

ZOONOSES SURVEILLANCE AND SAFEGUARD MEASURES IN SWISS ZOOS

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Summary

The 26 zoonoses notifiable in Switzerland are listed, the legal provisions applicable to them are briefly described, and an overview on the animal health situation of Switzerland regarding these diseases is given. Additional requirements regarding zoonoses exist in the context of the conditions for the importation of zoo and wild animals, for which details are provided. The zoonoses surveillance and safeguard measures currently implemented by the four scientific zoos of Switzerland are described and discussed. In conclusion, it is stated, that the situation in these zoos regarding zoonoses is fairly good, but certain problems still remain, predominantly in the field of zoonoses caused by bacterial agents. Finally, a series of proposals is made on how further to improve the situation regarding zoonoses in Swiss zoos.

Zusammenfassung

Die 26 in der Schweiz meldepflichtigen Zoonosen werden aufgeführt, die auf sie anwendbaren gesetzlichen Bestimmungen kurz beschrieben und ein Überblick über die Tierseuchenlage der Schweiz hinsichtlich dieser Krankheiten gegeben. Weitere Bestimmungen über Zoonosen gibt es im Rahmen der Einfuhrbedingungen für Zoo- und Wildtiere, wozu entsprechende Angaben gemacht werden. Die gegenwärtigen Überwachungs- und Schutzmassnahmen der vier wissenschaftlichen Tiergärten der Schweiz werden beschrieben und diskutiert. Es wird der Schluss gezogen, dass die allgemeine Lage ziemlich gut ist, dass aber nach wie vor bestimmte Probleme bestehen, namentlich hinsichtlich bakteriell bedingter Zoonosen. Abschliessend wird eine Reihe von Vorschlägen gemacht, wie die Zoonosen-Situation der schweizerischen Zoos noch weiter verbessert werden könnte.

Résumé

Cet article comprend la présentation des 26 zoonoses soumises à déclaration en Suisse, une courte description des dispositions légales applicables aux zoonoses, et une vue d'ensemble de la situation épizootique en Suisse. Puis, dans le cadre des conditions d'importation pour les animaux sauvages et de zoos, les dispositions supplémentaires concernant les zoonoses sont détaillées. De plus, les mesures de surveillance et de protection actuelles appliquées dans les quatre jardins zoologiques scientifiques de Suisse sont décrites et discutées. En conclusion on peut affirmer qu'en général, la situation actuelle est satisfaisante, mais que divers problèmes existent toujours, surtout par rapport à certaines zoonoses d'origine bactérienne. L'article se termine par une série de propositions pour améliorer encore la lutte contre les zoonoses dans les zoos suisses.

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Key words

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Introduction

The Swiss animal health legislation regulates a total of 80 infectious or contagious diseases, 26 of which have a zoonotic potential. This is only a small percentage of the more than 200 communicable diseases known to be common to man and animals (1, 16). Additional diseases are regulated in the context of the import conditions for certain taxa. While legislation and current practice address primarily the surveillance of zoonotic diseases in agricultural holdings, and to some extent in the wild, only one legal provision relates explicitly to zoological parks: in rabies protection zones, zoos are obliged to take safeguards in order to prevent the spreading of rabies from the animals to the visitors. Under the animal welfare legislation, however, zoos are obliged to ensure adequate veterinary surveillance and care of their animals.

It is the purpose of the present paper to review current practices of zoonoses surveillance and safeguard measures in the four scientifically directed zoos of Switzerland, and to make recommendations for improving the prevention of zoonoses in the future.

Animal Health Law and Animal Health Ordinance

Article 1 of the Animal Health Law obliges the Federal Council to designate the notifiable diseases, and gives five reasons for including a transmissible animal disease in the animal health legislation. The zoonotic potential of a disease is indicated as the first of these rationales. Based on his obligation, the Federal Council has designated a total of 80 diseases as notifiable. These diseases are grouped into to four different categories (Articles 2 to 5 of the Animal Health Ordinance). The four categories and the zoonotic diseases falling under them are the following:

- a. **Highly contagious diseases** include the diseases contained in List A of the International Zoosanitary Code of the OIE: foot-and-mouth disease, vesicular stomatitis, Rift Valley fever, sheep and goat pox and Newcastle disease.
- b. **Other diseases to be eradicated:** Anthrax, rabies, bovine brucellosis, tuberculosis (*Mycobacterium bovis* and *M. tuberculosis*), bovine spongiform encephalopathy, sheep and goat brucellosis (*Brucella melitensis*), porcine brucellosis and glanders (*Pseudomonas mallei*).
- c. **Diseases to be controlled:** Leptospirosis, coxiellosis, salmonellosis, epididymitis of rams (*Brucella ovis*), avian chlamydiosis and *Salmonella enteritidis* infection of poultry.
- d. **Diseases to be surveyed:** Echinococcosis, listeriosis, toxoplasmosis, yersiniosis, enzootic abortion (*Chlamydia*) in sheep and goats, trichinellosis and tularemia.

Whoever keeps or cares for an animal is obliged to notify suspect cases of disease or mortality to a veterinarian, who in turn has to notify the official veterinarian responsible for the area. The veterinary authorities will then decide on measures to be taken regarding the suspected animal or its holding in agreement with the provisions of the Animal Health Ordinance and technical guidance provided by the Federal Veterinary Office. Post mortem examinations and other tests have to be carried out at designated laboratories.

Switzerland is free from all highly contagious diseases, and vaccination against these diseases is prohibited. The measures to be taken in the event of an outbreak are in compliance with the corresponding EU legislation. As far as Newcastle Disease is concerned, Switzerland is rated „non-vaccinating“, and the commercial poultry flocks are serologically negative, although surveys revealed the presence of titres in wild birds (25).

Regarding other diseases to be eradicated, no cases of glanders, sheep and goat brucellosis and porcine brucellosis have been reported for many years, and Switzerland is considered free in the terms of the OIE International Animal Health Code from bovine brucellosis and tuberculosis. In order to maintain this status, the Federal Veterinary Office organises country-wide surveys in agricultural holdings, with random samples being taken to ascertain with a probability of 99 % that the prevalence is below 0,1 % of all susceptible herds. Zoological parks have not been included in these surveys. In 1998, however, a major survey will be done in deer farms.

Checking for *Echinococcus* cysts is routine practice in meat inspection, and all bear and wild boar meat placed on the market must have been inspected for *Trichinella*. Domestic pigs are considered free from

Trichinella in Switzerland. The only record of trichinellosis in a wild boar (*Sus scrofa*) dates from the pre-World War II period. While up to 9 % of wild carnivores, mainly red foxes (*Vulpes vulpes*) were *Trichinella*-positive, no trichinellae could be found in native rodents (10, 11, 27). Recent molecular-biological research revealed that the trichinellosis in the Swiss red fox population is not due to *Trichinella spiralis*, but to *Trichinella britovi* (15).

No random sampling is systematically carried out for other diseases. Random surveys may, however, be organised from time to time, in order to get a clearer picture on the presence, prevalence and distribution, or the absence of a disease.

To detect diseases of the categories b and c causing abortions - *Brucella abortus* and *Coxiella burnetii* (as well as IBR-IPV) in bovines, *Brucella melitensis* and *Coxiella burnetii* in ovines and caprines, and *Brucella suis* in porcines - the keepers of animals of the bovine, ovine, caprine or porcine species are obliged to notify all abortions in bovines after three months of pregnancy, and all abortions in ovines, caprines and porcines. This provision obviously applies also if such animals are kept in zoological parks.

Disease	1990	1991	1992	1993	1994	1995	1996
Anthrax	0	0	0	1	0	0	0
Rabies	24	99	120	168	225	23	5
Bovine brucellosis	0	0	0	0	0	0	1
Bovine tuberculosis	5	1	0	0	0	0	2
Bovine spongiform encephalopathy	1	9	15	29	64	68	45
Leptospirosis	42	54	51	78	81	57	25
Coxiellosis	115	108	99	63	74	69	46
Salmonellosis	88	92	96	44	72	58	106
Epididymitis of rams	()	()	()	()	()	()	34
Avian chlamydiosis	33	17	23	16	18	24	16
Salmonella enteritidis of poultry	()	()	()	()	29	17	29
Echinococcosis	()	()	()	()	()	()	1
Listeriosis	()	()	()	()	()	()	21
Toxoplasmosis	()	()	()	()	()	()	0
Yersiniosis	()	()	()	()	()	()	0
Enzootic abortion in sheep and goats	()	()	()	()	()	()	12
Tularemia	()	()	()	()	()	()	1

() = Disease not notifiable at that time

Import conditions

To prevent the introduction of diseases that are either notifiable or do not occur in Switzerland, the following taxa are subjected to animal health requirements upon importation: Primates, Carnivora, Lagomorpha, Equidae, Artiodactyla, Struthioniformes, Casuariformes, Rheiformes, Anseriformes, Galliformes, Columbiformes and Psittaciformes. In the case of Chiroptera, importers are informed about the risk of bat lyssa, but no further action is taken. Otherwise, the requirements include: official animal health certificate issued in the country of export, pre-export quarantine in certain cases only, post-import quarantine or on-farm-isolation, testing, vaccination or prophylactic treatment for specific diseases.

The following measures are imposed to prevent zoonotic risks:

Primates (including Tupaiidae): Strict quarantine of four to twelve weeks, depending of the sanitary status of the imported animals and of its establishment of origin, as stated on the animal health certificate accompanying the animals. Following importation, all primates have to be examined twice for *Salmonella* spp., *Shigella* spp. and endoparasites, and have to be inspected clinically for herpes virus infections and other zoonoses. With the exception of tree shrews, prosimians, marmosets and tamarins originating from holdings under veterinary supervision, all non-human primates have to be tuberculinised one to three times. The facilitation for tree shrews and small New World monkeys has been granted because in these groups of primates tuberculosis is by far less frequent than in Old World primates (9).

All primates (with the exception of tree shrews) originating from an uncontrolled environment also have to undergo a thoracic radiography. In the case of apes from an uncontrolled environment, specific tests have to be made regarding Hepatitis A and Herpes B.

Carnivora: Specific guarantees regarding rabies have to be given on the official animal health certificate. Following importation, the animals have to be kept under observation for 100 days, and no other carnivore having contact with the imported animal may leave the establishment. During the observation period, at least two tests for endoparasites, including *Isospora*, have to be carried out and, if necessary, the animals have to be treated. While carnivores imported by private persons or pet traders, or intended for release, have to be vaccinated against rabies during the observation period, this is not mandatory for carnivores kept in zoological parks.

Lagomophya: The animals have to be accompanied by an official animal health certificate stating that no case of tularemia has been notified at the place of origin and its surroundings of 10 km during the last 30 days prior to shipment. Quarantine of at least 15 days following importation, no testing requirements.

Equidae: Domestic and wild equidae must be accompanied by an official animal health certificate, stating a.o. that the country of origin is free from glanders and that the animals have undergone a complement fixation test for glanders with a negative result, that the country of origin is free from vesicular stomatitis or, if not, that the animals were serologically tested for this disease. No quarantine is necessary for animals circulating within Europe, and for animals from certain low-risk regions outside Europe.

Artiodactyla: Apart from guarantees regarding OIE List A diseases (freedom of country or region), it is required that the animals originate from a holding officially free from tuberculosis and brucellosis, and further guarantees are required for certain zoonoses (and other list B diseases) according to species: bovines must have been tested for tuberculosis and brucellosis within 30 days prior to dispatch. In addition, they must have been tested for leptospirosis (*L. pomona*, *tarassovi*, *australis*, *hardjo*, *icterohaemorrhagiae* and *grippotyphosa*) with a negative result, or have been treated twice at an interval of 14 days with 25 mg/kg dihydrostreptomycin. Ovines and caprines must come from a holding in which no cases of leptospirosis or coxiellosis have been notified within one year prior to dispatch. Within 30 days prior to dispatch, they must have been tested with negative results for tuberculosis, brucellosis, leptospirosis and coxiellosis. Porcines must come from a holding which is also officially free from Aujeszky's disease, and where no clinical cases of leptospirosis have occurred during the last 12 months prior to dispatch. Negative tests are required for FMD, Aujeszky's disease, brucellosis and leptospirosis (*L. pomona*, *australis*, *tarassovi*). After importation, the animals will be placed in a quarantine or kept under observation for at least three weeks. During this period, tests will normally be repeated.

In the case of bovines, ovines, caprines and porcines supplied by zoos, it is normally not possible to obtain a statement that the establishment is officially free from brucellosis and tuberculosis. In these cases, the pathological history of the herd of origin is reviewed, or if there are insufficient data, the quarantine period will be prolonged. Domesticated camelids are treated similar to bovines. For other ungulates, no specific guarantees must be given by the country of origin, but they, too, will be quarantined or kept separately, and will be tested for tuberculosis, brucellosis, leptospirosis, coxiellosis, salmonellosis and endoparasites. The coprological tests have to be done twice.

Ratites (excluding kiwis), **waterfowl**, **fowl**, **pigeons** and **doves:** It must be certified that the birds originate from a holding and an area where no notifiable poultry diseases have been identified during the last 40 days prior to dispatch, that they are clinically healthy, that in the case of ornamental pigeons, they have been vaccinated against paramyxovirus and in the case of other species that they have not been vaccinated against Newcastle disease. No specific tests are prescribed during the four weeks of quarantine as long as the birds remain clinically healthy.

Parrots and **parakeets:** Guarantees to be given by the country of export relate to psittacosis and Newcastle disease. Following importation, a quarantine of 8 weeks is carried out, during which the psittacines have to be subjected to a preventive antibiotic treatment against psittacosis (or alternatively to be individually tested with negative results). In the case of commercial shipments, tracer chicks are used to exclude the risk of Newcastle Disease.

Zoonoses surveillance and safeguard measures currently implemented by zoos

With regard to highly contagious diseases, Basel Zoo was struck by a memorable epidemic of foot-and-mouth disease in 1937 with several species being severely affected (2, 28). Another outbreak of foot

and mouth disease, affecting all four bovine species but no other ruminants, occurred at Zurich Zoo in 1949 (12). Since then, no other case of foot and mouth disease or any other highly contagious disease has occurred in any Swiss zoo, and since vaccination of list A diseases is prohibited, no specific surveillance and safeguard measures are implemented, except in the case of imports.

In all four zoos, the animal collections are under permanent veterinary supervision by veterinarians employed and/or contracted by the zoos.

In all four zoos, a post-mortem is carried out on every animal that dies in the zoo, with the zoos co-operating with the Institutes for Veterinary Pathology at the two faculties and, in one case, also with a private laboratory. If the carcass is in such a state (autolysis) that a detailed autopsy can no longer be conducted, the selection of analyses that can still be performed is normally not made at the zoo but by the relevant laboratory.

Obviously, the instructions concerning quarantine and the medical examinations to be carried out during quarantine are followed scrupulously by the staff of all four zoos. Systematic controlling of these measures is performed by the zoo veterinarian and checked by the Cantonal authorities in charge of implementing the law.

Basel Zoological Gardens

a. Measures concerning notifiable diseases:

Rabies: All the animals of the children's zoo that are or may be in direct contact with people, such as keepers, veterinarians or visitors, are regularly vaccinated against rabies with a vaccine registered for horses, cattle, pigs, cats and dogs (Rabisin[®], Chassot). Since the other species are not in direct contact with the keepers or visitors, they are only vaccinated before being exported if requested by the importing country. However, Basel Zoo is currently contributing to another aspect of the prophylactic combat against rabies by sending all the foxes shot or killed in traps within the zoo to the *Swiss Rabies Centre*. There, a pathological analysis is performed (immunofluorescence) in order to check whether these foxes had contracted the rabies virus, but also to determine the proportion of foxes that were vaccinated by baits laid out by the responsible authorities (detection of tetracyclines). In 1995, 75% of the foxes caught within the Canton of Basel-Stadt and sent to the Swiss Rabies Centre were vaccinated (3). Up to now, no cases of rabies have been found in the carcasses sent in by Basel Zoo.

Abortions: Laboratory analyses are performed on all abortions (of all gestation stages) in the zoo, and they are inspected systematically for diseases of the categories b and c that cause abortions (*Brucella abortus*, *Brucella melitensis*, *Brucella suis*, as well as *Salmonella* sp., *Chlamydia* sp., *Leptospira* sp. and *Coxiella burnetii*).

Leptospirosis: At the age of two months, young wolves (*Canis lupus occidentalis*) are vaccinated against leptospirosis (with a combined canine vaccine, such as Vetamun standard[®]). Since the Leptospirosis vaccination programme was taken up in 1993, no young wolves have died in the zoo, while this happened regularly before.

Salmonellosis: Since 1996, when an epidemic of salmonella broke out in the African elephants (*Loxodonta africana*) (19), special attention has been devoted to the surveillance of this pathogen. Every 4 months, the elephant group is inspected systematically for the excretion of these germs. Furthermore, the fight against rodents has been increased, and samples of dead rodent bodies are analysed regularly for bacteria to ensure effective surveillance.

Parasites: At present, no serological surveillance programme has been established for diseases such as echinococcosis or toxoplasmosis. However, in 1994 and 1996, routine necropsies revealed the presence of cysts of *Echinococcus multilocularis* in two crab-eating macaques (*Macaca fascicularis*). Cysts of toxoplasms were found in one woolly monkey (*Lagothrix lagotricha*) in 1970, in a further individual in 1981, in another in 1984 and in two specimens in 1990. In the eighties, a part of the group of woolly monkeys was subjected to serological tests, which revealed only one positive titre.

The carcasses of polar bears (*Thalarctos maritimus*) were regularly inspected for *Trichinella spiralis*, and approximately 40 years ago, this pathogen was indeed believed to be responsible for causing the itchy dermatoses seen in these animals (6).

It should be emphasised that the bears and wild boars killed to be fed to other animals are routinely inspected for *Trichinella* and cysts of *Echinococcus*.

b. Import requirements:

Basel Zoo has isolation rooms and stables on its service area, but is not equipped with quarantine facilities suitable to contain highly contagious diseases, and in recent years has therefore not been allowed to import cloven-hoofed ungulates from high risk areas.

When a group of animals from different sources is newly formed, arrival of the last individual is awaited before starting the examinations needed for quarantine. This implies that quarantine sometimes takes longer than required by the authorities. This was the case in a group of rainbow lorries (*Trichoglossus h. haematodus*): between September 1996 and February 1997, the individuals arrived in Basel zoo one after another from different institutions. The tests for *Chlamydia* infection were carried out only after several months, when all birds could be put into the same aviary.

c. Additional measures:

In 1994, a parasitological programme was established, which includes a regular coprological examination of all mammals except the primates surveyed by the Swiss Tropical Institute. In this way, the population at risk could be identified among these various groups of animals, and this population thus no longer needs to be treated on principle, but only if necessary.

The spider monkeys (*Ateles geoffroyi*) and the Douc langurs (*Pygathrix nemaeus*) are vaccinated each year against yersiniosis.

Currently, no special serological surveillance is performed either in monkeys and apes, or the zoo staff, concerning viral zoonoses, such as hepatitis A and B, as well as herpes B. Some keepers and the veterinarians are vaccinated against one or both hepatites, while others are not. The current questions focus first and foremost on the serology of herpes B within the group of *Macaca fascicularis*. Regarding the prevention of herpes virus Simiae (B Virus), a feasibility study with the aim of introducing the CDC guidelines (26) has been conducted in Basel Zoo in co-operation with specialists in occupational medicine and corporate physicians since April 1997. While awaiting the results of these studies, directives are followed which specify that direct contact with the macaques should be avoided whenever possible, and that the monkeys should never be handled without reason and without sedation. If a person is bitten or scratched by a monkey, especially in the case of *Macaca fascicularis*, emergency procedures (posted at the work site), including the washing and disinfection of the wound and the immediate information of the direct superior, are part of the measures to be taken on site. Afterwards, a hospital that has been informed of the risks by the zoo will take the appropriate steps. A tetanus booster will be given in all cases.

A serum bank for future serological analyses is being planned at Basel Zoo, but samples will only be taken during the medical treatment of affected animals and not just for the purpose of serological analysis. In this way, anaesthesia-related stress is inflicted only when a curative intervention is absolutely necessary.

Berne Municipal Zoo „Dählhölzli“

a. Measures concerning notifiable diseases:

Rabies: After the appearance of rabies in a small municipal park at Lausanne, where pygmy goats and nilghai antelopes (*Boselaphus tragocamelus*) became infected and more than 1000 visitors were exposed to the rabid animals, the Cantonal Veterinary Service of Berne decided to vaccinate animals believed to pose a particular risk. This vaccination programme started in 1978 and included domestic animals, bison, yaks, foxes, jackals and badgers (21, 22). When on 20th April 1979 the first case of rabies appeared on the territory of Berne Municipality, the touching of animals was prohibited to the public, as was the feeding by the public of the red and fallow deer (in most other species the feeding had been prohibited earlier), and in the freely accessible part of the park, dog owners were directed to keep their animals on the lead (22). The vaccination programme was extended to the susceptible staff (23). On 2nd February 1984, a rabid red fox was shot in the park. As the fox had been encountered in the bison enclosure, two non-vaccinated prairie bison calves (*Bison b. bison*) were shot (24). Today, rabies has disappeared from the region of Berne, and no official requirements exist.

From the sources quoted above, it appears that *avian tuberculosis* was a major problem in the mid-80ies. The issue was discussed with the Cantonal Public Health Service, and consequently the staff was periodically tuberculinised and x-rayed.

b. Import requirements:

Berne Zoo has some isolation rooms, but is not equipped with quarantine facilities suitable to contain highly contagious diseases. As the zoo focuses on the keeping of European fauna and does not import animals from high risk areas, this situation did not pose any particular problems in the past.

c. Additional measures

Today, the control of zoonotic and other infectious diseases, including, among others, the ones listed in the Animal Health Ordinance, is based on the systematic veterinary supervision and the post mortem examination of all carcasses, and on the following principles:

- Quarantine under veterinary control of all incoming animals not only those under official restrictions;
- Permanent parasitological control of all mammals, birds, reptiles and amphibians at a laboratory within the Zoo in co-operation with the Institutes for Pathology (Director: Prof. Dr. M. Suter) and Parasitology (Director: Prof. Dr. B. Gottstein), University of Berne;
- Treatment or vaccination of susceptible animals against rabies, leptospirosis, yersiniosis, *Chlostridium tetani*, *Erysipelothrix rhusiopathiae*;
- Collection of blood samples, whenever possible (transport, anaesthesia, veterinary treatments), for direct search for infectious diseases in laboratories and for establishing a serum bank;
- Post-mortem control of free roaming animal stock visiting the zoo area (red foxes, rodents, birds).
- Periodic vaccination of the exposed staff against rabies and tick-borne encephalitis.

Landscape and Animal Park Goldau

a. Measures concerning notifiable diseases

Rabies: In 1980 the Landscape and Animal Park Goldau experienced an outbreak of rabies, with two red deer (*Cervus elaphus*) and five fallow deer (*Dama dama*) dying of it, and the park was closed for 100 days. Thereafter, measures were taken to split up the park, so that one part could be kept open if a similar situation should arise again, and efforts have been made to keep out wild red foxes. Other trapping programmes are directed against brown rats and feral pigeons, being potential transmitters of leptospirosis, chlamydiosis and salmonellosis respectively. Specific prophylactic measures with regard to zoonoses comprise the regular vaccination of donkeys against rabies and tetanus, and systematic inspection of bears and wild boars killed to be fed to other animals for *Trichinella* and cysts of *Echinococcus*.

b. Import requirements:

The current facilities at Goldau allow merely for an on-farm isolation. As the zoo focuses on the keeping of European fauna and does not import animals from high risk areas, this situation did not pose any particular problems in the past.

c. Additional measures

The Landscape and Animal Park Goldau is situated between the rocks of a mountain slide. As the enclosures in this very natural environment are rather big, the capture of the animals implies a considerable workload. Therefore, the basic programme for preventing zoonoses focuses on:

- The keeping of high hygienic standards for animals, keepers and food.
- The absence (to the extent possible) from the park of wild animals, that may be potential carriers of zoonoses.
- The quarantine of animals which are brought into the park, including animals of unknown health status acquired from within Switzerland.

Zurich Zoological Gardens

a. Measures concerning notifiable diseases

Rabies: For as long as Zurich was situated in the rabies control zone, the zoo implemented the measures prescribed by the Cantonal Veterinary Service. Since rabies is no longer a problem, it was agreed with the Cantonal Veterinary Service no longer to vaccinate the animals, except in the case of export if so required by the country of destination.

b. Import requirements:

Zurich Zoo has a large quarantine building with several sub-units, which is suitable for the quarantine of high-risk animals. Quarantine procedures include: disinfection both in- and outside the quarantine room, changing of clothes and boots, wearing gloves and a breathing mask. The quarantine periods last as long as prescribed by the veterinary authorities, but at least 30 days. During this period all the water, excretions and rests of food are stored in a special tank within the facility. If necessary, the contents of this tank could be incinerated separately at the municipal incineration plant.

c. Additional measures:

On a voluntary basis, Zurich Zoo implements the following measures:

- Vaccination programmes against yersiniosis in the South America House encompassing all small primates, rodents and birds, against *Leptospira icterohaemorrhagiae* in European otters (*Lutra lutra*) and against *Clostridium tetani* in all equines;
- Systematic faeces sampling for bacteriological and parasitological testing, implemented according to an annual plan;
- Periodical testing of the exposed staff, once a year, for tuberculosis, and twice a year faecal examination for parasites and enterobacteriaceae.

Furthermore, all incoming animals, not only those under official restrictions, are subjected to a quarantine regime under veterinary control. On this occasion, one faecal examination for endoparasites and three faecal examinations for bacterial agents, in particular *Salmonella* spp., are carried out in all incoming mammals and birds, whether this is mandatory or not. In addition, the following tests not prescribed by the veterinary authorities are performed:

- *Primates*: bacterial examination of the faeces, also for *Campylobacter*. 17 parasitological examinations for *Strongyloides stercoralis* in species prone to this parasite. Serologic examination for herpes B virus, simian immunodeficiency virus and echinococcosis.
- *Rodents*: Faeces examination for leptospirosis, listeriosis, *Yersinia pseudotuberculosis* and *enterocolitica*, lymphocytic choriomeningitis (mice, hamsters), examination for trichophyton infection.
- *Lagomorphs*: Blood test for *Encephalitozoon cuniculi*, examination for trichophyton infection, faeces examination for *Yersinia pseudotuberculosis*.
- *Elephants*: Serological examination for orthopox virus infection, and intradermal tuberculin testing (although the results of tuberculinisation are not necessarily conclusive in elephants).
- *Equines*: Blood test (CFT) or conjunctival / intradermopalpebral test for glanders.
- *Camelids*: Serological examination for orthopox virus infection.
- *Birds*: Blood tests: twice for chlamydiosis and Newcastle disease.
- *Reptiles*: Faeces examination once for endoparasites (MIF, Amoebiasis) and once for bacterial agents (Salmonellosis); check for ectoparasites (ticks).

Discussion

Where the Swiss Federal Veterinary Office has imposed sanitary import requirements, these are very similar to the AZA recommended quarantine procedures (18), except that no testing for *Campylobacter* is prescribed in Primates, and no testing for *Salmonella* in birds. The strict observance of the quarantine requirements is one of the crucial factors for the prevention of zoonoses. There are, however, often practical problems, e.g. orang utans (*Pongo pygmaeus*) may show reactions to several tuberculin with no exposure to pathogenic mycobacteria or clinical evidence of tuberculosis (4). The question of how to deal with an orang utan with tuberculin responses in the absence of historical, clinical, radiographic, or cultural evidence of tuberculosis, remains unresolved.

However, for many taxa no official quarantine requirements exist. Furthermore, zoological parks have so far not been included in the official disease surveillance schemes, and the animal health legislation contains no specific provisions to ensure the health and safety of zoo visitors and zoo staff, except in the case of rabies.

The fact that zoological parks are greatly ignored by the relevant legislation does not mean that they face no zoonoses risks. On the contrary: in the past, bovine tuberculosis was widely distributed in Swiss zoos. It had devastating effects particularly on the carnivore (5) and primate (8) collections. As the Swiss cattle population became free from tuberculosis, the Swiss zoos succeeded too in eliminating this disease. Other zoonoses, such as infestations with intestinal protozoa (7), toxoplasmosis (13), campylobacteriosis (14), leptospirosis (17) or salmonellosis (18) continue to be a problem. Sometimes a disease appearing only sporadically led to an aggravated enzootic situation, as happened in the case of yersiniosis at the South America House of Zurich Zoo (20). There are also cases documented, in which a zoonotic disease spread from the animals to the staff, e.g. *Giardia lamblia* at Basel Zoo (7) or *Leptospira icterohaemorrhagiae* at Zurich Zoo (17). Since few Government regulations exist, the zoological parks have adopted additional measures to prevent zoonoses on a voluntary basis.

The most important measures are certainly the close clinical surveillance of the collections and the systematic performance of necropsies.

Permanent parasitological control is an essential component of the clinical surveillance. It does not only help to reduce the parasite burden within the animal stock by providing appropriate treatments, but it is equally important for detecting upcoming diseases. For several parasitic diseases, including e.g. *Hexamitiasis* in reptiles and *Strongyloides* infections in mammals, it is crucial to examine the faecal or cloacal samples as quickly as possible because they can easily be diagnosed within the sample only for a short period of time.

Regarding necropsies, it has to be stressed that the objectivity of post-mortem results can only be guaranteed if the person carrying out the autopsy is not the same as the one who diagnoses the disease and treats it clinically. As a matter of principle, all dead animals should be necropsied, even if the cause of death seems to be obvious (trauma, age, still born). Moreover, the mortality causes of fishes should be monitored, and an appropriate follow-up should be given to the necropsy results. This is not only important for diseases under official registration but also for other infectious diseases. For example, it is very often tolerated that fishes in tropical aquariums have tuberculosis. This type of tuberculosis or mycobacteriosis is caused by other agents than the mycobacteria of homothermes (v.e. *Mycobacterium poikilothermorum*). The zoonotic potential for humans seems to be low, but it exists (granulomas, lymphadenitis); keepers working at the aquarium and having direct, unprotected skin contact to the water, are at risk. After diagnosing tuberculosis in an aquarium with Malawi perches at Berne Zoo, it was decided to euthanise all subadult and adult perches for post mortem diagnosis. Water changes, rearing of juveniles and euthanising adults will help to eradicate the mycobacteria within the flock. These measures have to be implemented so as to interrupt the time the infection needs to manifest itself clinically and to produce excretors.

All four zoos have decided to go beyond Government requirements when introducing new specimens to their collections. In doing so, the AZA recommended quarantine procedures (18) are used as a guidance: in general, these include direct and flotation faecal examination for endoparasites, and, in the case of mammals, vaccinations as appropriate, in birds they comprise faecal culture for *Salmonella* sp., and in reptiles and amphibians checks for ectoparasites.

In the context of import quarantines, it is worth considering whether a social animal imported as an individual and to be integrated into a new group suffers less stress and is thus less prone to contract any disease (not only an infectious disease) if it can join its new mates immediately instead of spending one month or longer in complete isolation. In this case, it may be advantageous to place the whole group in quarantine. Obviously, the various risks would have to be assessed, which requires co-operation

between ethologists and veterinarians, and permission needs to be obtained from the competent veterinary service administration.

Two of the four zoos have encountered incidences with rabid foxes. At Zurich Zoo, it was proven that yersiniosis was introduced by migrating thrushes (*Turdus* spp.). The loss of 16 Canadian beavers (*Castor canadensis*) at Zurich Zoo, owing to a *Leptospira icterohaemorrhagiae* infection, coincided with an increase and the spreading over the entire zoo area of the wild brown rat (*Rattus norvegicus*) population, which was proven to be the carrier of *L. icterohaemorrhagiae* (17). At Basel Zoo, too it is suspected that the young wolves contracted leptospirosis from rats that excreted leptospores. The monitoring and, where necessary, the control of wild and feral animals living in or entering the zoo is, therefore, another important measure to contain zoonoses. The inclusion of wild animals found dead, trapped or shot on the zoo area in the post mortem surveillance provides important information on possible sources of zoonotic infections and parasitoses.

Keeping certain wild and feral animal populations at low levels helps also to prevent losses owing to predation: the successful efforts of the veterinary authorities in combating rabies have resulted in a countrywide increase of the fox population and, consequently, in growing numbers of foxes invading the zoos. At Berne Zoo, a series of birds was killed by foxes. At Basel Zoo, as a result of this trend, all the eggs and/or young of the group of flamingos were partly or totally destroyed and killed in 1995 and 1996. Since then, the zoo has succeeded in controlling foxes by setting up traps at strategic places. In 1997, no zoo animals were lost to foxes and no fewer than 15 foxes were caught.

So far, measures to protect the zoo staff have been taken merely on an ad hoc basis. The feasibility studies currently made at Basel Zoo in close co-operation with specialists in occupational medicine should permit establishing a surveillance programme for the zoo staff at risk, which includes bacterial and parasitological tests of stools, as well as a preventive vaccination plan, the scope of which has still to be defined. An important element of long-term surveillance could be the establishment and maintenance of a serum bank from staff at risk. Should the case arise, this would allow to recognise at once a possible sero-conversion at the time of contamination with a serious infectious agent, such as Herpes B. A zoo staff surveillance programme would also help to avoid the contagion of animals by people.

Conclusions and Recommendations

- The situation regarding zoonoses in the four scientifically directed zoos of Switzerland is fairly good. Certain problems remain, however, and the emergence of new and unexpected diseases, be it due to the addition of new animals to the collection or due to wild animals entering the zoo area, cannot be excluded.
- Therefore, close surveillance of the collections, as well as of the wild and feral animals on the zoo area, by qualified veterinary staff and up-to-date laboratories continues to be necessary. To improve the surveillance of the collections, all zoos should participate in the establishment of a serum bank and co-operate with other institutions at the national and international level.
- All zoos should continue to consider all animals entering the collection as potential carriers of zoonoses and other infectious or contagious diseases, and to place them in isolation or quarantine, until their sanitary status has been checked.
- All zoos, except Zurich, should improve their quarantine facilities.
- The efforts to develop a surveillance programme for zoo staff should be continued, and programmes adapted to the specific requirements of the individual institution should be established in all zoos.
- The Swiss Association of Scientific Zoos should develop guidelines on the surveillance of zoonoses and safeguard measures, encompassing both staff and collection, with a view to further improving and standardising the measures implemented by its member zoos, and should make these guidelines available to the smaller zoological establishments in Switzerland.
- The Swiss Federal Veterinary Office should include tests recommended by the quarantine procedures for AZA-accredited zoological parks, or routinely performed by the members of the Swiss Association of Scientific Zoos in its standardised import conditions.

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