MPH PROJECT

- Consultative Report-

A Tool to Assess the Public Health Risks of Wildlife Importation into the United States: The Case of Rodents from Latin America

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Executive Summary

An inherent risk of the wildlife trade – both formal (legal) and informal (illegal) – is the risk of disease introduction and/or emergence into the United States. Numerous proposals have aimed to prevent or control this risk by banning importation of select species, or by creating 'white lists' of species that are cleared for importation. These approaches could cause economic harm to certain private sectors, such as the pet industry, and would potentially place substantial burden on importers to provide proof of low risk for importation of individual species. In order to inform these critical policy and import decisions, there is a need for creation of an unbiased, scientifically-based, risk analysis framework that can be easily implemented by governmental agencies, NGOs and industry. As a feasibility study, we built a risk analysis framework following the general OIE guidelines, and applied it to a specific group of animals (rodents), a specific geographical location of origin (Latin America), and a specific outcome (risk of zoonoses entering the United States). This subset was chosen for the pilot given the lack of any health requirements for rodents coming into the United States (U.S.) from Latin America, and potentially the small number of traded species and zoonotic diseases to identify. This framework will be expanded to other taxa and geographic locations to ultimately inform policy. Through the hazard identification phase and the pathway analysis we identified 4 rodent species imported legally from 2 Latin American countries (Peru exports *Cavia porcellus*, and Guyana exports *Cuniculus paca, Dasyprocta spp*, and *Coendou prehensilis*) that are distributed to the pet industry once in the U.S.; and 15 zoonotic pathogens of potential concern. However, during the risk assessment phase these pathogens could not be qualitatively assessed completely due to lack of data. Despite this, there are potential recommendations to manage the risk of introduction of

zoonotic pathogens into the U.S. via rodents. These recommendations include surveillance, a tracking system for the rodents once they arrive in the U.S., appropriate PPE measures, and education on best practices for the pet owners and pet stores. From the beginning of the project, we laid out a risk communication strategy to involve all the stakeholders, seek expert opinion and get feedback from the community. One of the main conclusions of this pilot case study was the need for more research in order to obtain more data. Given that the risk analysis process is iterative, once data is available, it can be input into the framework and have a more informed process in the next iteration. Another conclusion is the need for the implementation of some management measures throughout the process based on the preliminary data presented. Also, risk communication plays a key role throughout the whole risk analysis process.

1. Introduction

It is estimated that approximately 60.3% of emerging infectious diseases are zoonotic, the majority of which come from wildlife- about 71.8% of these zoonotic pathogens - (Jones, 2008). One of the main routes for disease emergence and/or introduction is global wildlife trade (Pavlin et al. 2009; Smith et al. 2009; Travis et al. 2011).

The wildlife trade not only introduces a risk to public health, but it also has the potential to introduce invasive species and diseases to native wildlife, livestock, and companion animals. Further, wildlife trade may have an impact on the biodiversity of the country of origin of the species traded (Karesh et al, 2012).

The risk to public health is of concern to agency officials regulating the wildlife trade as well as experts studying emerging diseases. This concern was reflected in the 2010 GAO Report entitled *Live Animal Imports: Agencies Need Better Collaboration to Reduce the Risk of Animal-Related Diseases*. Report recommendations included United States Department of Agriculture Animal and Plant Health Inspection Service (USDA's APHIS) taking on a stronger regulatory role regarding prevention of wildlife disease introduction via international trade. Despite this concern, there is a lack of health regulations surrounding wildlife imports into the U.S. In 2004, The Convention on Biological Diversity identified wildlife trade as "the most glaring gap in the international legal system related to trade and invasive species" (Smith, 2012).

Previously proposed regulatory changes such as those put forth by H.R. 669 suggested an amendment to the Lacey Act banning all incoming wildlife; H.R. 669 proposed such a ban until a risk assessment could be performed by U.S. Fish and Wildlife Service (USFWS) within a timeline of 2 years for all species entering the country. Such a proposal ignored the capacity

limitations of the USFWS to complete such a task. Further, such "white list" proposals (recommending a list of species cleared for import) such as H.R. 669 are not popular with stakeholders such as the pet industry who would suffer significant economic losses under such a plan unless or until alternatives for sourcing of animals could be developed.

Historically, policies have been reactionary or urgent in response to a public health threat related to wildlife trade, such as the ban on importation of African rodents after introduction of monkeypox into the U.S. in 2003. Monkeypox is a zoonotic viral disease endemic to central and West Africa. African rodents are considered to be the natural host. Human infections during the 2003 outbreak resulted from contact with pet prairie dogs (native to the U.S.) that had contracted monkeypox from African rodents imported for the commercial pet trade (Smith, 2012).

Given the disease risk posed by importation of wildlife into the U.S., there is a need for a formal, science-based risk analysis framework that will help to inform the development of guidelines and policy for wildlife trade.

Risk analysis is a structured, evidence-based, standardized and iterative process that can help decision-making in the face of uncertainty and determine the potential impact of infectious and non-infectious diseases on ecosystems, wildlife, domestic animals and people. Results from the risk analysis can assist decision makers to consider an evidence-based range of options for prevention and mitigation of disease risks to the population(s) under considerations (OIE/IUCN, *In press*). Risk analysis therefore informs policy. There are several phases in a risk analysis, and each one of them answers specific questions **(Figure 1).** Briefly, the phases and the questions are:

a) Problem Description: What is the specific question (policy question) for the analysis?

b) Hazard Identification: What can cause the problem? And how can it happen?

c) Risk Assessment: What is the likelihood and what are the consequences of the hazard/s happening? And how much?

d) Risk Management: What can be done to minimize the impacts?

e) Risk Communication: Who is interested? Who is affected?

Figure 1. Risk Analysis Framework

There are formal standards for risk analysis already in place. The Office of International Epizooties (OIE) originally developed a risk analysis model primarily for importation of animals and animal products. There are several relevant OIE publications that provide some guidelines for the different countries in this arena of animal importations. In 1994, the OIE created the Working Group on Wildlife Diseases, which has prepared recommendations and oversees numerous scientific publications on the surveillance and control of the most important specific wildlife diseases (http://web.oie.int/wildlife/eng/en_wildlife.htm).

The traditional risk analysis framework from OIE is targeted towards livestock and agriculture-related species. The economical implications associated with disease risk in

agriculture have made risk analysis in this field a very useful and necessary tool. There are plenty of published case studies of risk analysis related to livestock. When it comes to wildlife however, it has been a much slower process. One of the motivations to start looking into wildlife disease risk is the public health implication, along with potential wildlife conservation side-benefits.

There are some publications that apply a risk analysis framework to wildlife. For example, Soldatini (2011) developed a risk assessment for wildlife interference with aviation at Italian airports, mainly looking into the impact that wildlife collisions have on aviation. The International Union for Conservation of Nature (IUCN) has historically done risk analysis related to wildlife translocations. Some countries already have risk assessments in place for their native wildlife translocations, and/or for wildlife trade. For example, Canada has a risk analysis for wild animal translocations that developed in conjunction with the OIE Wildlife Working Group (http://www.ccwhc.ca/wildlife_health_topics/risk_analysis/rskguidintro.php), but these examples are more geared solely towards the wildlife conservation aspect. However, there is still a dearth of published risk analysis for wildlife disease, and public health threats with a wildlife component in the literature. Some examples include: Travis (2006) who described a disease risk analysis framework to be used for primate conservation planning and decision making; and Corbellini (2012) who analyzed the risk of introduction of highly pathogenic Avian Influenza in southern Brazil via migratory birds. Fortunately, there is a new set of guidelines in press that combine OIE and IUCN risk analysis frameworks that will prove very useful and practical in analyzing wildlife disease risks for public health.

1. 2. Objectives

1. To build a risk analysis framework utilizing joint OIE/IUCN guidelines (*In press*) to assess the public health risk that wildlife trade poses to the United States (U.S.).
2. To pilot the risk analysis framework on a specific example: What is the risk of zoonotic transmission from Latin American (endemic) rodents imported to the U.S. and causing any kind of illness in a human.
3. To assess the usefulness of this approach to the above scenario.
4. To identify data 'gaps' to prioritize research needed to better understand the model-and inform policy- regarding public health risks from wildlife trade into the U.S.

1.3. Problem Description

The first phase of the risk analysis is the Problem Description. 'This phase outlines the background and context of the problem, identifies the goal, scope and focus of the risk analysis, formulates the risk analysis question(s), states assumptions and limitations and specifies the acceptable level of risk' (OIE/IUCN, *In press*). To ensure transparency, assumptions and limitations are documented and a statement on the acceptable level of risk formulated, bearing in mind that there are no 'zero risk' options.

As stated previously, wildlife trade plays an important role in the emergence and introduction of infectious diseases, which is a serious public health concern. Importation of wildlife through trade into the U.S. is very large. Over half a million shipments of wildlife containing >1.48 billion live animals were imported by the United States between 2000-2006 (Smith, 2009). It would be impossible to do a risk analysis of all taxa at once that are involved in the wildlife trade into the U.S.

In order to narrow down the risk analysis to a manageable task, and to be able to potentially pilot it to other taxa, we decided to focus on a specific group: rodents (order *Rodentia*). One reason we chose rodents as a pilot is the current lack of health requirements for rodents coming into the U.S. from regions other than Africa, and also because of the complexity of this group, as they are used as pets, in labs, zoos, and they are also considered pests.

Regarding public health concerns, we decided to focus specifically on zoonotic risk posed to the U.S. public. Other public health concerns related to imported wildlife in the U.S. or elsewhere were not included.

Rodents are being imported into the U.S. from all over the world with the exception of Africa from where imports have been banned since 2003 due to the Monkeypox outbreak. The

importations of rodents from Europe and the rest of North America are greater compared to those imported from Latin America (Lankau, 2013, *unpublished data*). We chose Latin America as the origin of focus in order to limit the scope of this initial pilot study; and because there are no federal health regulations for rodents imported from Latin America. Not only did we restrict our focus to Latin America as the origin of rodent exportation, but we further only considered rodents that are endemic to Latin America. There are likely other rodent species being imported from Latin America yet not endemic to there that were excluded from this analysis. Also, our analysis excluded species endemic to Latin America that are shipped from countries outside of Latin America that are captive-bred, and used for different purposes (for example, *Chinchilla lanigera*, endemic to Latin America, but bred in captivity in countries like Canada and used as pets and in the fur industry). For clarity, Latin America consists of Central and South America, and the Caribbean (http://en.wikipedia.org/wiki/Latin_America). A Latin American rodent is a species of rodent endemic to Latin America.

There are 2 types of wildlife trade: legal (formal) and illegal (informal) (Broad, 2001). This specific risk analysis focuses only in the formal trade, using the information available from the USFWS with the goal of decreasing uncertainties.

Also, rodents (and wildlife in general) can be traded in different ways (the main difference is live specimens versus dead specimens or parts or products thereof). For this analysis, we only focused on live rodents, as we assumed that the risk of live specimens would be greater than the dead ones. Based on all the parameters and assumptions described above, the risk analysis question was the following:

‘What is the risk of zoonotic disease introduction from rodent species endemic to Latin America, through trade from Latin America, into the U.S. population, causing any illness in an individual (human)?’

2. Hazard Identification

'The purpose of this phase is to identify all possible health hazards of concern. Criteria are established for ranking the importance of each hazard and its possible direct and indirect consequences within the bounds of the defined problem (OIE/IUCN, *In press*).'

In order to identify the potential hazards (in this case the hazards are infectious zoonotic pathogens in rodents) and to find out information about the specific rodent species that concern the specific risk analysis question (endemic and traded from Latin America), the following methods were performed:

1. An extensive literature search was conducted for all infectious pathogens found in rodents worldwide; then more specifically for zoonotic pathogens, and then we narrowed our list to zoonotic pathogens present in species endemic to Latin America, and then focused only on traded species from Latin America. In each step we searched for pathogens found in rodents regardless of the source (laboratory, experimentally, wild, captive).

2. Database analysis, specifically the database entitled "HP3" (EcoHealth Alliance, *unpublished data*). This database contains information regarding zoonotic viruses found in rodents.

3. Trade data analysis: USFWS LEMIS database (Law Enforcement Management Information System), 2007-2010. We extracted all data for Latin American endemic rodent species that were traded live from any Latin American country to the U.S.; and CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) species list looking for traded rodent species from Latin America protected by CITES.

4. Expert opinion: Questionnaires were sent to experts in rodent diseases and experts in zoonoses involving rodents. Questions asked pertained to information we could not gather from answers in the literature or the databases.

After this thorough review, a total of 329 infectious pathogens in rodents were identified. These pathogens were found in 17 reports through veterinary forums; 3 news bulletins; 4 books; 3 conference proceedings; 2 web documents; 142 peer-reviewed scientific papers, and the "HP3" database.

Four rodent species endemic to Latin America were traded from Latin America to the U.S. during 2007-2010 timeline for which we had USFWS trade data. These species were: *Cavia porcellus, Dasyprocta spp* (in this case the database only specifies Genus, so we considered any species within the Genus), *Cuniculus paca*, and *Coendou prehensilis.*

In order to narrow down the pathogens to those that interest us based on the risk analysis question, we built a decision-making tree with several criteria. We started with a list of all the infectious pathogens identified in rodent species (worldwide, any infectious pathogen found in a rodent). The total number was 329. The complete list of pathogens and their references can be found in **Appendix 1.** We applied 3 criteria to the 329 pathogens to identify and prioritize them. The criteria used are graphically represented below **(Figure 2),** and they are ordered from most certain to less certain based on the available information.

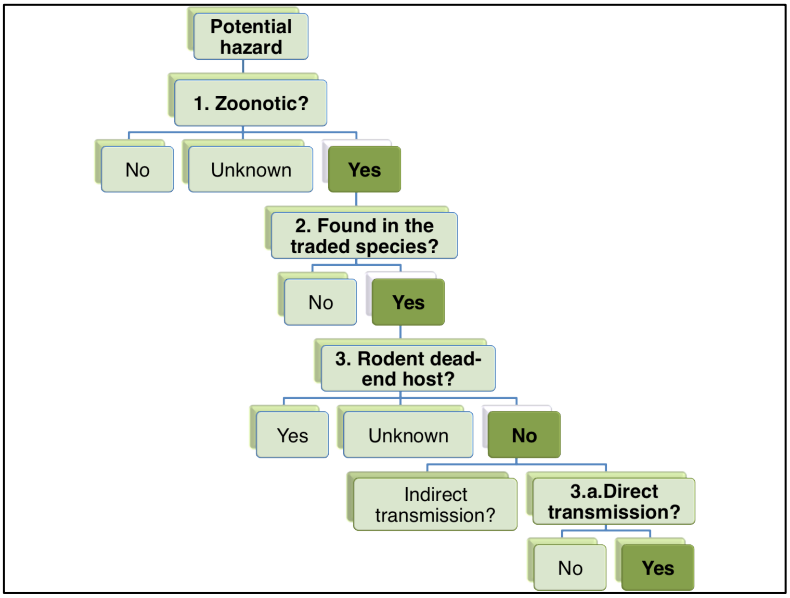

Figure 2. Decision-making tree with the criteria for the infectious pathogens found in rodents.

- Criterion 1. Is this hazard (infectious pathogen) zoonotic? (Yes/No/Unknown)- back to the policy question, what is relevant is to know if the infectious agent is zoonotic.

- Yes = 156 pathogens identified. These pathogens continue to the next criterion node.

- Unknown = 128 pathogens (they might be zoonotic): these are infectious pathogens that are not completely well understood yet but might have the potential to be zoonotic unless proven otherwise. The uncertainty regarding these pathogens is discussed later.

- Not zoonotic = 45 pathogens. The risk from these pathogens is negligible for the specific policy question, so they are excluded from the analysis.

- Criterion 2. From the pathogens that are known to be zoonotic (Y = 156), has the pathogen been found in any of these four rodent species that are traded from Latin America? (*Cavia porcellus, Dasyprocta spp, Cuniculus paca, Coendou prehensilis)*

- Yes = 39. These pathogens continue to the next criterion node.

- No = 117. These pathogens are not relevant for the policy question, so they are not further considered.

There is no Unknown for this step as the zoonotic pathogens either have been found in the traded species, or have not been found. This does not mean that it would not be possible for the pathogens to be present in these species if more surveillance and research were to be done. This means there is uncertainty in this step as well.

- Criterion 3. Is the rodent a dead-end for the pathogen? (Dead-end host: A host from which infectious agents are not transmitted to other susceptible hosts- hence the rodent would not release the pathogen-).

- Yes. We do not consider these pathogens any further. We were not able to identify any pathogens within this category.

- Unknown = 3 pathogens.

- No = 35 pathogens.

3a) If No, can the pathogen be transmitted from rodents directly to humans?

- Yes = 15 pathogens. These pathogens are the ones that will be assessed further (Higher risk).

- No = 20 pathogens (the pathogen spreads indirectly, so lower risk). For this specific question, we are not considering these pathogens any further.

Based on the criteria above, 15 pathogens need to be assessed. These pathogens are further examined during the next phase (risk assessment phase). **Appendix 3** has the complete list of these pathogens and the species where they were found.

Also the criteria applied to the hazards (infectious pathogens) allowed us to identify areas of uncertainty. First, there are 128 pathogens that are within the category of Unknown (if zoonotic or not); second, there is uncertainty about the pathogens found in the different species (these rodent species may harbor these pathogens as well but they have not been examined yet); third, there is uncertainty about the role of the rodents in the transmission (unknown if they are dead-end hosts for some pathogens). There are several ways to deal with uncertainty:

1. If the uncertainty is so great that nothing can be answered, the policy question must be changed, as long as stakeholders agree.

2. Uncertainty allows for the identification of research needs. With more research, we would be able to place some of the 'Unknowns' in either a 'Yes' or 'No' category. This is a costly and labor-intensive means to deal with uncertainty, but it might be in many cases the only way.

3. Seek expert opinion. If some of the 'Unknowns' are mainly based on lack of literature reports, experts may be able to answer some of the questions based on unpublished data, and if not, at least they would be able to help prioritize research needs.

2.1. Pathway Analysis

The pathway analysis provides a graphic depiction of the route that the hazard(s) of concern (zoonotic pathogens from rodent species endemic and traded from Latin American that are competently directly transmitted to humans) follow, and outlines the steps where the risk of release and exposure can increase or decrease.

The following figure **(Figure 3)** summarizes the theoretical pathway that the different species of live endemic rodents from Latin America follow from their source (Latin American

country) to the consumer in the U.S. There is some known information based on the trade data from USFWS (2007-2010), and other information is unknown.

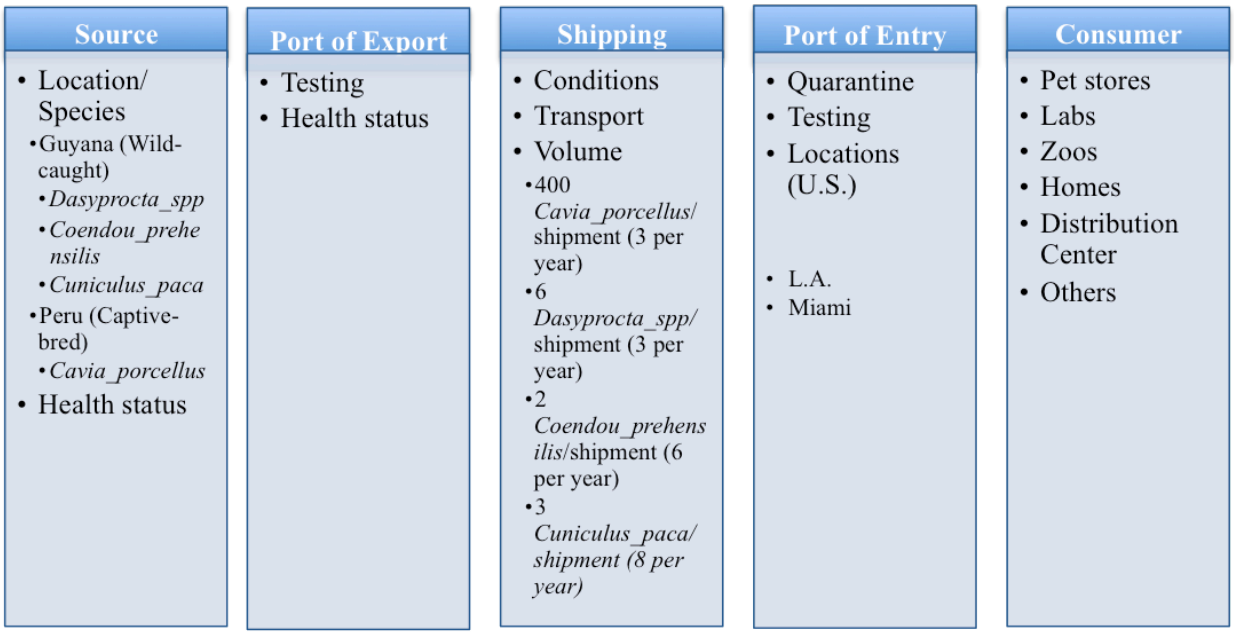

Figure 3. Summary of the pathway analysis for traded rodents from Latin America into the U.S.

The pathway begins at the source (Latin American country). Rodents are either wild-caught or captive-bred depending on the species and the location. Guyana, a Caribbean country located in the northeastern part of South America, is the source of 3 endemic traded rodent species, and all of them are wild-caught. These are: *Dasyprocta spp* in general (agoutis), *Coendou prehensilis* (Brazilian porcupine), and *Cuniculus paca* (lowland paca). Peru, a country located in the western part of South America, is the source of 1 endemic rodent species that is traded, which is *Cavia porcellus* (guinea pig), and this rodent species is captive-bred. Both Guyana and Peru ship live rodents to the U.S. Before these rodents are shipped to the U.S., there is no information about the conditions they are kept in the country of export, for how long, or if they get in contact with other wildlife, domestic animals, and what type of contacts occur.

It is not known how the health status of these rodents is before they get shipped from Guyana and Peru to the U.S. No specific regulations have been found regarding shipping of rodents from these countries into the U.S. It is known that the importer is legally required to declare all live animal shipments via paperwork to the USFWS. However, the importers may not declare even if it is required; and sometimes animals that are declared to be captive-bred are in fact wild-caught, which increases the uncertainties towards the risk analysis.

The conditions of shipment of the rodents are also unknown. They could be shipped by air, by sea, or by land. It is not known if they are shipped in individual boxes, in larger boxes with the same species, and/or with other species, and/or what type of boxes. It is not known if they share the same space with other wildlife, and for how long they are kept under those conditions.

What it is known from the USFWS data is the volume of shipment of each species of rodent. For instance, there is an average of 6 specimens of *Dasyprocta spp* in each shipment, and there are about 3 shipments per year (from Guyana). In each shipment of *Coendou prehensilis* there is an average of 2 animals, and there is about 6 shipments per year. In the case of *Cuniculus paca*, there are about 3 animals per shipment, and there are 8 shipments per year. In the case of *Cavia porcellus* exported from Peru, there are about 400 animals per shipment, and about 3 shipments per year. A 'snapshot' of the USFWS data between 2007-2010 is provided in **Appendix 2**.

Once the rodents are shipped they arrive into the U.S through a port of entry. Once in the U.S., there are no federal health regulations for imported rodents from Latin America (http://www.cdc.gov/animalimportation/bringinganimaltous.html), so shipments are not inspected. USFWS officials check the paperwork, and they have the right to do a visual

inspection to verify species and assess welfare conditions (not specifically to look for evidence of disease), although USFWS may not chose to do so, especially if the species are non-CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora). Based on the USFWS records, we know to which ports of entry the above rodent species coming from Latin America (Guyana and Peru) go. *Cavia porcellus* arrives through Los Angeles, CA (L.A.), and the other 3 rodent species (*Coendou prehensilis, Dasyprocta spp* and *Cuniculus paca*) arrive through Miami, FL.

Dasyprocta punctata (within *Dasyprocta spp*) and *Cuniculus paca* are both considered protected under CITES. This means that they would probably receive more 'attention' once they arrive in the U.S. (i.e., more likely to undergo a non-veterinary visual inspection for species verification and shipment condition than the other species).

Beyond the port of entry, there are more uncertainties about the rodent final destination.

Based on the available information from the USFWS database, we know a little about what businesses are acquiring the specific rodents from Latin America (at least between 2007-2010). In the case of *Coendou prehensilis,* there are 3 main companies that buy them: 2 of them are located in Florida, and 1 of them in the state of Mississippi. In the case of *Dasyprocta spp,* there are also 3 main companies that buy them (all of them located in Florida), 1 of them is the same as for *Coendou prehensilis.* In the case of *Cavia porcellus,* it seems that there is 1 main company that buys them, and it is located in New Jersey. In the case of *Cuniculus paca*, there is only 1 company, that also buys *Coendou prehensilis* and *Dasyprocta spp*, and it is located in Florida. All of these companies are related to the pet industry, information that was found through web search engines. Besides knowing where the main location of these companies are, it is uncertain if the rodents transit through or end up in those locations, or if they go somewhere

else (end user). Given the nature of the pet industry and these businesses, it is very likely that the rodents are distributed to other states, or are re-exported internationally. The final destination might be a household if these rodents are kept as pets, after the animal has transited through buyer, a distribution center, and a pet store. In order to understand the risk of zoonotic pathogens causing disease in people in the U.S. from rodents coming from Latin America, it is critical to understand the distribution of these imported rodents and their final destination, and this is information that is not required by government officials or recorded elsewhere for public knowledge.

As it has been mentioned throughout this section and in previous phases of the risk analysis, uncertainty is great for the pathway analysis as well. First of all, we are only considering legal (formal) trade, leaving out all the potential hazards from illegal trade. Second, we only have limited data from USFWS (2007-2010), and we are assuming that this data is accurate. It is true that within the dataset, there is consistency regarding the species traded and the countries of origin and ports of entry in the U.S. We are not examining data beyond 2010, so trade could have changed over the last 3 years. Then, regarding pre-shipping, shipping, and distribution, there are many data 'gaps' that increase the uncertainty. For instance, we do not know if there is any health testing pre-shipment (although this is unlikely unless required by an importing zoo or laboratory), what the shipping conditions are, or what the final destination of the rodent it truly is.

In the following figure (map), we represent the routes of the different rodent species from the time they leave Latin America until they are distributed once in the U.S.

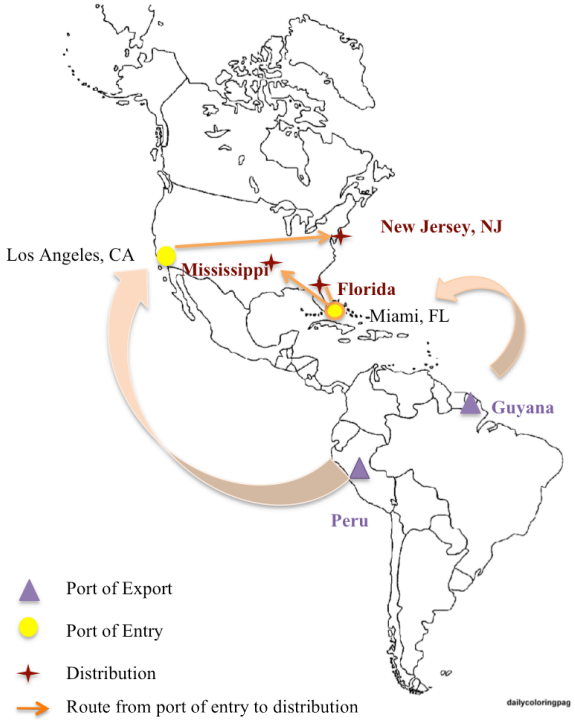

Figure 4. Route that the traded rodent species follow from Latin America to the U.S.

Based on the pathway analysis, these are the main generic risk assessment questions:

1. What is the risk of a *Cavia porcellus* (guinea pig) leaving Peru, transmitting a zoonotic disease to a human in the U.S., and causing illness?

2. What is the risk of a *Dasyprocta spp* leaving Guyana, transmitting a zoonotic disease to a human in the U.S. ,and causing illness?

3. What is the risk of a *Cuniculus paca* leaving Guyana, transmitting a zoonotic disease to a human in the U.S., and causing illness?

4. What is the risk of a *Coendou prehensilis* leaving Guyana, transmitting a zoonotic disease to a human in the U.S., and causing illness?

3. Risk Assessment

'The purpose of the risk assessment phase is to assess a) the likelihood of release of the pathogen (introduction) into the area of concern, b) the likelihood that the species of interest will be exposed to the hazard (pathogen) once released and c) the consequence of exposure to the pathogen. On this basis the hazards can be prioritized in descending order of importance' (OIE/IUCN, *In press*).

There are two main types of risk assessment: quantitative and qualitative, depending on how much quality data is available. In the case of a qualitative risk assessment, terms like 'high', 'medium' and 'low' are used to define risk. If it is quantitative, risk is presented in numerical terms. There is also a semiquantitative approach that is used when some data is available, but not enough to make it completely quantitative.

In our specific example, given the amount and quality of available data, we determined that a qualitative risk assessment was the best fit for the first iteration of the framework.

Based on the OIE definition of risk assessment, it is comprised of 3 main phases: release assessment, exposure assessment, and consequence assessment.

During this phase, we assessed those pathogens identified during the hazard identification phase that were considered of high risk based on the risk analysis question: zoonotic, found in the 4 traded rodent species from Latin America, rodents are not dead-end hosts for the pathogen, and the pathogen is transmitted directly to humans. The total number of pathogens to be assessed was 15.

Figure 5 represents in a schematic way the different parts of the risk assessment. In our specific example, this figure shows the potential ways in which rodents from Latin America arrive to the U.S., and how the pathogens that they may carry can be released, how humans could get exposed to them, and what needs to happen in order to result in any consequences.

As we have discussed earlier, uncertainty is present during this phase as well. In order to decrease the uncertainty and to focus on the risk analysis question, we are only assessing rodents that arrive alive in the U.S., and not those that arrive dead. We assumed that live rodents would have a higher zoonotic potential than dead ones.

Following Figure 5, the general risk assessment model is presented. It is divided in the 3 phases (Release, Exposure and Consequences). Examples of risk assessments for specific pathogens and specific pathways for our risk analysis question in this case study can be found in **Appendix 4.**

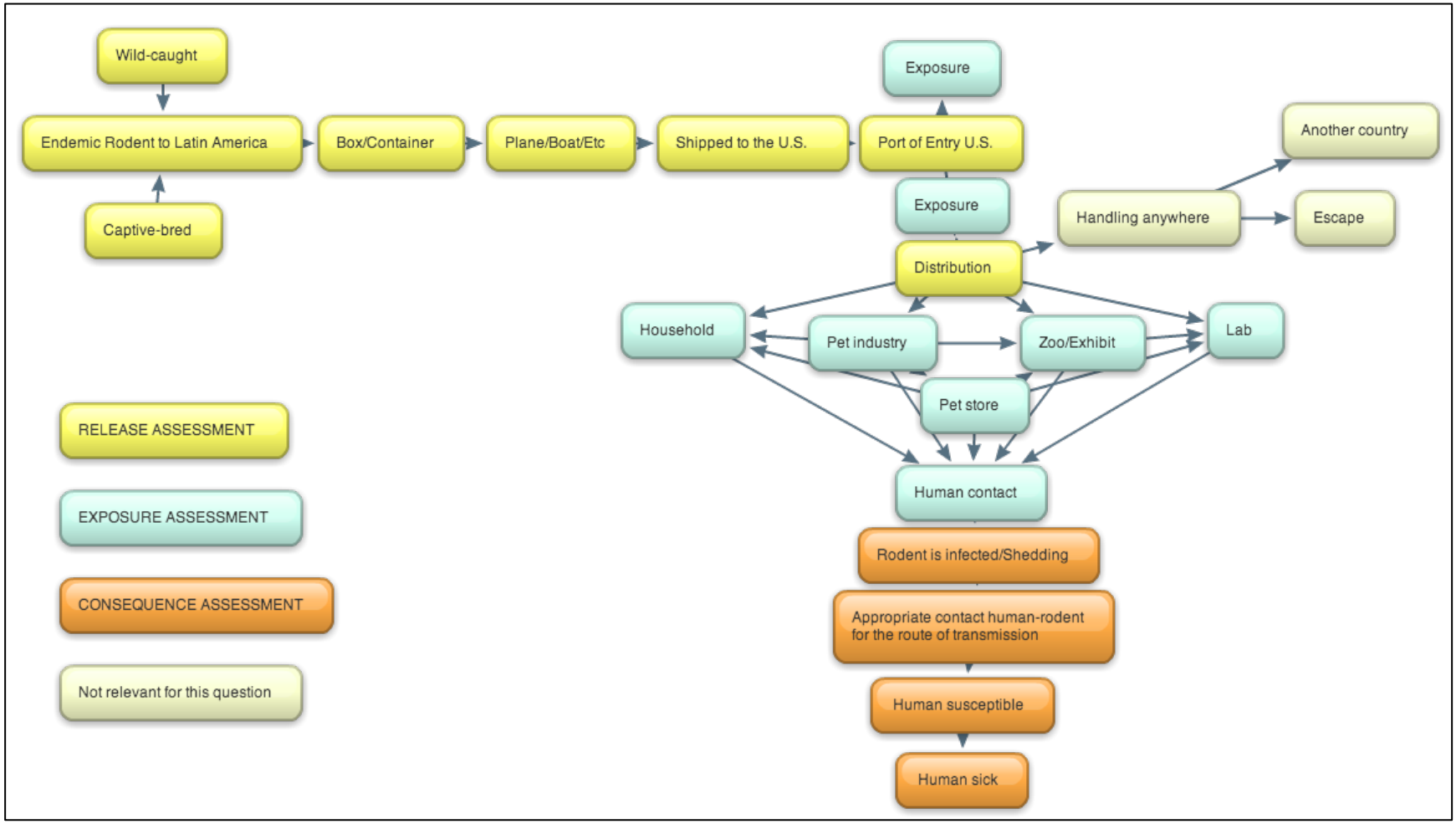

Figure 5. General risk assessment diagram for the rodent trade from Latin America (Release, Exposure and Consequences).

General Risk Assessment Model

1. Release Assessment: What is the risk of a rodent imported from a Latin American country resulting in release of the pathogen (X) in the U.S. to create potential for spread and disease in humans?. For each example, it is specified the 'type of human' that has contact with the rodent (for example, pet store).

	Type of information	**Certainty**	**Risk Score**
a) What is the prevalence at the source?			
b) What is the likelihood of an infected rodent not being found at the port of export/entry?			
c) What is the survival to shipment?			
d) What is the likelihood of a rodent getting infected during shipment? (from external source)			
e) What is the likelihood of cross-species transmission during shipment? (rodent-other non-rodent wildlife)			

If we do not have enough information during the release phase to assess the pathogen, the risk assessment stops here. If we do have information, the next phase is the Exposure assessment.

2. Exposure Assessment: Given that a rodent arrives in the U.S. infected with a zoonotic pathogen (X) , what is the risk of exposure to a human?

	Type of information	**Certainty**	**Risk Score**
a) What is the likelihood of the rodent shedding the pathogen at the time of contact?			
b) What is the likelihood that there is direct contact that enables the transfer of the pathogen?			

3. Consequence Assessment: Given the appropriate release of the pathogen (X), and proper exposure to it, what is the risk of it having consequences (getting a human sick)?

	Type of information	**Certainty**	**Risk Score**
a) What is the likelihood of 1 or more humans getting infected with the pathogen?			
b) What is the likelihood of 1 or more humans getting sick?			
c) What is the likelihood of 1 or more humans dying as result of getting sick?			
d) What is the likelihood of long-term consequences from getting sick with this pathogen?			
e) What is the likelihood of 1 human spreading the disease to another			

human?			

Key

NA = Not Applicable

NI = No Information

H = High

M = Medium

L = Low

DK = Don't know

EO = Expert opinion

G = Grey literature

PR = Peer-reviewed scientific literature

C = Certain

MC = Moderately certain

U = Uncertain

4. Risk Management

This phase reviews the potential risk reduction and management options and evaluates their likely outcomes. Decisions and recommendations can be made to mitigate risks associated with the identified hazards.

One of the main conclusions obtained from this first iteration of the risk analysis framework assessing the zoonotic risk to humans from Latin American rodents is the identification of data 'gaps'. The available data is not sufficient to make very well informed recommendations for decision and policy makers. More research is needed to obtain quality data. Throughout the risk analysis process, some areas of potential research were identified, based on the level of uncertainty. First, during the hazard identification phase, there were categories of unknown information (unknown if certain pathogens were zoonotic, unknown if certain rodent species were dead-end host for specific pathogens) and there were assumptions made regarding the species traded and the pathogens found on those species. During the pathway analysis, there were many uncertainties regarding the different steps that rodents from Latin America go through since they leave the Latin American country of origin until they get to their final destination. During the risk assessment phase, there were also many areas where the information was not available.

This means that one of the recommendations during the risk management phase is to do more research. Once the areas of uncertainty have been identified, there is a need to prioritize research, based on what information would be more valuable, resources, and expert opinion.

What we can infer from the process is that there are 15 pathogens that could potentially affect humans in the U.S., through the 4 traded rodent species from Latin America, and through

the 4 main pathways identified. Once the risk assessment phase is finished, these 15 pathogens will be ranked in regards to their level of risk.

In order to decrease the potential risk of these pathogens being released, people getting exposed to them, and having consequences (making humans sick), there are some measures that can be applied to proactively prevent this.

Part of the risk management phase is the identification of Critical Control Points (CCP). As it is defined in the OIE/IUCN guidelines *(In press*), CCP are identified as 'points in a hazard's biological pathway where practical risk reduction or prevention strategies could be implemented.' In the rodent example, the main critical control points are: at the source (there is a need for a health inspection and/or testing prior shipment); at the port of entry in the U.S. (where there is a need for health inspection, testing for specific pathogens, and/or quarantine before distribution), and distribution (there is a need for more information about the end point of the rodent, types of contact, etc). Regarding distribution, an option would be to establish a tracking system, where each rodent is identified individually and followed until the final destination. Given the trade data, it seems that most of the traded rodents for this example end up within the pet industry. Therefore, a potential risk management action would be to educate pet owners and pet stores on potential risks that they may face with rodents, and inform them about measures to take to protect themselves.

Another potential part of the risk management is doing a cost-benefit analysis in order to balance the cost of the measures that might get implemented keeping in mind the priority of the hazards to control. Contingency plans and emergency responses are also part of the risk management strategies. However these strategies are not discussed here.

If the consequences of disease entry resulting from trade are low, then post-introduction mitigation efforts may be more effective than focusing strictly on disease exclusion (Hueston et al, 2011).

5. Risk Communication

'This phase engages with relevant stakeholders in a way that maximizes the quality of the analysis and probability that recommendations arising will be implemented. It identifies and includes representation and perspectives from all stakeholder audiences relevant to the specific question' (OIE/IUCN, *In press*). Risk communication is a critical phase of the risk analysis and needs to be present from the beginning and throughout the whole process.

The first step in building the risk analysis framework to assess the public health risk from rodent trade from Latin America into the U.S. was to justify the need for the project. In order to do this, we identified a group of stakeholders associated with the issue (either they were interested in the topic, they had knowledge and expertise, and/or the results from the analysis were likely going to influence their decision-making). Originally, we identified 55 individuals representing different fields of expertise. All of them were sent an electronic request to participate in a survey. Out of the 55 individuals, 29 responded to our request.

The following table shows the final group of stakeholders that were identified and that participated in the survey (29), and their area of expertise (the expertise column refers to the specific individuals). Each row represents one participant.

Table 1. List of stakeholders and area of expertise.

Stakeholder Group	Expertise
National Center for Emerging Zoonotic and Infectious Diseases, Centers for Disease Control and Prevention (CDC)	Veterinary Epidemiology, One Health
National Wildlife Health Center, U.S.Geological Survey (USGS)	Wildlife Diseases

Association for Assessment and Accreditation of Laboratory Animal Care International	Laboratory Animal Medicine
U.S. Fish and Wildlife Service	Import/Export Wildlife inspection and enforcement
Bronx Zoo	Zoological medicine
U.S. Department of Agriculture-Animal and Plant Inspection Service (APHIS) Veterinary Services	Veterinary, Agriculture
Association of Fish and Wildlife Agencies	Science and research liaison climate change-wildlife diseases-invasive species
NY Department of Health	Zoonotic diseases
Texas A&M University	Mammalogy, Ecology, Conservation
Arizona Game and Fish Department	Wildlife Health, Epidemiology
Centers for Disease Control and Prevention (CDC)	Vector-borne, Zoonotic diseases
Centers for Disease Control and Prevention (CDC)	Veterinary medicine, Public Health, Epidemiology
Wildlife Disease Association	Wildlife diseases
Zoetis	Wildlife management, Veterinary preventive medicine
Environment Canada	Wildlife population monitoring
Department of Homeland Security	Veterinary, One Health
Canadian Cooperative Wildlife Health Centre	Wildlife diseases, Wildlife ecology
Wildlife Conservation Society	Zoological veterinary medicine
University of California, San Francisco	Laboratory animal medicine
National Wildlife Health Center, USGS	Epizootiology
Texas Department of State Health Services	Zoonotic disease control
Centers for Disease Control and Prevention	Immigrant and refugee health, Infectious diseases
Oregon Department of Fish and Wildlife	Wildlife health and disease, Epidemiology, Regulatory medicine
California Department of Public Health	Veterinary public health
Private veterinary clinic	General practice, Veterinary medicine, Epidemiology
New Mexico Department of Health	Public health, Zoonotic diseases
BC Ministry of Forests, Lands, and Natural Resources Operation	Wildlife veterinary

Once the stakeholders were identified and they agreed to participate, they were sent a survey with the goal of capturing their opinion about the issue, and to account for practical

considerations during the development of the risk analysis framework. The survey, which consisted of 14 questions, was built through the online tool Survey Monkey®, but stakeholders were also given the option to complete the survey as an attachment in an e-mail. It contained very broad questions about the public health risks of importation of wildlife into the U.S.; a few questions directly related to the potential risk of rodents imported into the U.S from Latin America, and they were also asked if their organization/agency would benefit from a risk assessment tool. All the 29 participants used Survey Monkey® to complete the survey.

Here there are some broad results, but a more detailed report is found on **Appendix 5.**

• 86.21% believe there is a risk to public health from importation of live rodents from Latin America.

• 86.67% believe it would be useful to have a quantitative risk assessment to evaluate public health risks from wild animal imports.

• 93.33% believe it would be useful to have a qualitative risk assessment to evaluate public health risks from wild animal imports.

• 70% believe it would be useful to have a risk assessment tool for their agency/organization.

From the beginning of the risk analysis framework, we made a tentative communication strategy and plan. This included sending out the first survey to the stakeholders mentioned above, plus giving feedback to those stakeholders that were interested in receiving it. A summary of the survey results like the one found in Appendix 5 was sent to those interested participants.

Then, we sought expert opinion. A second round of questions was sent to specific experts working with specific pathogens in rodents, or with rodents endemic to Latin America.

The goal of these questions was to complete some of the 'gaps' that the risk analysis showed as far as information concerning the pathogens identified as a potential hazards, that was not possible to fill any other way (peer-reviewed literature, grey literature, etc). The information provided by this group of experts was inserted into the risk analysis. A total of 13 individuals, different from the previous group of stakeholders, were identified, and they were sent an electronic request to participate in a short questionnarie. Out of the 13 total, 3 responded.

We only followed-up with the 3 of them, and did not pursue more questions at that point. We decided to wait to contact more experts until we had the risk assessment model ready so we would not waste the expert's time.

Both stakeholders and experts were asked if they wanted to get feedback from our analysis, and which means of communication they preferred (electronic or phone). Those experts native to Latin America were also asked their preferred language of comnunication (English or Spanish).

Apart from the surveys, some stakeholders were very interested in the short-term progress of the risk analysis framework, and we had conference calls and one in-person meeting with them. For instance, we went to Centers for Disease Control and Prevention (CDC) in Atlanta and received some feedback from their experts on the risk analysis.

Another piece of the communication strategy was to present the preliminary results in a poster to the scientific community at the Wildlife Disease Association meeting that was held in Knoxville, TN, in July 2013. Some feedback was received, and incorporated into the framework.

The publication of the results of the analysis is part of the risk communication planning, as it will give the stakeholders, the experts, and the community information to be used in their

respective areas of expertise, and for some of them, the results may influence their decision-making regarding this issue. The immediate next step in this process though, are to ask more questions to specific experts to help with the data 'gaps'.

6. Conclusions

A risk analysis is a standardized, evidence-based, iterative process that can prove useful in assessing public health risks from wildlife trade in the U.S., and can be used to ultimately inform policy. One of the big challenges when doing a risk analysis involving wildlife is the lack of quality data available, which increases the uncertainty, and it makes it very difficult to perform a quantitative analysis. For the pilot example assessing the zoonotic risk from rodent trade from Latin America into the U.S., the risk analysis proved to be a useful tool for targeting research needs. With more information and data, in future iterations of the process, it will be possible to do better assessments to identify and rank potential risks. One of the critical phases of the risk analysis is risk communication. It is very important to have a communication strategy from the beginning of the process, to engage stakeholders, and to be transparent throughout the entire process.

In this first iteration assessing the zoonotic risk from rodent trade from Latin America into the U.S., we identified 4 traded species, 2 exporting countries, and 15 pathogens of concern. The next step of this project is to use the risk assessment model to rank these 15 pathogens in regards to their risk level.

7. **Discussion**

In this specific pilot case study assessing the zoonotic risk from rodent trade from Latin America into the U.S., there are many assumptions made and many uncertainties as well. For example, we only considered legal (formal) trade, which means that other rodent species not accounted for that may harbor zoonotic pathogens could enter the U.S. Throughout the process, we identified uncertainties and we clarified where we made assumptions. It is clear that there is lack of quality data available to make informed decisions about the potential risks of the rodent trade. However, this is just the first iteration of this framework. Risk analysis is an iterative process, and once more data is available, it can be input into the model.

In order to collect more information to input into the model, research needs have to be prioritized. Experts need to be consulted on this, so resources can be allocated to the appropriate areas. During the risk management phase, we identified broadly critical control points (CCP). The first one was at the source, where it would be necessary to do health inspections and/or testing pre-shipping. This process would entail collaboration with the agencies and authorities at the country of origin (in the example Guyana and Peru), training people to do the health inspection and testing, and allocating resources to do it, among other things. The second CCP was at the port of entry in the U.S. For rodents coming from Latin America there are no health requirements. At this point, it would be necessary to do health inspections, testing for specific pathogens, and/or quarantine of rodents coming from Latin America, and collecting specific information regarding shipping conditions, distribution, etc. The third CCP is at the distribution level. There is not much information about the final destination of the rodents either. Collecting more information about that, and having perhaps a tracking system to know how many rodents and what species go where, would be useful for the risk assessment phase. Also part of the

distribution, and once at the consumer level (pet stores and pet owners), a passive surveillance system could be established. Reporting sick people that have contact with the 4 rodent species that came from Latin America, reporting sick rodents, and collecting periodic samples from pet stores, labs, or zoos could greatly inform the process if done correctly.

It is important to have a communication and collaboration system among different agencies, and even different countries, in which information is shared regarding potential public health risks coming from wildlife trade.

Way forward

The first priority for this pilot study is to finish the assessment of the 15 pathogens identified. If we do not have enough data to proceed, we will seek expert opinion to complete some of the 'gaps' in the risk assessment phase, and once the first iteration of the analysis is complete, we will publish the results. So far it is only possible to do a qualitative risk assessment, but a discussion with the stakeholders about performing a semiquantitative risk assessment might be one of the next steps. This was a pilot case study, and the same process could be applied to other taxa and to other scenarios to assess the public health risks from wildlife trade. Ultimately, the goal of this scientific and evidence-based process is to inform policy, so risk can be appropriately managed.

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10. Appendixes

- Appendix 1. List of all the pathogens identified at the beginning of the Hazard Identification phase.

- Appendix 2. USFWS Trade Data (snapshot for the 2007-2010 data).

- Appendix 3. List of pathogens identified at the end of the Hazard Identification phase that met all criteria.

- Appendix 4. Risk assessments examples.

- Appendix 5. Summary results from the survey sent to the stakeholders.

Appendix 1. Hazard Identification phase- List of all the infectious pathogens found in rodents worldwide.

Pathogen	Zoonotic?	In Traded Species?	Rodent Competent Spreader?	References
Acara_virus	N	N		Padovan, 2006
Actinomyces_bovis	Y	N		Merck Manual; Padovan, 2006
Allpahuayo_virus	N	N		Padovan, 2006
Amapari_virus	N	N		Padovan, 2006
Anaplasma_phagocytophilum	Y	N		Padovan, 2006
Andes_virus	Y	N		Padula, 2004; Torres-Perez, 2004;Medina, 2009;Levis, 1998;
Anhembi_virus	N	N		Padovan, 2006
Angiostrongylus_costaricensis	Y	N		Morera, 1971
Apeu_virus	U	N		Padovan, 2006
Apoi_virus	U	N		Padovan, 2006
Araguari_Virus	U	N		Padovan, 2006
Araraquara_virus	Y	N		Padovan, 2006
Artic_squirrels_hepatitis_virus	U	N		Padovan, 2006

Pathogen	Zoonotic?	In Traded Species?	Rodent Competent Spreader?	References
Aruac_virus	U	N		Padovan, 2006
Arumowot_virus	U	N		Padovan, 2006
Aspergillus	Y	N		Padovan, 2006
Bacillus_anthracis	Y	N		Padovan, 2006
Banzi_virus	U	N		Padovan, 2006
Barranqueras_virus	U	N		Padovan, 2006
Bartonella_birtlesii	N	N		Padovan, 2006
Bartonella_doshiae	N	N		Padovan, 2006
Bartonella_elizabethae	Y	N		CDC Website; Padovan, 2006
Bartonella_grahamii	Y	N		Padovan, 2006
Bartonella_taylorii	N	N		Padovan, 2006
Bartonella_tribocorum	N	N		Padovan, 2006
Bartonella_vinsonii	Y	N		Padovan, 2006
Bartonella_vinsonii	Y	N		Padovan, 2006

Pathogen	Zoonotic?	In Traded Species?	Rodent Competent Spreader?	References
Barur_virus	U	N		Padovan, 2006
Batai_virus	U	N		Padovan, 2006
Bayou_virus	Y	N		Padovan, 2006
Bear_Canyon_virus	Y	N		HP3; Fulhorst, 2002
Benevides_virus	U	N		Padovan, 2006
Benfica_virus	Y	Y	N	Padovan, 2006
Berne_virus	U	N		Padovan, 2006
Bertioga_virus	U	N		Padovan, 2006
Bhanja_virus	Y	Y	N	Hubálek, 1987;Padovan, 2006
Bimiti_virus	U	N		HP3
Black_creek_canal_virus	Y	N		Padovan, 2006
Bluetongue_virus	N	N		Padovan, 2006
Bordetella_bronchiseptica	Y	Y		Padovan, 2006
Borna_disease_virus	Y	N		HP3

Pathogen	Zoonotic?	In Traded Species?	Rodent Competent Spreader?	References
Borrelia_afzelii	Y	N		Padovan, 2006
Borrelia_andersonii	N	N		Padovan, 2006
Borrelia_burgdorferi	Y	N		Padovan, 2006
Borrelia_crocidurae	Y	N		Padovan, 2006
Borrelia_davisii	U	N		Padovan, 2006
Borrelia_duttonii	Y	N		Padovan, 2006
Borrelia_hermsii	Y	N		Padovan, 2006
Borrelia_garinii	Y	N		Padovan, 2006
Borrelia_japonica	N	N		Padovan, 2006
Borrelia_lusitaniae	Y	N		Padovan, 2006
Borrelia_miyamotoi	N	N		Padovan, 2006
Borrelia_parkeri	U	N		Padovan, 2006
Borrelia_sinica	U	N		Padovan, 2006
Borrelia_spielmani	Y	N		Padovan, 2006

Pathogen	Zoonotic?	In Traded Species?	Rodent Competent Spreader?	References
Borrelia_tanukii	N	N		Padovan, 2006
Borrelia_turdi	N	N		Padovan, 2006
Borrelia_valaisiana	U	N		Padovan, 2006
Brucella_abortus	Y	N		CDC Website; http://www.who.int/csr/resources/publications/Brucellos
Brucella_neotomae	N	N		Padovan, 2006;http://www.who.int/csr/resources/publications/Bru
Brucella_suis	Y	N		Padovan, 2006; http://www.who.int/csr/resources/publications/Brucellos
Bujaru_virus	U	N		HP3; Nitatpattana,2000
Bunyamwera_virus	U	N		HP3; Hardy, 1987
Bussuquara_virus	U	N		Padovan, 2006
Buttonwillow_virus	U	N		Padovan, 2006
Cache_valley_virus	U	N		Padovan, 2006
Calabazo_virus	N	N		Padovan, 2006
California_encephalitis_virus	Y	N		Padovan, 2006
Campylobacter_jejuni	Y	Y		Padovan, 2006

Pathogen	Zoonotic?	In Traded Species?	Rodent Competent Spreader?	References
Cano_delgadito_virus	N	N		Padovan, 2006
Capillaria_hepatica	Y	N		Sawamura,1999
Capim_virus	U	N		Padovan, 2006
Caraparu_virus	Y	N		HP3; Padovan, 2006
Castelo_dos_sonhos_virus	Y	N		Padovan, 2006
Catacamas_virus (CATV)	Y	N		Milazzo, 2006
Catu_virus	U	N		HP3; Padula, 2007
Caviid_herpesvirus1, 2, 3	U	Y		Padovan, 2006
Changuinola_virus	U	N		Padovan, 2006
Chlamydophila_psittaci	Y	Y		Padovan, 2006
Choclo_virus	Y	N		Maes, 2004
Citrobacter_rodentium	N	N		Padovan, 2006
Clostridium_piliforme	Y	Y		Padovan, 2006;http://netvet.wustl.edu/species/rats/ratbact.txt
Clostridium_tetani	Y	N		http://web.uconn.edu/mcbstaff/graf/Student%20presenta tions/C%20tetani/Ctetani.html

Pathogen	Zoonotic?	In Traded Species?	Rodent Competent Spreader?	References
Cocal_subtype_virus	Y	Y		Mackenzie, 1972
Coccioides_immitis	Y	N		Padovan, 2006
Colorado_tick_fever_virus	Y	N		HP3; PAHO, 2003;Padovan, 2006
Corynebacterium_kutscheri	Y	N		http://netvet.wustl.edu/species/rats/ratbact.txt
Corynebacterium_ulcerans	Y	N		http://www.scielo.br/pdf/rsp/v45n6/en_2848.pdf
Cowbone_ridge_virus	U	N		HP3; Gora, 2000
Cowpox_virus	Y	Y		CDC Website
Coxiella_burnetii	Y	N		Thompson, 2012
Crimean_congo_hemorraghic_fever_virus	Y	N		HP3; Sosa-Estani, 2002
Cryptococcus_neoformans	Y	N		Padovan, 2006
Cytomegalovirus	Y	Y		Padovan, 2006
Dera_Ghazi_Khan_virus	U	N		HP3;Varelas-Wesley, 1982
Dermatophilus_congolensis	Y	N		Merck Manual; Padovan., 2006
Dhori_virus	U	U		HP3; Song, 1995

Pathogen	Zoonotic?	In Traded Species?	Rodent Competent Spreader?	References
Dobrava-Belgrade_virus	Y	N		Padovan, 2006
Dugbe_virus	Y	N		Padovan, 2006
Eastern_equine_encephalitis_virus	Y	N		Padovan, 2006
Echinococcus _oligarthrus	Y	Y		Zimmerman, 2009
El_Moro_Canyon_virus	Y	N		Padovan, 2006
Emmonsia_parva_var_crescens	Y	Y		Padovan, 2006
Encephalomyocarditis_virus	U	N		HP3; Mills, 1994
Erysipelothrix_rhusiopathiae	Y	N		Padovan, 2006
Erlichia_spp	Y	N		Padovan, 2006
Everglades_virus	U	N		HP3; Kinnunen,2007
Flexal_virus	N	N		Padovan, 2006
Francisella_tularensis	Y	Y		Padovan, 2006;Christova, 2005;CDC Website
Gabek_Forest_virus	U	N		Padovan, 2006
Gan_gan_virus	U	N		HP3; Webb, 1965

Pathogen	Zoonotic?	In Traded Species?	Rodent Competent Spreader?	References
Germiston_virus	U	N		Padovan, 2006
Gordil_virus	U	N		Padovan, 2006
Ground_squirrel_hepatitis_B_virus	U	N		Padovan, 2006
Guajara_virus	Y	Y		Padovan, 2006
Guama_virus	Y	Y	N	HP3; Padovan, 2006
Guanarito_virus	Y	N		Fulhorst,1999; Tesh,1993; CDC website; HP3; Gonzalez, 2007
Guinea_ pig_adenovirus	Y	Y		HP3; http://www.criver.com/files/pdfs/infectious-agents/rm_ld_r_guinea_pig_adenovirus.aspx
Gumbo_limbo_virus	U	N		Padovan, 2006
Hantaan_virus	Y	N		Padovan, 2006
Helicobacter_pylori	N	Y		Padovan, 2006
Hepatitis_E_virus	Y	N		HP3; Padovan, 2006; Favorov,2000; WHO
Highlands_J_virus	U	U		HP3; Levis, 1999
Histoplasma_capsulatum	Y	N		Padovan, 2006
Icoaraci_virus	U	N		Padovan, 2006

Pathogen	Zoonotic?	In Traded Species?	Rodent Competent Spreader?	References
Ife_virus	N	N		Padovan, 2006
Ilehus_virus	Y	N		Padovan, 2006
Ippy_Virus	N	N		Padovan, 2006
Isfahan_virus	U	N		Padovan, 2006
Isla_vista_virus	N	N		Padovan, 2006
Issyk-Kul_virus	Y	N		Padovan, 2006
Itaqui_virus	U	N		Padovan, 2006
Itimirim_virus	U	N		Padovan, 2006
Jamanxi_virus	U	N		Padovan, 2006
Jamestown_Canyon_virus	Y	N		Padovan, 2006; CDC Website
Japanese_encephalitis_virus	Y	N		Padovan, 2006
Junin_virus	Y	N		Doyle, 1998; Mills, 1991 and 1992; CDC website
Juquitiba_virus	N	N		Padovan, 2006
Jutiapa_virus	U	N		Padovan, 2006

Pathogen	Zoonotic?	In Traded Species?	Rodent Competent Spreader?	References
Kaeng_Khoi_virus	U	N		Padovan, 2006
Kairi_virus	U	N		Padovan, 2006
Karshi_virus	Y	N		Padovan, 2006
Kemerovo_virus	Y	N		Padovan, 2006
Keystone_virus	U	N		Padovan, 2006
Khabarovsk_virus	U	N		HP3; Darwish, 1983
Kilham_rat_virus	U	N		HP3; Shope, 1988
Klamath_virus	N	N		Padovan, 2006
Klebsiella_pneumoniae	Y	N		Padovan, 2006
Kotonkon_virus	U	N		Padovan, 2006
Kountango_virus	U	N		Padovan, 2006
Kyasanur_Forest_disease_virus	Y	N		HP3; Padovan, 2006;Pattnaik, 2006
La_Crosse_virus	Y	N		CDC Website
Laguna_Negra_Virus (LNV)	Y	N		Chu, 2003;Yahnke, 2001; Carroll, 2005; Levis, 2004

Pathogen	Zoonotic?	In Traded Species?	Rodent Competent Spreader?	References
Langat_virus	U	N		Padovan, 2006
Lanjan_virus	U	N		Padovan, 2006
Lassa_virus	Y	U		HP3; Taylor (EID); CDC Website
Latino_virus	N	N		HP3; Tesh, 1978
Lebombo_virus	U	N		Padovan, 2006
Leishmania_amazonensis	Y	N		Vasconcelos, 1994
Leishmania lainsoni	Y	Y	N	Ashford, 1996
Leishmania_mexicana	Y	N		Kerr, 1995; Chable, 2005
Leishmania_panamensis	Y	N		Vasconcelos, 1994
Leptospira_interrogans_icterohaemorrhagiae	Y	N		Agudelo-Florez, 2009; Bharti, 2003; Leptospirosis, 2012; CDC Website
Leptospira_interrogans_pumona	Y	N		Agudelo-Florez, 2009; Bharti, 2003; Leptospirosis, 2012; CDC Website
Limestone_Canyon_virus	N	N		Padovan, 2006
Listeria_monocytogenes	Y	N		Padovan, 2006;wikipedia

Pathogen	Zoonotic?	In Traded Species?	Rodent Competent Spreader?	References
Ljungan_virus	U	N		Padovan, 2006
Lokern_virus	U	N		Padovan, 2006
Louping_ill_virus	Y	N		Padovan, 2006
Lymphocytic_choriomeningitis_virus	Y	Y	Y	Lymphocytic_Choriomeningitis_Virus
Lyssavirus	Y	Y		Padovan, 2006;Eidson, 2005
Macaua_virus	U	N		Padovan, 2006
Machupo_virus	Y	N		Johnson, 1965;CDC website;Padovan, 2006
Maciel _virus	N	N		Maes, 2004
Madrid_virus	U	N		HP3; Medina, 2009
Mahogany_Hammock_virus	U	N		Padovan, 2006
Main_Drain_virus	U	N		Padovan, 2006
Mammalian_ortheoreovirus	U	Y		Padovan, 2006
Maraba_virus	U	N		HP3; Robey, 1968
Marituba_virus	U	N		HP3; Padula, 2007

Pathogen	Zoonotic?	In Traded Species?	Rodent Competent Spreader?	References
Mason-Pfizer_monkey_virus	Y	N		HP3
Mayaro_virus	U	Y		Padovan, 2006
Microsporum_canis	Y	N		Padovan, 2006; Merck Vet Manual
Microsporum_gypseum	Y	N		Padovan, 2006; Merck Vet Manual
Mirim_virus	U	N		Padovan, 2006
Mobala_virus	U	N		Padovan, 2006
Modoc_virus	U	N		HP3; Hardy, 1974
Moju_virus	U	N		Padovan, 2006
Monkeypox_virus	Y	N		CDC Website
Mopeia_virus	U	N		HP3; Gonzalez, 2007
Mousepox	U	Y		Padovan, 2006
Mucambo_virus	U	N		Padovan, 2006
Mucor	Y	N		Padovan, 2006
Muju_virus	N	N		Padovan, 2006

Pathogen	Zoonotic?	In Traded Species?	Rodent Competent Spreader?	References
Muleshoe_virus	N	N		Padovan, 2006
Murid_herpesvirus_2,3 and 4	U	N		HP3; Schlegel, 2012
Murine_adenovirus A and B	Y	N		Padovan, 2006
Murine_hepatitis_virus	U	N		Padovan, 2006
Murine_pneumonia_virus	U	N		HP3; Tesh, 1969
Murine_pneumotropic_virus	U	N		HP3
Murutucu_virus	U	N		Padovan, 2006
Mycobacterium_avium	Y	N		Padovan, 2006
Mycobacterium_bovis	Y	N		CDC website; Padovan, 2006
Mycobacterium_lepraemurium	N	N		Padovan, 2006
Mycobacterium_microti	Y	Y		CDC Website; Padovan, 2006
Mycobacterium_tuberculosis	Y	Y		Padovan, 2006
Mycoplasma_arthritidis	U	N		Padovan, 2006
Mycoplasma_caviae	Y	Y		Padovan, 2006;http://www.phac-aspc.gc.ca/lab-bio/res/psds-ftss/mycoplasma-spp-eng.php

Pathogen	Zoonotic?	In Traded Species?	Rodent Competent Spreader?	References
Mycoplasma_cavipharyngis	U	Y		Padovan, 2006
Mycoplasma pulmonis	N	N		Padovan, 2006
Nepuyo_virus	U	N		Padovan, 2006
New_ York_virus	Y	N		HP3; Gonzalez, 2007
Northway_virus	U	N		Padovan, 2006
Oliveros_virus	N	N		Padovan, 2006
Omsk_hemorrhagic_fever_virus	Y	N		HP3; Darwish, 1983
Oriboca_virus	U	N		HP3; Root, 2005
Orientia_tsutsugamushi	Y	N		Padovan, 2006
Ossa_virus	U	N		Padovan, 206
Pacui_virus	U	N		Padovan, 2006
Papillomavirus	N	N		Padovan, 2006
Parana_virus	N	N		Padovan, 2006
Parvovirus	U	N		Padovan, 2006

Pathogen	Zoonotic?	In Traded Species?	Rodent Competent Spreader?	References
Pasteurella_multocida	Y	Y		Chomel, 1992
Patois _virus	U	N		HP3; Jones, 1987
Penicillium_martieffei	Y	N		Padovan, 2006
Picornaviridae	Y	Y		Merck Manual; Padovan, 2006
Pinchide_virus	N	N		Padovan, 2006
Pirital_virus	N	N		Fulhorst,1999; Weaver, 2000
Piry_virus	U	N		Padovan, 2006
Pixuna _virus	U	N		HP3; Medina, 2009
Playa_De_Oro_virus (OROV)	Y	N		Chu et al, 2008
Pneumocystis_carinii	Y	N		Padovan, 2006
Polyoma_virus	U	Y		Padovan, 2006
Potosi_virus	U	N		Padovan, 2006
Powassan_virus	Y	N		Padovan, 2006
Prospect_hill_virus	U	N		CDC Website; HP3

Pathogen	Zoonotic?	In Traded Species?	Rodent Competent Spreader?	References
Pseudomonas_pseudomallei	Y	N		http://www.engr.psu.edu/iec/abe/database/bPseudoP.htm
Puumala_virus	Y	N		Padovan, 2006
Rat_coronavirus	Y	N		HP3; Padovan, 2006;Parker, 1970
Resistencia_virus	U	N		Padovan, 2006
Restan_virus	U	N		Padovan, 2006
Rickettsia_akari	Y	N		Padovan, 2006
Rickettsia_australis	Y	Y		Padovan, 2006
Rickettsia_bellii	U	Y		Padovan, 2006
Rickettsia_canadensis	Y	N		Padovan, 2006
Rickettsia_conorii	Y	Y		Padovan, 2006
Rickettsia_japonica	Y	Y		Padovan, 2006
Rickettsia_montanensis	N	N		Padovan, 2006
Rickettsia_prowazekii	Y	N		Padovan, 2006
Rickesttsia_rhipicephali	Y	N		Padovan, 2006

Pathogen	Zoonotic?	In Traded Species?	Rodent Competent Spreader?	References
Rickettsia_rickettsii	Y	Y		Padovan, 2006
Rickettsia_sibirica	Y	Y		Padovan, 2006
Rickettsia_slovaca	Y	N		Padovan, 2006
Rickettsia_typhi	Y	N		Padovan, 2006
Rift_Valley_fever_virus	Y	N		HP3; Padovan, 2006
Rio_Grande_virus	U	N		Padovan, 2006
Rio_Mamoré_virus (RMV)	N			Chu et al, 2006
Rio_segundo_virus	N	N		Padovan, 2006
Rotavirus	Y	N		Padovan, 2006
Saarema_virus	Y	N		Padovan, 2006
Sabia_virus	Y	N		Gonzalez, 1996
Saint-Floris_virus	U	N		Padovan, 2006
Salanga_virus	U	N		Padovan, 2006
Salehabad_virus	U	N		HP3; Torres-Perez, 2010

Pathogen	Zoonotic?	In Traded Species?	Rodent Competent Spreader?	References
Salmonella arizona	Y	N		Padovan, 2006
Salmonella_cholerae_suis	Y	Y		Chiu, 2004
Salmonella_enteritidis	Y	N		Padovan, 2006;Lapuz, 2008
Salmonella_enteritidis_typhimurium	Y	Y		Chomel, 1992;LaboratoryAnimalMedicineBook-Fox
Sandfly_Fever_Naples_virus	U	N		Padovan, 2006
San_Perlita_virus	U	N		HP3; McInnes, 2011
Santarem_virus	U	N		Padovan, 2006
Schistosoma_mansoni	Y	N		CDC Website; AlrconDeNoya, 1997
Sendai_virus	U	N		HP3; Shope, 1964
Seoul_virus	Y	N		Padovan, 2006
Sialodacryoadenitis_virus	U	N		Padovan, 2006
Silverwater_virus	U	N		Padovan, 2006
Simbu_virus	U	N		Padovan, 2006
Sin_Nombre_virus	Y	N		HP3; Chu, 2006

Pathogen	Zoonotic?	In Traded Species?	Rodent Competent Spreader?	References
Snowshoe_hare_virus	Y	N		Padovan, 2006
Spirillum_minus	Y	N		Padovan, 2006
Squirrel_fibroma_virus	U	N		HP3; Weigler, 1996
Squirrel_parapoxvirus	U	N		HP3; Yanagihara, 1987
Staphylococcus_aureus	Y	N		Padovan, 2006
Staphylococcus_aureus	Y	N		Padovan, 2006
Streptobacillus_moniliformis	Y	N		CDC Website
Streptococcus_pneumoniae	N	Y		Padovan, 2006
Streptococcus_zooepidemicus	Y	Y		Padovan, 2006
St.Louis_Encephalitis_virus	Y	N		HP3;Padovan, 2006; Day, 1996
Tacaiuma_virus	U	N		Padovan, 2006
Tacaribe_virus	N	N		Salazar, 2002
Tahyna_virus	Y	N		Padovan, 2006
Tamiami_virus	U	N		Padovan, 2006

Pathogen	Zoonotic?	In Traded Species?	Rodent Competent Spreader?	References
Tanjong_rabok_virus	U	N		Padovan, 2006
Tetaropox_virus	U	N		Padovan, 2006
Tettnang_virus	U	N		Padovan, 2006
Thailand_virus	U	N		Padovan, 2006
Theiler_murine_encephalomyelitis_virus	U	N		Padovan, 2006
Theilovirus	U	N		HP3; Wang, 2000
Thogoto_virus	U	N		HP3; Schlegel, 2012
Tick-borne_encephalitis_virus	Y	N		Padovan, 2006
Timboteau_virus	U	N		Padovan, 2006
Tobetsu_virus	N	N		Padovan, 2006
Topografov_virus	N	N		Padovan, 2006
Toscana_virus	U	N		Padovan, 2006
Tribec_virus	U	N		Padovan, 2006
Trichinella_ spiralis	Y	N		http://animals.pawnation.com/trichinosis-rats-2139.html

Pathogen	Zoonotic?	In Traded Species?	Rodent Competent Spreader?	References
Trichophyton_mentagrophytes	Y	Y		Padovan, 2006; Merck Vet Manual
Trivittatus_virus	N	N		Padovan, 2006
Trixacarus_caviae	Y	Y		Chomel, 1992
Trypanosoma_cruzi	Y	N		Ramsey, 2012
Tula_virus	Y	N		Padovan, 2006
Turlock_virus	U	N		Padovan, 2006
Uganda_S_virus	U	N		Padovan, 2006
Urucuri_virus	U	Y	N	Padovan, 2006
Uukuniemi_virus	U	N		Padovan, 2006
VEEV	Y	N		Padovan, 2006; OIE website; Estrada-Franco, 2004; Aguilar, 2004; HP3
Volepox_virus	U	N		Padovan, 2006
Wad_Medani_virus	U	N		HP3; Shope, 1988
Western_equine_encephalitis_virus	Y	N		HP3; Padovan, 2006
West_Nile_virus	Y	N		HP3; Padovan, 2006;Tesh, 2005

Pathogen	Zoonotic?	In Traded Species?	Rodent Competent Spreader?	References
Wesselborn_virus	Y	N		Padovan, 2006
Whitewater_Arroyo_virus	Y	N		HP3
Witwatersrand_virus	U	N		Padovan, 2006
Woodchuck_hepatitis_B_virus	U	N		Padovan, 2006
Yellow_Fever_virus	Y	Y	N	Padovan, 2006
Yersinia enterocolitica	Y	Y		Chomel, 1992;Padovan, 2006
Yersinia pestis	Y	Y		Padovan, 2006; Mackenzie, 1972; CDC website
Yersinia pseudotuberculosis	Y	Y		Chomel, 1992;LaboratoryAnimalMedicineBook-Fox; Padovan, 2006
Zegla virus	U	N		Padovan, 2006

Appendix 2. USFWS trade data (2007-2010) concerning rodents imported from Latin America.

Genus	Species	Wldlfe Descritption	Quantity	Country origin	Country exporting	Purpose	Source	Port of entry	U.S. Importer/Exporter	Foreign S/R
COENDOU	PREHENSILIS	LIV	2	GUAYANA	GUAYANA	Trade	Wild-caught	MI	WORLDWIDE ZOOLOGICAL EXCHANGE	GARVIN TAYLOR
COENDOU	PREHENSILIS	LIV	2	GUAYANA	GUAYANA	Trade	Wild-caught	MI	WORLD WIDE ZOOLOGICAL EXCHANGE	CARMEN LOW
COENDOU	PREHENSILIS	LIV	2	GUAYANA	GUAYANA	Trade	Wild-caught	MI	ROSENBLUM, GARY DBA WORLD EXOTICS INC.	RAM SUKKHUGUYANA WILDLIFE & TROPICAL TRADERS
COENDOU	PREHENSILIS	LIV	2	GUAYANA	GUAYANA	Trade	Wild-caught	MI	ROSENBLUM, GARY DBA WORLD EXOTICS INC.	SEBASTIAN ABRAMS
COENDOU	PREHENSILIS	LIV	1	GUAYANA	CANADA	Trade	Wild-caught	MI	WORLD EXOTICS, INC	
COENDOU	PREHENSILIS	LIV	2	GUAYANA	GUAYANA	Trade	Wild-caught	MI	ROSENBLUM, GARY DBA WORLD EXOTICS INC.	ALLAN FUNG A FAT
COENDOU	PREHENSILIS	LIV	2	GUAYANA	GUAYANA	Trade	Wild-caught	MI	ROSENBLUM, GARY DBA WORLD EXOTICS INC.	ALLAN FUNG A FAT
COENDOU	PREHENSILIS	LIV	2	GUAYANA	GUAYANA	Trade	Wild-caught	MI	WORLD WIDE ZOOLOGICAL EXCHANGE	NARDIN EUGENE
COENDOU	PREHENSILIS	LIV	2	GUAYANA	GUAYANA	Trade	Wild-caught	MI	TROPICAL BIRDS, INC.	LALL,,MAHADAI, &MOHAN
COENDOU	PREHENSILIS	LIV	2	GUAYANA	GUAYANA	Trade	Wild-caught	MI	TROPICAL BIRDS, INC.	LALL,,MAHADAI, &MOHAN
COENDOU	PREHENSILIS	LIV	4	GUAYANA	GUAYANA	Trade	Wild-caught	MI	ROSENBLUM, GARY DBA WORLD EXOTICS INC.	SEBASTIAN ABRAMS

COENDOU	PREHENSILIS	LIV	2	GUAYANA	GUAYANA	Trade	Wild-caught	MI	ROSENBLUM, GARY DBA WORLD EXOTICS INC.	CARMEN LOW
DASYPROCTA	SPECIES	LIV	5	GUAYANA	GUAYANA	Trade	Wild-caught	MI	ROSENBLUM, GARY DBA WORLD EXOTICS INC.	RAM SUKKHUGUYANA WILDLIFE & TROPICAL TRADERS
DASYPROCTA	SPECIES	LIV	7	GUAYANA	GUAYANA	Trade	Wild-caught	MI	FAUNA FARMS	TROPICAL FLORA AND FAUNA INC
DASYPROCTA	SPECIES	LIV	5	GUAYANA	GUAYANA	Trade	Wild-caught	MI	FAUNA FARMS	
DASYPROCTA	LEPORINA	LIV	15	GUAYANA	GUAYANA	Trade	Wild-caught	MI	TROPICAL BIRDS, INC.	MAHADAI & MOHAN LALL
DASYPROCTA	SPECIES	LIV	7	GUAYANA	GUAYANA	Trade	Wild-caught	MI	FAUNA FARMS	FUNG-A-FAT ALLEN
DASYPROCTA	SPECIES	LIV	7	GUAYANA	GUAYANA	Trade	Wild-caught	MI	FAUNA FARMS	TROPICAL FLORA & FAUNA INC.
DASYPROCTA	SPECIES	LIV	8	GUAYANA	GUAYANA	Trade	Wild-caught	MI	FAUNA FARMS	
CUNICULUS	PACA	LIV	3	GUAYANA	GUAYANA	Trade	Wild-caught	MI	ROSENBLUM, GARY DBA WORLD EXOTICS INC.	RAM SUKKHUGUYANA WILDLIFE & TROPICAL TRADERS
CUNICULUS	PACA	LIV	2	GUAYANA	GUAYANA	Trade	Wild-caught	MI	ROSENBLUM, GARY DBA WORLD EXOTICS INC.	FIRZAUDUDAN SHAW
CUNICULUS	PACA	LIV	1	GUAYANA	GUAYANA	Trade	Wild-caught	MI	ROSENBLUM, GARY DBA WORLD EXOTICS INC.	ALLAN FUNG A FAT
CUNICULUS	PACA	LIV	3	GUAYANA	GUAYANA	Trade	Wild-caught	MI	ROSENBLUM, GARY DBA WORLD EXOTICS INC.	SEBASTIAN ABRAMS
CUNICULUS	PACA	LIV	2	GUAYANA	GUAYANA	Trade	Wild-caught	MI	WORLD WIDE ZOOLOGICAL EXCHANGE	RAJENDRA RAMROOP

CUNICULUS	PACA	LIV	3	GUAYANA	GUAYANA	Trade	Wild-caught	MI	ROSENBLUM, GARY DBA WORLD EXOTICS INC.	ALLAN FUNG A FAT
CUNICULUS	PACA	LIV	4	GUAYANA	GUAYANA	Trade	Wild-caught	MI	ROSENBLUM, GARY DBA WORLD EXOTICS INC.	GUYANA WILDLIFE TRAPPERS EXPORTERS
CUNICULUS	PACA	LIV	2	GUAYANA	GUAYANA	Trade	Wild-caught	MI	ROSENBLUM, GARY DBA WORLD EXOTICS INC.	ALLAN FUNG A FAT
CUNICULUS	PACA	LIV	2	GUAYANA	GUAYANA	Trade	Wild-caught	MI	WORLD WIDE ZOOLOGICAL EXCHANGE	SHAW,FIRZAUDUDEEN
CUNICULUS	PACA	LIV	2	GUAYANA	GUAYANA	Trade	Wild-caught	MI	WORLD WIDE ZOOLOGICAL EXCHANGE	NARDIN EUGENE
CUNICULUS	PACA	LIV	2	GUAYANA	GUAYANA	Trade	Wild-caught	MI	ROSENBLUM, GARY DBA WORLD EXOTICS INC.	SEBASTIAN ABRAMS
CUNICULUS	PACA	LIV	3	GUAYANA	GUAYANA	Trade	Wild-caught	MI	ROSENBLUM, GARY DBA WORLD EXOTICS INC.	CARMEN LOW
CAVIA	PORCELLUS	LIV	400	PERU	PERU	Trade	Captive-bred	LA	NORTH AMERICAN PETS	R.A.B.C. INTERGAME E.I.R.L
CAVIA	PORCELLUS	LIV	300	PERU	PERU	Trade	Captive-bred	LA	NORTH AMERICAN PETS	R.A.B.C. INTERGAME E.I.R.L
CAVIA	PORCELLUS	LIV	400	PERU	PERU	Trade	Captive-bred	LA	NORTH AMERICAN PETS	R.A.B.C. INTERGAME E.I.R.L
CAVIA	PORCELLUS	LIV	300	PERU	PERU	Trade	Captive-bred	LA	NORTH AMERICAN PETS	R.A.B.C. INTERGAME E.I.R.L
CAVIA	PORCELLUS	LIV	500	PERU	PERU	Trade	Captive-bred	LA	NORTH AMERICAN PETS	R.A.B.C. INTERGAME E.I.R.L
CAVIA	PORCELLUS	LIV	500	PERU	PERU	Trade	Captive-bred	LA	NORTH AMERICAN PETS	R.A.B.C. INTERGAME E.I.R.L

Appendix 3. List of pathogens identified during the hazard identification phase after applying a decision-making tree.

Pathogen	Rodent species
Bordetella_bronchiseptica	*Cavia porcellus*
Campylobacter jejuni	*Cavia porcellus; Dasyprocta spp*
Cowpox virus	*Cavia porcellus*
Francisella tularensis	*Cavia porcellus*
Lymphocytic_Choriomeningitis_Virus	*Cavia_porcellus*
Lyssavirus	*Cavia porcellus*
Mycobacterium microti	*Cavia porcellus*
Mycoplasma caviae	*Cavia porcellus*
Pasteurella multocida	*Cavia porcellus*
Salmonella_cholerae_suis	*Dasyprocta spp; Cavia porcellus*
Salmonella_enteritidis_typhimurium	*Cavia porcellus; Coendou prehensilis*
Streptococcus_zooepidemicus	*Cavia porcellus*
Trichophyton_mentagrophytes	*Cavia porcellus*
Trixascarus caviae	*Cavia porcellus*
Yersinia pseudotuberculosis	*Dasyprocta spp; Cavia porcellus*

Risk Assessment Model

Key

NA = Not Applicable	EO = Expert Opinion	C = Certain
NI = No Information	G = Grey literature	MC = Moderately certain
H = High	PR = Peer-reviewed scientific literature	U = Uncertain
M = Medium		
L = Low		
DK = Don't know		

Example 1

What is the risk of introduction of Lymphocytic Choriomeningitis Virus (LCMV) from Guinea pigs coming from Peru into the U.S. for pet trade purposes and causing illness in a human? (being this human related to the pet trade, either distribution center, pet store, consumer). For this example, we used the available information first and the pathogen could not be assessed due to lack of information, therefore the assessment stopped at the release phase. However, we made some assumptions for this example to be able to finish the process, and these assumptions appear in (parenthesis).

1. Release Assessment: What is the risk of a *Cavia porcellus* import from Peru resulting in release of LCMV in the U.S. to create potential for spread and disease in humans within the pet trade?

	Type of information	Certainty	Score
a) What is the prevalence at source?	NI (PR)	NA (C)	NA (L)
b) What is the likelihood of a rodent not being found at the port of export/entry?	EO	C	H
c) What is the survival to shipment?	NI (EO)	NA (C)	NA (M)
d) What is the likelihood of a rodent getting infected during shipment? (from external source)	NI (EO)	NA (C)	NA (L)

Release assessment score: DK (there is not enough information)- can't assess.

(Release Assessment score): L. And we moved to the next phase. For this phase however, there is some available information; ther are some assumptions made as well.

2. Exposure Assessment: Given that a *Cavia porcellus* arrives in the U.S. infected with LCMV , what is the risk of exposure to a human within the pet trade?

	Type of information	Certainty	Score
a) What is the likelihood of the rodent shedding the pathogen at the time of	PR	MC	M

contact?			
b) What is the likelihood that there is direct contact that enables the transfer of the pathogen?	G	MC	M

Exposure assessment score: M

3. Consequence Assessment: Given the appropriate release of the pathogen and proper exposure to it, what is the risk of it having consequences (getting a human sick)?

	Type of information	**Certainty**	**Score**
a) What is the likelihood of 1 or more humans getting infected with the pathogen?	(G)	(MC)	(H)
b) What is the likelihood of 1 or more humans getting sick?	PR	C	M
c) What is the likelihood of 1 or more humans dying as result of getting sick?	PR	C	L
d) What is the likelihood of long-term	PR	C	L

consequences from getting sick with this pathogen?			
e) What is the likelihood of 1 human spreading the disease to another human?	PR	C	L

Consequence assessment score: L

Total Asessment Score: L+M+L = L (Low risk)

Assumptions:

- Release: We assumed that the prevalence at source was medium, and that we knew that from peer-reviewed literature and there was enough evidence for it therefore we were certain. For survival for shipment we assumed that there was a good survival rate and that is why the risk is considered medium, plus the information was obtained through expert opinion that understands the trade, and we were certain of this. The last assumption for this phase also comes from an expert opinion regarding the likelihood of a rodent getting infected during shipment from an external source, and that was assumed to be low.

- Consequences: We assmued that the likelihood of 1 or more humans getting infected with the pathogen was high given that we we were only moderately certain about that, and the source is grey literature, so not as reliable.

Lymphocytic Choriomeningitis Virus, LCMV (Summary of the disease)

- Pathogen: LCMV is a rodent-borne zoonotic RNA virus within the family Arenaviridae.

- Species of rodent that can get infected: Its main reservoir host is the wild house mouse (*Mus musculus)*- prevalence in this rodent is between 3-40% (in the U.S.). Also, Syrian hamsters and laboratory mice serve as important natural hosts. Guinea pigs are susceptible. Other rodents may harbor the virus as well (presence of LCMV antibody was found in Algerian mice, *Mus spretus*).

- Clinical signs in the host (rodent): they may not show any clinical signs; in laboratory hamsters the clinical signs that have been observed include loss of activity, loss of appetite, rough coat, and after several weeks they can show weight loss, inflammation of the eyelids, and eventually even death.

- Incubation period: 5-6 days in experimental infections in adult mice.

- Shedding: saliva, nasal excretions, urine, milk, feces, semen. Viral persistence and shedding varies with the host and its age when it is infected. Persistent infections occur in some mice (*Mus musculus*) and hamsters that are exposed in utero or as newborns. These animals can shed the virus lifelong. Other mice and hamsters infected during the neonatal period may develop only transient viremia. Rodents infected after this time usually clear the virus completely. Chronic infections have not been reported in other species, including congenitally infected humans (http://www.cfsph.iastate.edu/Factsheets/pdfs/lymphocytic_choriomeningitis.pdf).

- Transmission

    - Between rodents: vertical (transovarially, transplacentally, mother's milk); wild house mice can infect guinea pigs or hamsters (this is the most common way that pet rodents get infected).

- Between rodent and human: direct or indirect; via aerosol, bite, abraded skin.

- Between humans: there have been reports of transmission through organ transplants; vertical transmission from mother to fetus.

- Clinical signs in humans: the infection can be asymptomatic or subclinical; if signs, they are flu-like symptons; occasionally rash, diarrhea, cough, lymphadenopathy, orchitis, delirium, and amnesia. An aseptic meningitis is posssible but rare. Recovery from the infection can take up to several months.

- Mortality in humans: death is rare. Fetal death is possible from intrauterine infection.

- Human population at risk: laboratory personnel and owners of pet hamsters

- Control: virus is highly sensitive to lipid solvents, detergents, and disinfectants like formaldehyde. Infectivity is lost at pH values below 5.5 and above 8.5. For laboratories, aquire mice and hamsters that are from populations shown by regular health surveillance testing to be free of LCMV, and maintain barriers to keep wild rodents out of the facilities.

- References:

National Research Council. Infectious diseases of mice and rats. 1991.

Padovan, D. Infectious diseases or wild rodents. Corvus Publishing Company. 2006

Pro-Med. LCMV, transplant recipients, fatal Australia: 2007

http://www.cfsph.iastate.edu/Factsheets/pdfs/lymphocytic_choriomeningitis.pdf

Risk Assessment Model: Example 2

What is the risk of a *Coendou prehensilis* leaving Guyana, competently releasing *Salmonella enteritidis typhimurium*, successfully exposing a human to it, and having consequences for that human (this human within the pet trade as the purpose of this species is pet trade). For this example, we used the available information first and the pathogen could not be assessed due to lack of information, therefore the assessment stopped at the release phase. However, we made some assumptions for this example to be able to finish the process, and these assumptions appear in (parenthesis).

1. Release Assessment: What is the risk of a *Coendou prehensilis* import from Guyana resulting in release of *Salmonella enteritidis thyphimurium* in the U.S. to create potential for spread and disease in humans within the pet trade?

	Type of information	**Certainty**	**Score**
a) What is the prevalence at source?	NI (PR)	NA (C)	NA (M)
b) What is the likelihood of a rodent not being found at the port of export/entry?	EO	C	H
c) What is the survival to shipment?	NI (EO)	NA (C)	NA (M)
d) What is the likelihood of a rodent getting	NI (EO)	NA (C)	NA (L)

infected during shipment? (from external source)			

Release assessment score: M

2. Exposure Assessment: Given that a *Coendou prehensilis* arrives in the U.S. infected with *Salmonella enteritidis typhimurium* , what is the risk of exposure to a human within the pet trade?

	Type of information	**Certainty**	**Score**
a) What is the likelihood of the rodent shedding the pathogen at the time of contact?	PR	VC	H
b) What is the likelihood that there is direct contact that enables the transfer of the pathogen?	PR	VC	H

Exposure assessment score: H

3. Consequence Assessment: Given the appropriate release of *Salmonella enteritidis typhimurium* and proper exposure to it, what is the risk of it having consequences (getting a human sick)?

	Type of information	**Certainty**	**Score**

a) What is the likelihood of 1 or more humans getting infected with the pathogen?	(G)	(MC)	(H)
b) What is the likelihood of 1 or more humans getting sick?	PR	C	M H -Children
c) What is the likelihood of 1 or more humans dying as result of getting sick?	PR	C	L
d) What is the likelihood of long-term consequences from getting sick with this pathogen?	PR	C	L
e) What is the likelihood of 1 human spreading the disease to another human?	PR	C	L M- Children

Consequence assessment score: M

Total Asessment Score: M+M+H = M (Medium risk)

Assumptions:

- Release: We assumed that the prevalence at source was medium, and that we knew that from peer-reviewed literature and there was enough evidence for it therefore we were certain. For survival for shipment we assumed that there was a good survival rate and that is why the risk is considered medium, plus the information was obtained through expert opinion that understands the trade, and we were certain of this. The last assumption for this phase also comes from an expert opinion regarding the likelihood of a rodent getting infected during shipment from an external source, and that was assumed to be low.
- Consequences: We assumed that the consequences for children would be greater than for adults.

Salmonella enteritidis typhimurium (Summary of the disease)

- Pathogen: *Salmonella enteritidis typhimurium* is a zoonotic bacteria that causes the disease salmonellosis.
- Species of rodent that can get infected: it has been reported in captive *Dasyprocta spp,* in pets *Cavia porcellus* and hamsters, and also in laboratory mice and rats.
- Clinical signs in the host (rodent): they can range from depression, diarrhea and dehydration to be fatal (there is 50-100% mortality).
- Incubation period: 5-7 days.
- Shedding: intermittent mainly through feces.
- Transmission

- Between rodents: ingestion of food and water contaminated with infected feces, urine or bedding material. Highly contagious.

- Between rodent and human: fecal-oral route. The most common way is by eating contaminated food or drinking contaminated water with infected rodent feces.

- Between humans: Person-to-person transmission of salmonella occurs when an infected person's feces, unwashed from his or her hands, contaminates food during preparation or comes into direct contact with another person.

- Clinical signs in humans: diarrhea, fever, abdominal cramps. In immunosuppressed , elderly and children, the infection can be serious.

- Mortality in humans: <1%.

- Human population at risk: mainly pet owners, especially children.

- Control: Salmonella bacteria is a facultative anaerobe (can grow with or without oxygen) and growth is only slightly reduced under nitrogen. The organism is able to grow in atmospheres containing high levels of carbon dioxide (possibly up to 80 % in some conditions). Optimum pH is between 6.5-7.5 to grow. It is not particularly hear resistant, and it gets inactivated during pasteurisation or equivalent heat process.

- References

Chomel, B. Pediatric Infectious Diseases Journal, 1992.

CDC Website (http://www.cdc.gov/nczved/divisions/dfbmd/diseases/salmonellosis/#what)

http://www.foodsafetywatch.com/public/481.cfm

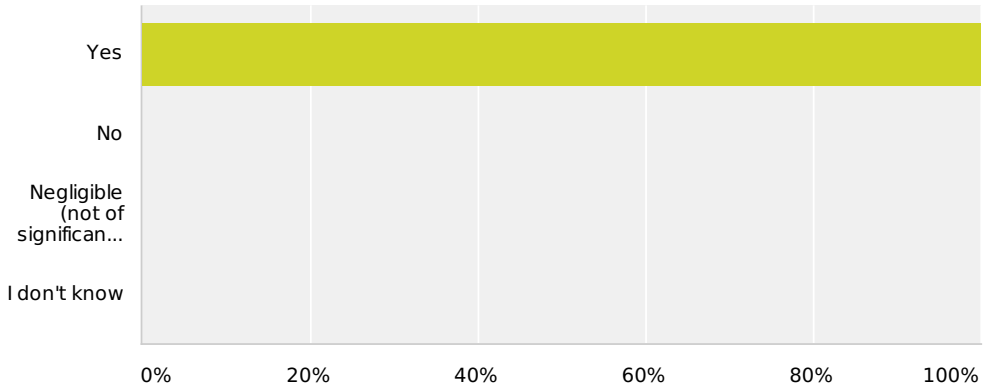
Q1 Please complete the following

Answered: 29 Skipped: 1

Answer Choices	Responses	
Name (It will be kept anonymous)	**100%**	29
Organization	**100%**	29
Area of expertise	**96.55%**	28
E-mail (Optional)	**72.41%**	21
Phone (Optional)	**44.83%**	13
Total Respondents: 29		

Q2 Do you believe importation of live wild animals into the US poses a risk to public health?

Answered: 28 Skipped: 2

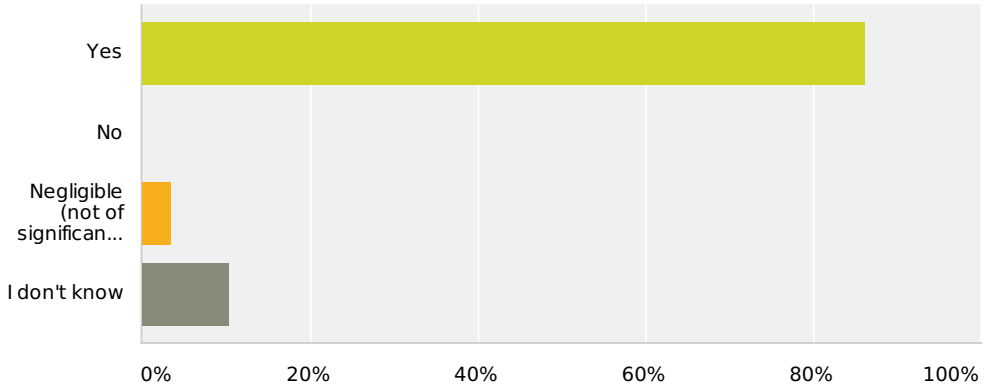


Answer Choices	Responses	
Yes	**100%**	28
No	**0%**	0
Negligible (not of significant concern)	**0%**	0
I don't know	**0%**	0
Total		28

Comment (8)

Q3 Do you believe importation of live rodents from Latin America (Central, South, Caribbean) into the US poses a risk to public health?

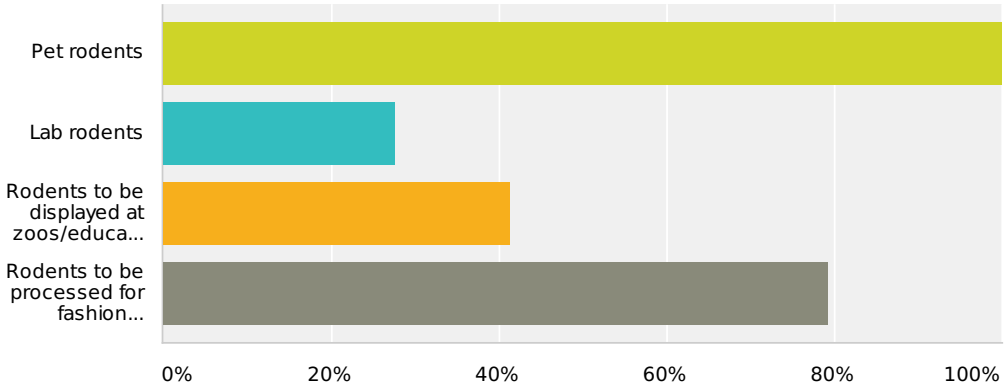
Answered: 29 Skipped: 1



Answer Choices	Responses	
Yes	**86.21%**	25
No	**0%**	0
Negligible (not of significant concern)	**3.45%**	1
I don't know	**10.34%**	3
Total		29
Comment (6)		

Q4 In your opinion, importation of which groups of live rodents from Latin America poses significant risk to public health (check all that apply)?

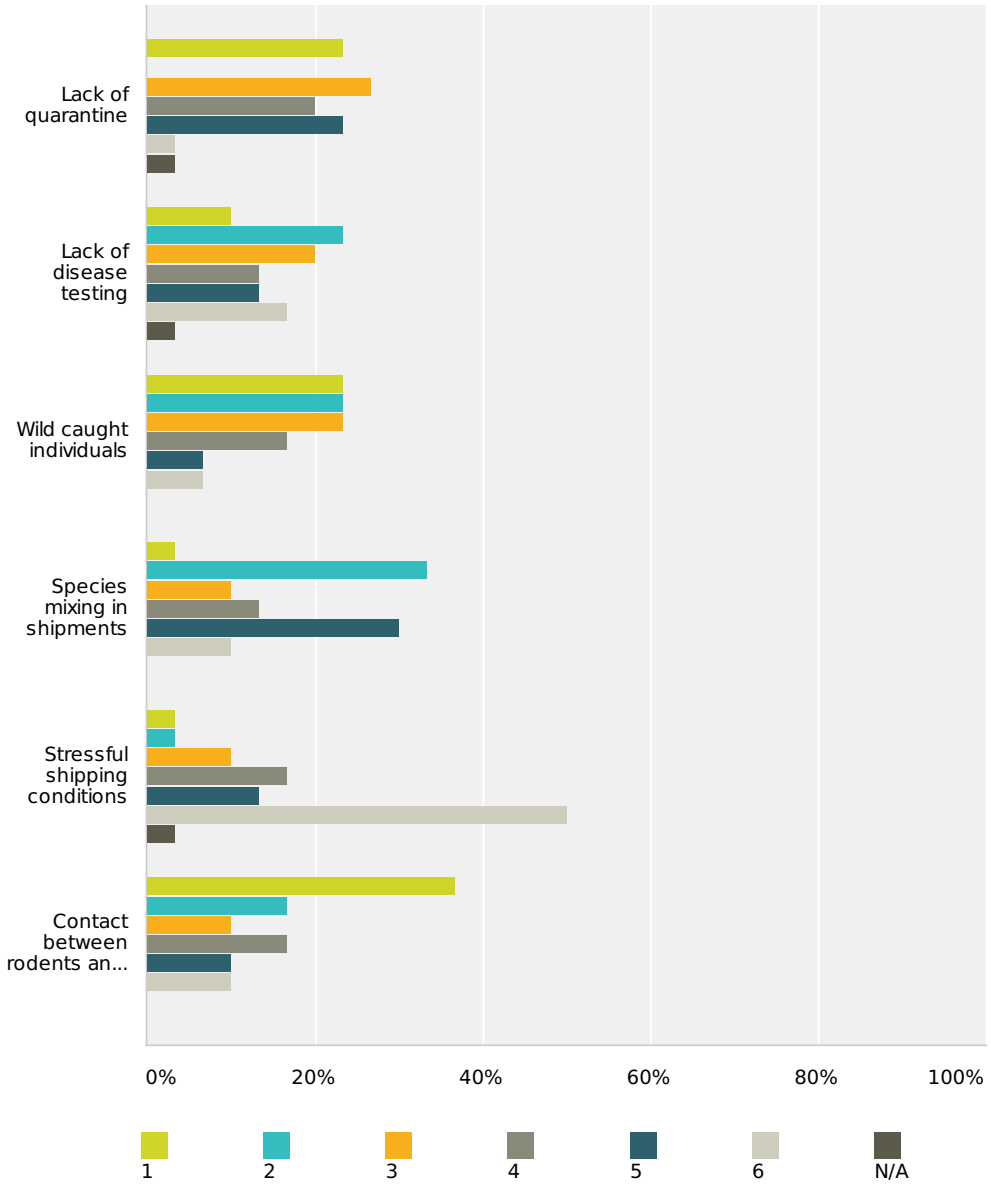
Answered: 29 Skipped: 1



Answer Choices	Responses	
Pet rodents	**100%**	29
Lab rodents	**27.59%**	8
Rodents to be displayed at zoos/educational facilities	**41.38%**	12
Rodents to be processed for fashion products	**79.31%**	23
Total Respondents: 29		
Other (please specify) (10)		

Q5 In your opinion, what are the main risk factors for disease transmission to humans from rodent importation into the US (please rank from highest to lowest risk using numbers 1-6)? Answers that are not deemed significant can be left unranked. 1 = highest risk; 6 = lowest risk

Answered: 30 Skipped: 0



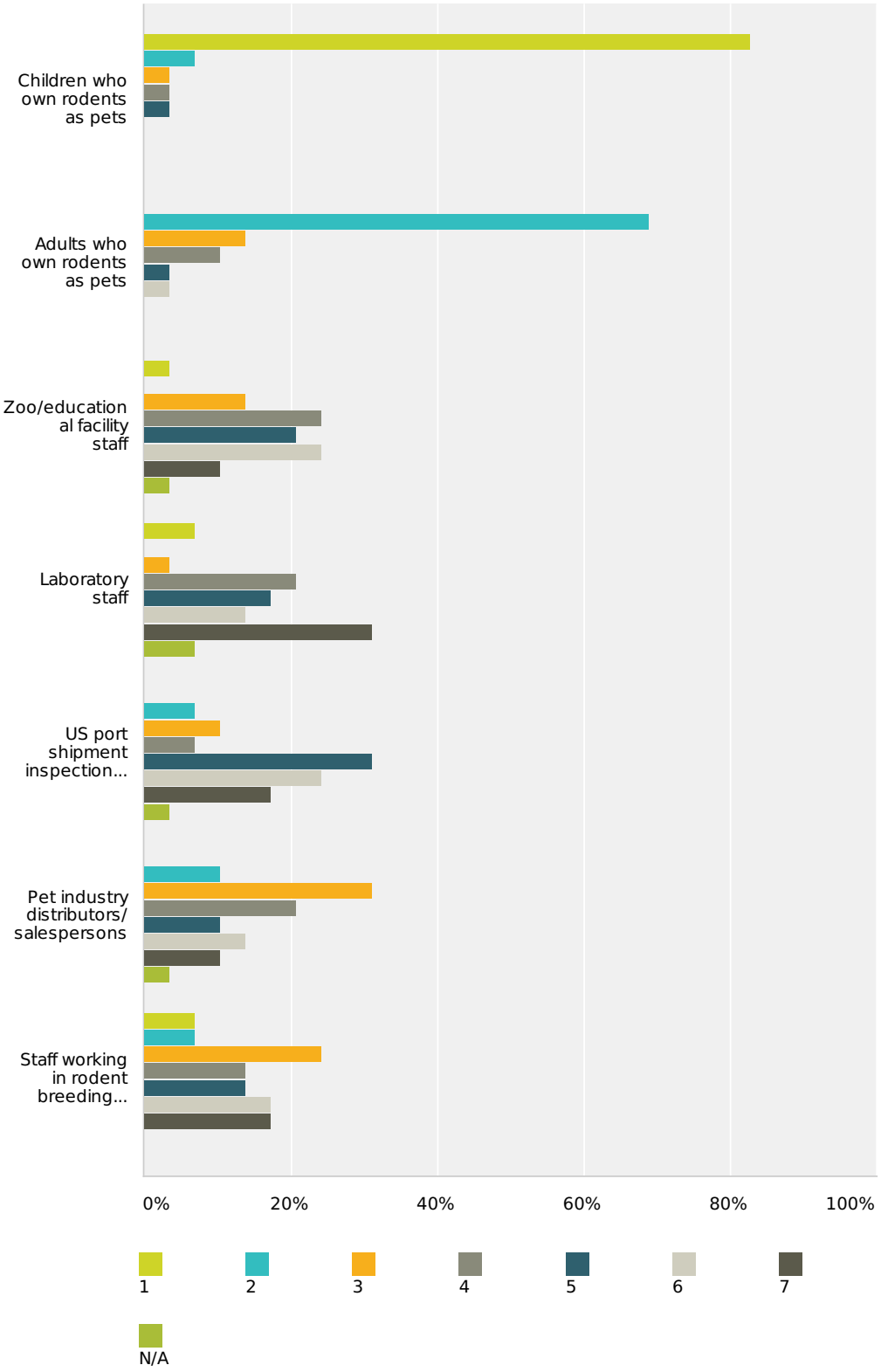
	1	2	3	4	5	6	N/A	Total	Average Ranking
Lack of quarantine	**23.33%** 7	**0%** 0	**26.67%** 8	**20%** 6	**23.33%** 7	**3.33%** 1	**3.33%** 1	30	4.69
Lack of disease testing	**10%** 3	**23.33%** 7	**20%** 6	**13.33%** 4	**13.33%** 4	**16.67%** 5	**3.33%** 1	30	4.52

Wild caught individuals	**23.33%** 7	**23.33%** 7	**23.33%** 7	**16.67%** 5	**6.67%** 2	**6.67%** 2	**0%** 0	30	5.20
Species mixing in shipments	**3.33%** 1	**33.33%** 10	**10%** 3	**13.33%** 4	**30%** 9	**10%** 3	**0%** 0	30	4.37
Stressful shipping conditions	**3.33%** 1	**3.33%** 1	**10%** 3	**16.67%** 5	**13.33%** 4	**50%** 15	**3.33%** 1	30	3.10
Contact between rodents and humans	**36.67%** 11	**16.67%** 5	**10%** 3	**16.67%** 5	**10%** 3	**10%** 3	**0%** 0	30	5.23

Q6 Please rank the following US populations from highest to lowest risk of contracting imported rodent-borne zoonoses as you perceive it (please rank by using numbers 1-7). Answers that are not deemed significant can be left unranked. 1 = highest risk; 7 = lowest risk

Answered: 29 Skipped: 1

Creating a public health risk assessment tool for wildlife species imported into the United States (



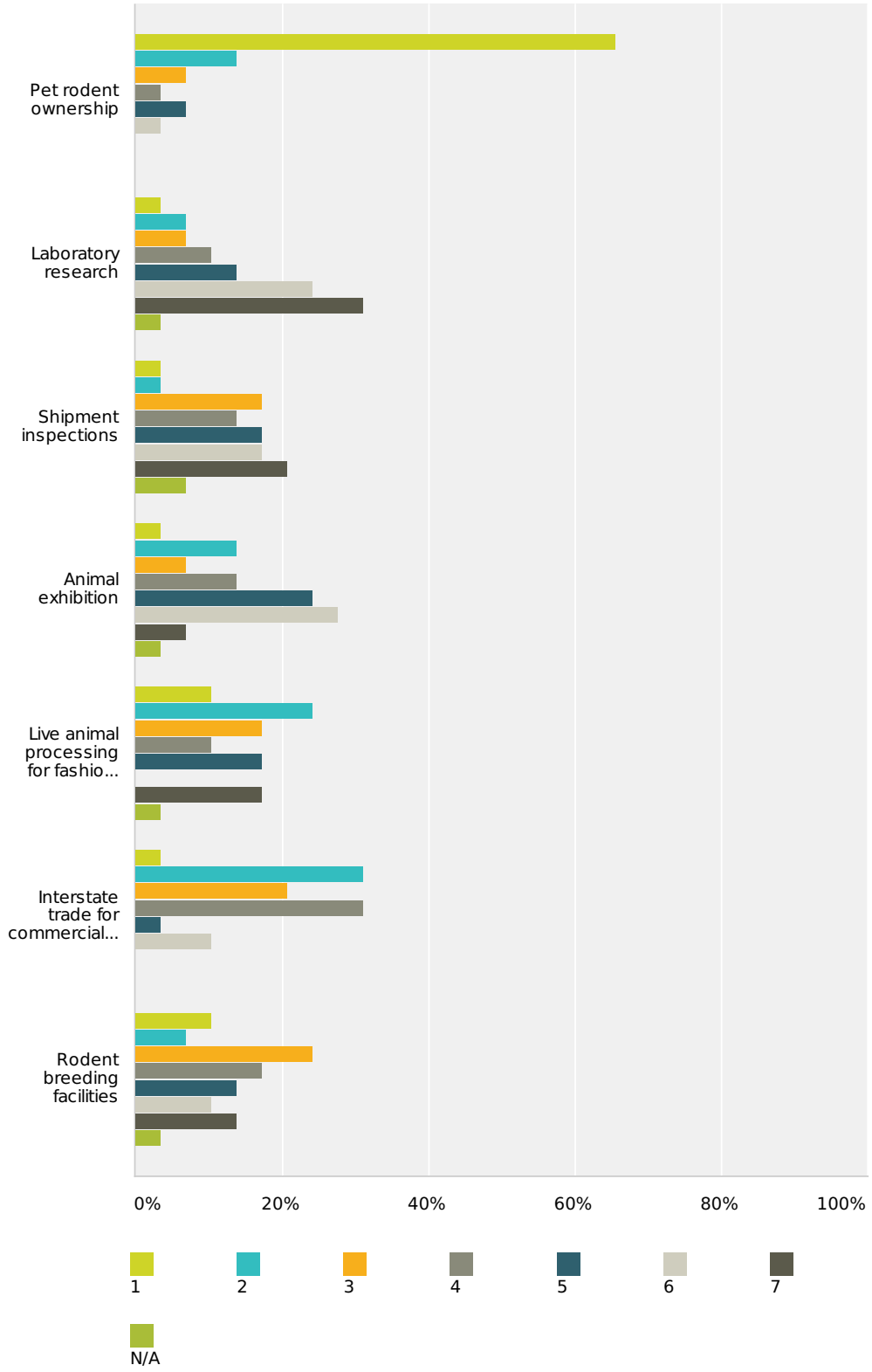
	1	2	3	4	5	6	7	N/A	Total	Average Ranking
Children who own rodents as pets	**82.76%** 24	**6.90%** 2	**3.45%** 1	**3.45%** 1	**3.45%** 1	**0%** 0	**0%** 0	**0%** 0	29	7.62

Adults who own rodents as pets	**0%** 0	**68.97%** 20	**13.79%** 4	**10.34%** 3	**3.45%** 1	**3.45%** 1	**0%** 0	**0%** 0	29	6.41
Zoo/educational facility staff	**3.45%** 1	**0%** 0	**13.79%** 4	**24.14%** 7	**20.69%** 6	**24.14%** 7	**10.34%** 3	**3.45%** 1	29	4.21
Laboratory staff	**6.90%** 2	**0%** 0	**3.45%** 1	**20.69%** 6	**17.24%** 5	**13.79%** 4	**31.03%** 9	**6.90%** 2	29	3.78
US port shipment inspection officials	**0%** 0	**6.90%** 2	**10.34%** 3	**6.90%** 2	**31.03%** 9	**24.14%** 7	**17.24%** 5	**3.45%** 1	29	3.89
Pet industry distributors/salespersons	**0%** 0	**10.34%** 3	**31.03%** 9	**20.69%** 6	**10.34%** 3	**13.79%** 4	**10.34%** 3	**3.45%** 1	29	4.82
Staff working in rodent breeding facilities	**6.90%** 2	**6.90%** 2	**24.14%** 7	**13.79%** 4	**13.79%** 4	**17.24%** 5	**17.24%** 5	**0%** 0	29	4.59

Q7 Please rank the human behaviors from highest to lowest risk of contributing to imported rodent-borne zoonoses as you perceive it (please rank by using numbers 1-7). Answers that are not deemed significant can be left unranked. 1 = highest risk; 7 = lowest risk

Answered: 29 Skipped: 1

Creating a public health risk assessment tool for wildlife species imported into the United States (

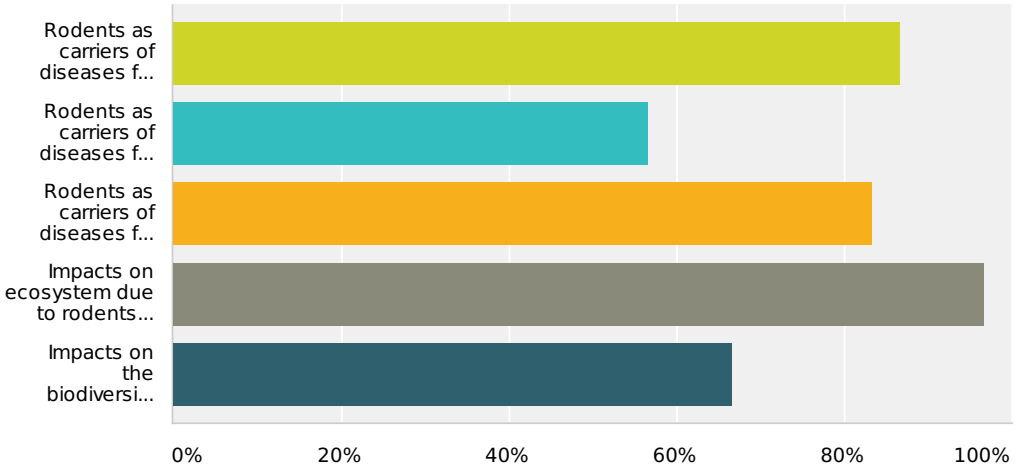


	1	2	3	4	5	6	7	N/A	Total	Average Ranking
Pet rodent ownership	**65.52%** 19	**13.79%** 4	**6.90%** 2	**3.45%** 1	**6.90%** 2	**3.45%** 1	**0%** 0	**0%** 0	29	7.17
Laboratory research	**3.45%** 1	**6.90%** 2	**6.90%** 2	**10.34%** 3	**13.79%** 4	**24.14%** 7	**31.03%** 9	**3.45%** 1	29	3.71
Shipment inspections	**3.45%** 1	**3.45%** 1	**17.24%** 5	**13.79%** 4	**17.24%** 5	**17.24%** 5	**20.69%** 6	**6.90%** 2	29	4.15

Animal exhibition	**3.45%** 1	**13.79%** 4	**6.90%** 2	**13.79%** 4	**24.14%** 7	**27.59%** 8	**6.90%** 2	**3.45%** 1	29	4.43
Live animal processing for fashion products	**10.34%** 3	**24.14%** 7	**17.24%** 5	**10.34%** 3	**17.24%** 5	**0%** 0	**17.24%** 5	**3.45%** 1	29	5.29
Interstate trade for commercial sale	**3.45%** 1	**31.03%** 9	**20.69%** 6	**31.03%** 9	**3.45%** 1	**10.34%** 3	**0%** 0	**0%** 0	29	5.69
Rodent breeding facilities	**10.34%** 3	**6.90%** 2	**24.14%** 7	**17.24%** 5	**13.79%** 4	**10.34%** 3	**13.79%** 4	**3.45%** 1	29	4.93

Q8 Which additional risks do you believe are associated with live rodent importation (check all that apply)?

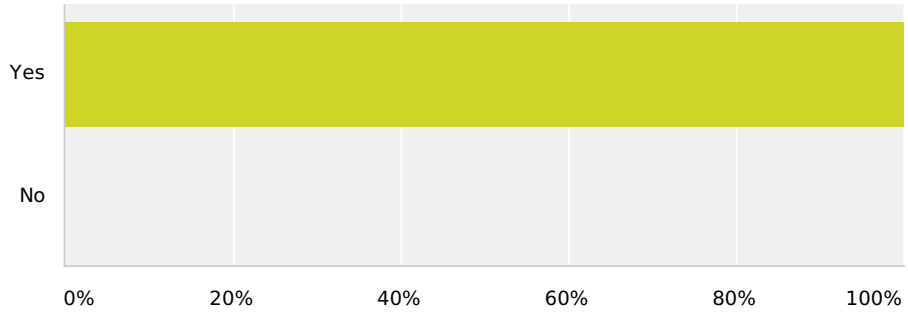
Answered: 30 Skipped: 0



Answer Choices	Responses	
Rodents as carriers of diseases for native wildlife	**86.67%**	26
Rodents as carriers of diseases for livestock	**56.67%**	17
Rodents as carriers of diseases for other companion animals	**83.33%**	25
Impacts on ecosystem due to rodents becoming invasive species	**96.67%**	29
Impacts on the biodiversity of the rodent's country of origin	**66.67%**	20
Total Respondents: 30		
Other (please specify) (2)		

Q9 Do you think there is added value in assessing these other components (identified in question 8)?

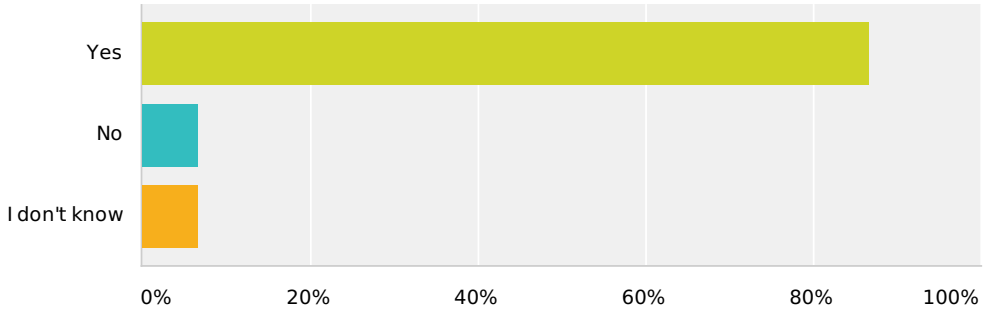
Answered: 30 Skipped: 0



Answer Choices	Responses	
Yes	**100%**	30
No	**0%**	0
Total Respondents: 30		
Comment (3)		

Q10 Do you believe a quantitative risk assessment tool to evaluate wild animal imports into the US would be useful for a better understanding of the public health risks?

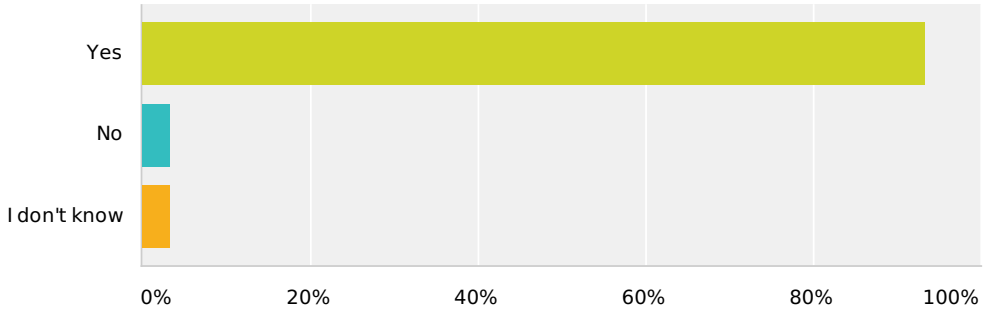
Answered: 30 Skipped: 0



Answer Choices	Responses	
Yes	**86.67%**	26
No	**6.67%**	2
I don't know	**6.67%**	2
Total Respondents: 30		
Comment (7)		

Q11 Do you believe a qualitative risk assessment tool to evaluate wild animal imports into the US would be useful for a better understanding of the public health risks?

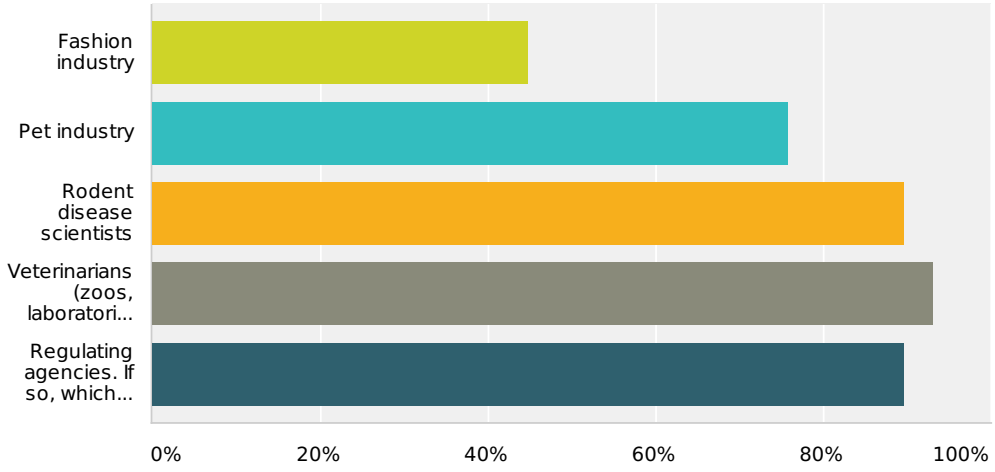
Answered: 30 Skipped: 0



Answer Choices	Responses	
Yes	**93.33%**	28
No	**3.33%**	1
I don't know	**3.33%**	1
Total Respondents: 30		
Comment (4)		

Q12 In your opinion, which stakeholder groups should be consulted to inform a science-based public health risk assessment of importation of rodents into the US from Latin America (check all that apply)?

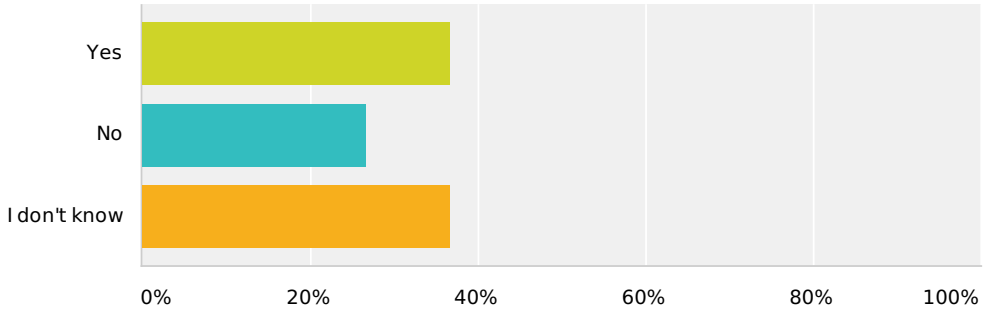
Answered: 29 Skipped: 1



Answer Choices	Responses	
Fashion industry	**44.83%**	13
Pet industry	**75.86%**	22
Rodent disease scientists	**89.66%**	26
Veterinarians (zoos, laboratories, exotic pets)	**93.10%**	27
Regulating agencies. If so, which ones? Please specify below	**89.66%**	26
Total Respondents: 29		
Other (please specify) (22)		

Q13 In your opinion, does your organization/agency want to participate in the development of a qualitative and/or quantitative assessment tool?

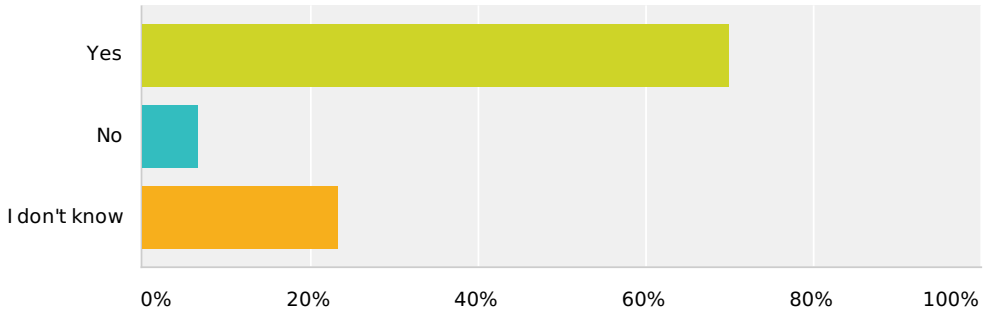
Answered: 30 Skipped: 0



Answer Choices	Responses	
Yes	**36.67%**	11
No	**26.67%**	8
I don't know	**36.67%**	11
Total Respondents: 30		

Q14 Do you think it would be useful for your organization/agency to have this risk assessment tool?

Answered: 30 Skipped: 0



Answer Choices	Responses	
Yes	**70%**	21
No	**6.67%**	2
I don't know	**23.33%**	7
Total Respondents: 30		

Q15 Optional: Additional comments, including transmission risks to populations and through behaviors

Answered: 8 Skipped: 22