

# **HUMAN-ANIMAL INTERACTIONS AT ZOOLOGICAL INSTITUTIONS**

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# HUMAN-ANIMAL INTERACTIONS AT ZOOLOGICAL INSTITUTIONS

## Abstract

**Objective** – To determine the preventive practices concerning zoonotic disease transmission between humans and animals in interactive exhibits at Association of Zoos & Aquariums (AZA) accredited institutions. Data were also analyzed to determine if annual budget was associated with particular preventive measures among the institutions.

**Design** – Cross-sectional questionnaire.

**Participants** –AZA accredited zoos and aquariums from across the United States and Canada.

**Procedures** – A questionnaire, approved by the AZA’s Animal Health Committee, was distributed electronically to 166 institutions from the 2008 AZA list of accredited institutions. Responses were collected, tallied according to grouping by annual budget, and analyzed using Chi-square analysis to determine independence.

**Results** – Forty-four of 166 (26.5%) of questionnaires were returned with data. The data indicated that all but one of 40 (97.5%) institutions with petting zoos provided hand sanitation, either via running water and soap or sanitizing gel at the exhibit exit. However, only half (17 of 34) of walk-through aviaries had some form of hand sanitation available at the exhibit exit. Only 17 of 40 (42.5%) petting zoos and 5 of 34 (14.7%) walk-through aviary exhibits had signs posted warning of the zoonotic dangers. Minor bite wounds associated with an aviary exhibit were reported from one institution, which was the only associated illness with either the petting zoo or walk-through aviary exhibits in this questionnaire. There were no statistical relationships between budget category and reported preventive measures.

**Conclusions** – Respondents had many practices already in place to minimize the risk of disease transmission to visitors. Institutions should evaluate their current preventive measures with regards to this questionnaire and make modifications as necessary. One area many institutions should add to their current practices is disinfecting interactive exhibit barriers that the public can contact, to remove potential zoonotic organisms. This questionnaire found 4 institutions were not vaccinating mammals in interactive exhibits for rabies. The subsequent risk posed to visitors is one easily avoided. Twenty-three institutions with petting zoos did not have signs warning of the zoonotic dangers, and risky practices (eg, leaving animals on exhibit with loose stool) were reported by 8 petting zoo institutions. Some form of hand sanitation, preferably soap and sinks with running water, and signs educating visitors of the zoonotic potential were missing at many walk-through aviaries in this questionnaire, despite the fact that all 34 institutions with aviaries reported visitors may contact feces in the exhibit. No relationships between budget category and reported preventive measures were found, indicating that none of these measures were cost prohibitive to institutions with these types of exhibits.

## **Introduction**

The One Health Initiative is a movement to combine all fields of medicine into a collaborative effort among physicians, veterinarians and other health professionals, with the goal of improving the overall health of humans, animals, and the environment. The premise of the initiative is that there is one health that involves people, domestic animals, and wildlife.<sup>1,2</sup> As a result, veterinarians are becoming more active participants to ensure the safety of humans when there are interactions with animals. Interactions between humans and animals can be an intentional or unintentional part of life. Steps can be taken to minimize the risk of disease transmission from one to the other, particularly from animals to humans. Some venues pose greater risks than others, such as interactive exhibits at zoological institutions that provide millions of human-animal interactions each year.<sup>3</sup> One survey estimated 6 million people in the United States visit a petting zoo each week, or 312 million people annually.<sup>4</sup> The interactive exhibits allow animals and humans to share a common space, and interaction is often encouraged through controlled feeding of the display animals. There are many enriching and educational benefits to these exhibits; thus, implementing appropriate safety precautions is a better solution than limiting opportunities for human-animal interactions as a response to zoonotic concerns.<sup>5,6</sup>

Currently, there are no federal laws focused on the protection of human health for those who participate in interactive animal exhibits. However, several state and local laws have been enacted in reaction to local disease outbreaks. A Pennsylvania state law requires animal exhibit operators to “promote public awareness of the risk of contracting a zoonotic disease” along with providing adequate hand washing facilities.<sup>7</sup> The Akron (OH) City Council passed a law mandating that running water, soap, towels or hand dryers, and trash baskets be located within 100 feet of petting zoo exhibits.<sup>8</sup> The USDA enforces the Animal Welfare Act, which ensures animals in these and all exhibits are being cared for appropriately.<sup>3,9</sup> Appropriate care translates into healthier animals that are less likely to transmit disease to humans visiting the exhibits. However, the act is not designed to directly focus on protection of human health. The Association of Zoos & Aquariums (AZA) accreditation process evaluates zoos and aquariums to ensure that the highest standards are being upheld with regards to animal care, education of the public, and safety for all persons and animals associated with the institution.<sup>10</sup> The AZA requires all institutions that have exhibits with human-animal contact to maintain a written policy regarding the safety of visitors and the animals in the exhibit. This policy is reviewed by the inspection committee during the initial accreditation inspection and upon all accreditation renewal requests.<sup>10</sup>

Despite the lack of widespread legal regulations, some inherent liability risk is still present. In addition to the Workers’ Compensation Act, most states have a Workers’ Occupational Disease Act that covers employees for costs associated with a disease that can be linked to their daily work. Additionally, when nondomestic animals are involved, the legal system has stated that there is a duty to prevent injury to the public from these wild animals. Thus, there is liability if an injury were to occur. It is important that institutions protect the visiting public from the possibility of injury through the posting of proper warnings and other precautions.<sup>11</sup>

Over half (868 of 1415, 61%) of the known human pathogens are zoonotic.<sup>12</sup> More than 50 of these zoonotic pathogens are present in the United States.<sup>12</sup> Some of the more common zoonotic pathogens affecting humans include *Salmonella* spp; *Cryptosporidium* spp; Shiga toxin-producing *Escherichia coli*, including *E. coli* O157:H7; methicillin-resistant *Staphylococcus aureus* (MRSA); dermatophytosis (ringworm); *Chlamydomphila psittaci*; and rabies. These diseases are transmitted from one individual or animal to another by 1 of 3 different methods: contact, aerosol, or vector-borne.<sup>1,4,6,12,13</sup> Most of the concern for disease transmission with interactive exhibits is via direct or indirect contact, and to a lesser extent aerosolization of pathogens. Contact includes direct physical contact with animals or indirect contact where pathogen exposure occurs through the animals' environment. There have been approximately 100 disease outbreaks in humans associated with animals in public settings, like petting zoos, in the last 15 years.<sup>3</sup> A review of the literature for published outbreaks between 1966 and 2002 found 38 outbreaks involving animal exhibits globally. The majority of these outbreaks involved enteric disease, specifically *E. coli* O157:H7, *Cryptosporidium* spp, or *Salmonella* spp. Many of these outbreaks were associated with a farm or fair setting; however, at least 9 of the outbreaks were in a petting zoo or similar setting.<sup>4,9,14</sup> A review of the literature showed 8 reported cases of human disease attributable to exposure that occurred in an interactive exhibit from 2005-2011 (**Table 1**). It is likely there were more isolated cases that were not reported to public health officials that could have been linked to exhibit animals had they been investigated.

Enteric diseases are typically the most common concern associated with interactive exhibits. Enteric pathogens are transmitted via the fecal-oral route. Therefore, hygiene measures, including hand washing, prohibiting eating and drinking within the exhibit, and cleaning the exhibit, are necessary to minimize disease transmission risk. Pathogens can reside on the animals' fur or skin, be contained in their saliva, or be present on the exhibit floor, bedding, walls, or barriers.<sup>3,13,20,21</sup> Animals can also be subclinical carriers, showing no outward signs of illness, but still shed organisms.<sup>3,13</sup> Many zoonotic pathogens require only a few organisms to cause disease. For instance, 30 *Cryptosporidium parvum* oocysts<sup>14</sup> or less than 10 *E. coli* O157:H7 organisms<sup>4</sup> are sufficient to cause human disease.

A widely recognized enteric pathogen is *E. coli* O157:H7. While commonly transmitted via contaminated food, this organism can also be transmitted directly to humans via animal feces. Symptoms commonly include watery or bloody diarrhea, fever, abdominal cramping, and nausea or vomiting. Immunocompromised individuals, the young, and the elderly are at a greater risk and may experience more severe symptoms, including kidney failure known associated with the potentially fatal hemolytic uremic syndrome (HUS).<sup>22</sup> Prevention is achieved by avoiding ingestion of animal feces and washing hands following any contact with animals, animal feces, or animal environments is critical.

Salmonellosis can be caused by many different species and strains of *Salmonella*. Although commonly a food-borne disease, it can also be transmitted from direct or indirect animal contact, specifically contact with animal feces. Signs commonly occur 1-3 days after infection and include diarrhea, fever, and abdominal pain. Prevention of disease includes proper hygiene and washing hands after contact with animal feces.<sup>23</sup>

*Cryptosporidium* is another zoonotic pathogen that can cause enteric disease in humans. *Cryptosporidium* has a protective outer shell, which allows for prolonged survival outside the body and increases the organism's tolerance to chlorine disinfection. Transmission is most commonly through infected water.<sup>24</sup> Signs typically develop 2-10 days after infection and consist of fever, dehydration, abdominal cramping, and vomiting. Prevention of disease transmission from animals includes minimizing contact with animal feces and proper hand washing if contact with feces has occurred.<sup>24</sup>

In addition to enteric disease, rabies, dermatophytosis, and soft tissue injuries (kicks, scrapes, bites, etc) can be associated with petting zoo animal exhibits.<sup>6,9,12,21</sup> Rabies is a Lyssavirus of the family Rhabdoviridae in which all mammals are susceptible. Raccoons, skunks, coyotes, bats, and foxes commonly serve as reservoirs for the disease. Transmission mainly occurs through infected saliva transferred via bites. However, contact with infected saliva and mucous membranes are other modes of transmission. Once infected, the central nervous system is targeted, leading to clinical signs indicative of disease. Early symptoms include general illness, such as fever, headache, and weakness that progress into insomnia, anxiety, confusion, partial paralysis, hypersalivation, dysphagia, and hydrophobia.<sup>25</sup> Once signs are present, the disease is almost always fatal. Prevention can be achieved by vaccinating susceptible mammals that potentially have contact with people and/or wildlife. If bitten, it is important to seek immediate medical care for post-exposure treatment if the animal is known or suspected to be rabid.<sup>25</sup>

Dermatophytosis, commonly known as “ringworm”, is typically caused by fungi of the genera *Trichophyton* or *Microsporum*. Dermatophytes are transmitted via direct contact with an infected animal or person. The pathogen may also contaminate environmental objects, such as bedding or towels and, infect other individuals through these fomites. Infection may develop between 4 and 14 days post-exposure and consist of local redness, scaling, pruritus, and possible hair loss. Dermatophytosis can easily be treated using medication (topical and/or oral depending on location).<sup>26</sup> Proper hygiene, including hand washing, is the simplest way to prevent the spread of the disease.

Walk-through aviary exhibits pose some of the same concerns (eg, *Salmonella*, soft tissue injuries, and bites) as petting zoo exhibits. However, there are other agents of concern, such as *C. psittaci*, avian influenza, and fungal spores, such as *Aspergillus* and *Cryptococcus*.<sup>21,27,28</sup> Psittacosis, also known as ornithosis or parrot fever, is caused by *C. psittaci*. Like many diseases of concern with interactive exhibits, the birds on exhibit may be subclinical carriers or may display nonspecific clinical signs of disease (often associated with periods of stress) with concurrent shedding of organisms.<sup>29</sup> Psittacosis is typically transmitted to humans by inhaling aerosolized organisms from dried feces or directly from respiratory tract secretions. Direct mouth-to-beak contact and handling infected birds' feathers and tissues can also result in disease transmission.<sup>29-32</sup> Clinical signs in humans include fever, chills, headache, muscle aches, dry cough, and radiographic evidence of pneumonia.<sup>32</sup> Symptoms can develop in as little as a few days or up to almost 3 weeks after exposure. Similar to many of the other pathogens discussed, *C. psittaci* is stable for greater than a month in feces in the environment.<sup>29</sup>

Avian influenza is a disease of concern in zoological collections, since highly pathogenic avian influenza (HPAI) can be carried by migratory birds.<sup>33</sup> Therefore, it is possible that the disease could be transmitted from wild birds into the collection at a zoological institution. HPAI has been detected in 96 different species, from 14 orders, many of which the 34 institutions from this questionnaire with aviaries included in their exhibits (eg, Ciconiiformes, Columbiformes, Galliformes, Passeriformes, and Psittaciformes).<sup>33</sup> HPAI within a zoological collection could be devastating for the birds and produce the potential for zoonotic transmission to people in a walk-through aviary exhibit.

Fungal spores, such as *Aspergillus* and *Cryptococcus*, can be found in aviary exhibits. *Aspergillus* is commonly found in decaying organic material (ie, leaves).<sup>34</sup> *Cryptococcus gattii* is also found in decaying matter and in soil in and around the base of trees. However, *C. neoformans* is found in the feces of wild birds, commonly pigeons.<sup>35</sup> These pathogens are transmitted when spores are aerosolized and inhaled by a passerby, leading to signs including headache, fever, cough, shortness of breath, and general malaise. The resulting disease is more severe in immunocompromised individuals. Thus, people with weaker immune systems should avoid exposure to these potential pathogens and enter walk-through aviaries with caution.<sup>34,35</sup>

Proper hand hygiene is one of the most important methods to prevent disease transmission.<sup>3,4,6,13,33,36</sup> One study measured overall hand hygiene compliance associated with a petting zoo to be 58.0% (340/583).<sup>36</sup> Washing with soap and running water is essential to remove any organic material present, as well as reduce the number of transient microorganisms on the skin. Importantly, is that drying hands on clothing, even after washing with soap and water, increases the risk of disease.<sup>13</sup> Therefore, adequate drying options, such as air dryers or disposable paper towels, must be provided. Hand sanitizing gels, primarily alcohol-based, are effective against many bacteria and viruses. The FDA recommends hand gels containing 60-95% ethyl or isopropyl alcohol to be protective. However, these are ineffective against some bacterial spores (ie, *Clostridium*) and protozoans (ie, *Cryptosporidium*), as well as in the presence of organic material.<sup>12</sup> Therefore, it is paramount to physically remove any visible organic material prior to using sanitizing gels.<sup>3,12</sup> Accordingly, hand washing stations should be present near interactive exhibits for appropriate hand hygiene and disease prevention for visitors.

There is little information documenting the human disease prevention measures in place at interactive exhibits in zoological institutions. The purpose of this report is to provide benchmark comparisons for all institutions and provide data for accrediting organizations. Secondly, the data were analyzed to determine the potential associations between annual budgets of responding zoological institutions and their human disease prevention practices for interactive exhibits.

## **Materials and Methods**

### **Sample population**

The 2008 list of AZA Accredited Zoos and Aquariums was used to contact 166 zoological institutions located in the United States and Canada. Thirty-two institutions were not contacted based on internet research, which revealed they did not have interactive exhibits. For those institutions with a veterinary contact listed, the veterinarian was contacted for information. For institutions without a veterinarian on record, the curator or director was contacted. The questionnaire was distributed as a Microsoft Word document via an email attachment, and a request was made for the information to be returned electronically. A cover letter was included for the responder, which provided a brief overview of the questionnaire and its purpose.

### **Questionnaire**

A questionnaire (**Appendix A**) was developed to obtain information on various practices of responding institutions regarding 2 different types of interactive exhibits: petting zoos and walk-through aviaries. The intent was to capture information regarding exhibit types where humans and collection animals shared a common space and could contact one another, regardless of whether or not direct contact was encouraged or allowed.

The questionnaire was approved by the AZA's Animal Health Committee and consisted of 36 questions divided into 3 sections. The first section consisted of 5 questions requesting general information from the institution (contact information, number of animals in the collection, annual budget, number of visitors annually, and number of employees/volunteers). The second section contained 20 questions and focused on petting zoo exhibits. The first question asked if the institution had a petting zoo exhibit. If the institution did not have this type of exhibit, they answered "No" and did not complete the remainder of the section. The final section had 11 questions and focused on walk-through aviary exhibits. Once again, if an institution did not have an exhibit of this type, they answered "No" to the first question and were not required to complete the remainder of this section.

The majority of the questions were closed format, eg, asked in a format requesting a Yes/No answer, with the intention of simplifying the questionnaire for the responder and helping increase the response rate. Certain questions required follow up clarification, which was obtained with an open-ended response question immediately following the question at hand.

### **Statistical analysis**

Population percentages were calculated for the Yes/No questions and data were analyzed with the Chi-square test for independence in SAS (SAS 9.2, SAS Institute, Cary, NC), with a significance level of  $P \leq 0.05$ .



## **Results**

Of the 166 questionnaires distributed, 56 (33.7%) institutions responded. Forty-four (26.5%) of the respondents indicated that they had at least 1 of the 2 exhibit types at their institution (**Table 2**). The remaining 12 (7.2%) institutions reported they had neither a petting zoo nor walk-through aviary exhibit; thus, they had no further data to contribute to the study. The responding institutions were divided into 3 groups based on their reported annual budget. Institutions were assigned to groups using the following criteria: Small institutions had budgets < \$2 million (n=13; range, \$738,000-\$1.8 million); Medium institutions had budgets  $\geq$  \$2 million, but < \$10 million (n=12; range, \$2.9 million – \$5.5 million); Large institutions had budgets  $\geq$  \$10 million (n=19; range, \$10.7 million – \$42 million).

### **Petting zoo**

Forty of the 44 (90.9%) responding institutions had a petting zoo exhibit. Based on the annual budget categories, these institutions were distributed as shown in Figure 1. The common names of animals exhibited at the responding institutions are listed in Table 3. A summary of the responses to each question from these institutions is shown in Table 4. These responses were distributed among the Small, Medium, and Large groups as shown in Figure 2. Statistical analysis showed no significant differences in the responses based on the 3 different budget categories (Small, Medium, and Large) ( $P > 0.05$ ).

None of the 40 respondents indicated any incidents of disease linked to the petting zoo exhibit. Two institutions reported having animals test positive for *E. coli* O157:H7. One of these had pigs test positive that were on display in the exhibit but were not animals within the interactive area. Six of the 40 institutions reported not vaccinating for rabies. Rabies vaccination was not relevant for the species displayed at 2 of these institutions. The remaining 4 institutions (10.0%) reported displaying a variety of mammals in which vaccinating for rabies is recommended (ie, goats, sheep, horses, donkeys, pigs, and llamas). The respondents indicated 38 of 40 (95.0%) performed fecal flotations and 29 of 40 (72.5%) performed direct fecal smears during their routine veterinary examinations.

### **Walk-through aviary**

Thirty-four of the 44 (77.3%) responding institutions had a walk-through aviary exhibit, divided based on annual budget as shown in Figure 3. The particular avian orders represented by the responding institutions are given in Table 5. A summary of the responses to the questions is given in Table 6. These responses are distributed among the Small, Medium, and Large groups based on annual budget (as described above) as shown in Figure 4. Statistical analysis showed no significant differences in the responses based on the 3 different budget categories (Small, Medium, and Large) ( $P > 0.05$ ).

Only 1 of the 34 (2.9%) respondents with a walk-through aviary exhibit indicated an illness linked to the aviary exhibit. This incident was reported to be minor bites. Twenty-three

of 34 (67.6%) institutions performed fecal flotations and 31 of 34 (91.2%) performed direct fecal smears during the routine veterinary examinations.

## **Discussion**

This project was designed to determine what preventive measures were currently in place at zoological institutions with interactive exhibits. The study was limited to AZA accredited institutions, of which all were fully accredited at the time of the project. Despite the limitation of contacting only AZA institutions with this questionnaire, the findings and recommendations from this report are important for any institution where the public and animals interact, whether directly or indirectly, within an exhibit.

Many of the questions on the questionnaire focused on exhibit design and surrounding facilities, specifically, the availability of hand washing stations and relevant signage that stressed the importance of hygiene after visiting the exhibit. Exhibit design can increase or decrease the risk for infection.<sup>3</sup> Over half of the institutions (65.0%) with petting zoo exhibits had a design where the entry and exit of the exhibit were the same. This simplifies where particular signs and hand washing stations should be located. For the remaining 35.0% of institutions with a separate entry and exit, signs describing the zoonotic potential and importance to practice good hygiene (ie, no eating, drinking, smoking) should be located near the entrance, while those with a reminder to wash your hands, as well as describing proper hand washing techniques, should be placed just outside the exit, along with the hand washing stations.

Signs educating the public on the potential zoonotic dangers were lacking at many institutions. Specifically, 23 of 40 (57.5%) petting zoos and 29 of 34 (85.3%) aviaries reported not having signage warning of zoonotic diseases. This is notable since awareness by the exhibit visitor of the potential disease risk has been shown to be protective against contracting disease.<sup>3,4,13</sup> However, 31 of 40 (77.5%) petting zoos reported having signage on proper hand washing techniques at the exhibit exit and 34 of 40 (85.0%) petting zoos recommended hand washing either directly by a staff member or by use of signs. These numbers are encouraging because both signage and verbal reminders of hand hygiene have a positive association with hand hygiene compliance.<sup>36</sup> It is recommended that signs are simple to read and available in a format that is age and language appropriate for common visitors to the exhibit.<sup>3</sup>

Hand washing stations with running water and soap were available at 32 of 40 (80.0%) petting zoos and 28 of 40 (70.0%) had hand sanitizing gel available. All but one of the 40 institutions with petting zoos (97.5%) provided hand sanitation either via stations with running water and soap or sanitizing gel at the exhibit exit. However, only half of the aviaries (17 of 34) had some form of hand sanitation available at the exhibit exit. This is problematic since numerous studies have shown the protective benefit of washing hands with running water and soap.<sup>3,4,9,14,33</sup> If an institution is evaluating their current hand washing stations or planning to install these facilities, one detail easily overlooked is ensuring that the hand washing stations are accessible to all, particularly smaller children, to allow for proper hand washing.<sup>37</sup> Hand sanitizing gels are an alternative when running water is not available. These gels have been shown to be effective in human health-care settings, but their effectiveness has not been thoroughly evaluated in settings such as those examined in this study. Several studies have indicated that hand sanitizing gels are not as protective as hand washing with soap and water.<sup>4,14</sup>

This is likely because some organic debris remaining on the person's hands, which allows pathogens to persist.

Environmental cleansing is another step in preventing disease transmission. Indirect transmission through environmental sources is a lesser recognized mode of transmission, but one that must be considered as a potentially important source of disease-causing agents.<sup>4</sup> An outbreak of *Salmonella enterica* serotype Enteritidis was reported in 65 people, mostly children, that viewed a Komodo dragon (*Varanus komodoensis*) exhibit and touched the wooden fencing of the exhibit. *Salmonella enterica* was isolated from 39 of the affected individuals, one of the Komodo dragons on exhibit, and the wooden fencing.<sup>3</sup> As with the hand washing recommendations, water and detergent should be used first to remove any organic material prior to applying disinfectant.<sup>12</sup> *Escherichia coli* can persist in the environment for long periods of time.<sup>5</sup> One outbreak involved 23 people attending a dance 14 weeks after a county fair had occurred in the same barn; *E. coli* O157:H7 was still cultured from the sawdust 42 weeks after the fair.<sup>3</sup> Williams et al<sup>38</sup> found *E. coli* persisted on moist wood in cool temperatures for at least 28 days. Moisture was found to influence survival duration more than temperature. The same study also found that 4000 colony forming units (CFUs) of Shiga toxin-producing *E. coli* O157:H7 were transferred to a person's hand simply by grabbing a steel gate that had been contaminated for the study.<sup>38</sup> As stated previously, less than 10 *E. coli* O157:H7 organisms can cause disease.<sup>4</sup> In this questionnaire, only 5 of 40 (12.5%) petting zoos reported routinely disinfecting the exhibit fencing. This may be the result of the logistical feasibility of cleaning the exhibit fencing. However, efforts should be made to clean and disinfect exhibits as they are currently constructed. Additionally, this disinfecting process should be considered when new exhibits are designed to allow for more routine and easy cleaning in the future.

Along with proper hand washing, general hygiene is also strongly recommended to help prevent disease transmission. Hand-to-mouth activity has demonstrated an increased risk of contracting disease.<sup>4</sup> Examples of hand-to-mouth activities that should be avoided include: eating, drinking, smoking, and finger nail biting. Children should avoid putting their fingers, hands, and anything else (ie, pacifiers, toys) in their mouths. Therefore, families should be strongly encouraged to leave unnecessary items (ie, strollers, toys, pacifiers, etc) outside of interactive exhibits. The majority (34 of 40; 85.0%) of petting zoos prohibited eating or drinking inside the exhibit. Similarly, 33 of 40 (82.5%) had a staff member monitoring the exhibit to ensure the safety of the patrons and the animals while inside the exhibit. Approximately one quarter of respondents (11 of 40; 27.5%) reported having vending machines or vendors selling food or drinks within 100 feet of the petting zoo exhibit. There is no reported minimum distance for these vendors or machines to be located from the exhibit; thus, 100 feet was arbitrarily selected for this questionnaire.

Many of the species on exhibit in petting zoos and walk-through aviaries can shed organisms without having signs of disease. Reducing animal stress is one way to minimize the potential for indiscriminate shedding. Greater than three quarters of the petting zoos (31 of 40; 77.5%) reported animals and visitors sharing the same space, and it is assumed that patrons and birds in walk-through aviaries share the same space. This interaction potentially increases the risk for the animals to become stressed and to shed organisms. To counteract the potential for increased stress, 92.5% of the petting zoos had an area for the animals to "escape" from the

visitors. Nine of 40 (22.5%) petting zoos stated they leave animals on exhibit when they have loose stools. One of these 9 was referring to aquatic animals, which naturally have loose stool, and thus can be ignored. A staple protocol for all interactive petting zoo exhibits should be: when an animal is noted to have loose stool, it should be removed from the public exhibit and the animal placed under veterinary care.<sup>21</sup>

Although the previous history of animals on display, including quarantine protocols and testing, were not addressed with this questionnaire, information on routine examinations was requested. All but one of 40 (97.5%) petting zoos and 29 of 34 (85.3%) walk-through aviaries reported the animals received routine veterinary examinations, typically annually. A majority of institutions with petting zoos reported routinely vaccinating animals for rabies. However, 4 institutions (10.0%) did not routinely vaccinate for rabies. The Compendium of Animal Rabies Prevention and Control<sup>39</sup> states that all mammals are believed to be susceptible to contracting the rabies virus. Consequently, it is recommended that animals that have frequent contact with humans, as well as those that can be exposed to wildlife that may be carriers of the disease, should receive current vaccination for rabies.<sup>39</sup> During 2009, 92% of the nearly 6700 reported cases of rabies in the United States were in wildlife species.<sup>40</sup> There is obviously a potential for infected wildlife to contact and transmit the virus to mammals housed in petting zoo exhibits, especially if they are housed outdoors overnight when there is little or no monitoring by staff. Zelefsky and Harrison<sup>41</sup> surveyed 32 zoos regarding mammalian bites and found 11 zoos reported an incident within the previous 5 years. Nine of those zoos were able to provide specific details on the incident. Petting zoo animals (goats and ponies) were involved in 2 of the incidents. Of the 9 animals detailed, 7 had been previously vaccinated for rabies. The study concluded there was a greater incidence of rabies on zoo grounds in wildlife than collection animals, but recommended vaccinating the collection for the safety of the animals and for humans visiting the exhibit. No human rabies deaths resulting from animal contact in a public setting have been documented. However, there have been numerous exposures that required post-exposure prophylaxis treatment and time consuming public health investigations.<sup>3</sup>

Psittacosis should be a primary concern for the 18 institutions housing psittacines in interactive exhibits, particularly the 8 institutions that specified they had budgerigars (*Melopsittacus undulatus*) and cockatiels (*Nymphicus hollandicus*), the most common species from which *C. psittaci* is isolated.<sup>29-31</sup> Humans feeding psittacines are at a higher risk due to the close contact. However, anyone entering aviary exhibits is at risk for exposure to feces and aerosolized pathogens. All of the 34 institutions with aviaries reported that visitors can come into contact with bird feces while in the exhibit, thus creating the potential for exposure to *C. psittaci* and other zoonotic pathogens. As previously stated, quarantine testing information was not requested, but it would be recommended that all psittacines to be placed in a walk-through aviary exhibit be screened for *C. psittaci*.<sup>29</sup>

Only 1 institution reported having an illness related to the interactive exhibit, which were minor bites in an aviary exhibit. However, a survey of the American Association of Zoo Veterinarians found 84/278 (30.2%) of respondents reported contracting a zoonotic infection, most commonly ringworm or psittacosis.<sup>42</sup> This may be due to multiple factors, including an increased exposure to both the sick and healthy animals in the institution's collection. Clinical signs in infected humans are often mild and nonspecific similar to those in animals. Mild flu-

like symptoms or diarrhea often do not result in a person seeking medical care if the signs are self-limiting. Therefore, these occurrences may not be consistently reported; and the pathogen causing the symptoms is often not traced to the source of zoonotic transmission. As a result, it is imperative to take the necessary precautions to minimize the possibility of disease transmission.

The small sample size should be considered when interpreting the results of this questionnaire. When the respondents were divided into groups based on annual budgets, the Medium group all had budgets less than \$5.5 million. This left a deficiency of institutions with \$5.5 to \$10 million being represented in this study. However, since no differences were found between Small, Medium, and Large budget groups, it is unlikely having representation of this group of institutions would have affected the data. Future questionnaires targeting AZA institutions that did not participate in the current study, as well as other institutions not currently AZA accredited, would be beneficial. Comparisons could then be made between AZA and non-AZA institutions to determine if receiving accreditation influences the protocols regarding interactive exhibits. A majority of the respondents to this questionnaire already had many practices in place to minimize the risk of disease transmission to zoo visitors. Institutions should evaluate their current preventive measures with regards to this questionnaire and make modifications as necessary. One practice many institutions should add to their current protocols is the disinfection of interactive exhibit barriers that the public can contact to remove potential zoonotic organisms. This questionnaire found 10% of institutions were not vaccinating mammals in contact exhibits for rabies; the subsequent risk posed to visitors is one that is easily avoided. Twenty-three institutions with petting zoos did not have signs warning of the zoonotic dangers. Others reported potentially risky practices such as leaving animals on exhibit with loose stools. Despite the fact that all 34 participating institutions with aviaries reported visitors may contact feces in the exhibit, some form of hand sanitation or signs educating visitors of the zoonotic potential were missing at 50% and 85.3%, respectively, of walk-through aviaries. No relationships between budget category and the reported preventive measures were found, indicating all institutions should be capable of installing these measures.

## **Abbreviations**

AZA – Association of Zoos & Aquariums

CDC – Centers for Disease Control and Prevention

CFU – Colony forming unit

FDA – Food and Drug Administration

HPAI – Highly pathogenic avian influenza

MRSA – Methicillin-resistant *Staphylococcus aureus*

USDA – United States Department of Agriculture

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## Tables

**Table 1 – Summary of recent (2005-2011) human disease outbreaks involving transmission from animals housed in interactive exhibits.**<sup>15-19</sup>

Year	Location	Pathogen
2004	North Carolina	<i>E. coli</i> O157:H7
2005	Arizona	<i>E. coli</i> O157:H7
	Florida	<i>E. coli</i> O157:H7
	Japan	<i>Chlamydophila psittaci</i>
2007	Florida	<i>E. coli</i> O157:H7
2009	Japan	<i>Trixacarus caviae</i>
2010	England	<i>Cryptosporidium parvum</i>
	England	<i>Cryptosporidium parvum</i>

**Table 2 – Institutions with at least one exhibit type (petting zoo or walk-through aviary) that responded to the questionnaire (n = 44).**

Little Rock Zoo (AR)	Fort Wayne Children's Zoo (IN)	Turtle Back Zoo (NJ)
Happy Hollow Zoo (CA)	Indianapolis Zoo (IN)	Seneca Park Zoo (NY)
San Francisco Zoo (CA)	Mesker Park Zoo (IN)	Staten Island Zoo (NY)
Granby Zoo (Canada)	Potawatomi Zoo (IN)	Cincinnati Zoo (OH)
Toronto Zoo (Canada)	Rolling Hills Wildlife Adventure (KS)	Columbus Zoo (OH)
Pueblo Zoo (CO)	Sedgwick County Zoo (KS)	Toledo Zoological Gardens (OH)
Mystic Aquarium (CT)	Sunset Zoo (KS)	Oklahoma City Zoo (OK)
Brandywine Zoo (DE)	Louisville Zoo (KY)	Greenville Zoo (SC)
Disney's Animal Kingdom (FL)	Baton Rouge Zoo (LA)	Chattanooga Zoo (TN)
Lion Country Safari (FL)	John Ball Zoo (MI)	Dallas Zoo (TX)
Zoo Miami (FL)	National Aquarium (MD)	Ellen Trout Zoo (TX)
Zoo Atlanta (GA)	St. Louis Zoo (MO)	Houston Zoo (TX)
Honolulu Zoo (HI)	Lincoln Children's Zoo (NE)	Fossil Rim (TX)
Niabi Zoo (IL)	Riverside Zoo (NE)	Gladys Porter Zoo (TX)
Scovill Zoo (IL)		Milwaukee County Zoo (WI)

**Table 3 – Common names of animals exhibited in petting zoos at the responding institutions (n = 40).\***

Common names	Number of institutions
Goats	37 (92.5%)
Sheep	22 (55.0%)
Pigs	15 (37.5%)
Horses	10 (25.0%)
Chickens	9 (22.5%)
Cows	9 (22.5%)
Llamas	9 (22.5%)
Donkeys	7 (17.5%)
Rabbits	6 (15.0%)
Ducks	4 (10.0%)
Guinea pigs/rodents	4 (10.0%)
Alpacas	3 (7.5%)
Reptiles	2 (5.0%)

\* If a species was represented once, it was not included in this table. More than one species was often exhibited at each institution.

**Table 4 – Percentage of responses to questions regarding petting zoo exhibits (n = 40).**

Question	Yes (%)	No (%)
Is visitor entry and exit the same?	65.0	35.0
Do visitors and animals share the same space?	77.5	22.5
Do animals have an “escape” area?	92.5	7.5
Is feeding the animals by the public available?	55.0	45.0
Is exhibit fencing routinely disinfected?	12.5	87.5
Are visitors monitored by staff while inside the exhibit?	82.5	17.5
Is food or drink available within 100 feet of exhibit?	27.5	72.5
Is food or drink prohibited inside the exhibit?	85.0	15.0
Are signs visible educating about zoonotic dangers?	42.5	57.5
At the exhibit exit:		
Is hand washing station with soap and running water available?	80.0	20.0
Is signage on hand washing techniques posted?	77.5	22.5
Is sanitizing gel available?	70.0	30.0
Is hand sanitation recommended (by staff or signage)?	85.0	15.0
Are animals routinely examined by a veterinarian?	97.5	2.5
Are animals left on exhibit if showing signs of loose stool?	22.5	77.5

**Table 5 – Common avian orders exhibited at institutions (n = 34) responding to the questionnaire.\***

<b>Avian order</b>	<b>Number of institutions</b>
Psittaciformes	18 (52.9%)
Anseriformes	12 (35.3%)
Columbiformes	10 (29.4%)
Passeriformes	10 (29.4%)
Ciconiiformes	7 (20.6%)
Galliformes	5 (14.7%)

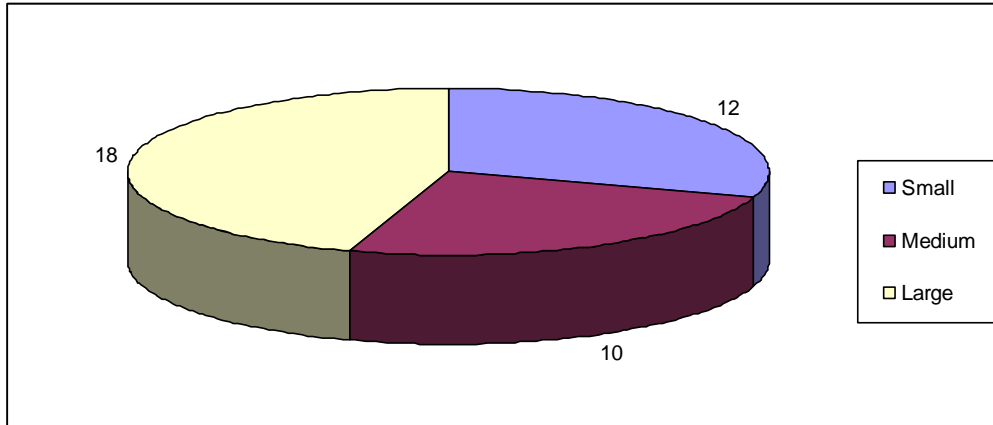
\*If an order was only represented once, it was not included in this table. More than one order may have been exhibited at each institution.

**Table 6 – Percentage of responses to questions regarding walk-through aviary exhibits (n = 34).**

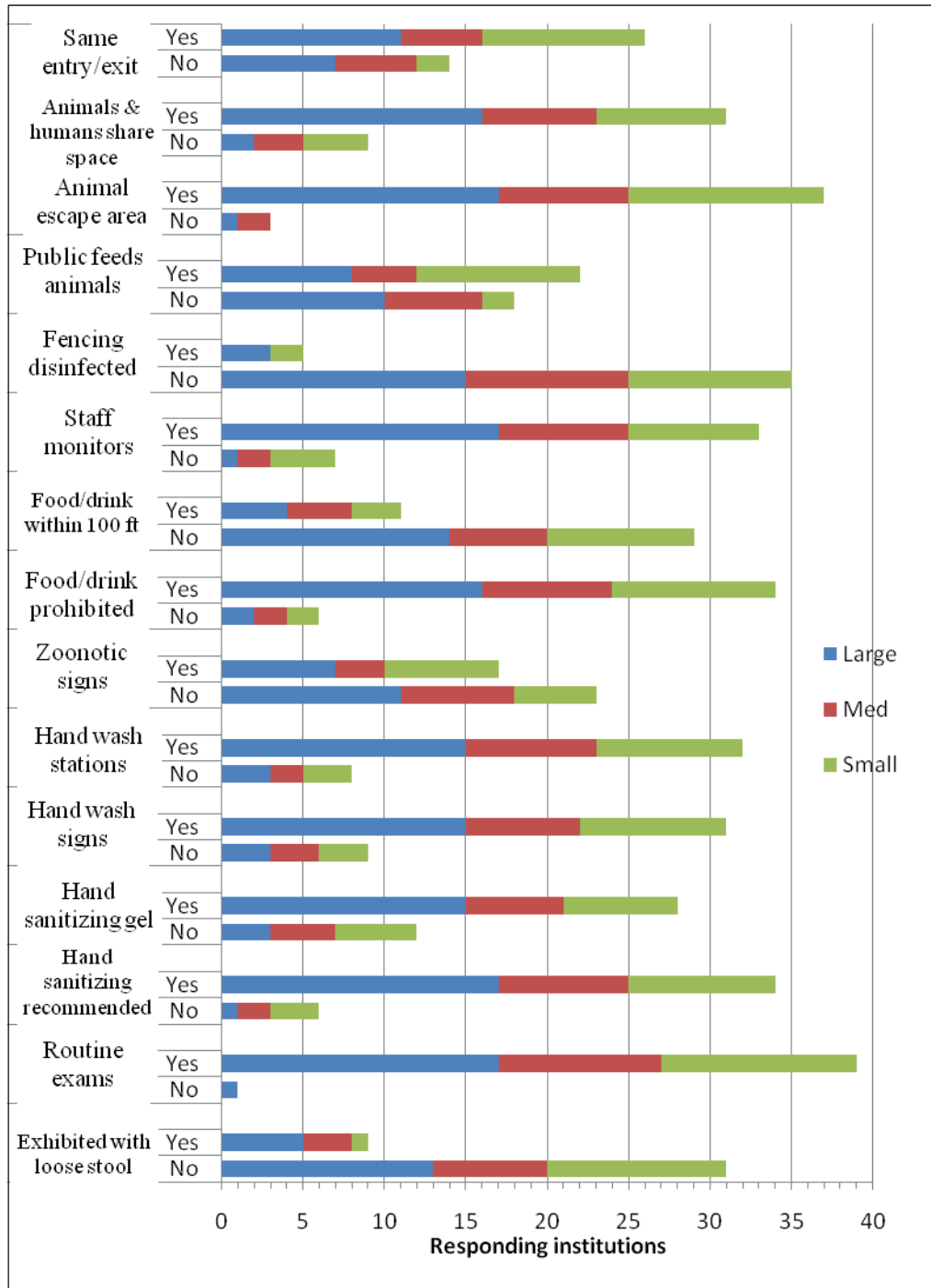
<b>Question</b>	<b>Yes (%)</b>	<b>No (%)</b>
Is interaction with the birds available/encouraged?	41.2	58.8
Are signs visible educating about zoonotic dangers?	14.7	85.3
Can visitors come in contact with bird feces?	100.0	0
Is hand sanitation available near the exhibit exit?	50.0	50.0
Are animals routinely examined by a veterinarian?	85.3	14.7

## FIGURES

**Figure 1 – Distribution of petting zoos among the Small, Medium, and Large groups based on annual budget (n = 40).**

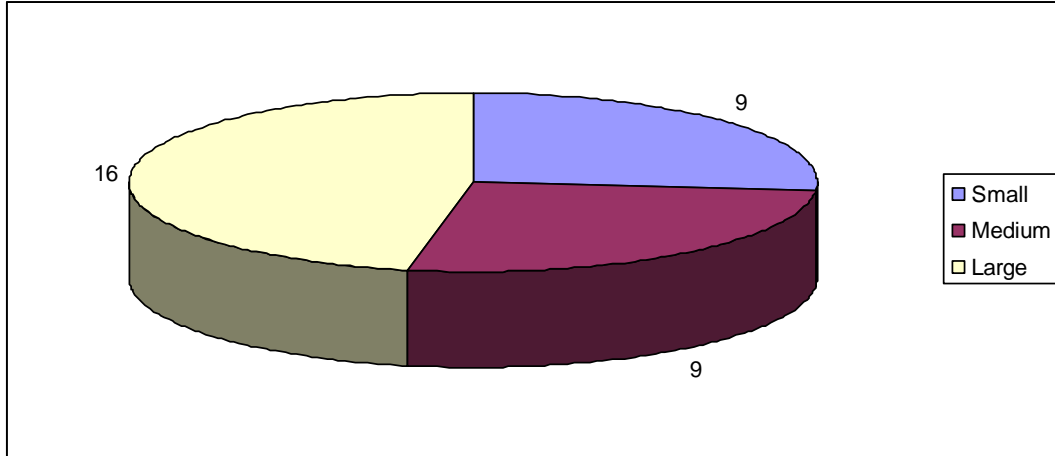


**Figure 2 – Bar graph showing distribution of responses to petting zoo questions among Small, Medium, and Large institutions (based on annual budget (n = 40; Small, n = 12; Medium, n = 10; Large, n = 18).\***

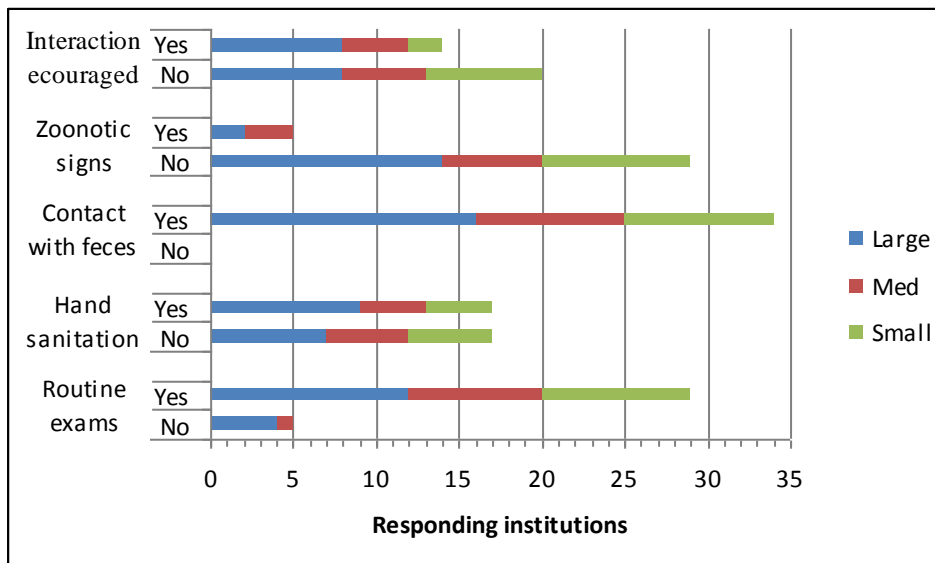


\* No statistical differences ( $P > 0.05$ ) between Small, Medium, and Large groups in the probabilities of “Yes” versus “No” response.

**Figure 3 – Distribution of walk-through aviaries among the Small, Medium, and Large groups based on annual budget (n = 34).**



**Figure 4 – Bar graph showing distribution of responses to aviary questions among Small, Medium, and Large institutions (based on annual budget (n = 34; Small, n = 9; Medium, n = 9; Large, n = 16).\***



\* No statistical differences ( $P > 0.05$ ) between Small, Medium, and Large groups in the probabilities of “Yes” versus “No” response.



## **Appendix**

### **Appendix A – Cover letter and questionnaire distributed to participating institutions.**

My name is Chris Marion. I received my DVM from Kansas State University (KSU) in 2006 and am currently continuing my education by pursuing a Master of Public Health, also at KSU. The final segment of this degree program involves a field project. For this project, I have chosen to focus on the potential spread of zoonotic disease in zoological institutions. My project is under the guidance of Derek Mosier, DVM, PhD, Dipl ACVP; James Carpenter, MS, DVM, Dipl ACZM; David Renter, DVM, PhD (all of KSU College of Veterinary Medicine); and Robert Klemm, PhD (Director of Conservation & Research, Sunset Zoo, Manhattan, KS).

Most accrediting regulations established by the AZA and USDA focus on the safety and welfare of the animals housed at the institution, but these regulations are not centered on protecting human health. However, these regulations do indirectly result in the preservation of human health. The aim of this project is to survey institutions for their current practices and designs in a few specific areas that pose the greatest zoonotic risk to humans and from that information create a set of recommendations and/or regulations for minimal standards to protect the health of those working, volunteering, and visiting zoological institutions. Our expectation is that the results of this survey will be useful in implementing a strategy that will ultimately protect human health at all institutions with interactive exhibits.

We would appreciate your cooperation in completing the attached questionnaire (survey takes approximately 20-30 minutes) regarding your institution. The information gathered will be confidential and used strictly for this survey; and the results presented will be pooled data and not be linked to any specific institution. All collaborators will be acknowledged in any subsequent publications or presentations.

This survey has been approved by the Animal Health Committee of the AZA. If you have any questions or problems, please feel free to contact me via phone 785-565-1140 (cell) or via e-mail [cmarion@vet.k-state.edu](mailto:cmarion@vet.k-state.edu). Thank you in advance for your time and assistance with this project. Christopher J. Marion, DVM

**Appendix B – Questionnaire**

**Human-Animal Interactions at Zoological Institutions**

Zoological institution: \_\_\_\_\_  
Completed by: \_\_\_\_\_  
Position: \_\_\_\_\_  
Phone number: \_\_\_\_\_  
E-mail: \_\_\_\_\_

General Information

1. Is the institution AZA accredited? Yes\_\_\_ No\_\_\_  
a. If no, please describe the current status (ie, probation, not seeking accreditation, etc.)  
\_\_\_\_\_  
\_\_\_\_\_
2. How many animals are in your institution’s collection? \_\_\_\_\_ species? \_\_\_\_\_
3. What is the annual operating budget of the institution (approximate)? \$ \_\_\_\_\_
4. How many visitors visit your institution annually? \_\_\_\_\_
5. How many veterinarians does the institution employ? FT \_\_\_\_\_ PT \_\_\_\_\_  
overall zoo staff \_\_\_\_\_ volunteers \_\_\_\_\_

Petting Zoo Exhibits

6. Is there an interactive “petting zoo” exhibit at your institution? Yes\_\_\_ No\_\_\_  
If no, skip to Question 26
7. What animals (common names) and quantity of each are housed in this exhibit? \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
8. Is the visitor entry and exit the same? Yes\_\_\_ No\_\_\_
9. Do visitors and the animals share a common space (no separation barriers)? Yes\_\_\_ No\_\_\_
10. Do the animals have an area to “escape” from the visitors if desired? Yes\_\_\_ No\_\_\_
11. Is feeding the animals by the public available? Yes\_\_\_ No\_\_\_  
a. If yes, check one: Always \_\_\_ During certain times \_\_\_
12. Describe the fencing used in the exhibit (wood [treated/untreated], metal railing, pig panels, chain link, etc). \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
13. Is the exhibit fencing routinely disinfected? Yes\_\_\_ No\_\_\_  
a. If yes, what is the frequency of cleaning? \_\_\_\_\_  
b. Briefly describe the process including disinfectants used. \_\_\_\_\_  
\_\_\_\_\_

14. Does a staff member monitor visitors while they are inside this exhibit? Yes\_\_\_ No\_\_\_
15. Is food or drink available within 100 feet of the exhibit (machines or actual vendors)? Yes\_\_\_ No\_\_\_
16. Is food and drink (except approved food for the animals) prohibited inside the exhibit? Yes\_\_\_ No\_\_\_
17. Are signs visible in or near the exhibit educating visitors to the potential zoonotic dangers of interacting with animals? Yes\_\_\_ No\_\_\_
18. At the exhibit exit:
- a. Is a hand washing station with running water and soap available? Yes\_\_\_ No\_\_\_
  - b. Is signage on hand washing recommendations/techniques posted? Yes\_\_\_ No\_\_\_
  - c. Is sanitizing gel available? Yes\_\_\_ No\_\_\_
  - d. Is hand sanitation recommended to visitors (by an employee or signage)? Yes\_\_\_ No\_\_\_
19. Are animals in this exhibit routinely examined by a veterinarian? Yes\_\_\_ No\_\_\_
20. What is the frequency of veterinary examinations? \_\_\_\_\_
21. What screening/diagnostic tests are performed during these exams? (check all that apply)
- |   |  |   |
|---|--|---|
| <input type="checkbox"/> CBC/Chem           | <input type="checkbox"/> Urinalysis & sediment | <input type="checkbox"/> Fecal flotation          |
| <input type="checkbox"/> Fecal direct smear | <input type="checkbox"/> Acid fast fecal stain | <input type="checkbox"/> Cytology                 |
| <input type="checkbox"/> Radiography        | <input type="checkbox"/> Ultrasonography       | <input type="checkbox"/> TB intradermal skin test |
| <input type="checkbox"/> Serology           | _____  |   |
| <input type="checkbox"/> Other              | _____  |   |
22. What vaccinations, if any, are routinely administered? (check all that apply)
- |   |   |  |
|---|---|--|
| <input type="checkbox"/> Rabies             | <input type="checkbox"/> Tetanus toxoid | <input type="checkbox"/> West Nile virus |
| <input type="checkbox"/> <i>Clostridium</i> | <input type="checkbox"/> Leptospirosis  | <input type="checkbox"/> EEE and/or WEE  |
| <input type="checkbox"/> Parainfluenza      | <input type="checkbox"/> Erysipelas     |  |
| <input type="checkbox"/> Other              | _____                                   |  |
23. Are animals left on exhibit if showing signs of loose stool? Yes\_\_\_ No\_\_\_
24. Have any animals ever tested positive for *E. coli* O157:H7? Yes\_\_\_ No\_\_\_
- a. If yes, please describe. \_\_\_\_\_
  - \_\_\_\_\_
  - \_\_\_\_\_
25. Have there been any reports of staff or visitor illness linked to the petting zoo exhibit? Yes\_\_\_ No\_\_\_
- a. If yes, please describe. \_\_\_\_\_
  - \_\_\_\_\_
  - \_\_\_\_\_

Interactive Bird/Aviary Exhibits

26. Do you have an interactive bird/ walk-through aviary exhibit? Yes\_\_\_ No\_\_\_  
If no, end of questionnaire
27. What animals (group names) and quantity of each are housed in this exhibit? \_\_\_\_\_
- \_\_\_\_\_
28. Is interaction with the animals available/encouraged (ie, feeding, perching, etc)? Yes\_\_\_ No\_\_\_

- a. If yes, please describe. \_\_\_\_\_
- 
29. Are signs visible in or near the exhibit educating visitors to the zoonotic dangers of animal interaction? Yes\_\_\_ No\_\_\_
30. Can visitors come in contact with bird feces? Yes\_\_\_ No\_\_\_
31. Is hand sanitation available near the exhibit exit? Yes\_\_\_ No\_\_\_
- a. If yes, please describe. \_\_\_\_\_
- 
32. Are animals in the exhibit routinely examined by a veterinarian? Yes\_\_\_ No\_\_\_
33. What is the frequency of veterinary examinations? \_\_\_\_\_
34. What screening/diagnostic tests are performed during these exams? (check all that apply)
- |  |   |   |
|--|---|---|
| <input type="checkbox"/> CBC/Chem              | <input type="checkbox"/> Fecal direct smear | <input type="checkbox"/> Fecal flotation              |
| <input type="checkbox"/> Acid fast fecal stain | <input type="checkbox"/> Cytology           | <input type="checkbox"/> <i>Chlamydophila</i> testing |
| <input type="checkbox"/> Radiography           | <input type="checkbox"/> Ultrasonography    |   |
| <input type="checkbox"/> Serology              |   |   |
| <input type="checkbox"/> Other _____           |   |   |
- 
35. What vaccinations, if any, are routinely administered? (check all that apply)
- |   |   |  |
|---|---|--|
| <input type="checkbox"/> Paramyxovirus      | <input type="checkbox"/> Polyomavirus   | <input type="checkbox"/> West Nile Virus |
| <input type="checkbox"/> <i>Clostridium</i> | <input type="checkbox"/> EEE and/or WEE |  |
| <input type="checkbox"/> Other _____        |   |  |
- 
36. Have there been any reports of staff or visitor illness linked to the aviary/bird exhibit? Yes\_\_\_ No\_\_\_
- a. If yes, please describe. \_\_\_\_\_
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Thank you again for taking your time to complete this survey. Your time is much appreciated, and without your assistance and information, this project would not be possible. Feel free to add additional comments if more room is needed for explanation for some of the questions. Please be sure to note which question you are continuing so the information can be applied accordingly.