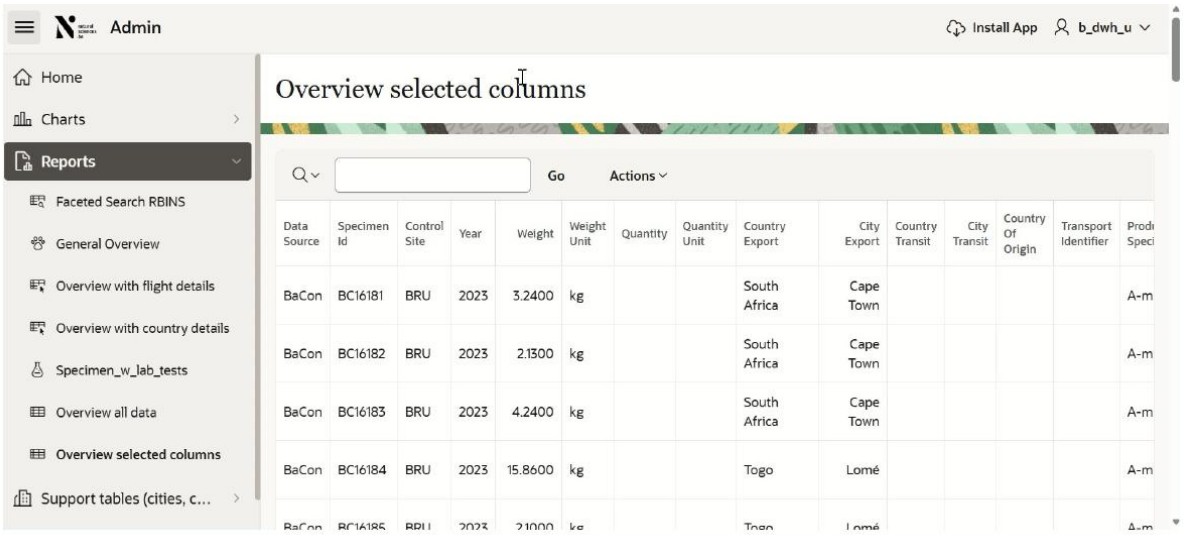

Figure 4.3.3. Example of an interactive report page in the current database, allowing users to select which columns to display without writing a query.

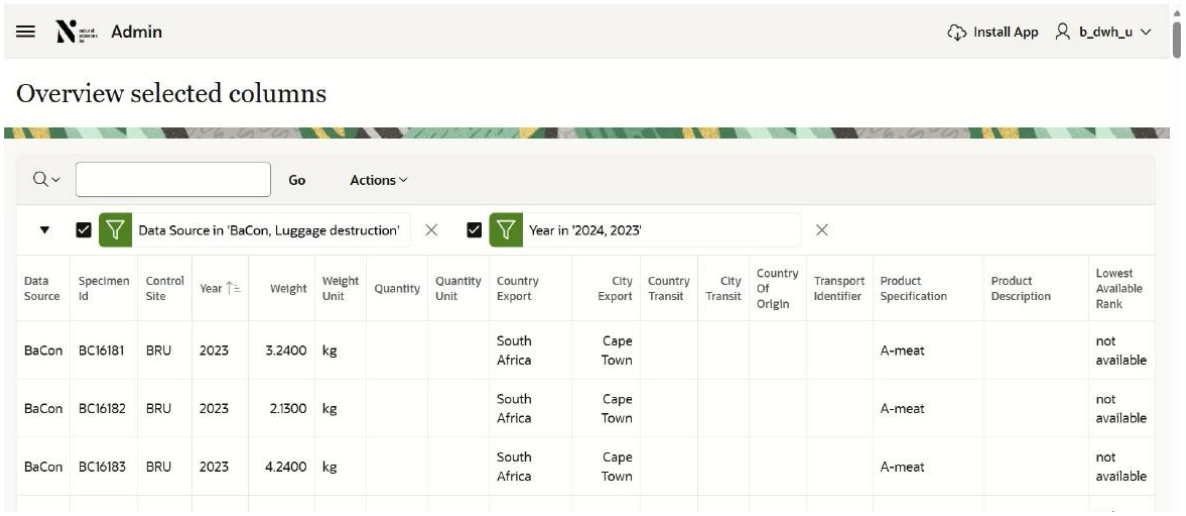

Figure 4.3.4. The same interactive report as Fig. 4.3.3, filtered to a chosen data source and set of years using the built-in facet filters.

The database supports different authorisation profiles to control which data a given user or user group can access. This can be used to show only specific, relevant data types to a given group, and to hide more sensitive fields entirely -- for example personal data of passengers or offenders, or information relevant to ongoing prosecutions -- addressing a recurring concern among some of the agencies providing data (in particular around CITES-related enforcement information), while still allowing broader sharing of the remaining, non-sensitive fields.

Data can currently be entered into the database either through the upload of standardised Excel templates, through (potential) direct links to other databases via an API, or through a combination of both; direct links additionally allow the underlying data to be refreshed more frequently than a periodic manual import would. Where feasible, we recommend aligning these Excel templates as closely as possible with the format of reports data providers already have to compile for other

purposes (for example, the format already used to compile the CITES Trade Database and EU-TWIX reports) so that data does not need to be prepared twice. On import into the centralised database, columns not relevant there can simply be ignored, and specific values can be automatically mapped onto the controlled vocabularies used elsewhere in the database, reducing both the burden on data providers and the downstream data curation effort within the centralised database itself.

Beyond linking to other project-internal or partner databases, the same mechanism could be used to connect the database directly to relevant external reference sources, such as the CITES Species+ checklist, to automatically validate or supplement taxonomic and CITES-listing information for entered records, or a species-identification database such as BopCo's DNA barcoding reference library.

Data can also be further processed by the user directly in the user interface of the database. Data can be filtered based on user's choice of fields, summarized into summary tables, and visualised in graphs of choice. An example of such a graph is shown in Figure 4.3.5.

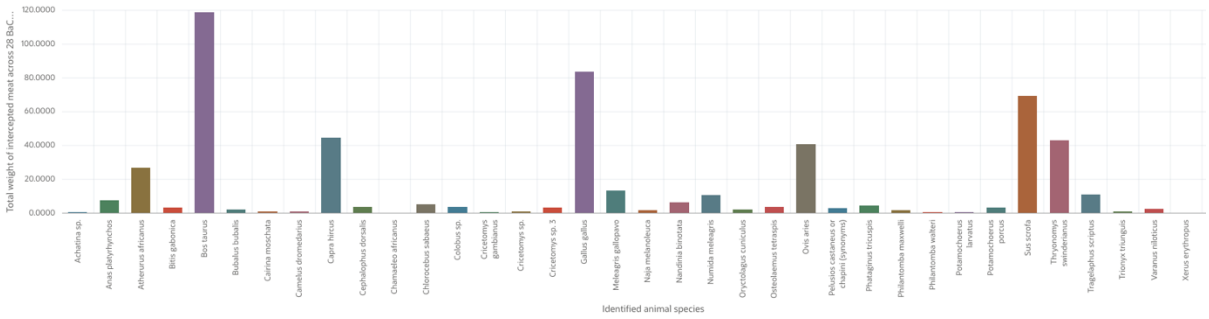

Figure 4.3.5. Example of a chart that can be directly made in the user interface of the INTERCEPT database.

4.3.4. Future scope of a centralised database and scenarios

4.3.4.1. Scope

In a centralised database data from different data sources can be brought together to generate a better overview. The more data sources are combined, the better and more comprehensive the overview. However, including more data entries and more data sources also comes at a greater cost as more effort is required to curate and link the data, and so more person-months need to be budgeted. Therefore, while the data sources listed in section 1 are all relevant to the import of animals and animal products and would ideally all be combined, the scope of a future centralised database could be more limited when resources are limited. For example, such a database could be limited to illegal imports only, to animal products only, to meat products only and/or to wild animal (product)s only. The latter, however, would be difficult to achieve at the moment as the distinction between wild and domestic animal products is currently usually missing in illegal import data (see section 1). In contrast, limiting to illegal imports only would be much more straightforward as in practice this would simply come down to not including the TRACES NT and the CITES Trade Database data sources. Moreover, as due to their nature these large databases are more complete and contain few links with other data sources, including them would offer a lower added value compared to other data sources (provided they are still analysed separately).

Including more data fields with information on control efforts and strategies, taxa, and product processing states for the illegal import data entries as recommended in section 1, would also require more effort and resources during the data collection and entry. However, it would enable this data to be used to assess the scale, associated risks and their evolution in time, substantially increasing their value and thus valorising already invested efforts.

4.3.4.2. Data fields for the future optimised centralised database

For the centralised database, we recommend to include the following data fields:

Identification fields:

- Record_ID
  The identifier of the data entry, as provided by the corresponding data source or a uniquely generated code if none is available.
- Data_source
  The dataset from which the record stems (e.g. 'TRACES', 'Small consignments register',…)
- Passenger/consignment
  The identifier of the passenger or consignment, which can be associated to multiple data entries, as provided by the corresponding data source (e.g. the TRACES reference number) or a uniquely generated code created by combining data from multiple fields (e.g. the unique combination of the in themselves non-unique date, control site and passenger numbers for the BaCon data)

Taxonomic fields:

- Lowest_available_taxon_declared
  The taxon declared by the sender/passenger. Currently only applicable for the legal import data, but could also be used for passenger declared taxa in passenger luggage data if recorded in the future.
- Lowest_available_taxon_officials
  The taxon suspected by border control officials (if deviating from the taxon declared by the sender/passenger and) if recorded in the future (e.g. for passenger luggage actions).
- Lowest_available_taxon_expert_morphological
  The taxon as identified by an expert based on morphological characteristics.
- Lowest_available_taxon_expert_molecular
  The taxon as identified by an expert based on molecular data (e.g. through DNA barcoding).
- Lowest_available_taxon
  A field which returns the most trustworthy taxon identification that is available: the data in 'Lowest_available_taxon_expert_molecular' if available, if not that in 'Lowest_available_taxon_expert_morphological' if available, if not that in 'Lowest_available_taxon_officials' if available, if not that in 'Lowest_available_taxon_declared' if available.

- Taxon_identification_type
- A field which returns which 'lowest available taxon' field is shown in 'Lowest_available_taxon'.
- Taxon_common_name
  A field which returns the common name of the taxon mentioned in 'Lowest_available_taxon'.
- Taxon_rank
  A field which returns the rank of the taxon mentioned in 'Lowest_available_taxon' (e.g. 'species', 'genus', 'family',…).
- Class
  A field returning the class of the 'Lowest_available_taxon' (e.g. 'Mammalia' (mammals), 'Aves' (birds),…).
- Order
  A field returning the order of the 'Lowest_available_taxon'. (e.g. 'Rodentia' (rodents), 'Artiodactyla' (artiodactyls), 'Crocodylia' (crocodilians),…).
- Family
  A field returning the family of the 'Lowest_available_taxon' (e.g. Hystricidae (Old World porcupines), 'Bovidae' (bovids), 'Crocodylidae' (crocodiles),...).
- Genus
  A field returning the genus of the 'Lowest_available_taxon' (e.g. 'Atherurus' (brush-tailed porcupines),…).
- Species
  A field returning the species of the 'Lowest_available_taxon'.
- CITES Appendix
  A field returning the CITES Appendix of the 'Lowest_available_taxon' if applicable. Note that for some taxa CITES Appendices can assigned at ranks higher than the species level. For example, for apes 'I' can be returned at the family level and for primates 'I/II' can be returned at the order level without knowing the exact species.
- EU Annex
  A field returning the EU Annex (of (EC) No 338/97) of the 'Lowest_available_taxon' if applicable. As for the CITES Appendix, this annex can be assigned at ranks higher than the species level.
- IUCN Category
  A field returning the International Union for Conservation of Nature's Red List of Threatened Species category if applicable.

Quantities:

- Weight
  The product/consignment weight in the unit provided in the 'Weight_unit' field (typically kg).

- Weight_unit
  The unit of the weight mentioned in 'Weight' field. Ideally all weights should be converted to kg.
- Gross_weight_consignment
  The gross weight of the consignment, currently only available for TRACES data. Note that for TRACES data multiple data entries from a single consignment have the same consignment gross weight, which does not allow most calculations.
- Quantity
  The product/consignment quantity in a unit other than weight (e.g. 'L', 'units',…) which is provided in the 'Quantity_unit' field. This field can be merged with the weight field if only data with either a weight or a quantity are entered into the database, but we would recommend to keep them separate in case the future scope would be expanded as both were available for some of the prototype database entries.
- Quantity_unit
  The unit of the quantity mentioned in the 'Quantity' field.
- Package_number
  The number of packages in the consignment. Currently only available for TRACES data.

Description:

- Product_specification
  The main category of an animal product (e.g. meat, fish, dairy, composite,…).
- Product_description
  A more detailed description of the product than 'Product_specification'.
- CN code
  A field from TRACES containing the Combined Nomenclature code, an EU Customs classification code.
- Compliance
  Whether the product is compliant or not.
- NC_reason
  The reason the product is non-compliant (if applicable).
- NC_reason_specification
  A field from the small consignment control data register in which the reason for non-compliance is specified further. For example, if the reason indicates the amount of a certain nutrient is too high, it specifies which nutrient.
- TRACES_declaration_required
  A field from the small consignment control data register which indicates if the consignment should have been declared in TRACES.
- Transport_condition
  A TRACES field which specifies the transport condition of the animal product (e.g. 'ambient', 'chilled', 'frozen',…).

- Processing_state
  A data field not yet included in federal data registers, but which could be used if animal product processing state data (e.g. raw, partially raw, cooked through, prepared, industrially processed,..) would be recorded in the future.
- Source
  Currently only available for CITES data (e.g. taken from the wild, bred in captivity,…)
- Purpose
  Currently only available for CITES data (e.g. educational, hunting trophy, commercial,…) and TRACES data (e.g. human consumption, animal feedingstuff,…)
- BC2BC
  A field from the small consignment control data register ('B2C, B2B, C2C, C2B') indicating if the consignment is a business-to-business, business-to-consumer, consumer-to-consumer or consumer-to-business transaction.
- Remarks

Action/control:

- Action_type
  In case of illegal import data this field indicates the action or control type the animal (product) was encountered.
- Action_ID
- A field which returns the action identifier, e.g. as a combination of the action type, date and collection site. This allows to have single field to filter on specific actions.
- Control_site
  The code of the control post at which the animal (product) was checked.
- Date_import
  The date of entry into Belgium.
- Date_control
  The date on which the animal (product) was checked.
- Documentary_check_results
  A TRACES field which indicates if the documentary check results were satisfactory or not.
- Physical_check_results
  A TRACES field which indicates if the physical check results were satisfactory or not.
- No_physical_check_reason
  A TRACES field which indicates the reason not to perform the physical check if applicable (e.g. 'Reduced checks').
- Number_of_animals_checked
  A TRACES field which indicates the number of live animals that were checked during the physical check.
- Welfare_check_results

- A TRACES field which indicates if the welfare check results were satisfactory or not.
  Impact_dead
- A TRACES field which indicates the number of dead animals encountered during the physical check.
  Impact_unfit
- A TRACES field which indicates the number of unfit animals encountered during the physical check.
- Lab_tests
  A TRACES field which indicates which laboratory tests were performed (if applicable). Can be used to add laboratory tests (e.g. for pathogen screening) performed for illegally imported animal (product)s if performed in the future.
- Lab_tests_results
  The results of the lab tests outlined in 'Lab_tests'.
- Acceptable_for_internal_market
  A TRACES field which indicates if the animal (product)s were deemed acceptable for the internal market.
- Measures
  A field indicating measures that were taken (e.g. 'destruction', 're-dispatch',..).

Geography:

- Import_transport_ID
  The transport identifier (e.g. flight number, vessel name, train number,…) entering Belgium.
- Import_airline
  The airline operating the flight entering Belgium, can be generated automatically from the 'Import_transport_ID'.
- Export_transport_ID
  The transport identifier (e.g. flight number, vessel name, train number,…) leaving from the country of export/dispatch. (Identical to 'Import_transport_ID' if there is no transit.)
- Transit_transport_ID
  The transport identifier (e.g. flight number, vessel name, train number,…) leaving from the transit country and entering Belgium.
- Export_airport
- The airport of export/dispatch.
- Export_country
  The country of export/dispatch.
- Export_city
  The city of export/dispatch.
- Transit_airport
- The transit airport if the imported animal (product) makes multiple stops.

- Transit_country
  The transit country if the imported animal (product) makes multiple stops.
- Transit_city
  The transit city if the imported animal (product) makes multiple stops.
- Origin_country
  Country where the animal (product) was sourced from. Currently only available for CITES and TRACES data.

While this seems like a long list of database fields, the following should be taken into consideration as well:

1) **The data fields can be filled in flexibly based on the data source and data availability.** In data overviews, the data fields shown can be reduced to those relevant for the viewed data. This means that on the one hand, for views displaying data of multiple data sources the data fields can be reduced to (some of) the data fields for which data is available for all or most of the included data sources. These types of overviews can thus remain more compact. On the other hand, allowing fields that only contain data for (a) certain data source(s) allow more informative data reports when displaying only data of that/those sources. With the same underlying database containing a large number of data fields, several optimised overviews with a reduced number of columns can thus be generated.

2) **The data fields should be finetuned to the intended (future) scope.** The list above takes into account all data sources included in the INTERCEPT database prototype. However, if the scope of the future centralised database would be more restricted, several fields data fields could be dropped depending on which data sources would be excluded. For example, if there would be no intention to include TRACES data in the future database, at least 12 data fields would remain empty. However, it is advisable to consider future expansion of the scope and to already include data fields that may not be filled in an early stage of a future centralised database, but which might be filled later on.

3) **The contents in some fields can be generated automatically based on data in other fields.** The large number of proposed data fields in the list above does not imply that data would need to be entered for each of these fields as the data for some fields could be generated automatically based on data in entered fields. This could for example be the case for most of the taxonomic fields. The 'Lowest_available_taxon' and 'Import_transport_ID' fields are very specific examples which would be automatically filled in based on other fields and which could seem redundant at first glance, but could allow easier filtering of the data based on a single data field. Likewise the 'Export_airport' and 'Transit_airport' fields might seem like unnecessary fields in addition to the city/country fields, but it might be faster for officials in the field to record the short and unique airport code (which is printed in a larger font on passenger luggage tags) instead of the city and country. The latter can then be generated automatically based on that code. If the data is not constrained to certain values (e.g. when

recorded on paper), this has the added advantage of avoiding ambiguous country entries like ‘Congo’ which could either refer to the Democratic Republic of the Congo or the Republic of the Congo.

For other fields entered data could be used for certain data types, but automatically generated for other data types. For example, for the small consignments control register the ‘Measures’ field could populated based on entered data, while the value ‘destruction’ could be filled in automatically for luggage destruction data.

4.3.3.3. Scenarios

Three possible scenarios for a future centralised database were identified, of increasing ambition and resource requirements: a baseline proof of concept, a 'middle of the road' option, and a high-end option.

Baseline (proof of concept): a harmonised database bringing the different data sources together under a single, consistent structure, accessed through an interface with login per user group and a set of specific reporting pages. This corresponds most closely to the current INTERCEPT prototype described in 4.3.2.

Middle of the road: an interoperable database, additionally exposing its data through read-only ('Get') APIs so that other systems can query it directly. Its interface would add a dedicated data submission section with built-in validation for quality control, alongside login per user group and reporting pages, all for an internal audience; data could also still be submitted via Excel templates built on synchronised, standardised reference lists (e.g. of countries or taxa).

High end: a fully FAIR (Findable, Accessible, Interoperable, Reusable) database, with both read and write ('Get/Post') API access. Its interface would extend the middle-of-the-road submission and reporting functionality with AI-assisted data validation, AI-powered (LLM-based) reporting, and the ability to upload supporting multimedia (e.g. photos, certificates), and would be available as a downloadable app for internal users. It would additionally offer a public-facing external dashboard presenting a curated, publicly accessible subset of the data to a wider audience, alongside the same standardised Excel submission templates as the other scenarios.

Moving from the baseline to the middle-of-the-road or high-end scenario would require substantially more development and maintenance resources, but would correspondingly increase the database's value for interoperability, data quality and external communication.

4.4. Species diversity of intercepted meat from passengers’ luggages.

Between August 2023 and December 2024, we sampled animal carcasses and meat confiscated during bimonthly Baggage Control ('BaCon') actions organised by Customs and FASFC and (Leaking) luggage destruction operations, carried out roughly every two to three months, and organised by Saniport and BAC Waste Management. In total, 637 specimens were sampled during 28 BaCon actions and 8 luggage-destruction actions

4.4.1. Taxonomic diversity and domestic/wild composition

Of the 637 specimens sampled, 578 (90.7%) were identified to at least genus level, and 569 (89.3%) to species level with high confidence. Most of the identified specimens, 432 (74.7%), were of domestic origin -predominantly cattle, chicken and pig - while 142 specimens (24.6%) were confirmed as wild meat (Figure 4.4.1.).

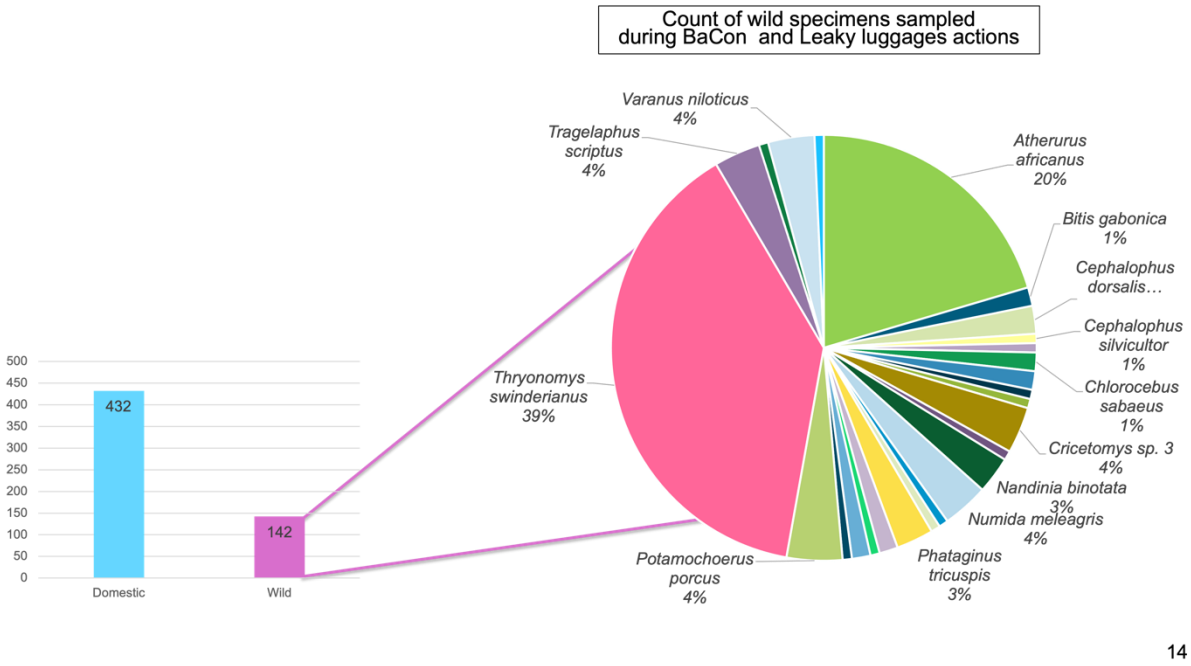

Figure 4.4.1. Domestic versus wild composition of the 578 genus-level identified specimens (left), and taxonomic diversity among the specimens confirmed as wild meat (right).

Specimens confirmed as wild meat (n = 142) spanned 25 distinct species, 17 of which are CITES-listed and several of which are classified as threatened on the IUCN Red List (Table I). A single species, the greater cane rat (Thryonomys swinderianus), accounted for around 39% of wild specimens, followed by the African brush-tailed porcupine (Atherurus africanus) at around 20%; the remaining species each contributed a few percent or less. This pattern -- a small number of species dominating a long tail of more occasional detections -- suggests that, while the trade draws on a wide range of taxa, it is in practice dominated by a handful of species.

Table 4.4.1. Wild species identified via DNA barcoding, with IUCN Red List category and CITES appendix / EU Wildlife Trade Regulation annex listing status (LC = Least Concern, NT = Near Threatened, VU = Vulnerable, EN = Endangered, CR = Critically Endangered, DD = Data Deficient).

Scientific name	Common name	N	IUCN category	CITES appendix	EU annex
Atherurus africanus	African brush-tailed porcupine	24	LC	-	-
Cephalophus dorsalis	Bay duiker	3	NT	II	B
Cephalophus silvicultor	Yellow-backed duiker	1	NT	II	B

Chamaeleo africanus	African chameleon	1	LC	II	B
Chlorocebus sabaeus	Green monkey	1	LC	II	B
Colobus sp.	Colobus monkey	2	CR-VU-EN-LC	II	A/B
Cricetomys gambianus	Gambian giant pouched rat	1	LC	-	-
Cricetomys sp.	Giant pouched rat	1	LC	-	-
Cricetomys sp. 3	Giant pouched rat	5	LC	-	-
Naja melanoleuca	Forest cobra	1	LC	-	-
Nandinia binotata	African palm civet	4	LC	-	-
Numida meleagris	Helmeted guineafowl	3	LC	-	-
Osteolaemus tetraspis	Dwarf crocodile	1	VU	I	A
Pelusios castaneus	West African mud turtle	1	LC	-	-
Phataginus tricuspis	Tree pangolin	1	EN	I	A
Philantomba maxwelli	Maxwell's duiker	1	LC	II	B
Philantomba walteri	Walter's duiker	1	DD	II	B
Potamochoerus larvatus	Bushpig	1	LC	-	-
Potamochoerus porcus	Red river hog	5	LC	-	-
Pternistis ahantensis	Ahanta francolin	6	LC	-	-
Thryonomys swinderianus	Greater cane rat	49	LC	-	-
Tragelaphus scriptus	Northern bushbuck	1	LC	-	-
Trionyx triunguis	African softshell turtle	1	VU	II	B
Varanus niloticus	Nile monitor	5	LC	II	B
Xerus erythropus	Striped ground squirrel	1	LC	-	-

The species accumulation curve had not reached a plateau after 28 sampling actions (Figure 4.4.2.)), indicating that the true species diversity moving through this single airport is still underestimated by the current sampling effort. Consistent with this, the 8 independent luggage-destruction actions added 3 further species (2 CITES-protected) that had not been observed in the BaCon actions. A comparison with an earlier study at the same airport (Chaber et al., 2023, sampling 2017–2018) reinforces this picture: 16 species detected in the present study were not recorded by Chaber et al., while 10 species recorded by Chaber et al. (6 of them CITES-protected) were not observed here.

Neither study alone therefore captures the full diversity entering via this route, and species composition may also shift over time.

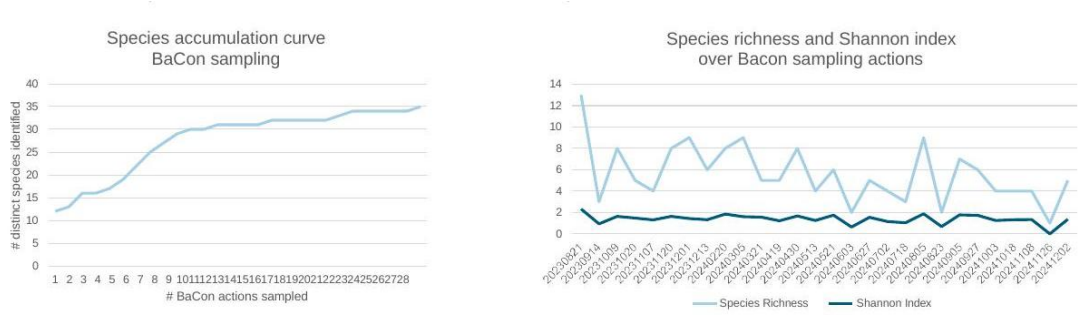

Figure 4.4.2. Species accumulation curve (left) and species richness / Shannon diversity index (right) across the 28 BaCon sampling actions.

4.4.2. Reliability of field identification

Because confiscated meat is frequently smoked, cooked, salted or cut into small pieces, morphological identification in the field is inherently more difficult than molecular identification. Comparing officials' field classification of each specimen as domestic or wild against the DNA-based result showed field identification to be reasonably accurate overall: 93% of samples field-classified as wild meat were confirmed as such by DNA barcoding, and 92% of samples field-classified as domestic meat were confirmed as domestic -- meaning that 8% of presumed domestic meat was, in fact, wild meat. This level of agreement supports using field classification as a practical, if imperfect, basis for prioritising which specimens receive further sampling or molecular confirmation.

4.4.3. Estimating the number of animals involved

The number of specimens sampled is not equivalent to the number of animals represented, since a single carcass -- particularly for larger domestic species -- is often subdivided into multiple packaged cuts before being confiscated. By matching anatomical features between meat cuts (e.g. corresponding bone or tissue cross-sections), a minimum number of individual animals could be estimated for the more commonly encountered species. For example, the domestic-meat specimens are estimated to represent a minimum of only around 109 chickens, 80 cattle and 38 pigs -- considerably fewer individual animals than the specimen count alone would suggest. Most wild species, by contrast, were represented by specimens with no matching cuts identified, so their specimen and minimum-individual counts are more similar. Figure 4.4.3. shows the comparison between total number of specimens sampled, and the estimated total number of individuals and the sum of the measured weights of the specimens.

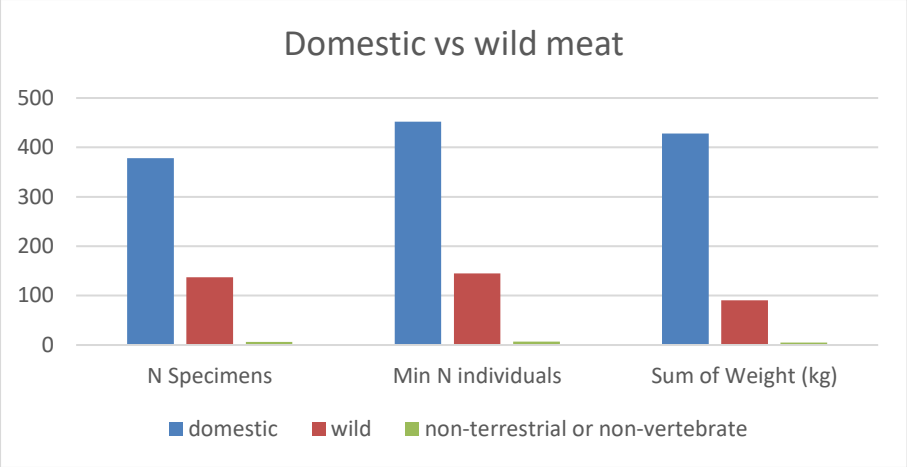

Figure 4.4.3. Comparison of the number of specimens, the minimum number of individuals and the sum of the weight of the sampled specimens.

4.4.4. Geographic origin of imports

Flight origin was recorded for the majority of specimens, though this information should be interpreted with some caution: passengers may have travelled via connecting flights not captured in the data, and flight information was frequently missing for specimens collected during luggage-destruction actions. With that caveat, the meat sampled overall originated predominantly from countries in Africa, with a smaller number of samples originating from Asia. This is primarily a reflection of the selection of flights that were monitored by customs: these indeed primarily came from western or central Africa, and some from Asia.

Restricting this to the 110 (of 142) wild-meat specimens for which flight origin was known, all originated from Western or Central Africa -- none of the sampled wild meat could be traced to a flight originating in Asia. Cameroon, Ghana and the Democratic Republic of the Congo together accounted for the large majority of wild-meat specimens with known origin, followed by smaller numbers from Togo, Burkina Faso and Nigeria (Table II). The greater cane rat was the most frequently detected wild species from each of these four largest source countries.

Table 4.4.2. Country of origin of wild-meat specimens with known flight origin (n = 110 of 142 wild specimens; the remaining 32 lacked flight-origin information).

Country of origin	N wild specimens	Dominant species (N)
Cameroon	34	African brush-tailed porcupine (11)
Ghana	30	Greater cane rat (19)
Democratic Republic of the Congo	16	Greater cane rat (8)
Togo	11	Greater cane rat (8)
Burkina Faso	6	Greater cane rat (5)
Nigeria	6	Greater cane rat (6)
Angola	5	no single dominant species (max. 1 per species)
Ethiopia	1	Colobus monkey (1)
Sierra Leone	1	Bay duiker (1)

4.5. Viral pathogen detection frequency and diversity

Pooled, homogenised meat samples (4–5 specimens per pool; 40 pools in total) were subjected to unbiased metagenomic RNA/DNA sequencing. Resulting contigs were compared against reference sequences by BLASTn, screened to remove likely false positives (e.g. endogenous host sequence, laboratory or human contamination), and cross-referenced against known vertebrate-virus host ranges. Each detected virus was further annotated with its WOAH listing status (listed / not listed / unknown) and a literature-based zoonotic and veterinary concern level (high / medium / low / no concern / unknown-uncharacterised). Sequencing failed partially for 5 of the 40 designed pools, so these were excluded, leaving 35 pools for the results below.

All summary statistics in this section are calculated at the level of the pool (presence/absence of a finding). Categories represented by fewer than 3 pools are marked with an asterisk (*) throughout and should be read as indicative only.

4.5.1. Overall detection and risk profile

A complete list of confirmed virus detections is presented in Table 4.5.1.

Table 4.5.1. All viruses detected in 35 pools of meat samples included in this study.

Pool	Virus family	Virus common name	WOAH category	concern level, based on literature	Animal species of specimens in pool	Animal species of specimens in pool - common name	Specimen state	Action type	Origin of specimens	Nr of specimen pooled
pool01	Nodaviridae	unknown nodavirus	unknown	completely unknown virus	*Varanus niloticus*	Nile monitor lizard	raw	BaCon, LD	Middle Africa, NA	4
pool01	Picornaviridae	unknown picornavirus	unknown	completely unknown virus	*Varanus niloticus*	Nile monitor lizard	raw	BaCon, LD	Middle Africa, NA	4
pool02	Anelloviridae	Chicken anemia virus	not listed	high veterinary concern	*Gallus gallus*	Chicken	cooked	BaCon	Middle Africa	5
pool02	Orthoherpesviridae	Gallid alphaherpesvirus	not listed	medium veterinary concern	*Gallus gallus*	Chicken	cooked	BaCon	Middle Africa	5
pool02	Anelloviridae	Gyrovirus homsa3	not listed	high veterinary concern	*Gallus gallus*	Chicken	cooked	BaCon	Middle Africa	5
pool03	Orthomyxoviridae	Avian influenza (unknown pathogenicty)	listed / non-listed affecting wildlife	high veterinary, high zoonotic concern	*Bos taurus*	Cattle	cooked	BaCon	Western Africa	5
pool03	Coronaviridae	Bovine coronavirus	not listed	medium veterinary concern	*Bos taurus*	Cattle	cooked	BaCon	Western Africa	5
pool03	Picornaviridae	Bovine rhinitis B virus	not listed	high veterinary concern	*Bos taurus*	Cattle	cooked	BaCon	Western Africa	5
pool03	Reoviridae	rotavirus A	not listed	medium veterinary concern, medium zoonotic concern	*Bos taurus*	Cattle	cooked	BaCon	Western Africa	5
pool03	Genomoviridae	uncharacterised genomivirus	unknown	probably part of normal virome	*Bos taurus*	Cattle	cooked	BaCon	Western Africa	5
pool03	Parvoviridae	unknown parvovirus	unknown	completely unknown virus	*Bos taurus*	Cattle	cooked	BaCon	Western Africa	5
pool03	Parvoviridae	unknown parvovirus	unknown	completely unknown virus	*Bos taurus*	Cattle	cooked	BaCon	Western Africa	5
pool03	Paramyxoviridae	unknown respirovirus	unknown	medium veterinary concern, medium zoonotic concern	*Bos taurus*	Cattle	cooked	BaCon	Western Africa	5
pool04	Paramyxoviridae	parainfluenza virus 5	not listed	medium veterinary concern	*Bos taurus*	Cattle	raw	BaCon	Western Africa	5
pool04	Picobirnaviridae	unknown picobirnavirus	unknown	uncharacterised virus related to viruses of medium zoonotic and veterinary concern	*Bos taurus*	Cattle	raw	BaCon	Western Africa	5
pool04	Rhabdoviridae	unknown tibrovirus (rhabdovirus)	unknown	unknown virus related to viruses of low veterinary and zoonotic concern	*Bos taurus*	Cattle	raw	BaCon	Western Africa	5
pool05	Paramyxoviridae	Peste-des-petits ruminants virus	listed	high veterinary concern	*Capra hircus*	Goat	cooked	BaCon	Western Africa, Middle Africa	5
pool05	Picornaviridae	unknown enterovirus	unknown	unknown virus related to virus of mild veterinary concern	*Capra hircus*	Goat	cooked	BaCon	Western Africa, Middle Africa	5
pool05	Picornaviridae	unknown picornavirus	unknown	completely unknown virus	*Capra hircus*	Goat	cooked	BaCon	Western Africa, Middle Africa	5
pool06	Genomoviridae	unknown genomivirus	unknown	probably part of normal virome	*Atherurus africanus*	African brush-tailed porcupine	cooked	BaCon	Middle Africa	5
pool06	Alloherpesviridae	unknown herpesvirus	unknown	completely unknown virus	*Atherurus africanus*	African brush-tailed porcupine	cooked	BaCon	Middle Africa	5
pool06	Papillomaviridae	unknown papillomavirus	unknown	low veterinary concern	*Atherurus africanus*	African brush-tailed porcupine	cooked	BaCon	Middle Africa	5

pool06	Papillomaviridae	unknown papillomavirus	unknown	low veterinary concern	*Atherurus africanus*	African brush-tailed porcupine	cooked	BaCon	Middle Africa	5
pool06	Peribunyaviridae	unknown peribunyavirus	unknown	uncharacterised virus	*Atherurus africanus*	African brush-tailed porcupine	cooked	BaCon	Middle Africa	5
pool08	Parvoviridae	unknown parvovirus	unknown	completely unknown virus	*Thryonomys swinderianus*	Greater cane rat	cooked	BaCon	Western Africa	5
pool08	Polyomaviridae	unknown polyomavirus	unknown	uncharacterised virus related to viruses of medium zoonotic and veterinary concern	*Thryonomys swinderianus*	Greater cane rat	cooked	BaCon	Western Africa	5
pool09	Picornaviridae	unknown coxsackie-like sapelovirus (picornaviridae)	unknown	completely unknown virus	*Nandinia binotata*	African palm civet	cooked	BaCon, LD	Middle Africa, NA	4
pool09	Hepadnaviridae	unknown hepatitis B virus	unknown	uncharacterised virus related to viruses of high public health and veterinary concern	*Nandinia binotata*	African palm civet	cooked	BaCon, LD	Middle Africa, NA	4
pool09	Retroviridae	unknown spumavirus	unknown	uknown virus related to virus of high veterinary concern	*Nandinia binotata*	African palm civet	cooked	BaCon, LD	Middle Africa, NA	4
pool10	Retroviridae	Enzootic nasal tumor virus 2	not listed	medium veterinary concern	*Bos taurus*	Cattle	prepared	BaCon	Western Africa	5
pool10	Coronaviridae	infectious bronchitis virus	listed	medium veterinary concern	*Bos taurus*	Cattle	prepared	BaCon	Western Africa	5
pool10	Nodaviridae	unknown nodavirus	unknown	completely unknown virus	*Bos taurus*	Cattle	prepared	BaCon	Western Africa	5
pool10	Picornaviridae	unknown picornavirus	unknown	completely unknown virus	*Bos taurus*	Cattle	prepared	BaCon	Western Africa	5
pool11	Retroviridae	Enzootic nasal tumor virus 2	not listed	medium veterinary concern	*Gallus gallus*	Chicken	prepared	BaCon	Eastern Africa	5
pool11	Orthoherpesviridae	Gallid alphaherpesvirus	not listed	medium veterinary concern	*Gallus gallus*	Chicken	prepared	BaCon	Eastern Africa	5
pool11	Coronaviridae	infectious bronchitis virus	listed	medium veterinary concern	*Gallus gallus*	Chicken	prepared	BaCon	Eastern Africa	5
pool11	Picornaviridae	unknown megrivirus	unknown	unknown virus related to viruses of medium veterinary concern	*Gallus gallus*	Chicken	prepared	BaCon	Eastern Africa	5
pool11	Picornaviridae	unknown picornavirus	unknown	completely unknown virus	*Gallus gallus*	Chicken	prepared	BaCon	Eastern Africa	5
pool12	Orthoherpesviridae	Gallid alphaherpesvirus	not listed	medium veterinary concern	*Gallus gallus*	Chicken	prepared	BaCon	Middle Africa	5
pool14	Genomoviridae	unknown genomivirus	unknown	probably part of normal virome	*Bos taurus*	Cattle	prepared	BaCon, LD	Middle Africa	5
pool14	Genomoviridae	uncharacterised genomivirus	unknown	probably part of normal virome	*Bos taurus*	Cattle	prepared	BaCon, LD	Middle Africa	5
pool14	Astroviridae	unknown astrovirus	unknown	uncharacterised virus related to viruses of medium zoonotic and veterinary concern	*Bos taurus*	Cattle	prepared	BaCon, LD	Middle Africa	5
pool14	Astroviridae	unknown astrovirus	unknown	uncharacterised virus related to viruses of medium zoonotic and veterinary concern	*Bos taurus*	Cattle	prepared	BaCon, LD	Middle Africa	5
pool14	Nodaviridae	unknown nodavirus	unknown	completely unknown virus	*Bos taurus*	Cattle	prepared	BaCon, LD	Middle Africa	5
pool14	Peribunyaviridae	unknown peribunyavirus	unknown	completely unknown virus	*Bos taurus*	Cattle	prepared	BaCon, LD	Middle Africa	5

pool14	Picornaviridae	unknown picornavirus	unknown	completely unknown virus	*Bos taurus*	Cattle	prepared	BaCon, LD	Middle Africa	5
pool14	Orthoherpesviridae	unknown varicellovirus	unknown	unknown virus related to viruses of medium public health and veterinary concern	*Bos taurus*	Cattle	prepared	BaCon, LD	Middle Africa	5
pool14	Arenaviridae	unknown virus	unknown	completely unknown virus	*Bos taurus*	Cattle	prepared	BaCon, LD	Middle Africa	5
pool15	Retroviridae	Avian leukosis virus	not listed	medium veterinary concern	*Bos taurus*	Cattle	cooked	BaCon	Middle Africa	5
pool15	Arenaviridae	unknown virus	unknown	completely unknown virus	*Bos taurus*	Cattle	cooked	BaCon	Middle Africa	5
pool16	Asfarviridae	African swine fever	listed	high veterinary concern	*Bos taurus*	Cattle	prepared	BaCon, LD	Middle Africa	5
pool16	Retroviridae	Avian leukosis virus	not listed	medium veterinary concern	*Bos taurus*	Cattle	prepared	BaCon, LD	Middle Africa	5
pool16	Picornaviridae	unknown picornavirus	unknown	completely unknown virus	*Bos taurus*	Cattle	prepared	BaCon, LD	Middle Africa	5
pool20	Anelloviridae	Chicken anemia virus	not listed	high veterinary concern	*Gallus gallus*	Chicken	cooked	LD	Middle Africa, NA	5
pool20	Orthoherpesviridae	Gallid alphaherpesvirus	not listed	medium veterinary concern	*Gallus gallus*	Chicken	cooked	LD	Middle Africa, NA	5
pool20	Paramyxoviridae	Newcastle disease virus	listed	high veterinary, medium zoonotic concern	*Gallus gallus*	Chicken	cooked	LD	Middle Africa, NA	5
pool20	Picornaviridae	unknown picornavirus	unknown	completely unknown virus	*Gallus gallus*	Chicken	cooked	LD	Middle Africa, NA	5
pool20	Arenaviridae	unknown virus	unknown	completely unknown virus	*Gallus gallus*	Chicken	cooked	LD	Middle Africa, NA	5
pool21	Retroviridae	Avian leukosis virus	not listed	medium veterinary concern	*Gallus gallus*	Chicken	cooked	BaCon	Western Africa	4
pool21	Orthoherpesviridae	Gallid alphaherpesvirus	not listed	medium veterinary concern	*Gallus gallus*	Chicken	cooked	BaCon	Western Africa	4
pool21	Anelloviridae	Gyrovirus galga1	not listed	high veterinary concern	*Gallus gallus*	Chicken	cooked	BaCon	Western Africa	4
pool22	Anelloviridae	Gyrovirus galga1	not listed	high veterinary concern	*Gallus gallus*	Chicken	industrial	BaCon	Asia	4
pool23	Polyomaviridae	unknown polyomavirus	unknown	uncharacterised virus related to viruses of medium zoonotic and veterinary concern	*Cricetomys sp. 3*	pouched rat	partly raw, prepared	BaCon	Middle Africa	5
pool24	Pneumoviridae	Avian metapneumovirus	not listed	medium veterinary concern	*Anas platyrhynchos*	Mallard	industrial	BaCon	Asia	4
pool24	Hepadnaviridae	Duck hepatitis B virus	not listed	low veterinary concern	*Anas platyrhynchos*	Mallard	industrial	BaCon	Asia	4
pool25	Retroviridae	Avian leukosis virus	not listed	medium veterinary concern	*Cephalophinae*	Duikers	cooked, raw	BaCon, LD	Western Africa, Middle Africa, NA	5
pool25	Coronaviridae	infectious bronchitis virus	listed	medium veterinary concern	*Cephalophinae*	Duikers	cooked, raw	BaCon, LD	Western Africa, Middle Africa, NA	5
pool25	Orthoherpesviridae	unknown herpes simplex virus	unknown	unknown virus related to viruses of public health and veterinary concern	*Cephalophinae*	Duikers	cooked, raw	BaCon, LD	Western Africa, Middle Africa, NA	5
pool25	Picornaviridae	unknown megrivirus	unknown	uncharacterised virus related to viruses of medium zoonotic and veterinary concern	*Cephalophinae*	Duikers	cooked, raw	BaCon, LD	Western Africa, Middle Africa, NA	5

pool25	Picornaviridae	unknown megrivirus	unknown	unknown virus related to viruses of medium veterinary concern	*Cephalophinae*	Duikers	cooked, raw	BaCon, LD	Western Africa, Middle Africa, NA	5
pool25	Nodaviridae	unknown nodavirus	unknown	completely unknown virus	*Cephalophinae*	Duikers	cooked, raw	BaCon, LD	Western Africa, Middle Africa, NA	5
pool25	Peribunyaviridae	unknown peribunyavirus	unknown	completely unknown virus	*Cephalophinae*	Duikers	cooked, raw	BaCon, LD	Western Africa, Middle Africa, NA	5
pool25	Picornaviridae	unknown picornavirus	unknown	completely unknown virus	*Cephalophinae*	Duikers	cooked, raw	BaCon, LD	Western Africa, Middle Africa, NA	5
pool25	Phenuiviridae	unknown virus, related to insect viruses	unknown	completely unknown virus	*Cephalophinae*	Duikers	cooked, raw	BaCon, LD	Western Africa, Middle Africa, NA	5
pool26	Genomoviridae	unknown genomivirus	unknown	probably part of normal virome	*Capra hircus*	Goat	prepared	BaCon	Western Africa, Middle Africa, Eastern Africa	4
pool26	Picornaviridae	unknown kobuvirus	unknown	uncharacterised virus related to viruses of medium zoonotic and veterinary concern	*Capra hircus*	Goat	prepared	BaCon	Western Africa, Middle Africa, Eastern Africa	4
pool27	Picornaviridae	unknown hepatovirus	unknown	uncharacterised virus related to viruses of medium zoonotic and veterinary concern	*Capra hircus*	Goat	raw, partly raw	BaCon, LD	Western Africa, Middle Africa, Eastern Africa, Europe	4
pool28	Orthomyxoviridae	Avian influenza (unknown pathogenicty)	listed / non-listed affecting wildlife	high veterinary, high zoonotic concern	*Numida meleagris*	Helmeted guineafowl	cooked	BaCon, LD	Western Africa, Middle Africa, NA	4
pool28	Coronaviridae	infectious bronchitis virus	listed	medium veterinary concern	*Numida meleagris*	Helmeted guineafowl	cooked	BaCon, LD	Western Africa, Middle Africa, NA	4
pool28	Astroviridae	unknown astrovirus	unknown	uncharacterised virus related to viruses of medium zoonotic and veterinary concern	*Numida meleagris*	Helmeted guineafowl	cooked	BaCon, LD	Western Africa, Middle Africa, NA	4
pool28	Picornaviridae	unknown megrivirus	unknown	unknown virus related to viruses of medium veterinary concern	*Numida meleagris*	Helmeted guineafowl	cooked	BaCon, LD	Western Africa, Middle Africa, NA	4
pool29	Picornaviridae	unknown picornavirus	unknown	completely unknown virus	*Phataginus tricuspis*	Tree pangolin	cooked, raw	BaCon, LD	Western Africa, Middle Africa, Eastern Africa	4
pool29	Phenuiviridae	unknown virus, related to insect viruses	unknown	completely unknown virus	*Phataginus tricuspis*	Tree pangolin	cooked, raw	BaCon, LD	Western Africa, Middle Africa, Eastern Africa	4
pool30	Retroviridae	Enzootic nasal tumor virus 2	not listed	medium veterinary concern	*Sus scrofa*	Pig	cooked	BaCon, LD	Western Africa	4
pool30	Orthoherpesviridae	unknown varicellovirus	unknown	unknown virus related to viruses of medium public health and veterinary concern	*Sus scrofa*	Pig	cooked	BaCon, LD	Western Africa	4
pool30	Arenaviridae	unknown virus	unknown	completely unknown virus	*Sus scrofa*	Pig	cooked	BaCon, LD	Western Africa	4
pool33	Parvoviridae	unknown parvovirus	unknown	completely unknown virus	*Primates*	Primates	cooked	BaCon	Western Africa, Middle Africa, Eastern Africa	4
pool33	Parvoviridae	unknown parvovirus	unknown	completely unknown virus	*Primates*	Primates	cooked	BaCon	Western Africa, Middle Africa, Eastern Africa	4
pool34	Orthoherpesviridae	Gallid alphaherpesvirus	not listed	medium veterinary concern	*Gallus gallus*	Chicken	raw	BaCon, LD	Middle Africa, Eastern Africa	4

pool34	Anelloviridae	Gyrovirus galga1	not listed	high veterinary concern	*Gallus gallus*	Chicken	raw	BaCon, LD	Middle Africa, Eastern Africa	4
pool34	Retroviridae	reticuloendotheliosis virus	not listed	medium veterinary concern	*Gallus gallus*	Chicken	raw	BaCon, LD	Middle Africa, Eastern Africa	4
pool34	Picornaviridae	unknown megrivirus	unknown	unknown virus related to viruses of medium veterinary concern	*Gallus gallus*	Chicken	raw	BaCon, LD	Middle Africa, Eastern Africa	4
pool34	Parvoviridae	unknown parvovirus	unknown	unknown virus related to viruses of medium veterinary concern	*Gallus gallus*	Chicken	raw	BaCon, LD	Middle Africa, Eastern Africa	4
pool35	Bornaviridae	unknown bornavirus	unknown	unknown virus related to virus of high zoonotic concern	*Reptilia*	Reptiles	raw, prepared	BaCon	Middle Africa	4
pool35	Parvoviridae	unknown parvovirus	unknown	completely unknown virus	*Reptilia*	Reptiles	raw, prepared	BaCon	Middle Africa	4
pool35	Parvoviridae	unknown parvovirus	unknown	completely unknown virus	*Reptilia*	Reptiles	raw, prepared	BaCon	Middle Africa	4
pool35	Parvoviridae	unknown parvovirus	unknown	completely unknown virus	*Reptilia*	Reptiles	raw, prepared	BaCon	Middle Africa	4
pool36	Astroviridae	unknown astrovirus	unknown	uncharacterised virus related to viruses of medium zoonotic and veterinary concern	*Ovis aries*	Sheep	cooked	BaCon	Western Africa	5
pool37	Orthoherpesviridae	Ovine gammaherpesvirus 2	not listed	high veterinary concern	*Ovis aries*	Sheep	raw, partly raw	BaCon	Western Africa, Middle Africa	5
pool39	Peribunyaviridae	unknown peribunyavirus	unknown	completely unknown virus	*Thryonomys swinderianus*	Greater cane rat	cooked	BaCon	Middle Africa	4
pool39	Picobirnaviridae	unknown picobirnavirus	unknown	uncharacterised virus related to viruses of medium zoonotic and veterinary concern	*Thryonomys swinderianus*	Greater cane rat	cooked	BaCon	Middle Africa	4
pool39	Peribunyaviridae	Yaba-7 virus	unknown	unknown virus related to viruses of medium veterinary concern	*Thryonomys swinderianus*	Greater cane rat	cooked	BaCon	Middle Africa	4
pool40	Picornaviridae	unknown picornavirus	unknown	completely unknown virus	*Tragelaphus scriptus*	Bushbuck	cooked, raw	BaCon	Middle Africa, Eastern Africa	5

Confirmed vertebrate-virus signal (i.e. passing false-positive filtering, and not flagged as endogenous, host-derived or a likely contaminant) was present in 31 of the 35 analysed pools (88.6%). Twenty-six pools (74.3%) contained at least one virus classified as medium/high concern or as WOAH-listed. Across all 35 pools, 77 distinct virus taxa were detected in total. Five of these are causative agents of the World Organisation of Animal Health (WOAH)-listed diseases (Table 4.5.2): African swine fever, avian influenza, infectious bronchitis, Newcastle disease, and Peste des petits ruminants — all major notifiable diseases of livestock. When these viruses are detected in a population of farm animals, the entire population needs to be culled, with obvious dramatic economic consequences.

Table 4.5.2. WOAH-listed viruses detected in intercepted meat pools.

Virus (disease)	Host species detected in	Region(s) of origin	Sampling context
African swine fever virus (*Asfivirus haemorrhagiae*)	Cattle*	Middle Africa	BaCon + LD
Avian influenza virus (*Alphainfluenzavirus influenzae*)	Helmeted guineafowl	Western + Middle Africa	BaCon + LD
Infectious bronchitis virus (*Gammacoronavirus galli*)	Cattle, Chicken, Duikers, Helmeted guineafowl	Western Africa, Eastern Africa, Western + Middle Africa	BaCon, BaCon + LD
Newcastle disease virus (*Orthoavulavirus javaense*)	Chicken	Middle Africa	LD
Peste des petits ruminants virus (*Morbillivirus caprinae*)	Goat	Western + Middle Africa	BaCon

Two caveats apply to Table 4.5.2. First, it was not possible to determine whether the two avian influenza detections were by strains of Low or High Pathogenicity, as we lacked genomic coverage of the HA gene – this is required to infer the pathogenicity level. Second, African swine fever virus is not known to infect cattle, but only pigs and boar, so its detection in a cattle-associated pool (a single, short, 259 bp contig at 100% identity) most plausibly reflects cross-contamination during sample pooling or processing rather than active infection of that host. Both cases illustrate a broader limitation of pooled short-read metagenomics: a positive signal confirms the presence of viral genetic material within the pool, but not necessarily infection of, or transmission risk from, the specific host species it is nominally associated with.

4.5.3 Differences by host species

Table 4.5.3. and Figures 4.5.1-2 summarise results by host species. The three species with the most substantial sampling (≥ 3 pools) — cattle, chicken and goat — all showed a very high pool-level prevalence of viruses of concern (85.7–100%) and multiple WOAH-listed detections, with a richness of 2.0–2.6 distinct viruses per pool sampled. All remaining species are represented by only 1–2 pools and are indicative only.

Table 4.5.3. Confirmed virus detections and richness by host species (35 pools; * = fewer than 3 pools sampled, interpret with caution).

Host species	**Pools**	**Pools with ≥ 1**	**Pools with ≥ 1**	**Distinct**	Average
Cattle	7	85.7	85.7	18	2.57
Chicken	6	100	100	15	2.50
Goat	3	100	100	6	2.00
African brush-tailed porcupine*	2	50.0	0	3	1.50
Greater cane rat*	2	100	100	5	2.50
Sheep*	2	100	100	2	1.00
African palm civet*	1	100	100	3	3.00
Bushbuck*	1	100	0	1	1.00
Duikers*	1	100	100	8	8.00
Helmeted guineafowl*	1	100	100	4	4.00
Mallard*	1	100	100	2	2.00
Nile monitor lizard*	1	100	0	2	2.00
Pig*	1	100	100	3	3.00
Primates*	1	100	0	1	1.00
Reptiles*	1	100	100	2	2.00
Sheep + pig (mixed pool)*	1	0	0	0	0.00
Tree pangolin*	1	100	0	2	2.00
Water buffalo*	1	0	0	0	0.00

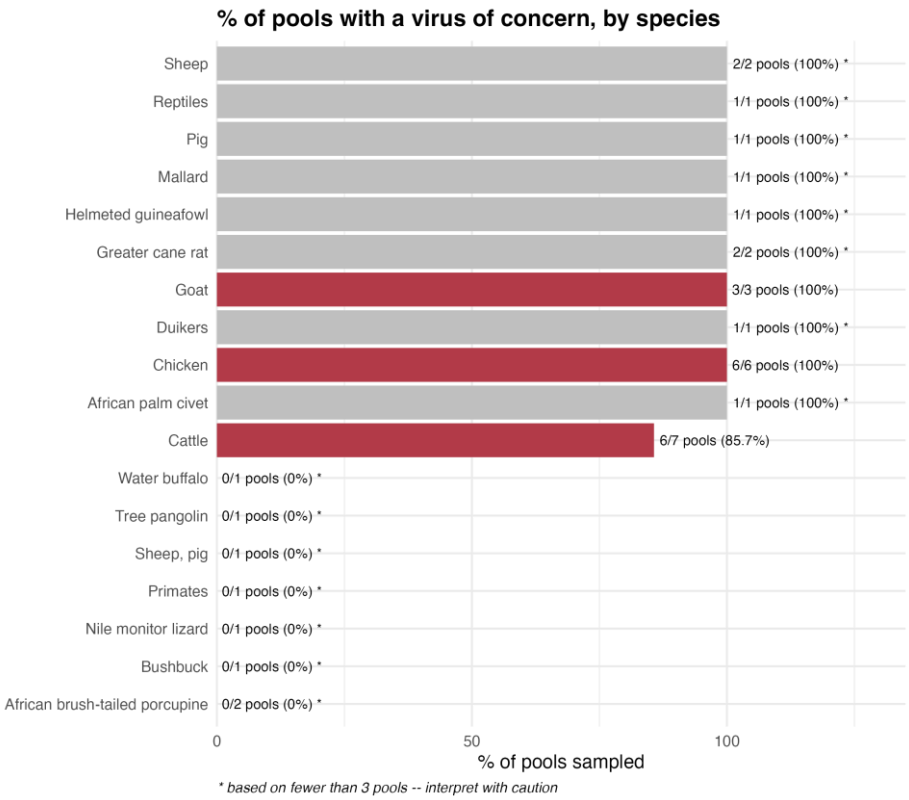

Figure 4.5.1. Percentage of pools containing at least one virus of concern, by host species.

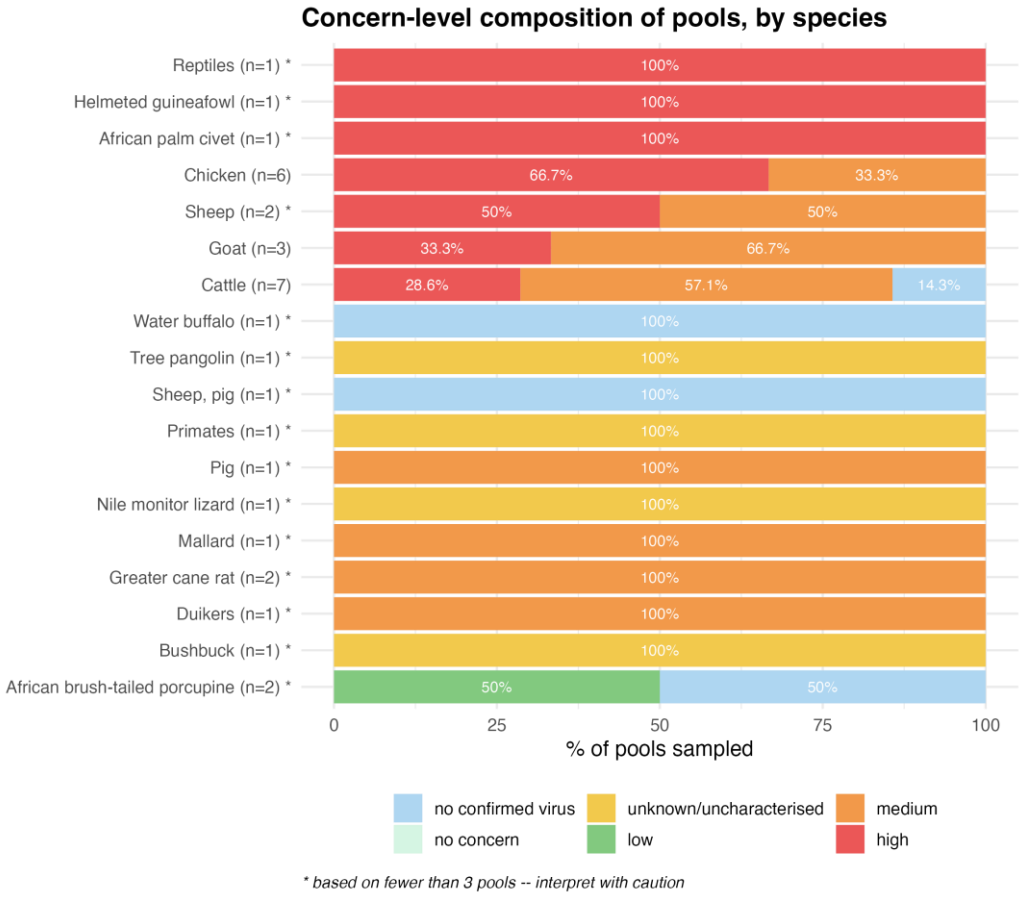

Figure 4.5.2. Composition of pools by concern level of their single most severe confirmed finding, by host species.

4.5.4. Wild versus domestic

Domestic-species pools had a markedly higher prevalence of a concerning virus (19 of 22 pools, 86.4%) than wild-species pools (7 of 13 pools, 53.8%), and a higher prevalence of WOAH-listed viruses (27.3% vs 15.4% of pools; Figures 4.5.3 -4.5.4). This should not, however, be read as meaning domestic-origin meat is straightforwardly “more dangerous”: in 76.9% of wild-species pools the single most severe finding was an unknown/uncharacterised virus, versus 36.4% of domestic-species pools. This asymmetry mirrors how much better-characterised livestock viromes are relative to wildlife viromes in current reference databases, rather than necessarily reflecting a true difference in underlying risk. Consistent with wildlife viromes being comparatively under-characterised and under-sampled, wild-species pools showed a higher average richness per pool sampled (2.23 distinct viruses/pool) than domestic-species pools (1.73), and contributed 41 of the 77 total distinct viruses detected overall (46 for domestic-species pools; 10 viruses were shared between the two groups).

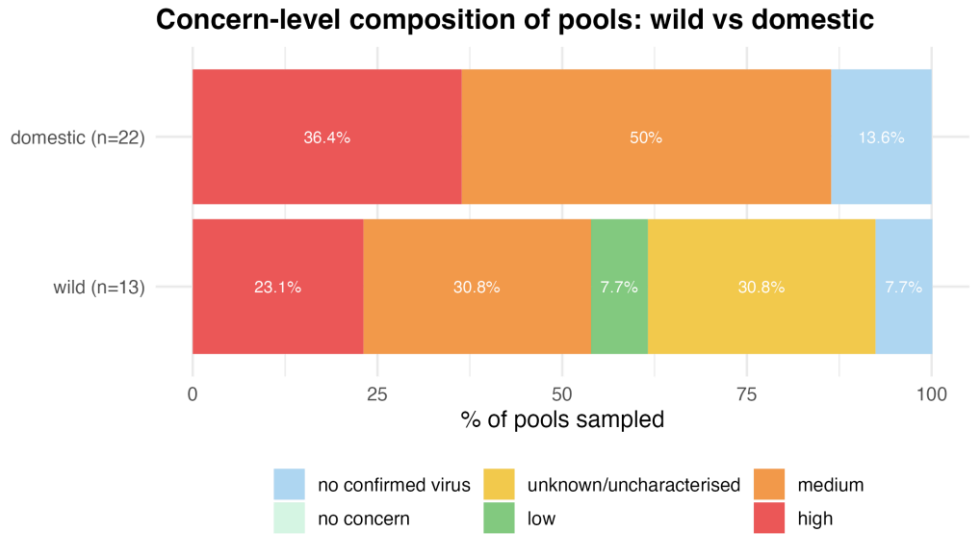

Figure 4.5.3. Composition of pools by concern level of their single most severe confirmed finding: wild versus domestic host species.

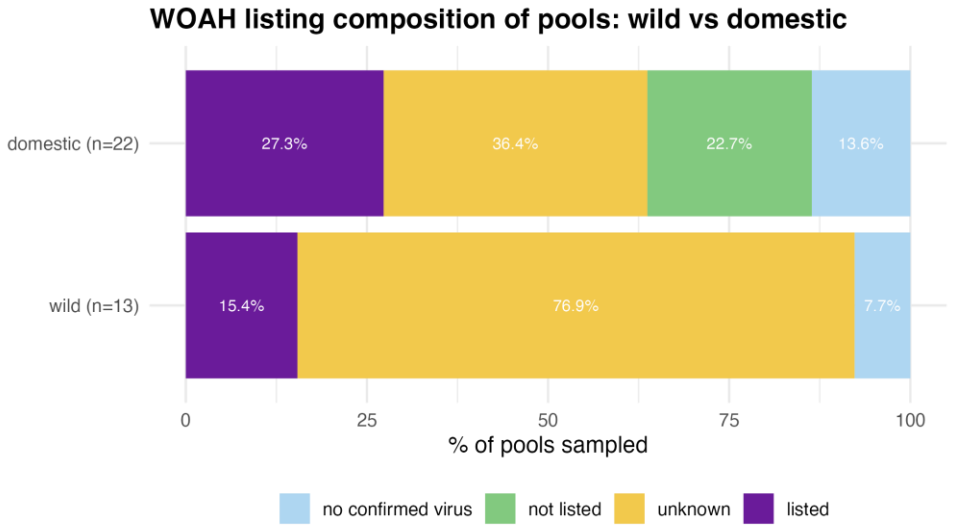

Figure 4.5.4. Composition of pools by WOAH-listing status of their single most severe confirmed finding: wild versus domestic host species.

4.5.5 Differences by region of origin

Pools linked to Middle Africa (n = 24) and Western Africa (n = 16) — the two most heavily sampled regions — showed the highest prevalence of concerning viruses (70.8% and 81.2% of pools respectively) and the highest richness (2.08 and 2.00 distinct viruses per pool). Eastern Africa (n = 7) was lower on both counts (57.1% prevalence; 2.00 viruses/pool) but showed a markedly higher share of unknown/uncharacterised findings (42.9% of pools) than Middle or Western Africa (16.7% and 12.5% respectively), again most likely reflecting reference-database gaps for that region's fauna and viruses rather than a genuinely lower viral burden. Asia and Europe are each represented by only 1–2 pools and are indicative only.

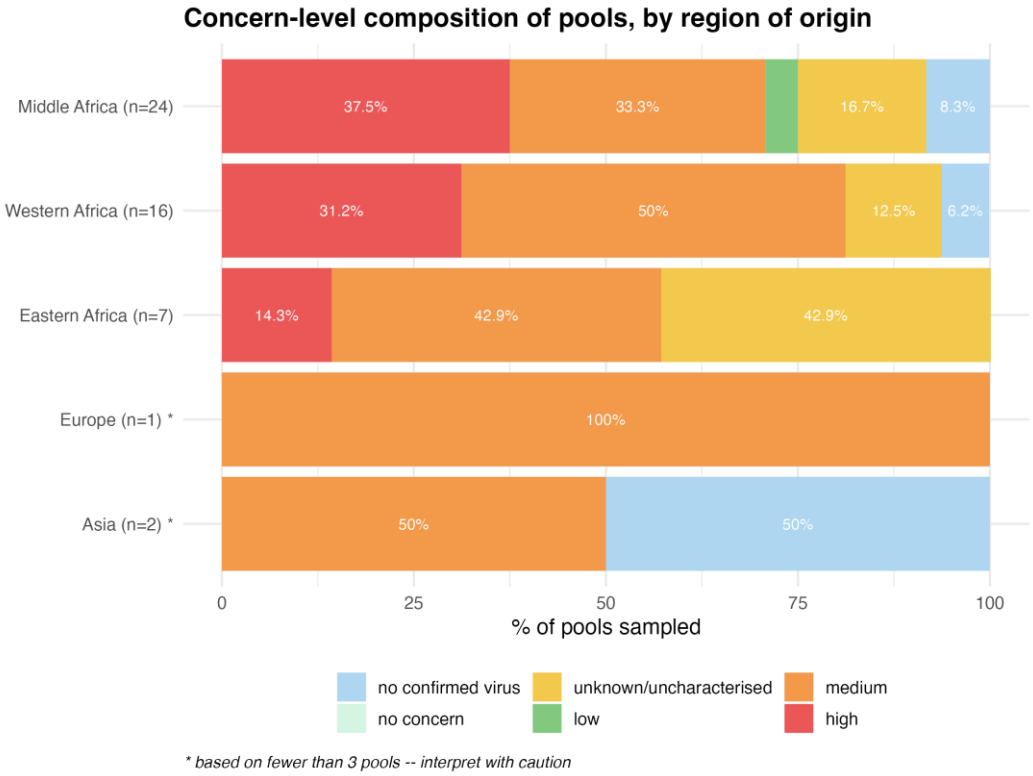

Figure 4.5.5. Composition of pools by concern level of their single most severe confirmed finding, by region of origin.

4.5.6. Limitations of the virus screening

- Metagenomic sequencing is unbiased but less sensitive than targeted qPCR; low-titre or degraded viral RNA/DNA — expected in cooked or otherwise processed meat — may go undetected, so the absence of a signal cannot be read as absence of the pathogen.
- Detection of viral sequence does not by itself establish infectivity or viability of the virus in that matrix, especially in cooked or heavily processed meat; whether these viruses remain infectious along the trade chain is an open question this project could not resolve within its timeframe and budget.
- False-positive filtering and the WOAH/concern-level classification reflect the best currently available reference sequences and published literature; they will need periodic revision as databases and disease knowledge evolve, particularly for the 45 of 126 confirmed hit records (35.7%) currently classified as unknown/uncharacterised.
- Sample sizes per category are frequently small (many species and one region represented by only 1–2 pools, flagged throughout with an asterisk); resulting percentages should be read as indicative, and larger, sustained sampling is needed before firm species- or region-specific conclusions can be drawn.
- Pooling (4–5 specimens per pool) means a positive pool cannot be attributed to a single specific individual, and, as illustrated in Section 4.5.2, carries a residual risk of cross-contamination between specimens processed together.

5. DISSEMINATION AND VALORISATION

The project team invested substantially in translating and communicating our project's insights results to various audiences: (i) Belgian federal and international policy makers directly concerned with wildlife trade and zoonotic disease prevention; (ii) the scientific community, through conference presentations, posters and seminars; (iii) customs and FASFC agents in the field, via training on biosafety protocols, (iv) via disseminating INTERCEPT results to interested stakeholders via two workshops and (iii) the general public, through press and media coverage. The project also invested in training and capacity building beyond the direct research team.

5.1 International policy engagement: PREZODE

PREZODE (PREventing ZOonotic Disease Emergence) is an international initiative bringing together researchers and policymakers to reduce the risk of future zoonotic spillovers; the project team contributed to its work on evaluating the risk of international trade as a pathway for disease emergence.

- **08/03/2023** -- Biodiversity and Health Workshop: A Belgian One World, One Health vision aiming at tackling the emergence of zoonotic disease.
- **30/06/2023** -- PREZODE workshop 2 (online).
- **06/10/2023** -- PREZODE workshop 3.
- **17/05/2024** -- PREZODE Working Group 1: international trade.
- **04/06/2025** -- Workshop on zoonotic disease prevention, including presentation of a policy memorandum.
- **10/09/2025** -- Meeting on the implementation of the next interministerial mandate.

5.2 Task force on sustainable wildlife trade and the national action plan

In parallel, the project team engaged directly with the interministerial task force on sustainable wildlife trade in exotic species, coordinated by FPS Public Health, which is developing Belgium's national action plan on the trade in exotic animals ("National Action Plan: "One World, One Health – Exotic Animals – Plan for Responsible Trade on Ecological and Health Grounds",". This is the most direct policy-facing channel through which INTERCEPT's findings and recommendations are being fed into ongoing Belgian federal policy development.

- **04/05/2023** -- Meeting on the draft plan of the task force on sustainable wildlife trade in exotic species.
- **03/07/2024** -- Presentation of the Belgian Action Plan on trade in exotic animals, and preparation of an upcoming stakeholder meeting.
- **06/11/2025** -- Illegal wild meat import interministerial working group.
- **29/01/2026** -- Illegal wild meat import working group: data management.
- **13/02/2026** -- Illegal wild meat working group: biosecurity (session I).
- **19/02/2026** -- Illegal wild meat working group: biosecurity (session II).
- **24/02/2026** -- Illegal wild meat trade working group: border controls.

5.3 INTERCEPT-organised stakeholder workshops

Beyond participating in external events, the project team organised two dedicated multi-stakeholder workshops, during which we translated INTERCEPT's findings into concrete input for Belgian and European policy on wildlife trade and biosafety.

Workshop on scale and risks of import of animals and animal products into Belgium (31 May 2024, RBINS, Brussels).

The project team organised a half-day workshop at RBINS, bringing together external experts to discuss wildlife trafficking and the scale and risks of animal(-product) imports into Belgium, alongside a presentation of INTERCEPT's own preliminary findings. The programme included presentations on wildlife trafficking in Europe and TRAFFIC's role in addressing it (Justine Guiny, TRAFFIC), CITES enforcement and the implications of the new EU Environmental Crime Directive (Farah Bouquelle, Ghent University, and Jan Van den Berghe, Court of First Instance East Flanders), and the characteristics of demand for unregulated African meat in and through Europe (Sandrella Morrison-Lanjouw, Utrecht University), followed by a presentation of INTERCEPT's context (Maud Istasse, FPS Health) and preliminary findings (Sophie Gryseels, RBINS/University of Antwerp). The event closed with a panel discussion, 'Challenges in monitoring and combatting wildlife and animal product trafficking', with Justine Guiny (TRAFFIC), Sandrella Morrison-Lanjouw (Utrecht University), Rixta Lycklama à Nijeholt (FASFC), Ioan Szalo (Customs and Excise) and Elke Malfait (CITES), moderated by Valeria Colombo (WOAH).

The workshop drew 45 attendees, spanning Belgian federal agencies (FASFC, the CITES unit and Saniport at FPS Public Health, Customs), scientific institutions (RBINS, Sciensano, the Royal Museum for Central Africa, BopCo and several universities), and international organisations and NGOs (TRAFFIC, WOAH, DG Environment, the Federation of Veterinarians of Europe, the Wildlife Conservation Society, IFAW).

The panel discussion highlighted that existing data on imports (TRACES for legal consignments; the BaCon, customs and postal-seizure registers for interceptions) is fragmented across agencies, frequently lacks species-level detail, and cannot capture the illegal imports that go undetected altogether - and that combining these sources faces both technical (differing formats) and legal (data access, personal data protection) obstacles. Panellists distinguished three broad profiles among passengers bringing in prohibited animal products - tourists unaware they are committing an offence, travellers acting for cultural reasons, and deliberate traffickers - and argued that deterrence measures and clearer public information should be tailored to this distinction. Suggested priorities included risk-based control targeting informed by existing data, EU-wide harmonisation of import conditions (which currently vary by species and product), and stronger engagement with source countries. Panellists also underlined the public- and animal-health stakes of the issue, citing the 2001 UK/EU foot-and-mouth disease outbreak (traced to illegally imported, insufficiently treated meat), the ongoing spread of African swine fever, and past cases of illegally imported animals carrying avian influenza and rabies, as concrete precedents for the risks posed by unchecked imports.

Workshop on the illegal importation of wild meat (12 December 2024, Brussels).

Building on the May workshop, the project team co-organised a larger, cross-border workshop together with FPS Public Health, Food Chain Safety and Environment, WWF France and TRAFFIC. The event brought together around 60 representatives of French and Belgian public authorities (customs, animal and human health border control agencies, civil aviation authorities), scientific institutions, the air transport sector (Air France, Brussels Airlines, Brussels Airport, IATA), civil society and academia -- the first cross-border forum of its kind specifically dedicated to the illegal wild meat trade.

The morning programme opened with a keynote from Pierre Kerkhofs (Director General, DG Environment, FPS Health), followed by presentations on the scale and characteristics of the illegal wild meat trade in Europe (Justine Guiny, TRAFFIC, and Lorélie Escot, WWF France) -- which estimated annual illegal wild meat imports of 273 tonnes through Paris airports and 46 tonnes through Brussels airport, with CITES-listed species accounting for around a third of reported seizures -- the Belgian draft national action plan on the trade in exotic species (Maud Istasse, FPS Health), French customs' efforts against illegal meat imports in travellers' luggage (Benjamin Baud, DGDDI), and French civil aviation's initiatives with airlines and foreign authorities (Morgan Verin, DGAC). The project team presented INTERCEPT's own findings on the scale of exotic meat imports (Laura Cuypers) -- reporting that, as of that date, 625 meat specimens had been sampled and 514 identified to at least genus level, of which an estimated 17-26% were wild meat including 11 CITES-protected species (figures later refined in the project's final analysis, Section 4.3) -- and on the pathogen diversity detected in the wild meat trade (Sophie Gryseels). Air France presented its own private-sector awareness and staff-training initiative (Marie-Pierre Pernet).

The afternoon consisted of three breakout groups - (1) knowledge, data collection and research, including pathogens; (2) control and enforcement; and (3) engagement and cooperation with the air transport sector - which together produced 11 priority recommendations, subsequently consolidated into 10 formal policy recommendations published in an accompanying policy brief co-authored by FPS Public Health, RBINS, WWF France and TRAFFIC:

1. A centralised database on illegal wild meat, ideally at EU level (a national database as a faster, practical first step).
2. Standardised, easy-to-use sampling protocols for border control agents.
3. Advanced, standardised species-identification techniques, including rapid DNA-based identification.
4. Enhanced biosafety for personnel handling seized meat (personal protective equipment and training).
5. A comprehensive and balanced penalty system covering non-CITES wild meat, not only CITES-listed species.
6. Simplification of the applicable EU legislation (Delegated Regulation (EU) 2019/2122), removing the numerous current exemptions.
7. Training programmes and 'ready-to-use', targeted materials for air transport staff, developed jointly with public authorities and civil society.
8. A harmonised EU approach across the aviation sector, coordinated through bodies such as ICAO.

9. Structured outreach to source/destination countries, including via an interministerial working group involving foreign affairs ministries.
10. Amendment of Annex 9 of the ICAO Chicago Convention to strengthen provisions against wildlife trafficking.

Several of these recommendations echo, and reinforce, INTERCEPT's own recommendations (Section 4.7) -in particular on centralised/interoperable data-sharing, standardised sampling and identification protocols, and biosafety measures for personnel - and directly feed into the finalisation of Belgium's national action plan on the trade in exotic species.

The presentations and the recommendations and report that was made of the workshop can be found here: https://bebiodiversity.be/en/blog/2025/01/30/illegal-wild-meat-a-problem-for-biodiversity-and-health/

5.4 Scientific dissemination: conferences, seminars and presentations

Project results were presented at a range of scientific, forensic and taxonomic venues, both to specialist audiences (wildlife forensics, taxonomy, virology) and at RBINS-internal events aimed at a broader research audience.

- **25--26/03/2024 --** Poster presentation at the Empowering Biodiversity Research III conference (Fanny Kratz).
- **10/04/2024 --** 'Wildlife Trade in Europe' on line seminar, World Organisation of Animal Health (WOAH) -- presentation (Sophie Gryseels).
- **18/04/2024 --** Taxphyl Day, RBINS -- presentation (Sophie Gryseels).
- **26/04/2024 --** Research Day, RBINS -- poster presentation.
- **14--15/05/2024 --** Conference 'Europe United Against Old and New Pandemics' -- attended (no presentation).
- **23/05/2024 --** Taxonomy Recognition Day -- poster presentation.
- **11--12/09/2024 --** EU Wildlife Forensic Conference -- presentation (Laura Cuypers). *https://forensics.natur.cuni.cz/wp-content/uploads/2025/01/Agenda-of-the-EU-Wildlife-Forensic-Conference.pdf*
- **22--23/01/2025 --** BeOH event 'Ecosystems in the Balance -- Supporting Future Policy and Research' -- poster presentation and participation in the working group on wildlife trade. *https://www.biodiversity.be/6060/*
- **23/05/2025 --** Taxonomy Recognition Day, RBINS -- poster presentation.
- **26/05/2025 --** Presentation of INTERCEPT project to Minister Vanessa Matz during her visit to RBINS (Sophie Gryseels).
- **02/04/2026 --** Belgian Wildlife Disease Society (BWDS) symposium -- presentation (Fanny Kratz).

5.5 Public and media outreach

INTERCEPT attracted recurring interest from national and international press, providing an opportunity to raise public awareness of the scale and biosafety risks of the illegal wild meat trade beyond the research and policy communities.

- **07/03/2024 --** INTERCEPT featured on the German radio station Deutschlandfunk Kultur. *https://www.deutschlandfunkkultur.de/affenfleisch-im-koffer-illegaler-buschfleisch-handel-und-seine-folgen-dlf-kultur-5f7d7266-100.html*
- **11/04/2024 --** INTERCEPT featured on a Deutsche Welle podcast. *https://www.dw.com/en/illegal-bushmeat-trade/audio-68795767*
- **01/11/2024 --** INTERCEPT featured in a Gazet van Antwerpen (GVA) news article. *https://www.gva.be/economie/beer-kangoeroe-en-zelfs-giraf-waarom-de-rage-van-exotisch-vlees-eten-nu-helemaal-voorbij-is/37596608.html*
- **17/11/2025 --** Flyer prepared for the 2025 CITES Conference of the Parties (CITES COP).
- **09/07/2026 --** VRT NWS article referencing import limitations on animal and plant products, drawing on feedback provided by the INTERCEPT team in response to similar articles over the preceding two years.

5.6 Training and capacity building

The team also invested in training and hosting visits from students and international peers, building capacity beyond the direct research outputs of INTERCEPT itself.

- **08/01/2025 --** Visit from Howest Biomedical Laboratory Technology students (module 'Working in Forensic Research'), Royal Museum for Central Africa (RMCA).
- **17/04/2025 --** Visit to the Belgian Defense Lab (DLD-BIO) – presentation on INTERCEPT project.
- **07/05/2025 --** Visit from researchers of Charles University and Czech customs (including the director of Prague Airport and the director of its Investigation Department), covering BaCon actions, cargo controls and RBINS.
- **14--18/07/2025 --** Visit from Czech student Juliana Walterová, to learn RNA extraction methods for the metagenomic screening of airport meat samples.
- **25/08/2025 --** Presentation of the sampling protocol for non-researchers, Brussels Airport (Zaventem).
- **08/12/2025 --** Visit from Howest students, Royal Museum for Central Africa (RMCA).

6. PUBLICATIONS

Conference presentations:

- Laura Cuypers, oral presentation. Monitoring the trade in exotic animal products through DNA barcoding of passenger-imported meat. EU Wildlife Forensic Conference 11 – 12 September 2024, Prague, Czech Republic. https://forensics.natur.cuni.cz/wp-content/uploads/2025/01/Agenda-of-the-EU-Wildlife-Forensic-Conference.pdf
- Laura Cuypers, poster presentation. Monitoring the trade in exotic animal products through DNA barcoding of passenger-imported meat. BeOH event: Ecosystems in the balance 22-23 Jan 2025, Brussels, Belgium. https://www.biodiversity.be/6060/

- Fanny Kratz, oral presentation. Project INTERCEPT, Monitoring the trade in exotic animals, wild meat and the pathogens they carry in Belgium. Belgian Wildlife Disease Society Symposium 6 April 2026, Brussels, Belgium.

We have disseminated the following protocols:

- Cuypers L, Kratz F, Smitz N, Gryseels S. (2025) Meat sampling protocol for non-researchers.
- Cuypers L, Kratz F, Smitz N, Gryseels S. (2025) SOP meat sampling and molecular species identification.

Preliminary title of scientific paper in progress: Scale of illegally imported wild and domestic meat and their pathogens into Europe via Brussels Airport.

The INTERCEPT database is accessible for authorised users at:
https://apext.rbins.be/data/r/ws_intercept/

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Evelyn Neefs, An Delange (FPS Mobility)

Niels Deriemaecker (Belnet)

Gunter Kathagen (FPS Employment, Labour and Social Dialogue)

Aziz Naji* (Belspo)

ANNEXES

Annexes can be found in https://drive.google.com/drive/folders/1-ZhyNZb6lgc2uokzRA7m7-49F1ITwGHb?usp=drive_link

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