GUIDELINES FOR THE

# HUMANE TRANSPORTATION OF RESEARCH ANIMALS

NATIONAL RESEARCH COUNCIL
*OF THE NATIONAL ACADEMIES*

# GUIDELINES FOR THE HUMANE TRANSPORTATION OF RESEARCH ANIMALS

Committee on Guidelines for the
Humane Transportation of Laboratory Animals

Institute for Laboratory Animal Research

Division on Earth and Life Studies

NATIONAL RESEARCH COUNCIL
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This report is respectfully dedicated to the memory of

CHARLES KEAN

March 25, 1942 – June 25, 2004

who dedicated his life to the care of humans and animals alike

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# Preface

This project was initiated in response to a letter from Charles Kean, an Associate Professor of Physiology and Pharmacology and Director of the Animal Care Facility at Loma Linda University, to the National Research Council's (NRC's) Institute for Laboratory Animal Research (ILAR), the Association for Assessment and Accreditation of Laboratory Animal Care (AAALAC) International, and the Office of Laboratory Animal Welfare (OLAW) of the National Institutes of Health (NIH) outlining the research animal care community's concerns about the safe and humane transportation of research animals. Dr. Kean requested that those organizations look into the transportation of research animals and into issues that were adversely affecting animal welfare. In response, ILAR hosted a meeting of various stakeholders to identify and discuss important issues in the transportation of research animals. The meeting was funded by NIH and included representatives of the scientific community, professional veterinary organizations, regulatory and accrediting agencies, animal breeders, and the transportation industry. Special thanks are due to the following for participating in the meeting, which took place December 4, 2001:

**Kathryn Bayne**, AAALAC International
**Frank Black**, Air Transportation Association of America, Inc.
**Ralph Dell**, ILAR
**Nelson Garnett**, OLAW
**James Geistfeld**, Taconic Farms, Inc.
**Charles Kean**, Loma Linda University

**Carl Kole**, United Airlines
**J. Michael Krop**, US Postal Service
**Steven Leary**, Washington University
**Emilie Rissman**, University of Virginia
**Robert Russell**, Harlan Sprague Dawley, Inc.
**James Taylor**, Office of Animal Care and Use, NIH
**Richard Watkins**, US Department of Agriculture (USDA) Animal and Plant Health Inspection Service
**William White**, Charles River Laboratories

The meeting delineated the problems encountered during and resulting from air and ground transportation of live animals. The participants also focused on mechanisms to solve the problems, including the potential for a future ILAR study. As a result of this meeting, the Elizabeth R. Griffin Research Foundation, NIH, and the National Center for Infectious Diseases sponsored an ILAR committee to address problems associated with transportation of research animals and produce a report that includes recommendations intended for government agencies as well as for individual investigators/animal facility managers who may need to ship animals in the future.

Transportation of research animals may raise concerns related to the well-being of the animals and concerns about how animals are affected by general environmental conditions. These concerns often depend on the species being transported. Shipments from breeders to research institutions are generally well executed through the use of company-owned fleets of environmentally controlled vehicles, but arranging transport from vendors without established transport systems, or between research institutions, can be challenging. Animals may be shipped in vehicles without controlled environments and could be subjected to extreme temperatures. Specific requests for temperature-controlled vehicles may not be honored because the shipper may not have temperature-controlled vehicles available or the request may not have been passed on to a subcontractor hired by the shipper to transport the animals. The USDA has regulatory jurisdiction and inspection authority over transportation of animals through the Animal Welfare Act. However, most animals shipped are rats and mice, which are not covered under the act. The Public Health Service, whose oversight does include those species, does not inspect research animal transportation activities unless a complaint is filed.

The major problem in transporting nonhuman primates is that few airlines are willing to carry the animals. International shipment, the most common transportation of nonhuman primates, is often delayed by a cumbersome, multiagency permitting process involving the USDA Veterinary Service, US Fish and Wildlife Service, the Centers for Disease Control and Prevention (CDC), and the Department of Transportation (DOT). Airlines have little incentive to carry the animals because it is not profitable and workers must wear protective clothing when handling them. The latter is disturbing both for workers and for travelers who see them. Finally, many animal rights activists have successfully lobbied the airlines to stop transporting nonhuman primates nationally and internationally.

Transportation of research animals is an essential component of the research enterprise. The integrity and well-being of the animals being transported are necessary for the quality of the research and the welfare of the animals. The lack of clear guidelines that cover all species can cause confusion for individuals without extensive experience in arranging transportation for research animals. In addition, investigators may find it difficult to identify a responsible shipper that will arrange for appropriate caging, inclusion of food and water, and other animal needs during transportation.

In the aftermath of the bioterror incidents involving anthrax in the fall of 2001, the possibility that research animals will be used to carry or disseminate bioterrorism agents must be considered. Breaches in good transportation practices, either purposeful or accidental, could result in the spread of infectious agents. In addition, new legislation (such as the Animal Health Protection Act of 2002) and several guidelines related to homeland security have the potential to complicate the importing, exporting, and transportation of animals and specimens for biomedical research.

The issues identified in the preceding statements led to appointment of the ILAR Committee on Guidelines for the Humane Transportation of Laboratory Animals. The committee held three meetings—in April, September, and December 2004. During the course of its deliberations, the committee sought assistance from many people, who gave generously of their time to provide valuable advice and information that were used in its deliberations. Special thanks are due to the following:

**Richard Phelan**, Taconic Farms, Inc.
**Bonnie P. Dalton**, Science Directorate, Ames Research Center, National Aeronautics and Space Administration
**Gale Galland**, Division of Global Migration and Quarantine, National Center for Infectious Diseases
**Frank Kohn**, FWS
**John Monetti**, World Courier
**Erik Liebegott**, Transportech, LLC
**Robert Fernandez**, Direct Services
**William White**, Charles River Laboratories

**Carol Wigglesworth**, OLAW
**Bobby Brown**, CDC
**Carl Kole**, Special Cargos, United Airlines
**Charles Kean**, Animal Research Facility, Loma Linda University
**Barbara Kohn**, Office of Animal Care, USDA
**Eileen Edmonson**, Office of Hazardous Materials Safety, DOT

The report has been reviewed in draft form by individuals chosen for their diverse perspective and technical expertise, in accordance with procedures approved by the NRC's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of the report:

**Susan Eicher**, Purdue University, West Lafayette, IN
**Steven Griffey**, University of California, Davis, CA
**Kathleen Hancock**, Virginia Polytechnic University, Alexandria, VA
**Barbara Hansen**, All Children's Hospital, St. Petersburg, FL
**Donald Lay**, Purdue University, West Lafayette, IN
**Tim Morris**, GlaxoSmithKline, United Kingdom
**William Morton**, Paris NHP, Edmonds, WA
**Barbara Orlans**, Georgetown University, Washington, DC
**Frankie Trull**, National Association for Biomedical Research, Washington, DC
**William White**, Charles River Laboratories, Wilmington, MA
**Walter Woolf**, Air Animal, Tampa, FL

Although the reviewers listed above provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of the report was overseen by:

**Johanna Dwyer**, Tufts University, Boston, MA
**Steven Pakes**, University of Texas Southwestern Medical Center and VA North Texas Health Care System, Dallas, TX

Appointed by the NRC, they were responsible for making certain that an independent examination of the report was carried out in accordance

with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of the report rests entirely with the authoring committee and the institution.

Ransom L. Baldwin, Chair
Committee on Guidelines for the
Humane Transportation of
Laboratory Animals

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# Tables and Figures

# Abbreviations and Acronyms

| | |
|---|---|
| AAALAC | Association for Assessment and Accreditation of Laboratory Animal Care International |
| AATA | Animal Transportation Association |
| APHIS | Animal and Plant Health Inspection Service |
| AVMA | American Veterinary Medical Association |
| AWA | Animal Welfare Act |
| BMBL | Biosafety in Microbiological and Biomedical Laboratories |
| CDC | Centers for Disease Control and Prevention |
| CITES | Convention on International Trade in Endangered Species of Wild Fauna and Flora |
| DGMQ | Division on Global Migration and Quarantine |
| DRGs | Dangerous Goods Regulations |
| DOT | Department of Transportation |
| EAIPP | Etiologic Agent Import Permit Program |
| EDIM | Group A rotavirus |
| ESA | Endangered Species Act |
| EU | European Union |
| FASS | Federation of Animal Science Societies |
| FDA | Food and Drug Administration |

| | |
|---|---|
| FY | fiscal year |
| FWS | Fish and Wildlife Service |
| | |
| GD-VII | Theiler's murine encephalomyelitis virus strain |
| GIS | Geographic Information System |
| | |
| HANT | Hantaan |
| HEPA | high-efficiency particulate air (filters) |
| HMR | Hazardous Materials Regulation |
| HPA | hypothalamic pituitary adrenal axis |
| | |
| IATA | International Air Transport Association |
| ICAO | International Civil Aviation Organization |
| ILAR | Institute for Laboratory Animal Research |
| | |
| KRV | Kilham Rat virus |
| | |
| LARS | Live Animals Regulations |
| LCM | Lymphocytic choriomeningitis |
| LCMV | Lymphocytic choriomeningitis virus |
| LCT | lower critical temperature |
| | |
| MAD | Mouse adenovirus |
| MCMV | Murine cytomegalovirus |
| MHV | Mouse hepatitis virus |
| MPV (OPV) | Mouse parvovirus (Orphan parvovirus) |
| MTLV | Mouse thymic virus |
| MVM | Minute virus of mice |
| | |
| NAP | National Academies Press |
| NCRR | National Center for Research Resources |
| NIH | National Institutes of Health |
| NPRC | National Primate Research Center |
| NRC | National Research Council |
| | |
| OIE | Office International des Épizooties |
| OLAW | Office of Laboratory Animal Welfare |
| | |
| PhRMA | Pharmaceutical Research and Manufacturers of America |
| PHS | Public Health Service |
| PPE | personal protective equipment |
| PVM | pneumonia virus of mice |

| | |
|---|---|
| REO 3 | Reovirus type 3 |
| RHD | Rabbit haemorrhagic disease |
| RPV (OPV) | Rat parvovirus (Orphan parvovirus) |
| RRV | Ross River virus |
| | |
| SARS | Sudden Acute Respiratory Syndrome |
| SDA/RCV | Sialodacryoadentitis virus/Rat corona virus |
| SIV | Simian immunodeficiency virus |
| SPS Agreement | Agreement on the Application of Sanitary and Phytosanitary Measures |
| | |
| TNZ | thermoneutral zone |
| | |
| UCT | upper critical temperature |
| USDA | US Department of Agriculture |
| | |
| WTO | World Trade Organization |

# Summary

Transportation of research animals is an essential component of the biomedical research enterprise that can have substantial, although often little understood, effects on the physiological and psychological condition of the animals. Both environmental conditions and the novelty of the transportation experience can cause stress, which can cause short-term changes in physiology and thus affect subsequent research if the animals are utilized immediately after transportation. In addition, transportation stress in great intensity or duration can adversely affect animals' well-being.

Individuals at research facilities often find arranging transportation of animals a challenge. A confusing patchwork of local, national, and international regulations; a perceived lack of high-quality shipping services; a dearth of science-based good practices; and a lack of biosafety standards all represent difficulties with which people are confronted when attempting to move research animals to or from their institution.

In recognition of these challenges and the potential for transportation to affect subsequent research, the National Institutes of Health (NIH) and the National Center for Infectious Diseases asked the National Research Council to form a committee of experts to address current problems encountered in the transportation of research animals and to offer recommendations for rectifying the problems for the benefit of research animals and the research community.

Developing science-based good practices was the major focus of the committee's efforts, which was particularly challenging given the dearth of literature available on transportation practices and the effect of transportation on the most common research animals. However, using the extensive body of literature that is available on agricultural animals, the committee was able to develop, in Chapter 3, a set of good practices based on some universal concepts of physiology and a scientific understanding of species-specific needs and differences. Good practices were developed to address thermal environment, space requirements, food and water requirements, social interaction and group transportation, handling, monitoring of transportation, emergency procedures, and personnel training. Although precise engineering standards are often preferred by human assessors, the scientific literature supports few engineering standards. Therefore, the good practices recommended by the committee were developed as "performance standards," which define an outcome (such as animal well-being or safety) and provide criteria for assessing that outcome without limiting the methods by which to achieve that outcome. The use of performance standards allows institutions and organizations the flexibility to adjust their procedures to optimize animal welfare according to the species being transported, the mode of transportation, and local environmental conditions.

During public hearings, it was evident that the issue causing the greatest confusion among those attempting to ship research animals is the overlapping authority that multiple federal agencies have over the research animal transportation process. In Chapter 2, the committee identifies the federal agencies that may be involved in the process and summarizes their agencies' statutory authority, the aspects of the transportation process that they regulate, and how they enforce their authority (inspection, permitting, and issuing standards). In addition, the committee identifies the major international treaties and agreements that may pertain to the importation or exportation of animals into or from the United States. At the end of the chapter is a checklist of questions that can be used to identify the standards that apply when transporting animals into, out of, or within the United States.

Several of the federal statutes were enacted to prevent the introduction, transmission, or spread of communicable disease in the United States, which could occur either intentionally or unintentionally through human exposure to animals. Infectious pathogens are not only a risk to public health, but can jeopardize animal health, research programs, and agricultural resources if introduced into animal colonies and laboratories. In Chapter 4, the committee identifies diseases of research animals that can be transmitted to humans, agricultural animals, and other research animals, and recommends good practices to avoid biosafety problems during transport and introduction at a new facility. Utilizing a good shipper is important for maintaining biosecurity during transport, as well as for ensuring the safety and comfort of the animals. The committee identifies characteristics of a good shipper (Chapter 4) and also provides a checklist of factors to consider when arranging transportation of research animals between research facilities (Chapter 1).

The committee also examined the existing system for transporting research animals by truck in the United States (Appendix B). By combining information on the locations where research animals are utilized and the locations of the major research animal vendors and breeders in the United States, the committee was able to construct a geographic information system model. This hypothetical model provides a qualitative sense of the patterns of transportation of research animals. In addition, this section presents the results of a quantitative modeling effort to locate additional supply points "optimally" and an assessment of the potential benefit of the additional supply points.

## MAJOR RECOMMENDATIONS

### Declining Availability of Air Transportation for Nonhuman Primates

Over the last 10-15 years, most foreign and domestic airlines have implemented a ban on transporting nonhuman primates destined for research. Many factors may have contributed to this decline, including concerns about zoonoses, the high cost of training personnel and acquiring protective equipment, the negative reactions of airline passengers, pressure from animal rights activists, and the unprofitable nature of live-animal transportation. Currently, only one domestic airline and five foreign airlines will consistently transport nonhuman primates. In the committee's judgment, the most promising solution for ensuring a stable means of transporting nonhuman primates into and within the United States is for NIH, through the National Center for Research Resources, to update and implement the National Primate Plan. This plan could include several different actions to be pursued, including developing national nonhuman primate resources and ensuring financial allowances for costs associated with chartering private airplane transportation.

The committee also recommends that the National Primate Research Centers (NPRCs) and research institutions utilizing nonhuman primates work together to encourage the development of reliable ground transportation for nonhuman primates. Although ground transport of nonhuman primates does occur, it is not widespread, possibly due to economic constraints and because most ground transportation companies are geared toward the transportation of rodents and other small mammals. However, NPRCs and researcher institutions could prepare for the possibility that domestic transportation on commercial airlines may one day become unavailable by partnering to encourage reliable ground transport, perhaps through professional societies.

The committee also recommends that federal agencies that fund nonhuman-primate research and the commercial shipping community coordinate an initiative to develop a self-contained overshipper to ship nonhuman primates (and other animals) that pose a significant risk of zoonotic exposure. An overshipper is a closed, environmentally controlled container into which a standard primary enclosure is loaded in order to prevent a zoonotic exposure. The advantages in safety, security, and convenience could encourage more airlines to transport nonhuman primates. In addition, with increased research focus on potential agents of bioterrorism, an overshipper could increase the ability of the research community to access or exchange established animal models of infectious and zoonotic diseases.

## Regulatory Burden

The complex and confusing regulatory environment surrounding the transportation of research animals led the committee to recommend the establishment of an interagency working group to coordinate all federal inspection and permitting activities related to the transportation of research animals and their products. Currently five federal agencies have oversight authority on various aspects of the transportation process. The resulting overlap of authority presents a significant regulatory burden to individual researchers and commercial shipping operations. Establishing a working group would centralize operations and communications, and would reduce regulatory burden by minimizing the number of inspections and permits that must be issued for each shipment. The committee also recommends that the various federal agencies work to clarify confusing and inconsistent regulations that pertain to transportation of research animals and their products, and in particular the Animal Welfare Act regulations, which are the federal regulations that establish standards for animal welfare that apply to most species of research animals during transportation.

## Animal Welfare

Many issues must be considered in order to ensure the comfort, well-being, and safety of research animals during transportation. This can present a challenge to individuals at research institutions that have little previous experience with facilitating the transportation of research animals. These investigators may be unfamiliar with practices that address the welfare of animals, methods that minimize transit time, and characteristics of an effective commercial shipper. Therefore, the committee recommends that research institutions, whether commercial or academic, designate a single individual to be responsible for ensuring the safe shipment and receipt of research animals. This individual would ensure appropriate registration and permitting, as well as the use of US Department of Agriculture-certified carriers, properly trained subcontractors, and appropriate transportation enclosures. It is expected that designation of a responsible individual will alleviate the burden on investigators of becoming familiar with the intricacies of federal regulations and resources such as commercial services, and will, most importantly, ensure the welfare of the animals involved.

# 1

# Introduction

Over the last 10 years, the biomedical research enterprise has undergone tremendous growth. The amount of federal funding for biomedical research has more than doubled since 1995, and the pharmaceutical, biotechnology, and contract research sectors have all seen double-digit growth (PhRMA, 2005). That growth has been accompanied by parallel increases in research infrastructure, including an increase in the numbers of animals used in biomedical research. The humane transportation of research animals has been a priority, but there are concerns that the rapid increase in the numbers of animals transported, the increasing use of genetically modified animals that may have medical considerations, the complexity of permitting and inspection of research animals, and the dwindling availability of transportation services are adversely affecting the quality and ease of transportation in the United States.

Because of those concerns, the National Center for Infectious Diseases of the Centers for Disease Control and Prevention (CDC) and the National Institutes of Health asked the Institute for Laboratory Animal Research of the National Research Council to convene a committee to address problems associated with the transportation of research animals. The detailed charge to the committee is as follows:

> A committee will be formed to address current problems encountered in the transportation of research animals and make recommendations to rectify these problems to the benefit of the research community and the

> animals themselves. The committee will focus on all species used in biomedical research and all possible modes of transportation. Specifically, they will address: animal welfare concerns during transportation; availability of quality transportation services for animals, or lack thereof; overlaps or gaps in regulatory oversight; permitting issues; transportation of tissues/specimens; regulatory burden reduction; and potential biosecurity concerns.

The Committee on Guidelines for the Humane Transportation of Laboratory Animals, convened in April 2004, includes experts in veterinary medicine, biosecurity, stress and its psychophysiological effects, research animal logistics and regulatory issues, transportation modeling, research animal welfare during transportation, and the development of transportation guidelines. The committee met three times to deliberate and develop its report. During two of the meetings, the committee held workshops to solicit information from interested parties and the public. In addition, people could provide comments to the committee through the National Academies project website.

Transportation of research animals in the United States may be divided into two major categories: animals transported from a commercial breeder to a research facility, and animals transported between research facilities. It has been reported (White, 2004) that the large commercial rodent breeders transport in excess of 1.5 million containers of animals a year within the United States. Of those shipments, 45% go to for-profit customers and 55% to nonprofit customers. Most (about 92%) of the shipments are made by ground transportation and the remainder by air. The large commercial rodent breeders have established truck routes and either use an in-house fleet of environmentally controlled vehicles or have a standing relationship with shipping companies that specialize in research animal transportation. It is estimated that 70% of containers arrive at their destination in less than 24 hours, 16% in 24–48 hours, and 14% in more than 48 hours (White, 2004).

Commercial breeders' experience with transportation failures is relatively small. The large commercial rodent breeders estimate that only 0.035% of containers experience a problem during transportation, defined as a customer complaint or rejection of shipment: 0.03% of containers shipped by ground transportation and 0.04% of containers shipped by air transportation experience problems (White, 2004).

The importation and exportation of animals to this country are also of interest to this committee. Data on importation and exportation are not available for the majority of research animals, but the importation of nonhuman primates is tracked through the CDC Division of Global Migration and Quarantine because of the concern about zoonotic diseases (a detailed discussion of the Division of Global Migration and Quarantine is found in Chapter 2). The majority of nonhuman primates imported into the United States over the last 4 years were cynomologus macaques. Currently, about half the shipments of nonhuman primates into the United States occur through Los Angeles; most of the rest go through San Francisco and Chicago (CDC, 2005c).

Many options are available for transportation of animals between research facilities. A single company might handle the door-to-door delivery of the animals. Most often, when a single company, known as a carrier, is used, the company will pick up a shipment of animals, consolidate the shipment with other shipments, fly or truck the consolidated shipment with its own fleet of vehicles along established shipping routes, and deliver the shipment to its destination. Occasionally, researchers will use a carrier to ship animals to another institution, unaware that, if the destination is not near an established shipping route or if there are not enough shipments to consolidate, the carrier might subcontract the delivery to a third-party carrier. It is also possible to have a specialty courier pick up, transport, and deliver a shipment of animals in a dedicated vehicle.

Sometimes it is necessary to use two or more transport companies. In that case, a company known as a freight forwarder or handler will pick up a shipment, deliver it to a third-party carrier, which may consolidate shipments and ship to an intermediary destination, and then pick up the shipment from the third-party carrier and deliver it to its destination.

Little information is available on the transportation of research animals between research institutions within the United States. Public records on such transportation are not maintained. Because of the lack of relevant data, the committee could not draw any conclusions about the quality of this type of transportation. The committee chose to identify some of the issues that an individual researcher should consider when making arrangements for the transportation of animals between research facilities (see Table 1-1). To further assist individuals, the committee also identified characteristics of good shippers (please refer to Table 4-3 in Chapter 4).

Many companies can coordinate or directly transport shipments of research animals in environmentally controlled trucks (AAALAC International, 2003). In addition, the US Department of Agriculture (USDA) maintains a list of registered carriers (trucking or airline companies that transport animals) and handlers (companies that pick up shipments and deliver to a third-party carrier for transportation) on its website at:

http://www.aphis.usda.gov/ac/publications.html

TABLE 1-1 Checklist of Issues to Consider When Arranging Transportation Between Research Facilities

| | |
|---|---|
| **Shipping Container** | • Is the shipping container appropriate for the expected conditions?<br>• Does the container comply with USDA standards set for warm-blooded vertebrates except rats, mice, and birds?<br>• Does the container comply with International Air Transport Association standards if transport includes air travel? |
| **Shipping Company** | • Will the same company be transporting the animals during all legs of the journey, or will a third-party carrier or subcontractor be used for some legs? |
| **Environmental Conditions** | • Are environmentally controlled vehicles used for all segments of ground transportation?<br>• If environmentally controlled vehicles will not be used, or air travel is involved, does the shipping company have contingency plans for maintenance of the animals if the ambient temperature is below or exceeds acceptable ranges?<br>• Does the shipping company have standard operating procedures for ensuring that animals are not exposed to extreme environmental conditions during transfer between vehicles and at the end destination? |
| **Training** | • Does the company provide specialized training for all employees involved in transportation of animals?<br>• If a third-party carrier or subcontractor is involved in the transportation, are they also trained? |

# 2

# Regulations and Guidelines for the Transportation of Research Animals

The purposes of this chapter are to identify national and international agencies responsible for the safe, humane, and expeditious transportation of live research animals and biological materials (tissues and specimens) derived from animals, to summarize and review regulations governing their transportation, and to identify overlaps and gaps among regulations and agency responsibilities insofar as they represent strengths and impediments (see Table 2-1). The first section of the chapter focuses on national and the second on international transportation regulatory agencies, their responsibilities and their regulations. Although the committee has attempted to provide a comprehensive summary of transportation regulations and requirements (see Table 2-6 at end of chapter), the shipper is advised to check with the appropriate agencies prior to shipment to ensure compliance with current regulations and requirements.

## NATIONAL REGULATIONS AND GUIDELINES

Several federal agencies in the United States regulate the transport of research animals and their tissues specifically or of species that might be used for research. The agencies are vested with authority under various federal statutes. In this section, the regulations and guidelines to inform readers unfamiliar with the web of regulations are discussed. All of the regulations and guidelines are applicable to the transportation of research animals, but only two laws identify standards for humane care during

TABLE 2-1 Federal Statutes/Programs Relevant to the Transportation of Vertebrate Research Animals and Products in the United States[a]

| Agency | Agency Program or Federal Regulation | Nonhuman Primates | | Cats and Dogs | |
|---|---|---|---|---|---|
| | | Interstate | Import/export | Interstate | Import/export |
| **USDA** | Animal Welfare Act | X | X | X | X |
| **FWS** | CITES | | X | | ++ |
| | Lacey Act | X | X | | |
| | Endangered Species Act | X | X | | |
| **CDC** | Division on Global Migration and Quarantine (DGMQ) | | X* | | X* |
| | Etiologic Agent Import Permit Program (EAIPP) | | | | |
| **DOT** | Infectious Substances Program | | | | |
| | Radioactive/Poisonous Materials Program | | | | |
| **FDA** | 42 CFR 70.2 and 21 CFR 1240.30 | | | | |

[a] Multiple columns may be applicable to a single shipment of animals or animal products.
* Regulates importation only.
** Regulates importation and interstate transportation only.
*** Regulates interstate transportation only.
\+ Animals that are known to harbor a human pathogen fall under the purview of DGMQ. Animals with human pathogens fall under the purview of EAIPP only when they are experimentally infected.
++ Wild-domestic hybrids, such as leopard cats, may be considered wildlife under CITES.
+++ EAIPP regulates the importation and interstate transportation of all bats, regardless of disease status.

| | Rats of genus *Rattus*, Mice of genus *Mus*, and Birds (Interstate, Import, Export) | All Other Warm-blooded Vertebrates (Interstate, Import, Export) | Wildlife (or products of wildlife) (Interstate, Import, Export) | Endangered/Threatened Wildlife (or products thereof) (Interstate, Import, Export) | Live Animals with Zoonotic/Infectious Diseases (Interstate, Import, Export) | Animal Products with Zoonotic/Infectious Diseases (Interstate, Import, Export) | Live Animals Containing Radioactive/Poisonous Material (Interstate, Import, Export) | Animal Products Containing Radioactive/Poisonous Material (Interstate, Import, Export) |
|---|---|---|---|---|---|---|---|---|
| | | X | X | X | | | | |
| | | | | X | | | | |
| | | | X | X | | | | |
| | | | | X | | | | |
| | | | | | X*,+ | | | |
| | | +++ | | | X**,+ | X** | | |
| | | | | | X | X | | |
| | | | | | | | X | X |
| | | | | | X*** | | | |

transportation: the Animal Welfare Act (AWA), which details specific standards for animal care during transportation, and the Lacey Act, which provides that wildlife be transported in accordance with the International Air Transport Association (IATA) Live Animals Regulations (LARs).

## DEPARTMENT OF AGRICULTURE

The AWA provides standards for the humane handling, care, treatment, and transportation of animals (AWA, 7 USC 2131 et seq.). AWA regulatory authority is vested in the Secretary of Agriculture and implemented by the US Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS). With the exception of rats of the genus *Rattus* and mice of the genus *Mus*, bred specifically for research purposes, as well as all birds, and livestock or poultry used for improving animal nutrition, breeding, management, production efficiency, or food or fiber quality, the AWA regulates the transportation of all warm-blooded animals intended for use in research, teaching, or testing (9 CFR 1.1). That regulation applies to transportation of AWA-covered species within the United States, as well as their transportation on foreign air carriers traveling into, within, or from the United States, its territories or possessions, or the District of Columbia (Federal Register, Vol 69, No 66, pages 17899–17901).

With regard to the transportation of animals, the act contains standards for consignment (delivery of animals to an entity for transport), primary transportation enclosure, primary conveyance, food and watering requirements during transportation, terminal facilities, care in transit, and handling. The AWA contains standards for different groups of similar species, with separate rules for transporting dogs and cats, guinea pigs and hamsters, rabbits, nonhuman primates, marine mammals, and all other covered warm-blooded animals. The AWA standards are rather extensive and pertain directly to animal welfare. They are summarized in Appendix B for ease of use.

## US FISH AND WILDLIFE SERVICE

The US Fish and Wildlife Service (FWS) regulates the importation, exportation, and interstate trade of dead and live wild animals and their tissues and products imported into or exported[1] from the United States

[1]Wildlife (including parts and products) that are in transit through the United States from one foreign country to another foreign country are exempt provided that the wildlife stays in the United States only for the time needed to transfer the specimen to the mode of transportation used to continue to the final destination and remain under control of Customs and Border Protection. Wildlife that is listed as injurious (Part 16), endangered or threatened

for any purpose (including research). *Wildlife* means any wild animal, whether alive or dead, including any wild mammal, bird, reptile, amphibian, fish, mollusk (clam, snail, squid, or octopus), crustacean (crab, lobster, or crayfish), insect, sponges, corals, or other invertebrate, whether or not bred, hatched, or born in captivity and including any part, product (including manufactured products and processed food products), egg, or offspring thereof.

The FWS authority to regulate wildlife stems from the Fish and Wildlife Act of 1956 (16 USC §§ 742a-754j-2). All wildlife being imported into or exported from the United States must be declared to FWS through completion of Form 3-177 at the time of entry or exportation and is subject to inspection. Wildlife being transported through the United States to a final international destination does not require declaration to FWS, unless it is listed as an injurious (50 CFR 16), endangered, or threatened species (50 CFR 17 and 50 CFR 222-224); a marine mammal (50 CFR 18 and 50 CFR 216); a migratory bird (50 CFR 21); or a bald or golden eagle (50 CFR 22).

FWS requires that all wildlife be imported and exported through a series of designated ports. As shown in Table 2-2, some port locations are designated to allow the importation or exportation of any wildlife, and others are restricted to allow only particular species of wildlife.

## Endangered Species Act

The purpose of the Endangered Species Act (ESA) of 1973 (16 USC §§ 1531-1544) is to conserve and recover species of fish, wildlife, and plants that are listed as threatened or endangered in the United States or elsewhere and to preserve the ecosystems upon which these species depend (ESA Section 2(b)). Criminal and civil penalties are designated under the ESA for violations. Nonhuman-primate species listed under the ESA are detailed in Table 2-3. Other species that are currently listed as endangered or threatened under the ESA can be found on line at:

http://www.fws.gov/endangered/wildlife.html#Species

FWS regulates species listed as endangered and threatened under the ESA through a system of permits. The permits are required to use these species for scientific purposes, to operate a captive-breeding program, and to transport these species through importation, exportation, or interstate

species (Parts 17 and 222-224), marine mammal (Parts 18, 216), migratory bird (Part 21), or a bald or golden eagle (Part 22) and is moving through the United States is considered an import and cannot be treated as in transit.

TABLE 2-2 Designated Port for Importation or Exportation of Wildlife or Derivatives

| Ports Designated for Endangered or Threatened Species | Ports Designated for Wildlife Originating in Canada or the United States | Ports Designated for Wildlife Originating in Mexico |
|---|---|---|
| Anchorage, AK | Alcan, AK | Brownsville, TX |
| Atlanta, GA | Blaine, WA | Calexico, CA |
| Baltimore, MD | Buffalo, NY | El Paso, TX |
| Boston, MA | Calais, ME | Laredo, TX |
| Chicago, IL | Champlain, NY | Lukeville, AZ |
| Dallas-Fort Worth, TX | Cleveland, OH | Nogales, AZ |
| Houston, TX | Derby Line, VT | San Diego, CA |
| Honolulu, HI | Detroit, MI | |
| Los Angeles, CA | Dunseith, ND | |
| Louisville, KY | Eastport, ID | **Ports Designated for Import/Export of Wildlife from Alaska** |
| Memphis, TN | Grand Portage, MN | |
| Miami, FL | Highgate Springs, VT | |
| Newark, NJ | Houlton, ME | |
| New Orleans, LA | International Falls, MN | Alcan, AK |
| New York, NY | Jackman, ME | Fairbanks, AK |
| Portland, OR | Minneapolis-St. Paul, MN | Juneau, AK |
| San Francisco, CA | Pembina, ND | |
| Seattle, WA | Portal, ND | |
| | Port Huron, MI | |
| | Raymond, MT | |
| | Sault Sainte Marie, MI | |
| | Sumas, WA | |
| | Sweetgrass, MT | |

trade. The various permit application forms are too numerous to describe here, but are listed in detail at the FWS Permit Website:

http://www.fws.gov/permit

The ESA also establishes FWS as the entity responsible for administering the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (50 CFR 23). FWS also administers CITES through a permit system, which is discussed in detail in the next section. It is important to recognize that in some instances, a single FWS application is used to obtain both an ESA and CITES permits, though not all species listed under ESA are CITES-listed species and vice versa. Applications generally require 60-90 days for processing.

TABLE 2-3 Endangered Species Act Listed Species of Nonhuman Primates

***Endangered***

*Allocebus* spp. (hairy-eared dwarf lemurs)
*Alouatta palliate* (mantled howler monkey)
*Ateles geoffroyi frontatus* (Central American spider monkey)
*Ateles geoffroyl panamensis* (Central American spider monkey)
*Avahi* spp. (Avahi, woolly lemurs)
*Brachyteles arachnoids* (woolly spider monkey)
*Bradypus torquatus* (Brazilian three-toed sloth)
*Cacajao* spp. (uakaris)
*Callimico goeldii* (Goeldi's marmoset)
*Callithrix aurita* (buffy tufted-ear, white-eared marmoset)
*Callithrix flaviceps* (buff-headed marmoset)
*Cercocebus galeritus galeritus* (Tana River mangabey)
*Cercocebus torquatus* (white-collared mangabey)
*Cercopithecus Diana* (Diana monkey)
*Cercopithecus erythrogaster* (red-bellied monkey)
*Cercopithecus erythrotis* (red-eared nose-spotted monkey)
*Cercopithecus lhoesti* (L'hoest's monkey)
*Cheirogaleus* spp. (dwarf lemurs)
*Chiropotes albinasus* (white-nosed saki)
*Chiropotes satanas satanas* (southern bearded saki)
*Colobus satanas* (black colobus monkey)
*Daubentonia madagascariensis* (Aye-aye)
*Gorilla gorilla* (gorilla)
*Hapalemur* spp. (bamboo lemurs and gentle lemurs)
*Hylobates* spp. (including Nomascus) (gibbons)
*Indri* spp. (indri)
*Lagothrix flavicauda* (yellow-tailed woolly monkey)
*Lemur* spp. (ring-tailed lemurs)
*Leontopithecus* spp. (golden-rumped tamarin)
*Lepilemur* spp. (sportive lemurs)
*Macaca silenus* (lion-tailed macaque)
*Mandrillus leucophaeus* (drill)
*Mandrillus sphinx* (mandrill)
*Microcebus* spp. (mouse lemurs)
Monkey, black howler
*Nasalis concolor* (Pagi Island langur)
*Nasalis larvatus* (proboscis monkey)
*Pan paniscus* (pygmy chimpanzee—wild)
*Pan troglodytes* (wild chimpanzee)
*Phaner* spp. (fork-marked lemurs)
*Planigale ingrami subtilissima* (little planigale)
*Pongo pygmaeus* (orangutan)
*Procolobus pennantii kirki* (Zanzibar red colobus monkey)
*Procolobus preussi* (Preuss' red colobus monkey)
*Procolobus rufomitratus* (Tana River red colobus monkey)
*Propithecus* spp. (sifakas)
*Pygathrix nemaeus* (douc langur)
*Rhinopithecus avunculus* (Tonkin snub-nosed monkey)
*Rhinopithecus bieti* (Yunnan snub-nosed monkey)
*Rhinopithecus brelichi* (guizhou snub-nosed monkey)
*Rhinopithecus roxellana* (Sichuan snub-nosed monkey)
*Saguinus bicolor* (pied tamarin)
*Saguinus oedipus* (cotton-top marmoset)
*Saimiri oerstedii* (red-backed squirrel monkey)
*Semnopithecus entellus* (gray, Hanuman langur)
*Tamarin*, white-footed
*Trachypithecus francoisi* (Francois' langur)
*Trachypithecus geei* (golden langur)
*Trachypithecus pileata* (capped langurs)
*Varecia* spp. (ruffed lemur, variegated lemurs)

***Threatened***

*Alouatta pigra* (black howler monkey)
*Macaca arctoides* (stump-tailed macaque)
*Macaca cyclopis* (Formosan rock macaque)
*Macaca fuscata* (Japanese macaque)
*Macaca sinica* (Toque macaque)
*Nycticebus pygmaeus* (lesser slow lorise)
*Pan troglodytes* (chimpanzees—captive)
*Presbytis potenziani* (long-tailed langur)
*Presbytis senex* (purple-faced langur)
*Saguinus leucopus* (white footed tamarin)
*Tarsius syrichta* (Philippine tarsier)
*Theropithecus gelada* (gelada baboon)

### Lacey Act

The FWS is also vested with federal regulatory authority from the Lacey Act of 1900 (18 USC 42). The Lacey Act is the oldest federal wildlife protection law in the United States and prohibits inhumane and unhealthful transportation conditions for any animal defined as "wildlife" (see above for definition). The regulations for transportation under the act (found in 50 CFR 14.101-14.172, which are specific for mammals and birds) are similar to the IATA-LARs. The Lacey Act also applies the guidelines provided in the LARs to nonairline methods of transportation (Kreger and Farris, 2003).

## CENTERS FOR DISEASE CONTROL AND PREVENTION

The Centers for Disease Control and Prevention (CDC) is a component of the US Department of Health and Human Services and enforces regulations to prevent the introduction, transmission, or spread of communicable diseases in the United States. CDC regulates the importation of any animal or animal product capable of carrying a zoonotic disease. CDC regulates importation through permitting, registration, and quarantine; it does not regulate the welfare or care of the animals.

### Importation of Live Animals

CDC regulates the importation of dogs, cats, turtles, nonhuman primates, and other animals. Dogs and cats are subject to inspection by CDC at the port of entry. Dogs must be accompanied by proof of vaccination against rabies at least 30 days before entry into the United States unless they were in areas considered rabies-free for at least 6 months before importation. Importation of dogs or cats into the United States does not require a permit or other paperwork from CDC. Dogs too young to be vaccinated or without a current rabies vaccination may be admitted into the United States if the owner signs a confinement agreement (Form 75.37), which can be accessed from the following website:

http://www.cdc.gov/ncidod/dq/animal.htm

To prevent infection of members of the public with Salmonella and Arizona bacteria, shipments containing more than six turtles with a carapace length of less than 4 in. or viable turtle eggs generally cannot be imported into the United States (42 CFR 71.52). However, shipments containing more than six turtles with a carapace length of less than 4 in. or viable turtle eggs or any combination of turtles and turtle eggs may be imported into the United States for bona fide scientific, educational purposes, or for exhibition when accompanied by a permit issued by CDC, Division of Global Migration and Quarantine (DGMQ) (42 CFR 71.52(c)(2)).

CDC may also implement prohibitions on the importation of animals when new health risks to humans arise. As of June 2003, CDC had prohibited the importation of all African rodents into the United States because of concerns about monkeypox (42 CFR Part 71.56). In January 2004, CDC prohibited the importation of civets because of concerns about severe acute respiratory syndrome (CDC, 2004). However, importation of those animals for scientific, exhibition, or educational purposes is allowed with written permission from CDC (42 CFR 71.56; CDC, 2004). Since February 2004, CDC has prohibited the importation of Asian birds from selected countries due to highly pathogenic avian influenza A (H5N1). For more information about obtaining a permit or permission to import turtles, African rodents, or other prohibited animals, contact the CDC DGMQ at 404-498-1670 or online at:

http://www.cdc.gov/ncidod/dq/nonhuman.htm

Monkeys and other nonhuman primates cannot be imported as pets, but importation for scientific research, exhibition, or education is permitted. Under the Federal Quarantine Regulations (42 CFR 71.53), people importing nonhuman primates for research purposes must register with the CDC DGMQ and must

- Certify that imported nonhuman primates will be used only for *bona fid*e science, education, or exhibition;
- Implement disease control measures to minimize human exposure to the animals during transportation, isolation, and quarantine;
- Isolate each shipment of nonhuman primates for 31 days, monitor the animals for illness, test for tuberculosis, maintain records regarding illness and death, and test for filovirus infection in shipments where illness or death occurs during the quarantine period;
- Report suspected zoonotic illness to CDC; and,
- Maintain records regarding the distribution of each shipment (NRC, 2003a).

Before registration and periodically thereafter, the CDC DGMQ inspects importer facilities and reviews their operations, including assessing transportation and disease-control measures and reviewing animal health records. For each shipment of nonhuman primates into the United States, CDC must review proposed plans for each shipment and monitor the handling of arriving shipments at the port of entry and at the quarantine facility (NRC, 2003a). To receive information on the importation of nonhuman primates and to register as an importer of nonhuman primates, contact the CDC DGMQ, whose phone number and website are provided above.

### Importation and Transportation of Etiologic Agents

The CDC Etiologic Agent Import Permit Program regulates the importation and subsequent transfer within the United States of live bats, as well as animals, insects, or animal tissues that contain etiologic agents. *Etiologic agents* are defined by CDC as a viable microorganism or its toxin which causes, or may cause, human disease; however, CDC does not specifically identify the microorganisms, viruses, or prions that it considers etiologic agents.

Contact information and permit applications for importation of etiologic agents or live bats (Office of Management and Budget form 0920-0199) are available at:

http://www.cdc.gov/od/ohs/biosfty/imprtper.htm

## US DEPARTMENT OF TRANSPORTATION

The US Department of Transportation (DOT), Pipeline and Hazardous Materials Safety Administration (PHMSA), Office of Hazardous Materials establishes regulations to govern the transportation of hazardous materials in interstate, intrastate, and foreign commerce under the Hazardous Materials Regulations (HMR; 49 CFR 171-180). Hazardous materials include materials that are poisonous, radioactive, and infectious—all of which may be contained in animals or animal products that may be transported in the course of biomedical research. An *infectious substance* is defined by DOT as a material known to contain or suspected of containing a pathogen, including a virus, microorganism, or prion that has the potential to cause disease in humans or animals. Live animals that contain an infectious substance are required to be transported under terms and conditions approved by PHMSA's Associate Administrator for Hazardous Materials Safety.

The HMR cover five areas of shipper responsibility:

- Determining the hazard class(es) of the material offered for transportation;
- Communicating the hazard(s) using shipping papers, labels, markings, placards, and emergency-response information, as required;
- Packaging requirements;
- Operational rules, including for transportation by air; and,
- Training and security.

The majority of these tasks are performed by the shipper. The carrier must also ensure that the materials received comply with and are transported in accordance with the HMR. The HMR also require people or institutions that are shipping certain types or amounts of hazardous materials, such as materials extremely toxic by inhalation, to register annually with DOT (49 CFR 107.601).

There are many exceptions, as some materials and situations that are common in biomedical research are not subject to the requirements of the HMR. The exceptions are too numerous to describe here, but persons interested in shipping hazardous materials, including infectious, poisonous, or radioactive animal products or live infectious animals, should contact PHMSA's Hazardous Materials Information Center to determine whether shipment would be subject to the requirements of the HMR or visit their website online at:

http://hazmat.dot.gov/

## PUBLIC HEALTH SERVICE

Institutions that are funded by Public Health Service (PHS) funds are subject to the PHS Policy on the Humane Care and Use of Laboratory Animals (commonly referred to as the PHS Policy). Under the Health Research Extension Act of 1985, the PHS Policy mandates adherence to the guidelines in the *Guide for the Care and Use of Laboratory Animals* (the *Guide*) (NRC, 1996). The *Guide* provides performance standards on the transportation of research animals. It states that all transportation of animals should be planned to minimize transit time and the risk of zoonoses, protect against environmental extremes, avoid overcrowding, provide food and water when indicated, and protect against physical trauma.

The PHS Policy does not provide for regular inspections. Rather, institutions are expected to police themselves in order to ensure compliance with the principles of the PHS Policy and the *Guide*. The National Institutes of Health Office of Laboratory Animal Welfare will conduct investigations when it receives complaints.

## FOOD AND DRUG ADMINISTRATION

Under 42 CFR 70.2 and 21 CFR 1240.30, authority is given to the commissioner of the Food and Drug Administration (FDA) to take actions believed "reasonably necessary to prevent" the spread of communicable disease when state and local actions are inadequate. By that authority, FDA prohibits the intrastate and interstate transportation—for the purposes of commerce, sale, or any other type of commercial or public distribution—of psittacine birds, molluscan shellfish, turtles, and African rodents or other animals that may carry the monkeypox virus (refer to 21 CFR 1240.65, 21 CFR 1240.60, 21 CFR 1240.62, 21 CFR 1240.63, respectively). Essentially, CDC prohibits the importation of the animals, and FDA prohibits their domestic interstate and intrastate movement, with special procedures for exceptional circumstances.

Exceptions to the prohibitions are possible only by obtaining written permission from the FDA. A written request must be sent to the Listed Animal Permit Official at the FDA Center for Veterinary Medicine. The request must include the reasons why an exemption is needed and a description of the animals involved, how the animals will be transported, holding facilities, quarantine procedures, and veterinarian evaluation of the transportation. For more information, visit the following website:

http://www.fda.gov/cvm/

## STATE HEALTH AND AGRICULTURAL REGULATIONS

All states have regulations that control the movement of animals into them, although not all of these regulations pertain to research animals. For example, the California Department of Health Services requires a permit to transport nonhuman primates into the state. Links to the regulations have been organized by the USDA APHIS Veterinary Services at:

http://www.aphis.usda.gov/vs/sregs/

State regulations that pertain specifically to wildlife are found at:

http://offices.fws.gov/statelinks.html

The committee recommends that people arranging transportation of research animals consult those websites, particularly when arranging for transportation of animals between research institutions.

## INTERNATIONAL REGULATIONS FOR TRANSPORTING RESEARCH ANIMALS

Regulations pertaining to the international transportation of live animals, tissues, and specimens are intended to ensure the comfort of animals and the safety of animals and their handlers, and to minimize the biosecurity risks associated with the handling of live animals and of the colonies into which live animals are introduced. The international regulatory system is a patchwork of agreements and agencies that govern the following:

- Pest control and biosecurity;
- Research animals;
- Agriculture;
- Conservation of endangered species; and,
- Animals used in exhibits or events (shows or sports).

Because several agencies share responsibility for enforcing international transportation statutes and most countries have importation requirements, the regulatory climate is often complicated. The following is a discussion of the international treaties, agencies, or laws that provide regulation or guidance on the transportation of research animals. With the exception of CITES, enforced in 169 countries, each country has its own system of laws and guidance that may or may not draw on the treaties and laws discussed here. The Air Cargo Tariff book, published by the International Air Transport Association, is a source of information on international documentation and import requirements, though one should be aware that the information can change rapidly and requirements may be specific to a province or region. The committee suggests that the person(s) or institution(s) importing animals into the United States or exporting animals from the United States contact the consulate or website of the foreign country to determine which treaties the country enforces and the specific requirements for complying with local laws. In some cases, negotiations are necessary to address incompatibilities between US export and foreign import requirements. An export broker may be useful in assisting a shipper in fulfilling foreign importation requirements.

## CITES

CITES, also called the Washington Convention, establishes a permit system for regulating the trade of plants and animals threatened by extinction and those that may be threatened by extinction if trade of that species is not controlled. In this context, *trade* refers to movement of a specimen across international borders for any purpose and includes commercial and noncommercial trade. It includes the importation, exportation, or re-exportation (exportation of a specimen that was imported) of live and dead plants and animals or parts or derivatives of them. At the time of publication, some 169 nations are parties to CITES. In the United States, the ESA of 1973 implements the international CITES treaty (50 CFR 23). FWS administers both the ESA and the CITES treaty and therefore is the authority responsible for issuing importation and exportation permits in the United States.

Under CITES, animals covered by the treaty are listed in three appendixes:

- Appendix I lists species threatened with extinction. Trade in specimens of those species is permitted only in exceptional circumstances; commercial trade is prohibited.
- Appendix II lists species not necessarily threatened with extinction but in which trade must be controlled to avoid use incompatible with their survival.
- Appendix III lists species that are protected in at least one country that the animal is native to and that has asked other CITES parties for assistance in controlling the trade.

A database listing all of the CITES-listed species has been established. It can be accessed online at:

http://www.cites.org/eng/resources/species.html

The permitting requirements pertaining to the transportation of Appendix I, II, and III specimens are summarized in Table 2-4. In addition to requiring specific permits, CITES, under Resolution 10.21, endorses the IATA LARs for air and surface transportation. CITES-listed species can be imported or exported only through the following designated ports in the United States:

Anchorage, AK
Atlanta, GA
Baltimore, MD
Boston, MA
Chicago, IL
Dallas-Fort Worth, TX
Honolulu, HI
Houston, TX
Los Angeles, CA
Louisville, KY
Memphis, TN
Miami, FL
Newark, NJ
New Orleans, LA
New York, NY
Portland, OR
San Francisco, CA
Seattle, WA

Nonhuman primates are the group of CITES species most commonly used in biomedical research in the United States. As shown in Table 2-5, wild-caught species of nonhuman primates are in both Appendix I and Appendix II. However, animals in Appendix I that are bred in captivity for commercial purposes at a facility registered with the CITES secretariat

TABLE 2-4 Permitting Requirements Under CITES

| Appendix I | Appendix II | Appendix III |
|---|---|---|
| Importation and exportation permits required<br><br>Permits are limited to specimens that will be used in scientific research, education, or conservation | Exportation permit required if exporting from any country | Exportation permit required only if exporting from the nation that listed the species in Appendix III |

are considered Appendix II specimens for the purposes of permitting (CITES Article VII.4). Furthermore, where a management authority of the state of export is satisfied that an animal was bred in captivity, a certificate by that management authority stating that the animal was bred in captivity *may* be accepted in lieu of any other required permits or certificates (CITES Article VII.5). This exemption also pertains to tissues derived from a captive-bred animal. However, the term 'bred in captivity' only applies when the animals in question are of a second or subsequent generation bred in captivity *and* there has been no introduction of specimens from the wild into the breeding population except to prevent or alleviate deleterious inbreeding (CITES Resolution Conf. 10.16-revised). As noted in Chapter 1, nonhuman primates are regularly imported into the United States for research purposes. Practically speaking, this means that, with rare exception, nonhuman primates bred for research in the United States cannot attain the designation of 'bred in captivity.'

## INTERNATIONAL CIVIL AVIATION ORGANIZATION

The International Civil Aviation Organization (ICAO), an agency of the United Nations, publishes *Technical Instructions for the Safe Transport of Dangerous Goods by Air* biannually (currently the 2005-2006 edition). The *Technical Instructions* expand on the broad provisions governing the international transportation of dangerous goods by aircraft, which are in Annex 18 to the Convention on International Civil Aviation and are based on the United Nations recommendations for the Transport of Dangerous Goods. The *Technical Instructions* contain the detailed regulations necessary for the safe transportation of dangerous goods by aircraft and are for use by all parties involved in the transportation chain, such as shippers, carriers, and country authorities. They are recognized by the US DOT as an alternative to complying with the HMR.

TABLE 2-5 CITES Listed Species of Nonhuman Primates

| **Appendix I** | **Appendix II** |
|---|---|
| *Alouatta coibensis* (Coiba Island howler monkey)<br>*Alouatta palliate* (mantled howler monkey)<br>*Alouatta pigra* (Mexican black howler monkey)<br>*Ateles geoffroyi frontatus* (black-foreheaded spider monkey)<br>*Ateles geoffroyi panamensis* (Panamanian red spider monkey)<br>*Brachyteles arachnoids* (woolly spider monkey, southern muriqui)<br>*Cacajao* spp. (uakaris)<br>*Callimico goeldii* (Goeldi's marmoset)<br>*Callithrix aurita* (buffy tufted-ear marmoset)<br>*Callithrix flaviceps* (buffy-headed marmoset)<br>*Cercocebus galeritus galeritus* (tana crested mangabey)<br>*Cercopithecus Diana* (Diana monkey)<br>*Cheirogaleida* spp. (dwarf, lemurs)<br>*Chiropotes albinasus* (white-nosed bearded saki)<br>*Daubentonia madagascariensis* (aye-aye)<br>*Gorilla gorilla* (gorilla)<br>*Hylobatidae* spp. (gibbons)<br>*Indridae spp.* (indrises, woolly lemurs, avahs, sifakas)<br>*Lagothrix flavicauda* (yellow-tailed woolly monkey)<br>*Lemuridae* spp. (large lemurs)<br>*Leontopithecus* spp. (lion tamarins)<br>*Macaca silenus* (lion-tailed macaque)<br>*Mandrillus leucophaeus* (drill)<br>*Mandrillus sphinx* (mandrill)<br>*Nasalis concolor* (pig-tailed langur)<br>*Nasalis larvatus* (proboscis monkey)<br>*Pan* spp. (chipanzees)<br>*Pongo pygmaeus* (orangutan)<br>*Presbytis potenziani* (Mentawai Island leaf-monkey)<br>*Procolobus pennantii kirkii* (Kirk's red colobus)<br>*Procolobus rufomitratus* (tana river red colobus)<br>*Pygathrix* spp. (snub-nosed monkeys, douc langurs)<br>*Saguinus bicolor* (Brazilian bare-faced tamarin)<br>*Saguinus geoffroyi* (Geoffroy's tamarin)<br>*Saguinus leucopus* (white-footed tamarin)<br>*Saguinus oedipus* (cotton-top tamarin)<br>*Saimiri oerstedii* (Central American squirrel monkey)<br>*Semnopithecus entellus* (hanuman langur)<br>*Trachypithecus geei* (golden langur)<br>*Trachypithecus pileatus* (capped langur) | All primate species not listed in Appendix I |

## INTERNATIONAL AIR TRANSPORT ASSOCIATION

The mission of the IATA is to "represent, lead, and serve the airline industry." IATA is also a collective link between third parties and the airline industry. Working standards for the aviation industry are developed within IATA to foster safe and efficient air transportation and to serve the stated policies of most of the world's governments.

### Live Animals Regulations

The LARs are applicable to air transportation companies that are members of IATA. Persons or organizations that ship live animals by IATA-member airlines, whether as cargo or as baggage, must comply with the LARs in their entirety.

The IATA LARs, updated yearly, were adopted by CITES and the World Animal Health Organization (described below) as the guidelines for transportation of animals by air. Those regulations have been used by the Council of Europe as a basis for its code of conduct for the international transportation of farm animals. The European Union has adopted the LARs as the minimal standards for transporting animals in containers, pens, and stalls. The regulations are intended to prevent harm to these receptacles and to handling personnel when animals are being transported. Furthermore, they act to meet flight safety requirements for the benefit of the traveling public, the crew, and the airplane. The LARs consist of government regulations and specific variations filed by such agencies as USDA and FWS. For example, US variations USG-01 through USG-20 belong to USDA and contain more restrictive guidance than is required by the AWA. Similarly, USG-21 through USG-40 is issued by FWS. For more information about the IATA LARs, go online at:

http://www.iata.org/ps/publications/9105.htm

### Dangerous Goods Regulations

The IATA Dangerous Goods Regulations (DGRs) are similar to the ICAO Technical Instructions for the Safe Transport of Dangerous Goods by Air. However, the DGRs include additional requirements that are more restrictive than the Technical Instructions, to reflect industry standard practices or operational considerations.

*Dangerous goods* are defined as goods that meet the classification criteria of one or more of nine United Nations hazard classes. These hazard classes are identical to those used by the US DOT's Office of Hazardous Materials Standards, Pipeline and Hazardous Materials Safety

Administration, and include toxic, infectious, and radioactive animal tissues, and live infectious animals. The DGRs do not have official standing under the US DOT's HMR.

For more information on the IATA DGRs, go online at:

http://www.iata.org/whatwedo/dangerous_goods1

## WORLD ANIMAL HEALTH ORGANIZATION

The primary functions of the World Animal Health Organization, also known as the Office International des Épizooties (OIE), are preventing and raising awareness of zoonoses worldwide. OIE was created in January 1995 as part of the World Trade Organization (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement), which aims to harmonize animal health standards and thus reduce their dampening effect on international trade. The main goals of the OIE are:

- To ensure transparency in the global animal disease and zoonosis situation;
- To collect, analyze, and disseminate scientific veterinary information;
- To provide expertise and encourage international solidarity in the control of animal diseases;
- Within its mandate under the WTO SPS Agreement, to safeguard world trade by publishing health standards for international trade in animals and animal products;
- To improve the legal framework and resources of national veterinary services; and
- To provide a better guarantee of the safety of food of animal origin and to promote animal welfare through a science-based approach.

Among other tasks, the SPS Agreement charges OIE with developing international standards, guidelines, and recommendations for protecting animal health and preventing zoonoses. To that end, OIE has developed the *Terrestrial Animal Health Code* and the *Aquatic Animal Health Code*, which provide OIE member countries with standards, guidelines, and detailed recommendations for establishing their own regulations regarding the importation of animals, animal genetic material, and animal products.

OIE is also responsible for improving systems by which information on animal health is gathered and analyzed on a global basis. OIE manages the world animal health information system, which uses data submitted by member countries to help identify the diseases, including zoonoses, that present the most serious threats to animal and human health worldwide. During the recent outbreak of avian influenza in Asia, OIE played a crucial role in alerting countries of the outbreak and recommending courses of action. As a result of OIE's activities, many countries temporarily halted importation from the affected areas.

Several years after OIE's founding, its member countries decided to give animal welfare high priority and to include it in their 2001-2005 strategic plan. Although OIE had not been specifically mandated by the WTO SPS to protect animal welfare, the OIE's status as the international authority on animal health and zoonoses and the member countries' strong need for guidelines to assist them in conducting bilateral negotiations led the member countries to the conclusion that OIE should provide international leadership in protecting the welfare of imported animals.

Member countries recognized that from a public-policy perspective, the protection of animals involved many scientific, ethical, economic, and political considerations. Therefore, they endeavored to develop a detailed vision and strategy that would incorporate and balance those considerations. Ultimately, the OIE International Committee decided that OIE would give high priority to animals used in agriculture and aquaculture and would address the issues of transportation, humane slaughter, and killing for disease-control purposes first, followed by housing and management. OIE would address other issues, such as research animals and wildlife, as resources permitted.

Member countries delegate responsibility for OIE reporting and participation to the directors of their veterinary services. For the United States, the USDA APHIS Associate Deputy Administrator for International Services assumes that role.

## THE EUROPEAN UNION

The European Union (EU) laws regulating the transportation of research animals are enforced by the Health and Consumer Protection Directorate General. Research animal transportation is addressed through legislative and nonlegislative actions in three interrelated policy areas:

- Consumer policy (Treaty Articles 95 and 153);
- Public health (Treaty Articles 95, 152, and 300); and
- Food safety, animal health, animal welfare, and plant health (Treaty Articles 37, 95, and 152).

The first EU legislation on the protection of animals during transportation, Council Directive 77/489/EC, resulted from the 1968 Convention of the Council of Europe. It has since been replaced by the more detailed Council Directive 91/628/EC as amended by Directive 95/29/EC, which introduced important changes such as the approval of transporters, the route plan, and loading densities and traveling-time limits. EU legislation on the transportation of live animals applies to all animals transported for commercial purposes. The present framework of general provisions has been introduced by Council Directive 91/628/EEC, which in Chapter I, Part E, provides that:

- Animals shall be transported in containers, pens, or stalls appropriate for the species, complying, at least, with the most recent IATA live-animal regulations.
- Precautions shall be taken to avoid extremely high or low temperatures on board, having regard for the species of animals. In addition, severe fluctuations of air pressure shall be avoided.
- In freight aircraft, a type of instrument approved by the competent authority shall be carried for slaughtering animals if necessary.

Council Directive 86/609/EEC was issued on the protection of animals used for experimental and other scientific purposes on November 24, 1986. It sets minimal standards for housing and care and for the training of personnel handling animals and supervising the experiments, but it does not provide specific standards on transportation of animals. Council Regulation 1/2005 was passed in January 2005 and will introduce new rules that will apply directly to each member state effect 2007. These rules introduce changes to improve animal welfare and enforcement, but do not change the maximum journey times that apply through the current Directive.

TABLE 2-6 Checklist of Research Animal Regulations and Guidelines

| | **Yes** | **No** |
|---|---|---|
| Is the species to be transported a live, warm-blooded animal other than a bird or an animal of the genus *Rattus* or *Mus*? | Comply with AWA regulations.<br>Subject to inspection by USDA. | No action required |
| Is the species (or its tissues or products) to be imported or exported considered wildlife (including all CITES-listed species and nonhuman primates)? | Obtain FWS permits, consult: http://www.fws.gov/permits/applicationmain.shtml<br>Comply with CDC Foreign Quarantine Regulations.<br>Comply with IATA LARs.<br>Subject to inspection by FWS. | No action required |
| Is the species (or its tissues or products) to be transported (exported, imported, or interstate trade) listed as threatened or endangered by FWS?<br>Consult: http://www.fws.gov/endangered. | Obtain FWS permits, consult: http://www.fws.gov/permits/applicationmain.shtml<br>Subject to inspection by FWS.<br>Comply with IATA LARs. | No action required |
| Is an animal or its products wild-caught, listed under CITES as an Appendix I species, and being transported internationally?<br>Consult: http://www.cites.org/eng/resources/species.html. | Obtain importation and exportation permits from the appropriate countries.<br>Obtain FWS permits, consult: http://www.fws.gov/permits/applicationmain.shtml<br>Subject to inspection by FWS. | No action required |
| Is an animal or its products to be transported internationally and<br>• listed under CITES as an Appendix II species<br>***OR***<br>• a captive-born animal and listed under CITES as an Appendix I species?<br>Consult: http://www.cites.org/eng/resources/species.html. | Obtain export permit from country of export.<br>Obtain FWS permits, consult: http://www.fws.gov/permits/applicationmain.shtml<br>Subject to inspection by FWS. | No action required |
| Is the species to be imported a dog or cat? | Dogs require proof of rabies vaccination.<br>Subject to inspection by CDC. | No action required |

*continued*

TABLE 2-6 Continued

| | Yes | No |
|---|---|---|
| Is the species to be imported a nonhuman primate, African rodent, civet, turtle of carapace length of less than 4 in., or other species prohibited by CDC?<br>Consult http://www.cdc.gov/ncidod/dq/animal.htm. | Obtain permit, written permission, or registration from CDC Division of Global Migration and Quarantine.<br>Subject to inspection by CDC. | No action required |
| Is the species to be imported a live bat or animal, insect, or animal tissue that contains an etiologic agent? | Submit OMB Form 0920-0199 to CDC's Etiologic Agent Import Permit Program. | No action required |
| Does the animal or animal product to be transported contain poisonous, radioactive, or infectious material? | Contact DOT's Hazardous Materials Information Center for further requirements.<br>If shipped by air, comply with IATA DGRs. | No action required |
| Are the species to be transported live, vertebrate animals that were purchased with PHS funds? | Comply with PHS Policy and *Guide for the Care and Use of Laboratory Animals*. | No action required |
| Is the animal to be transported within the United States a nonhuman primate, African rodent, civet, turtle of carapace length of less than 4 in., or other species prohibited by FDA?<br>Consult http://www.fda.gov/cvm/ | Submit written request for permission from Listed Animal Permit Official at FDA's Center for Veterinary Medicine. | No action required |
| Is the animal being imported into the United States or traveling between states? | Comply with regulations from destination state available at: http://www.aphis.usda.gov/vs/sregs<br>Comply with CDC Foreign Quarantine Regulations.<br>Wildlife-specific state regulations are available at: http://offices.fws.gov/statelinks.html | No action required |
| Is the animal being transported by air? | Comply with IATA LARs (all species)<br>Comply with 50 CFR 14 subpart J (AWA-covered species only) | No action required |

# 3

# Good Practices in the Transportation of Research Animals

Animals are transported to facilitate research, teaching, and training, and for breeding-colony establishment and maintenance. Stress during transportation is unavoidable and can affect the quality of ensuing research activities. However, when science-based good practices in animal handling and transport are identified and implemented, the transportation experience can be made less stressful.

There are a few publications and articles that discuss common practices for the transportation of research animals, including the *AATA Manual for the Transportation of Live Animals* (AATA, 2000), the *IATA Live Animals Regulations* (IATA, 2005), and a Report of the Transport Working Group Established by the Laboratory Animal Science Association (Swallow *et al.*, 2005). In addition, an extensive collection of scientific literature relating to the effects of transportation on agricultural animals has been produced, in part because the livestock industry often requires that animals be shipped to new locations during the production cycle, which involves social and economic pressures for the animals to arrive in optimal condition. Much of this literature is summarized in the *Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching* (FASS, 1999).

Unfortunately, there is sparse scientific literature on the effects of transportation on most common research animals, but good practices for all research animals can be established by drawing some universal concepts from the available scientific literature and by understanding species-specific needs. Although precise engineering standards are often preferred by human assessors, the scientific literature supports few engineering standards. This report emphasizes *science-based performance standards*, which define an outcome (such as animal well-being or safety) and provide criteria for assessing that outcome without limiting the methods by which to achieve that outcome (NRC, 1996). The use of performance standards allows researchers and shippers the flexibility to adjust their procedures to optimize animal welfare on the basis of the species being transported, the mode of transportation, and local environmental conditions.

## STRESS DURING TRANSPORTATION

Although the word *stress* generally has adverse connotations, stress is a familiar aspect of life—a stimulant for some, a burden for others. Numerous definitions have been proposed for *stress*. Each definition focuses on aspects of an internal or external challenge, disturbance, or stimulus; on perception of a stimulus by an organism; or on a physiological response of the organism to the stimulus (Goldstein, 1995; Sapolsky, 1998; Selye, 1975). An integrated definition states that stress is a constellation of events including a stimulus (stressor), a reaction in the brain precipitated by the stimulus (stress perception), and an activation of the body's physiological fight or flight systems (stress response) (Dhabhar and McEwen, 1997). Transportation stressors can be physical (changes in temperature, humidity, or noise), physiological (limitation of access to food and water), and psychological (exposure to novel individuals or environments).

It is important to recognize that stress does not always have adverse consequences (Dhabhar and McEwen, 2001; Pekow, 2005), and it is often overlooked that a stress response has healthful and adaptive effects (Dhabhar and McEwen, 1996; McEwen, 2002).

Stress can be harmful when it is long-lasting and animals are unable to adapt successfully to it (Dhabhar and McEwen, 1997; Irwin, 1994; Kiecolt-Glaser *et al.*, 2002; McEwen, 2002); therefore, an important distinguishing characteristic of stress is its duration. Acute stress is defined as stress that lasts for minutes, hours, or a few days; and chronic stress as stress that persists for months or years (Dhabhar and McEwen, 1997; McEwen, 2002). Most transportation events last only a few days and are considered acute stress events. Even the transportation of animals from overseas does not take more than a few days, so there is little concern about chronic stress during transportation. However, care must be taken to minimize post-trip stress in order to ensure that animals are not chronically stressed.

Transportation of animals involves three phases or periods: pretrip, intermodal, and post-trip. During the intermodal period, trip time has a large effect on the stressfulness of the experience. Animals experience a sudden and large stress response at the initiation of transportation. That response declines until a lower plateau is reached. Then, after a longer period, the stress of transportation gradually increases, especially if feed and water are not consumed. For small species in extreme thermal conditions, the length of time that an animal remains at a plateau of stress response before the stress of transportation begins to increase can be rather short (minutes). However, an animal with a large body store of nutrients in extreme thermal conditions may remain at that plateau of stress response for many days.

A main issue of concern during transportation is an animal's psychological experience. Normally, animals live in a uniform, familiar environment; during transport, almost every aspect of their environment changes. The transportation enclosure, motion, human handling, temperature, light, and perhaps social group mates, odors, sounds, floor surface, food and water availability, vibrations, unusual gravitational forces (such as during acceleration, braking, or turning of vehicles), and other factors all change from moment to moment. That change in multiple sensory experiences will be perceived as stressful, even under the best of conditions, for two major psychological reasons: the transportation experience is not part of the normal routine, and the animal has no control of the situation. Stress during transportation is unavoidable, so the optimal conditions for moving animals from one location to another would be those that minimize the intensity and duration of excessive stress. Reduction in the number of transportation experiences and in novelty are two ways to make transportation more predictable and to minimize stress; however, most animals will travel only once in their lifetime—from the location where they are bred to the research location. In that case, the goal is to make the single transportation experience as predictable as is practically possible, for example, by providing access to familiar bedding during transportation.

Efforts to minimize excessive stress should be implemented from the time animals are removed from their home cages in the shipping location to the time they are delivered to home cages in the receiving location. Minimizing the intensity and duration of stress in animal home cages is also important and is under the purview of animal caretakers at each institution where animals are housed. However, it must be recognized that even mild manipulations such as moving an animal from one room to another in the same animal facility have been shown to increase corticosterone levels and result in transient but marked changes in endocrine, serological, and hematological measures (Gartner *et al.*, 1980). Repeated transportation from one location to another in the same building was shown to increase numbers of sulfomucin-producing cells in mucosa of the descending colon of Sprague Dawley rats (Rubio and Huang, 1992). A simple rule of thumb for stress minimization during transportation involves trying to mimic the animal's accustomed living conditions as closely as possible while recognizing that animals are resilient and can adapt to an array of conditions provided that their optimal living conditions are restored within a reasonable time frame.

Acute stress from successful transportation is not likely to affect the long-term health of an animal adversely, but it can substantially change important psychophysiological measures in ways that could alter the outcome of research if it is performed before these measures normalize. Most studies suggest that animal responses to transportation stress include activation of the brain, changes in behavior, neuroendocrine and peripheral endocrine responses, and activation of homeostatic mechanisms, but these responses can vary with age, species, and strain. They are generally of short duration. Some studies have attempted to define post-transportation recovery times that are required for normalization of specific measures after transport. Physiological changes due to transportation and recovery times are outlined below for the major species of research animals. Generally, physiological changes return to normal within a day or two of transportation. However, it is important to recognize that the sparse literature suggests that some psychophysiological measures may take longer to normalize after transportation and that the time until normalization can be influenced by the duration and intensity of the stress of transportation and the particular stress-responsivity characteristics of the species or strain being transported. In practice, many investigators allow 2 to 3 days to a week or more for animals to recover after transportation and to acclimate to their new environment.

## Rodents

The level of plasma corticosterone, one of the prinicipal stress hormones, increases substantially after transportation (Aguila *et al.*, 1988; Drozdowicz *et al.*, 1990; Landi *et al.*, 1982). The increase is accompanied by changes in immune characteristics, such as a decrease in splenic natural killer cell activity (Aguila *et al.*, 1988), total white cell numbers, lymphocyte counts, thymus weight (Drozdowicz *et al.*, 1990), and humoral immunity (Landi *et al.*, 1982). Body weight also decreases, even in rodents that have access to food and water during transportation (Dymsza *et al.*, 1963; Wallace, 1976; Weisbroth *et al.*, 1977). It has been suggested that normalization of most physiological changes (including corticosterone and body weight) occurs in 2 to 4 days (van Ruiven *et al.*, 1996). However, other measures may take several weeks to normalize. For example, in animals that experience a light-dark shift (as can occur during transportation between continents), the corticosterone circadian rhythm can take more than 2 weeks to resynchronize (Weinert *et al.*, 1994).

The strain of animal can also influence the magnitude of physiological changes caused by transportation. Reproduction in some strains of mice is adversely affected by transportation (Hayssen, 1998), and some murine strains (A/J, DBA/1, SWR, and other strains with different haplotypes of the H-2 histocompatibility complex) may show a greater incidence of shipping-associated development of isolated cleft palate when pregnant females are shipped during the 5 days of gestation before embryonic palate closure (Barlow *et al.*, 1975; Brown *et al.*, 1972; Gasser *et al.*, 1981). Studies have also shown that laboratory mice may be more resilient to transportation-associated stressors than wild-caught animals (Wallace, 1976).

### Nonhuman Primates

There are only sparse data on the effects of transportation in nonhuman primates (Wolfensohn, 1997). One study involving owl monkeys documented the effect of international transportation on body weight (Malaga *et al.*, 1991). All animals in the study lost weight, but the amount of body weight lost was a function of age and not the length of transportation (3 to 14 days). Younger animals lost more weight than mature animals but regained more weight than adults during the 30 days after transportation, irrespective of the length of transportation.

Pregnancy outcome and reproduction rates after transportation have also been studied in nonhuman primates. Pregnancy outcomes of pig-tailed macaques, long-tailed macaques, and baboons were studied by Sackett (1981). He found that shipment during any trimester of pregnancy had no effect on the production of viable offspring versus unshipped controls. Rates of reproduction in the three species were also tracked over a period of 8 years. In general, numbers of offspring produced were unchanged after air transport and in some cases slightly greater. The only adverse effect, not present in all species, was increased latency in rebreeding after transportation.

### Livestock

In cattle, as in other farm species, body temperature rises, heart and respiration rates increase, the hypothalamic pituitary adrenal axis (HPA) activates, and there is an increase in levels of nonesterified fatty acids, blood cortisol, glucocortoid, and glucose after transportation (Marahrens *et al.*, 2003; Nyberg *et al.*, 1988; Warriss *et al.*, 1992). Creatine kinase, albumin, and total plasma protein concentrations also tend to increase with the duration of the journey (Warriss *et al.*, 1995).

In general, physiological changes are largely determined by the age of the animal. For example, transported calves that are less than 4 weeks old do not appear to exhibit as large an HPA response as do mature cattle (Cole *et al.*, 1988; Mormede *et al.*, 1982). At 8 weeks, the response begins to change. Corticosteroids increase, but glucose is variable, either increasing or remaining unchanged (Crookshank *et al.*, 1979; Kent and Ewbank, 1983, 1986a, 1986b; Simensen *et al.*, 1980). In general, those changes return to baseline immediately after transportation (Knowles *et al.*, 1999; Warriss *et al.*, 1992), although some genotypes may have altered endocrine concentrations for months after transport (Nyberg *et al.*, 1988). Young pigs and calves have also been found to have an unstable metabolic rate after transportation, requiring 6 to 9 days to stabilize (del Barrio *et al.*, 1993; Heetkamp *et al.*, 2002; Schrama *et al.*, 1992).

The limited physiological responses observed in adult animals can be much more pronounced after extended periods of food and water deprivation. Livestock are often transported without access to food and water for safety reasons, and the longer the period of deprivation, the longer the time necessary for normalization. Extended periods (more than a day) without food and water may result in 5 days or more before normalization of physiological measures (Warriss *et al.*, 1995).

## ALLOMETRIC SCALING AND IMPLICATION FOR TRANSPORTATION PRACTICES

Transported research animals vary greatly in size, from small rodents to very large sea mammals, and within each species animals can vary in size from neonates to adults. As the size of animals varies, so do the biological processes that affect transportation practices. However, variations in processes such as heat production, metabolic rate, and space requirement are not linear functions of animal size (Lindstedt and Schaeffer, 2002). In other words, an animal that is twice the size of another animal does not have twice its metabolic rate. Rather, the relationship is exponential. The term *allometric scaling* is used to describe methods of quantifying the dependence of biological processes on body mass (West *et al.*, 1997). Implicit in allometric scaling is the principle that small animals occupy more space per unit of body weight than larger animals. Small animals also produce more heat per unit of body weight than larger animals.

The relationships between surface area, metabolic rate, and space required by mammals are defined by the following allometric equations:

Surface area ($m^2$) = $0.1 \times weight^{2/3}$ (Curtis, 1983)
Basal metabolic rate (kcal/hr) = $3.0 \times weight^{3/4}$ (Curtis, 1983)
Floor area (lateral recumbency, $m^2$) = $0.1 \times weight^{1/3}$ (Baxter, 1984)

The larger surface area and basal metabolic rates per unit of body weight of smaller animals means that they evaporate more water and lose more heat per unit of body weight than larger animals. The practical implication is that smaller animals are more susceptible to changes in temperature (cold or hot), wind speed, and humidity. The core temperatures of smaller animals can decrease in cold environments more quickly than those of larger animals.

Smaller animals also become dehydrated more quickly than larger animals and cannot live without water as long. That is because of the larger evaporative skin area and/or respiration rate of small animals. Some species have special adaptations to conserve water, but even among these species, the general relationships between young (smaller) and older (larger) animals apply.

Smaller animals generally have higher metabolic rates per unit of body weight than larger animals. That means that smaller animals can go without food for less time than larger animals, which, because they are larger, have relatively greater nutrient reserves.

## THERMAL ENVIRONMENT

Provision of a proper thermal environment is the most important element of safe and humane animal transportation. Temperature has been implicated as the major factor in leading to animal mortality during transportation in many species (Abbott *et al.*, 1995; e.g., Bayliss and Hinton, 1990; Slanetz *et al.*, 1957). The principles of a safe thermal environment during transportation are not different from those in normal housing. The goal is to identify the range of ambient temperatures over which an animal is able to maintain a physiologically normal core body temperature. In this section, the basic principles of thermoregulation in warm-blooded animals are discussed to provide the scientific basis of the committee's recommendations and to inform the professional judgment of researchers, staff, and institutional animal care and use committees in meeting performance standards.

### Principles of Thermoregulation

Warm-blooded animals are known as homeotherms because they maintain a constant body temperature through a high metabolic rate. That process keeps body temperature constant, independent of the ambient temperature. The average body temperatures of the most common research animal species are listed in Table 3-1.

The thermoneutral zone (TNZ) is the range of ambient temperatures within which an animal's metabolic rate is at a minimum and body tem-

TABLE 3-1 Thermoregulation Data on Common Research Animal Species

| Species | Average Rectal or Intraperitoneal Temperature (°C) | Reference | Thermo-neutral Zone (°C)[a] | Reference |
|---|---|---|---|---|
| Mouse | 36.5 ± 1.3 | Herrington, 1939 | 26 to 34 | Gordon, 1985; Herrington, 1940; Oufara *et al.*, 1987 |
| Rat | 36.7 ± .9 | Herrington, 1940 | 26 to 33 | Gordon, 1990; Gwosdow and Besch, 1985; Swift and Forbes, 1939; Szymusiak and Satinoff, 1981 |
| Guinea pig | 39.2 ± .7 | Herrington, 1940 | 28 to 30 | Fewell, Kang, and Eliason, 1997 |
| Rabbit | 39.5 (38.6 to 40.1) | Robertshaw, 2004 | 15 to 20 | Brody, 1945 |
| Hamster | 36.8 ± .2 | Jones *et al.*, 1976 | 28 to 32 | Jones *et al.*, 1976 |
| Rhesus macaque | 39.1 (37.9 to 40.0) | Johnson and Elizondo, 1979 | 24.7 to 30.6 | Johnson and Elizondo, 1979 |
| Dog | 38.9 (37.9 to 39.9) | Robertshaw, 2004 | 20 to 26 | Brody, 1945 |
| Pig | 39.2 (38.7 to 39.8) | Robertshaw, 2004 | 16 to 23 | Huynh *et al.*, 2005 |
| Cat | 38.6 (38.1 to 39.2) | Robertshaw, 2004 | 35 to 38 | Adams *et al.*, 1970 |
| Sheep | 39.1 (38.3 to 39.9) | Robertshaw, 2004 | 21 to 25 | Brody, 1945 |
| Beef cow | 38.3 (36.7 to 39.1) | Robertshaw, 2004 | –18 to 23 | Hahn, 1999 |
| Dairy cow | 38.6 (38.0 to 39.3) | Robertshaw, 2004 | –15 to 26 | Hahn, 1999 |
| Stallion | 37.6 (37.2 to 38.1) | Robertshaw, 2004 | 5 to 25 | Morgan, 1998 |
| Mare | 37.8 (37.3 to 38.2) | Robertshaw, 2004 | 5 to 25 | Morgan, 1998 |
| Goat | 39.1 (38.5 to 39.7) | Robertshaw, 2004 | 13 to 21 | Brody, 1945 |

[a]Thermoneutral zones can vary by strain, age, and reproductive or health status. The measurement of an animal's thermoneutral zone may also be influenced by the room temperature and caging condition of the animal's regular housing.

[b]That results in no substantial change in core temperature over the time period indicated in parentheses. In some cases, lowest and highest tolerated ambient temperatures were determined in acclimated animals.

| Lowest Tolerated Ambient Temperature[b] (°C) | Reference | Highest Tolerated Ambient Temperature[b] (°C) | Reference |
|---|---|---|---|
| –5 (3 hr) | Oufara *et al.*, 1987 | 34 (2 to 3hr) | Oufara *et al.*, 1987 |
| –15 (3 hr) | Depocas *et al.*, 1957 | 34 (100 min) | Gordon, 1987 |
| –20 (1.5 hr) | Huttunen, 1982 | 36 (30 min) | Fewell *et al.*, 1997 |
| –10 (2 hr) | Harada and Kanno, 1975 | 32.2 (2 hr) | Besch and Brigmon, 1991 |
| –30 (1hr) | Pohl, 1965 | 32 (60 to 80 min) | Jones *et al.*, 1976 |
| 15 (1 hr) | Johnson and Elizondo, 1979 | 40.0 (1 hr) | Johnson and Elizondo, 1979 |
| –35 (30 min) | Good and Sellers, 1957 | 35.0 (2 hr) | Besch *et al.*, 1984 |
| –20 (indefinitely) | FASS, 1999 | 35 (indefinitely) | FASS, 1999 |
| –5 (1.5 hr) | Hensel and Banet, 1982 | 35 (1.5 hr) | Adams *et al.*, 1970 |
| — | — | — | — |
| — | — | — | — |
| — | — | — | — |
| — | — | — | — |
| — | — | — | — |
| –13 (indefinitely) | Schaeffer *et al.*., 2001 | — | — |

perature is maintained solely through autonomic responses (piloerection and peripheral vasomotor tone) and behavioral responses (adjusting posture to bring limbs close to or away from body) (Bligh and Johnson, 1973). In Figure 3-1, the committee has modeled the relationship between metabolic rate and ambient temperature in homeotherms. The TNZ is represented in Figure 3-1 as the area between C, the lower critical temperature, and D, the upper critical temperature (UCT). This zone is narrow in some species, particularly the smaller research animals (see Table 3-1). The midpoint of the TNZ is usually 7 to 10°C below normal rectal temperature and 5°C below normal skin temperature (Brody, 1945).

The TNZs for rats and mice (Table 3-1) vary in the scientific literature because TNZ estimates depend on the environments in which the animals are housed and assessed. TNZs can also vary considerably with age and reproductive status, as illustrated for chickens in Figure 3-2 and several other livestock species in Figure 3-3. Comparable data on commonly used laboratory species are not available.

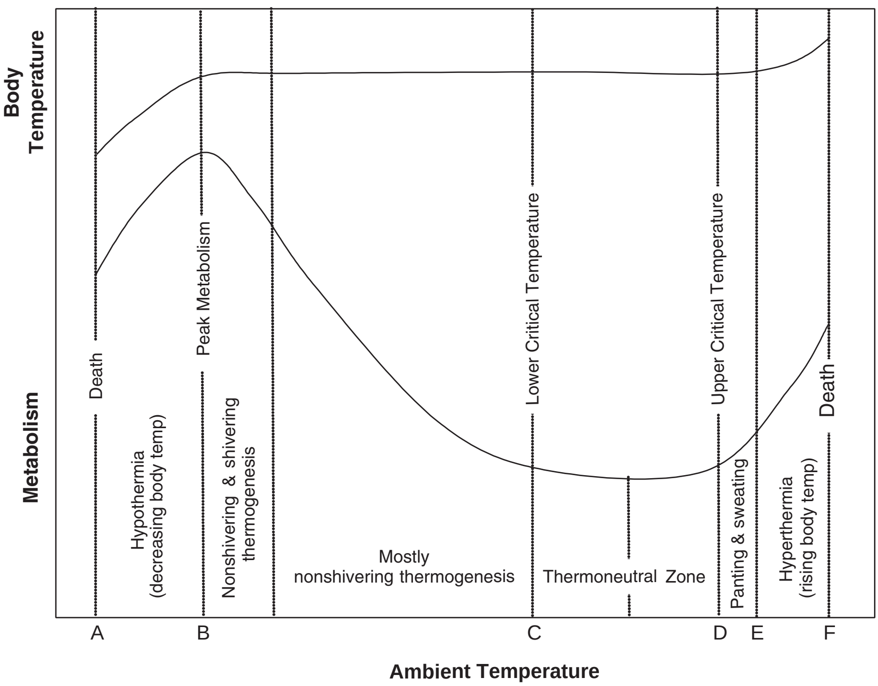


**FIGURE 3-1** Graph representing relationship between metabolic rate and ambient temperature in homeotherms.

When the ambient temperature falls below the TNZ, physiological mechanisms collectively referred to as nonshivering thermogenesis (oxidation of fatty acids and brown adipose tissue) are initiated; they increase metabolic rate, balance heat production and loss, and maintain body temperature (Robertshaw, 2004). As ambient temperatures continue to fall, nonshivering thermogenesis is no longer adequate to offset heat loss and maintain body temperature. Shivering thermogenesis (involuntary contractions of skeletal muscles) then occurs and further increases heat production (Robertshaw, 2004). As ambient temperatures continue to decrease, heat production through nonshivering and shivering thermogenesis reaches the maximum rate that can be sustained over long periods. This point of maximal heat production is known as peak metabolism (B in Figure 3-1) (Robertshaw, 2004). The peak metabolic rate is 3 to 4 times the basal metabolic rate in most species (Brody, 1945). If the ambient

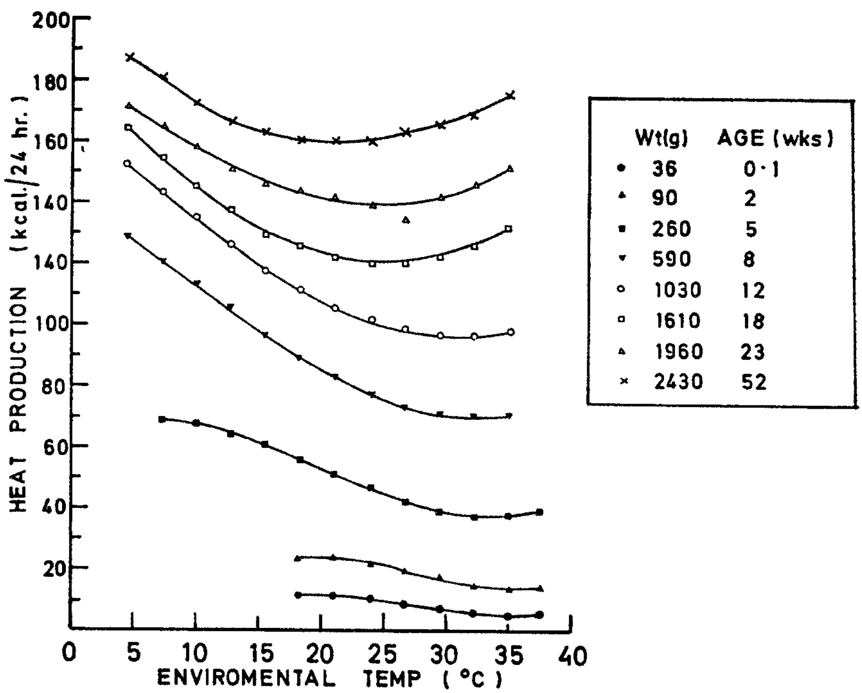


**FIGURE 3-2** Changes in thermoneutral zone (range of ambient temperatures at which an animal's heat production is at a minimum) with age and size in chickens. TNZ of chickens shifts to lower temperatures as chickens grow and age. Reprinted from Fuller, 1969.

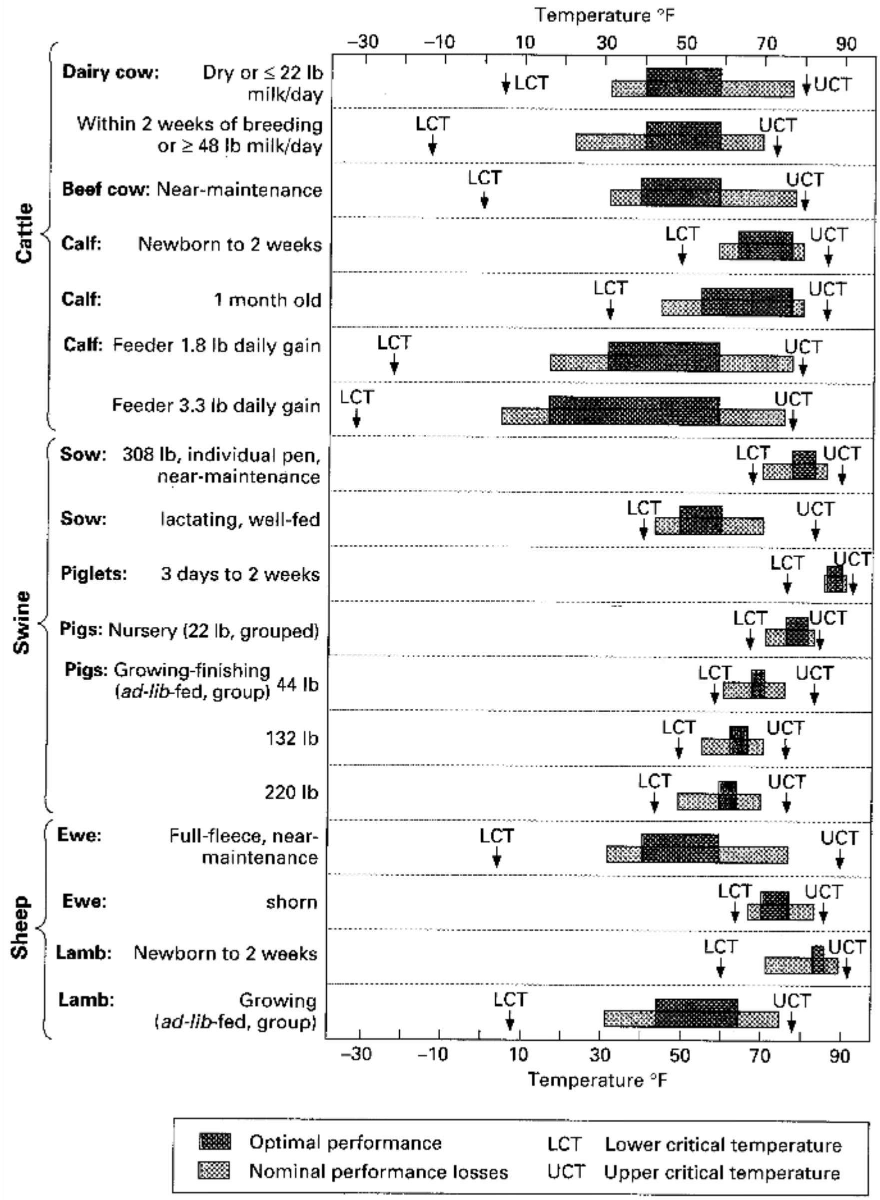


**FIGURE 3-3** TNZ of various agricultural animals. Reprinted with permission from Taylor, R.W., and T.G. Field. 2004. *Scientific Farm Animal Production*, 8th ed. Upper Saddle River, NJ: Prentice Hall; p352. ©2004 Pearson Education, Inc.

temperature decreases further (below B in Figure 3-1), heat production decreases, body temperature decreases (hypothermia), and death eventually occurs. Animals can boost exertions at peak metabolic rates 10 to 15 times their basal metabolic rates during periods of high exertion (Robertshaw, 2004), as occurs in humans during a 100-m race. However, these peak metabolic rates cannot be sustained and are of little value in maintaining body temperature during prolonged cold exposure.

The range of ambient temperatures over which an animal can maintain its core body temperature is depicted in Figure 3-1 between B and E. The lowest ambient temperature at which an animal can maintain its body temperature is generally much lower than its TNZ (see Table 3-1), but the highest ambient temperature at which an animal can maintain its body temperature is generally close to the upper limit of its TNZ. This is because most research animals are nonsweating species (Brody, 1945) and have a limited capacity for dissipating heat. When the ambient temperature rises above the upper limit of the TNZ, heat is dissipated by increasing radiant heat loss (through increased peripheral vascular flow) and evaporative heat loss (through panting, sweating, and saliva spreading). When the ambient temperature is at body temperature, there is no radiant heat loss. Panting can still dissipate heat when ambient temperature reaches body temperature, but it has less capacity to dissipate heat because the energy expended (and heat produced) as panting increases eventually offsets the heat lost through panting (Brody, 1945).

Sweating provides the largest capacity for heat dissipation in homeotherms, so it is important to recognize that most common research animals are nonsweating species and do not have the same capacity to dissipate heat as profusely sweating species such as humans and horses. For example, at an ambient temperature of about 36°C, all of the heat produced by a human can be dissipated through sweating, but only 30 to 40% of the heat produced by nonsweating species—such as rodents, cats, dogs, rabbits, swine, sheep, and cattle—can be so dissipated (Brody, 1945). It should be noted that most nonhuman primates—rhesus macaques are an exception (Johnson and Elizondo, 1979)—have not been observed to sweat over their general body surface and should be considered nonsweating species for the purposes of determining safe ambient temperatures for transportation (Stitt and Hardy, 1971).

Animal handlers must be acutely aware that although they as humans may be able to remain reasonably comfortable because sweating reduces their heat load, the nonsweating animals they care for are not able to remain comfortable through sweating. That must be emphasized during the training of handlers, because temperatures well within human tolerance zones can be deadly to many species of research animals (Ohara *et al.*, 1975; Oufara *et al.*, 1987; Wright, 1976).

### Safe Temperature Ranges During Transport

An animal must be transported in an environment in which it can maintain its body temperature, becoming neither hyperthermic nor hypothermic. Due to the many and often interacting physiological and environmental variables that can affect body temperature, it is impossible to specify exact ambient temperature ranges that guarantee that animals will remain homeothermic during transportation. The thermal requirements of animals vary widely depending on age, physiological state, and the environment in which they were previously housed and to which they have adapted. For example, newborns are less tolerant of thermal extremes than adults, and late-pregnancy and lactating animals are less tolerant of heat. In addition, animals previously maintained in cold environments with high feed intakes and high rates of resting heat production (Young, 1975) do not tolerate heat as well as animals previously maintained in a hot environment with low feed intakes and low metabolic rates (NRC, 1981). The effect of the higher rates of heat production associated with pregnancy, lactation, and cold acclimation is an increase in the amount of heat that animals must dissipate as environmental temperatures approach and exceed body temperature, that is, a reduction in heat tolerance.

It could be suggested that homeothermic animals be transported in ambient temperatures within their TNZ. The range of the TNZ for most agricultural animals is large, allowing for safe transportation over a relatively wide range of ambient temperatures (see Table 3-1). The Livestock Weather Safety Index was developed to guide decision making for transporting swine during weather extremes (Livestock Conservation Institute, 1970). More information about the Livestock Weather Index can be found at the National Institute for Animal Agriculture (formerly known as the Livestock Conservation Institute) website:

http://animalagriculture.org/

The TNZ for the more common research animals (rodents, cats and dogs, and nonhuman primates) is narrower than in livestock. However, upper limit of the safe range for transport of those animals is also based on the UCT of an animal's TNZ. Unlike humans, who can maintain their body temperatures above their TNZ through sweating, most research animals are nonsweating species and have a limited capacity for dissipating heat.

Though the highest ambient temperature at which those animals can maintain their body temperature is close to the upper limit of its TNZ, the lowest ambient temperature at which those animals can maintain their body temperature is generally much lower than its TNZ. In order to determine the lower limit of the range of ambient temperatures for safe transportation, the committee turned to the acclimation literature. It is well established in the cold-acclimation literature that the more common research animals can be housed in conditions around 6°C for weeks or months with no ill effects (Besch *et al.*, 1984; Depocas *et al.*, 1957; Gordon, 1988; Whiting and Brandt, 2002). Therefore, the lower limit of the temperature range for safe transport was defined as the lowest temperate to which a species had been successfully acclimated (see Table 3-2).

The temperature ranges in Table 3-2 should be considered only as a general guideline. In many cases, air temperature alone is insufficient to determine whether a particular animal or species can be transported safely. Wind chill, sun exposure, and particularly humidity can greatly influence the temperature that an animal effectively experiences (see Table 3-3). For example, air feels colder with even a slight wind. In addition to environmental factors, physiological factors can affect the ambient temperature at which an animal can maintain its core body temperature. These factors include physiological states such as late pregnancy and lactation, previous acclimation, disease status, hydration state, feeding level, exercise, anesthesia, and body fat.

Nevertheless, short-term exposures to thermal extremes during transportation do not generally result in adverse physiological effects except when the short-term temperature exposures are particularly high. As documented in Table 3-1, most common research animal species are able to maintain their core temperature over the course of several hours at extreme temperatures. Even animals with narrow TNZs (e.g., Xin, 1997) can tolerate high temperatures and large fluctuations in temperature over extended periods if provided appropriate food and hydration. **The committee recommends that professional judgment be considered the final determinant of whether the ambient temperatures that animals will be exposed to during transportation are safe.** Many factors must be considered if professional judgment is utilized, including humidity, stocking density, the characteristics of the transportation cage, plumage and hair coat, previous adaptation, metabolic and behavioral characteristics, physiologic status, food and water consumption, trip length, and potential temperature extremes.

The effects of physiological and environmental factors on the effective temperature that an animal experiences during transportation have been well documented in birds and can be generalized to most other species. Birds with feather loss or poor feather condition lose insulating capability. This loss can be detrimental under cold conditions and beneficial in hot conditions. Likewise, thin birds are less able to maintain their body temperature in cold conditions than birds with more adequate body

TABLE 3-2 Ambient Temperature Range for Safe Transportation of Common Adult Research Animals[a]

| Species | Ambient Temperature Range for Safe Transportation[b] (°C) | References |
|---|---|---|
| Mouse | 4[c] to 34 | Oufara *et al.*, 1987 |
| Rat | 6[c] to 33 | Depocas *et al.*, 1957 |
| Guinea pig | 4[c] to 34 | Himms-Hagen *et al.*, 1995 |
| Rabbit | 4[c] to 33[c] | Cooper *et al.*, 1980; Honda *et al.*, 1962 |
| Hamster | 6[c] to 34[c] | Jones *et al.*, 1976; Pohl, 1965 |
| *Macaca mulatta* | 6[c] to 35 | Oddershede and Elizondo, 1980, 1982 |
| Dog | –10[c] to 28 | Nagasaka and Carlson, 1965 |
| Pig | –20 to 35[d] | FASS, 1999 |
| Cat | 5[c] to 30[c] | Adams, 1963; Hensel and Banet, 1982 |
| Sheep | –12[c] to 25 | Horton, 1981 |
| Beef cow | –18 to 23 | |
| Dairy cow | –15 to 26 | |
| Stallion | 5 to 25 | |
| Mare | 5 to 25 | |
| Goat | –13[c] to 21 | Schaeffer *et al.*, 2001 |

[a]Humidity, wind chill, sun exposure, hydration state, physiological state, age, acclimation, and so on, can greatly influence these ranges (see Table 3-3). Professional judgment must be used in determining safe transportation of research animals.

[b]The maximum and minimum temperatures of the range were derived from the upper limit and lower limit, respectively, of that species thermoneutral zone as described in Table 3-1, unless otherwise noted. Most larger mammals can be transported when the temperature is below freezing as long as the temperature inside the transport compartment does not cause frostbite or other signs of extreme cold. Conditions inside transport compartments, especially warm, deep bedding will allow animals to establish a microenvironment that is comfortable. Professional judgment should be used to assess risks to animal welfare when animals are preconditioned or not preconditioned for transport.

[c]Temperature derived from the lowest or highest temperature to which that species has been acclimated. It is possible that animals could be safely transported at more extreme temperatures; however, the literature neither supports nor negates the possibility.

[d]Recommended thermal conditions for swine.

conditions (Schrama *et al.*, 1996). The age of the animal also influences the thermal conditions that are suitable for safe transport. As shown in Figure 3-2, young birds have a narrower TNZ than mature birds. Thus the temperature at which thermogenesis begins is higher in younger birds, making these animals more susceptible to cold.

The phenotypes of some animal strains and transgenic animals must also be considered when the animals have abnormal metabolic characteristics. Some pigs carry a mutation in a gene that causes malignant hyper-

TABLE 3-3 Effects of Various Factors on Effective Environmental Temperature and Relative Risk to Animal Health and Welfare

| Factor | Very Cold Outside Temperature | Risk | Very Hot Outside Temperatures | Risk |
|---|---|---|---|---|
| High relative humidity | Little effect | Low | Much warmer | Very high |
| High air velocity | Much colder | High | Feels colder as long as air temperature is below animal core temperature | Low |
| Food deprivation | Much colder | High | Little effect | Low |
| Water deprivation | Colder | Medium | Much warmer | High |
| High stocking density | Warmer | Zero or positive effect | Much warmer | Very high |
| Illness (fever) | Colder | Medium | Warmer | Medium |
| Fat (high subcutaneous insulation) | Warmer (protective) | Low | Warmer | High |
| Stress susceptible genotypes[a] | Colder | High | Warmer | Very high |
| Surface cover (plumage and hair coat) | Warmer | Protective | Warmer | High |
| Previous experience or adaptation to cold temperatures | Warmer | Zero or positive effect | Warmer | High |
| Previous experience or adaptation to hot temperatures | Colder | High | Colder | Zero or positive effect |

[a]May include malignant hyperthermia or transgenic animals that have thermoregulatory or physiological dysfunction.

SOURCE: Table adapted from Schrama *et al.*, 1996.

thermia when stress is experienced (McGlone and Pond, 2003). These animals become warm and red-skinned during stress and develop muscle tremors and an inability to walk. In some instances, animals may die as a result of malignant hyperthermia.

Behavior can affect the thermal experience. The stocking density of birds within the transportation crate may inhibit or encourage thermal regulating behaviors, such as stretching and fanning wings during heat episodes or huddling close to other birds under cold conditions. Posthatch-fasted male chicks held in shipping containers exhibited dispersal behaviors at 35ºC (Xin and Harmon, 1996), and birds transported at high densities during hot weather are more prone to heat stress (Schrama *et al.*, 1996). As chicks were subjected to lower temperatures, huddling became more evident, and the most huddling occured at 20ºC (Xin and Harmon, 1996). Those behaviors also altered moisture production within the container; there was more moisture loss from animals as they spread out at higher temperatures.

Safe temperature ranges for transportation are more difficult to establish for poikilotherms such as reptiles and amphibians. In poikilotherms, a decrease or increase in body temperature of a few degrees is not a cause for concern. Animal activity and alertness may be better indicators of comfort temperature than body temperature (which varies considerably with air temperature).

### Effect of Transportation Caging on Thermal Environment

A major factor that can influence an animal's effective environmental temperature is the nature of its transportation cage. Transportation containers for small research animals (such as rodents and chicks) are almost always stacked. That feature potentially restricts air flow into or around the containers and can increase the temperature in a container to exceed that of the surrounding environment. For example, when a commonly used commercial chick container was stacked six high in four stacks with 2.5 cm of vertical distance between containers and 5.1 cm between the stacks, the temperature inside the containers was about 5.5 to 10°C above the ambient temperature (Tanaka and Xin, 1997). The IATA Live Animals Regulations (Container Standard #84) and the Animal Welfare Act (9 CFR 3.14(c)(2), 9 CFR 3.36(a)(6), 9 CFR 3.61(a)(5), 9 CFR 3.87(c)(2), 9 CFR 3.137(a)(5)) provide guidance on using spacers or projecting rims in order to prevent obstruction of the ventilation openings and provide space for air circulation.

Transportation containers with biocontainment filters can similarly restrict air flow into a container, increasing the container temperature. In some facilities, rodent transportation caging is autoclaved for reuse. It has been suggested that such autoclaving may increase the air resistance of the biocontainment filter and restrict air flow (White, 2004). Until it can be established that reautoclaving biocontainment filters does not restrict air flow below acceptable levels, the committee suggests that the prudent course of action is to avoid reautoclaving and reuse of the containers.

### Behavioral Monitoring of Thermal Environment

Ideally, all animals should be transported in environmentally controlled vehicles. That method would eliminate concerns about thermal stress. However, such transportation is often unavailable, particularly for nonrodent species, and other precautions and procedures, such as monitoring animal behavior, must be used to ensure the animals' welfare.

As discussed above, when ambient temperatures change, animals use both physiological and behavioral mechanisms either to increase heat production or to promote heat loss and maintain a homeothermic state. Evidence of those mechanisms does *not* necessarily indicate that an animal has become hypothermic or hyperthermic. However, prolonged display of the behaviors listed in Table 3-4 is an indication that the animal is stressed and may not remain homeothermic. Although the temperature ranges in Table 3-2 can generally be considered safe for the transportation of research animals, many factors can affect the effective ambient temperature (see Table 3-3). **Therefore, when animals cannot be transported in environmentally controlled vehicles, the committee recommends frequent visual inspection of the animals when practical, as signs of thermogenesis or heat loss may indicate that the animal's thermal environment should be adjusted.** Exposure to unaccustomed temperature extremes, particularly high temperature, can be more stressful, harmful, and deadly than suspected by researchers and staff who are accustomed to handling and observing animals in controlled housing conditions.

### Thermal Acclimation

When it is anticipated that an animal will encounter extreme temperatures during transportation, as may occur during loading of animals onto airplanes during winter and summer in some parts of the United States, prior acclimation may be appropriate, if practical. During acclimation, prolonged exposure to a single component of the environment—in this case either heat or cold—results in physiological changes that allow an animal to respond more effectively to that component (Robertshaw, 2004). For example, rats acclimatized to 6ºC can maintain their body temperature when exposed to –15ºC for a period of at least 3 hr (Gordon, 1990).

TABLE 3-4 Behavioral and Physiological Signs of Thermal Status

| Species | Signs of Thermogenesis | Signs of Heat Loss |
|---|---|---|
| Rodents | Piloerection<br>Cutaneous vasoconstriction (paleness of skin of ears or feet)<br>Shivering<br>Drawing limbs close to body (curling up) | Saliva spreading<br>Cutaneous vasodilation (redness of skin of the ears or feet)<br>Closed-mouth panting (increased respiratory frequency) |
| Dogs and cats | Piloerection<br>Cutaneous vasoconstriction (paleness of skin of ears or feet)<br>Shivering<br>Drawing limbs close to body (curling up) | Open-mouth panting<br>Extending limbs (maximizing surface area)<br>Cutaneous vasodilation (redness of skin of ears or feet) |
| Agricultural animals (cows, sheep, goats, and horses) | Piloerection<br>Cutaneous vasoconstriction (paleness of skin of ears or feet)<br>Shivering<br>Drawing limbs close to body (curling up) | Sweating<br>Closed-mouth panting (increased respiratory frequency) |
| Birds | Piloerection<br>Cutaneous vasoconstriction (paleness of skin of ears or feet)<br>Shivering<br>Drawing limbs close to body (curling up) | Open-mouth panting |

SOURCE: Adapted from Robertshaw, 2004.

## SPACE ALLOCATION

The need for space allocations during transportation of research animals is the subject of public concern and regulations—but few scientific studies. The space needs of animals during transportation are different from their space needs in resident housing. Space needs also vary with animal temperament, social relationships, thermal environment, and species-specific behavioral requirements.

It is clear that the floor space required during transportation is different from the floor space required during long-term housing. In conventional housing, there are often few adverse effects of providing too much space, but this is not the case during transportation. If transported animals have too much space, they can fall, injure themselves, or even be killed.

Animals should never be in a situation in which they may come into contact with container walls with force or roll around. At the other end of the spectrum, animals should never have so little space that they pile on top of one another; this situation can cause animal injury and may potentially lead to suffocation.

Although smaller animals occupy less space than larger animals, they occupy more space per unit of body weight. Thus, 10 1-kg animals require more space than one 10-kg animal if other considerations are equal. However, the space that animals occupy depends on their posture. All species commonly adopt distinct postures during transportation. For example, horses and adult cattle stand during the entire trip, but rodents, pigs, young calves, dogs, and cats lie down during stable parts of the trip. The order of space occupancy from greatest to least is lateral recumbency, sternal recumbency, sitting, and standing. The space needs of individual animals also depend on whether they are transported alone or in groups and on whether they normally stand or lie down during transportation. The personnel responsible for placing animals in transportation caging must be familiar with the normal behavior of each species to assess the adequacy of the floor space provided.

Determining the appropriate density of animals in a transportation cage or vehicle must take into account weather conditions, the physical characteristics of the species (such as horns, pilage condition), and the preferred posture, if any, adopted during transportation. Simply providing transported animals large amounts of space may not be conducive to their welfare in all instances. For example, low stocking densities can present problems with balance during transportation. Many species, including cattle, rarely adopt a vulnerable posture such as lateral recumbency. If they remain standing, those animals may fall down as the transportation vessel experiences movement in different directions. Even if they eventually adopt a sternal recumbent posture, they can fall or roll in the transportation compartment and be injured. Cattle tend to prefer standing, so it is imperative that they can adjust footing or brace against other cattle to prevent slipping and falling.

Some people have suggested that a high stocking density is preferable for horses and cattle because the animals "hold each other up," preventing injuries due to falls or rolls (Friend, 2001). However, studies of stocking density indicate that high stocking densities are associated with a higher rate of injury (Friend, 2001). Pushing and mounting behaviors tend to increase with stocking density (Tarrant *et al.*, 1992), which can lead to injury. Also, the ability of animals to rise after a fall is hampered at high stocking densities, leading to more injuries and a greater severity of injury (Collins *et al.*, 2000). In addition, high stocking densities decrease social interactions among animals and may prevent them from assuming a preferred orientation (parallel or perpendicular to motion) during travel (Eldridge *et al.*, 1988; Kenny and Tarrant, 1987; Lambooy and Hulsegge, 1988; Tarrant *et al.*, 1992). Based on the literature, a moderate stocking density for cattle and horses maximizes animal welfare (Swanson and Morrow-Tesch, 2001; Tarrant and Grandin, 2000).

There is abundant literature on the space requirements or stocking densities necessary to optimize the welfare of agricultural animals during transportation, but none on the most common species of research animals—rats and mice. Rodent vendors have developed space allowances for rodents on the basis of practical experience. When a regression of the space allowances for agricultural animals and rodents was performed (Table 3-5), the trend line (Figure 3-4) had a very high coefficient of determination ($r^2 = 0.9915$). That value suggests that there is a mathematical algorithm that describes the transportation space required to maximize the well-being of group-transported animals, and it provides information on the transportation space required for unusual research animals for which space requirements are unknown. Transportation space requirements for guinea pigs and hamsters mandated in the Animal Welfare Act also follow the trend line; although they are not obviously based on empirical data, those space requirements might be appropriate. The algorithm would be useful to people who are attempting to determine the transportation space needs for an uncommon species of research animal for whose transportation there are neither guidelines nor much practical experience.

## FOOD AND WATER

Most animals react to the experience of being transported by becoming anorexic and adipsic. The stressful experiences of a novel environment, movement of the transportation vehicle, and food and water sources that differ from those in the animal's previous environment for logistical reasons inhibit food and water consumption. However, animals lose weight more rapidly when transported than they would normally during the same period without feed and water. That consequence implies that transportation is stressful for reasons beyond the lack of feed and water.

Provision of feed or water during transportation can be problematic because of food spoilage and water spillage; wetting of the floor by spilled water, which results in chilling, slipping, and injuries; animals' lack of ability to eat or drink while in motion; motion sickness; and lack of motivation to eat or drink during the trip. Thus, providing food or water may not be of any benefit during short trips because of lack of motivation to consume food and water. Provision of feed and water during very long trips requires special attention, especially if the vehicle stops or has periods of stability during which animals may seek food and water. In

TABLE 3-5 Space Allowances for Group-Transported Animals[a]

| Species | (lb) | (kg) | ($ft^2$) | ($m^2$) | Source |
|---|---|---|---|---|---|
| Mice | 0.053 | 0.024 | 0.09 | 0.008 | Harlan[b] |
| Mice | 0.055 | 0.025 | 0.04 | 0.004 | Jackson Laboratories[b] |
| Mice | 0.075 | 0.034 | 0.10 | 0.009 | Harlan[b] |
| Mice | 0.077 | 0.035 | 0.07 | 0.006 | Charles River[b] |
| Gerbils | 0.077 | 0.035 | 0.08 | 0.007 | Charles River[b] |
| Gerbils | 0.110 | 0.050 | 0.11 | 0.010 | Charles River[b] |
| Gerbils | 0.132 | 0.060 | 0.13 | 0.012 | Charles River[b] |
| Gerbils | 0.154 | 0.070 | 0.18 | 0.017 | Charles River[b] |
| Rats | 0.110 | 0.050 | 0.13 | 0.012 | Charles River[b] |
| Rats | 0.110 | 0.050 | 0.10 | 0.009 | Taconic[b] |
| Rats | 0.163 | 0.074 | 0.16 | 0.015 | Harlan[b] |
| Rats | 0.165 | 0.075 | 0.16 | 0.015 | Charles River[b] |
| Rats | 0.165 | 0.075 | 0.11 | 0.010 | Taconic[b] |
| Rats | 0.218 | 0.099 | 0.19 | 0.018 | Harlan[b] |
| Rats | 0.220 | 0.100 | 0.21 | 0.019 | Charles River[b] |
| Rats | 0.220 | 0.100 | 0.12 | 0.011 | Taconic[b] |
| Rats | 0.273 | 0.124 | 0.22 | 0.020 | Harlan[b] |
| Rats | 0.276 | 0.125 | 0.27 | 0.025 | Charles River[b] |
| Rats | 0.276 | 0.125 | 0.13 | 0.012 | Taconic[b] |
| Rats | 0.328 | 0.149 | 0.25 | 0.023 | Harlan[b] |
| Rats | 0.331 | 0.150 | 0.30 | 0.028 | Charles River[b] |
| Rats | 0.331 | 0.150 | 0.15 | 0.014 | Taconic[b] |
| Rats | 0.384 | 0.174 | 0.29 | 0.027 | Harlan[b] |
| Rats | 0.386 | 0.175 | 0.18 | 0.017 | Taconic[b] |
| Rats | 0.441 | 0.200 | 0.33 | 0.031 | Charles River[b] |
| Rats | 0.494 | 0.224 | 0.35 | 0.032 | Harlan[b] |
| Rats | 0.505 | 0.229 | 0.43 | 0.040 | Harlan[b] |
| Rats | 0.551 | 0.250 | 0.44 | 0.041 | Charles River[b] |
| Rats | 0.551 | 0.250 | 0.24 | 0.023 | Taconic[b] |
| Rats | 0.606 | 0.275 | 0.29 | 0.027 | Taconic[b] |
| Rats | 0.661 | 0.300 | 0.53 | 0.050 | Charles River[b] |
| Rats | 0.717 | 0.325 | 0.36 | 0.034 | Taconic[b] |
| Rats | 0.882 | 0.400 | 0.67 | 0.062 | Charles River[b] |
| Rats | 0.882 | 0.400 | 0.49 | 0.045 | Taconic[b] |
| Rats | 0.992 | 0.450 | 0.89 | 0.083 | Charles River[b] |
| Hamsters | 0.110 | 0.050 | 0.11 | 0.010 | Charles River[b] |
| Hamsters | 0.132 | 0.060 | 0.13 | 0.012 | Harlan[b] |
| Hamsters | 0.176 | 0.080 | 0.13 | 0.012 | Charles River[b] |
| Hamsters | 0.220 | 0.100 | 0.15 | 0.014 | Harlan[b] |
| Hamsters | 0.287 | 0.130 | 0.17 | 0.015 | Harlan[b] |
| Guinea Pigs | 0.549 | 0.249 | 0.27 | 0.025 | Harlan[b] |
| Guinea Pigs | 0.769 | 0.349 | 0.33 | 0.031 | Harlan[b] |
| Guinea Pigs | 0.772 | 0.350 | 0.27 | 0.025 | Charles River[b] |
| Guinea Pigs | 1.210 | 0.549 | 0.44 | 0.041 | Harlan[b] |
| Guinea Pigs | 1.323 | 0.600 | 0.44 | 0.041 | Charles River[b] |
| Guinea Pigs | 1.764 | 0.800 | 0.53 | 0.050 | Charles River[b] |

*continued*

TABLE 3-5 Continued

| Species | (lb) | (kg) | ($ft^2$) | ($m^2$) | Source |
|---|---|---|---|---|---|
| Rabbits | 7.915 | 3.59 | 1.44 | 0.134 | Harlan[b] |
| Swine | 10.00 | 4.54 | 0.70 | 0.065 | Whiting and Brandt, 2002 |
| Swine | 20.00 | 9.07 | 0.90 | 0.084 | Whiting and Brandt, 2002 |
| Swine | 30.00 | 13.60 | 1.00 | 0.093 | Whiting and Brandt, 2002 |
| Swine | 50.00 | 22.70 | 1.50 | 0.139 | Whiting and Brandt, 2002 |
| Swine | 60.00 | 27.20 | 1.70 | 0.158 | Whiting and Brandt, 2002 |
| Swine | 70.00 | 31.20 | 1.80 | 0.167 | Whiting and Brandt, 2002 |
| Swine | 80.00 | 36.30 | 1.90 | 0.177 | Whiting and Brandt, 2002 |
| Swine | 90.00 | 40.80 | 2.10 | 0.195 | Whiting and Brandt, 2002 |
| Swine | 100.00 | 45.40 | 2.20 | 0.204 | Whiting and Brandt, 2002 |
| Swine | 110.00 | 49.90 | 2.30 | 0.214 | Whiting and Brandt, 2002 |
| Swine | 120.00 | 54.40 | 2.50 | 0.232 | Whiting and Brandt, 2002 |
| Swine | 130.00 | 59.00 | 2.60 | 0.242 | Whiting and Brandt, 2002 |
| Swine | 140.00 | 63.50 | 2.80 | 0.260 | Whiting and Brandt, 2002 |
| Swine | 150.00 | 68.00 | 2.90 | 0.269 | Whiting and Brandt, 2002 |
| Sheep (Full Fleece) | 60.00 | 27.00 | 2.20 | 0.210 | FASS, 1999 |
| Sheep (Full Fleece) | 80.00 | 36.00 | 2.60 | 0.240 | FASS, 1999 |
| Sheep (Full Fleece) | 100.00 | 45.00 | 3.00 | 0.270 | FASS, 1999 |
| Sheep (Full Fleece) | 120.00 | 55.00 | 3.40 | 0.310 | FASS, 1999 |
| Calves | 200.00 | 91.00 | 3.50 | 0.320 | FASS, 1999 |
| Calves | 300.00 | 136.00 | 4.80 | 0.460 | FASS, 1999 |
| Calves | 400.00 | 182.00 | 6.40 | 0.570 | FASS, 1999 |
| Calves | 600.00 | 273.00 | 8.80 | 0.800 | FASS, 1999 |
| Cattle (Horned) | 800.00 | 364.00 | 10.90 | 1.000 | FASS, 1999 |
| Cattle (Horned) | 1,000.00 | 455.00 | 12.80 | 1.200 | FASS, 1999 |
| Cattle (Horned) | 1,200.00 | 545.00 | 15.30 | 1.400 | FASS, 1999 |
| Cattle (Horned) | 1,400.00 | 636.00 | 19.00 | 1.800 | FASS, 1999 |

[a]More space may be given during transportation than is listed, but more floor space increases the risk of animal injury. More space per animal is needed in warm weather and during long trips (over 48 hr; FASS, 1999). Space allowances are to be tempered with professional judgment to accommodate strains, species, thermal conditions, special models, and protocol requirements.

[b]Space allowances calculated from caging density and cage specification data available in corporate literature.

cases where an animal may refuse food because it is presented in a novel form or source, animals should be adapted to the travel and post-travel diets and to feed and water dispensers before travel. Exposure to the food forms and water sources that will be used during travel before the trip may help to reduce dehydration and weight losses during transportation.

Small animals (young animals or small animal species of any age) can survive less time without food and water than larger animals. Water is the

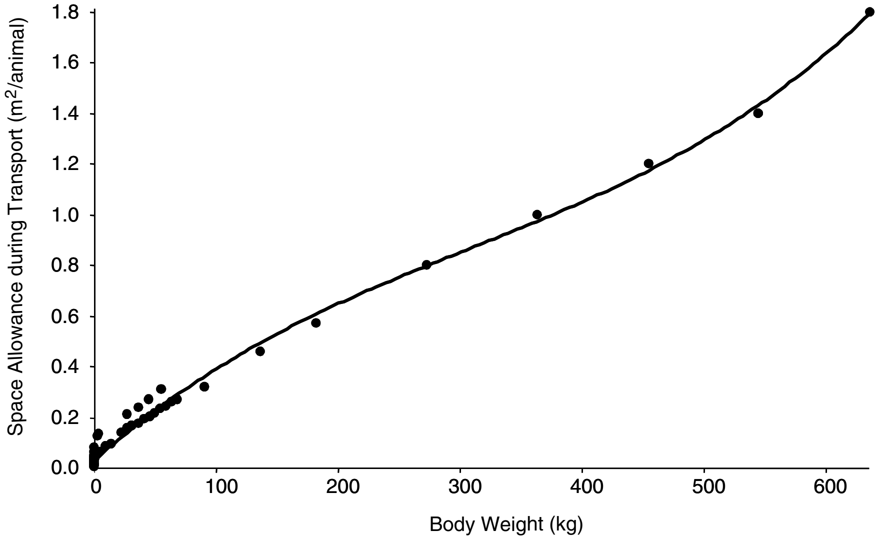


**FIGURE 3-4** Space allowances during transportation. Based on transportation space allowances in Table 3-5. Second-order polynomial regression resulted in trend line ($y = 8^{-9}x^3 - 8^{-6}x^2 + 0.0043x + 0.0302$) with a coefficient of determination ($r^2$) of 0.9929.

most important consideration for trips of intermediate length for most species. Small animals lose more heat, require more calories per unit of body mass, and become dehydrated more quickly than larger animals. Schlenker and Muller (1997) identified the duration of water and food deprivation as factors in the high mortality of air-shipped chicks. Post-hatching metabolic changes and physical development of chicks exacerbate the development of pathological conditions.

In most cases, small animals (less than 1 kg) will require a source of food and water during transportation that lasts more than a few hours. Several commercially available gel moisture sources have been developed to provide an alternative to the use of water bottles during transportation (Maher and Schub, 2004). These gel moisture sources provide uniform, spill-proof, and contamination-free hydration for rodents; however, they are not nutritionally complete, and a food source should also be utilized during transportation. Xin and Lee (1996) found that the provision of water (or a substitute) and feed were also important for sustaining male day-old chicks during long trips (experiments were conducted under simulated conditions for a duration of 72 hr).

Larger animals can go longer without food or water without ill effects. Studies indicate that only after 24 hr of road transportation does a lack of water and physical fatigue become detrimental to cattle welfare (Knowles *et al.*, 1997; Tarrant and Grandin, 2000). Cattle are typically fasted for 6 to 12 hr before transportation (Lapworth, 2004), and this state must be considered when assessing the physical condition of cattle during transportation. The primary reason for fasting is to limit manure accumulation in the trailer and thus prevent slipping and falling.

Horses can also experience dehydration after 24 hr of transportation (Friend, 2000; Friend *et al.*, 1998; Stull and Rodiek, 2000). Friend et al. (1998) found that horses transported for long distances during hot weather drank less water (20.9 L) than horses penned under similar conditions (38.2 L). In a later study, Friend (2000) found that respiration, heart rate, blood sodium, osmolality, and chloride were significantly higher in nonwatered horses after 30 hours of transportation in hot conditions (indicating dehydration), than in horses that had received water during similar transport. However, offering of water to horses transported under cool conditions appeared to result in no added benefit to their well-being. Stull and Rodiek (2000) assessed the condition of show horses transported in a commercial van during the summer. They, too, concluded that after 24 hr of transportation, horses begin to show changes in physiological markers of hydration. In general, it appears that horses in good physical condition can be safely transported in hot weather for at least 24 hr, when provided with water.

Estimating the amounts of food and water that should be placed in the enclosure during transportation is relatively simple. Initially, the caloric and water requirements of the species must be determined. That information can be found in the *Nutrient Requirements of Domestic Animals* series, a group of reports from the National Academies that cover farm animals, laboratory species, wildlife, and companion animals. When the minimal requirements have been determined, several other factors must be considered, including (Wallace, 1976):

- Expected duration of the journey;
- Initial weight and life stage of the animal (for example, caloric and water requirements vary with age);
- Special requirements of the species or strain of animal (for example, some transgenic animals may have altered nutritional or caloric requirements); and
- Expected environmental conditions (for example, animals may consume more water in low-humidity environments).

## SOCIAL INTERACTION AND GROUP TRANSPORTATION

Animals can be transported in individual or group enclosures (caging or vehicles). Isolation, such as during transportation, can minimize social stress in solitary animals and species, but isolation can induce stress in social species (Tamashiro *et al.*, 2005). New social groups of nonsocial animals constitute a stressor, and these animals should be transported individually. Socially dominant pigs are less adversely influenced by the stress of transportation than are socially intermediate or submissive pigs (McGlone *et al.*, 1993). Some animals, particularly large ones, are aggressive and are best transported alone or with conspecifics in sensory but not physical contact. Baldock and Sibly (1990) found that spatial isolation (4 to 90 m) alone did not have a substantial effect on heart rate in sheep, but that visual isolation produced a substantial increase in heart rate, vocalization, and activity within the first 5 min of treatment.

For prey species such as sheep, being shipped near a predator species such as a dog is especially stressful and should be avoided. In contrast, having familiar conspecifics in the same compartment reduces the stress of a new experience. Most laboratory and farm animals are social animals, and they are often housed in compatible social groups at the site of trip origin. If social groups are transported, it is recommended that the groups be established before transportation where appropriate so that dominance orders will not need to be established during or after transportation. However, it has been found that rats adapt quickly to unfamiliar social environments (Sharp *et al.*, 2005) and unfamiliar social environments have no negative effect when chickens travel together in the same shipping enclosure (Knowles and Broom, 1990). The performance standard for social interaction is the lack of social aggression and injury resulting from aggressive social interactions.

## HANDLING

An animal's experience can greatly affect its response to the transportation environment. Animals can be preconditioned to transportation by being exposed to the transportation container and the food or water that will be available during transportation. In addition, frequent human handling before the handling associated with transportation will help animals to respond better to the transportation experience. Animals that have been socialized with people and have been handled respond more favorably to the handling associated with transportation than those not similarly exposed. In many cases, preconditioning animals to handling already occurs as part of routine husbandry procedures. For example, rodents are often handled on a daily or weekly basis in breeding and research facilities; additional handling to precondition the animals to transportation handling is probably not necessary.

Many species of research animals are typically handled and then caged for transportation, and this practice can produce an additive stress effect of both the handling and the novel enclosure. Although an animal's stress response to human handling associated with transportation may not be completely ameliorated, the method of handling can reduce or exacerbate the stress response. Kannan and Mench (1996) demonstrated substantial physiological response differences between methods of handling of laying hens. Either birds were captured and then held and carried inverted (single carry or multi-bird carry) or single birds were captured and then held upright and carried gently. When compared with unhandled controls, both methods produced an alarm response. However, gentle upright handling yielded a lower response than inverted handling. Kannan and Mench (1996) also found that caging of the birds produced a powerful fear response. Capture, carrying, and caging were found to be less stressful to chickens when conducted under low light (Knowles and Broom, 1990).

The activity of horses during road transportation can contribute to the increased incidence of injury or stress. The physiological responses of horses to head restraint (cross-tied vs. loose) after 24 hr of transportation were measured by Stull and Rodiek (2000). Cross-tied horses had higher blood glucose and cortisol concentrations, neutrophil-to-lymphocyte ratios, and white blood cell counts than horses traveling loose in small compartments. The authors recommended that horses be allowed to travel loose during long periods of transportation.

## MONITORING TRANSPORTATION

For facilities or people that transport large numbers of animals, the quality of transportation can be monitored by tracking mortality, morbidity, and injury during transportation and comparing these measures with published data. For instance, Malaga et al. (1991) reported that in-transit mortality for air transport of owl monkeys (*Aotus nancymai*) was 0.67% and total mortality at the end of a 30-day observation period was 2.44%. When mortality, morbidity, or injury exceed published norms (for instance, exceeding 2 standard deviations from the mean), action should be taken to adjust protocols or provide training. If small numbers of animals are occasionally transported, careful attention should be paid to ensuring that a reputable shipper is used and that the entire trip is adequately planned to transfer the animals smoothly from consignor to carrier, shipper, and consignee.

## EMERGENCY PROCEDURES

Emergencies may occur during any phase of the shipping process. During the peritrip period, emergencies encountered have included extended delays before the start of long trips, exposure to extreme temperatures, animal escapes, and mechanical problems with transportation vehicles.

To ensure animal comfort and safety, all plans for animal shipments must include instructions for emergency responses in accordance with the mode of transportation used. For example, Appendix B of the International Air Transport Association Live Animals Regulations contains a section covering emergency responses. The section provides a summary of actions appropriate to emergency situations, including delays, container damage, escapes, illness, and segregation. It is important that when an emergency occurs, those directly involved with the transport of the animals (the shipper and the organization and individual(s) providing transport) need to be able to contact each other and the means of contact be established prior to transport. Planning must also include procedures to follow in the event of an emergency. Both a primary plan and a backup plan should be available for each phase of the trip. For example, if animals are to be transported by plane or truck and a mechanical problem causes a long delay, animal needs must be accommodated to avoid tragedy. Animals should not remain unprotected from extreme weather for more than a few minutes, and comfortable accommodations should be available.

In rare circumstances, a situation may arise in which it must be determined whether euthanasia of an animal is necessary. For example, an animal might become moribund during transportation, or might endanger the safety of the human handlers, as can happen if a horse becomes uncontrollable during a flight and kicks at the aircraft's doors. A part of the emergency procedure plan should document specifics that identify which persons are trained and qualified to make and carry out decisions (usually a veterinarian) and the methods and equipment to administer anesthesia or perform euthanasia safely in the transportation situation.

## PERSONNEL TRAINING

Personnel who handle animals must be properly trained in routine and emergency procedures for the species they handle. Training should include procedures applicable to the mode of transportation and should cover at least

- Shipper and carrier responsibilities;
- Inspection of primary enclosures;

- Documentation;
- Acceptance, handling, and delivery;
- Loading and off-loading procedures and precautions;
- Operator and government regulations; and
- Emergency procedures.

Personnel must also be trained in species-specific husbandry and environmental requirements of animals. They can be deemed competent when they possess, as appropriate to the species and mode of transportation, the following:

- Ability to recognize when an animal becomes ill or unfit for transport;
- Ability to recognize signs of stress and alleviate the cause, if possible;
- Knowledge of how to contact and interact with local emergency personnel, including veterinarians who have skills in the treatment of injuries; and
- Knowledge of the administration of veterinary drugs and methods of euthanasia.

Personnel must also be trained to recognize physiological signs that a problem is developing in a particular animal or group of animals. The signs may include

- Increased respiratory rate (in warm weather);
- Excessive sweating (in species that sweat during warm weather);
- Excessive shivering or huddling (in cool weather);
- Aggressive interactions and injuries associated with fighting;[1]
- Excessive weight loss;[1] and
- Dehydration.[1]

At least one person associated with each segment of the trip should be fully trained. Employers should provide training (initial and recurrent) for employees with respect to transportation of animals so that their employees will be able to ensure the safety of animals and of their own equipment and can explain to shippers the conditions under which animals are transported. Personnel that simply move containers into, out of, or between conveyances also must have at least minimal training to recognize potentially unsafe conditions (for the animal or the handler) and to know whom to contact in case of questions or problems.

[1]Normative benchmarks should be known for the species in a given transportation protocol.

An American Veterinary Medical Association animal air-transportation study group evaluated, on a national basis, the adequacy of employee training as related to the protection of dogs and cats in air transportation (AVMA, 2002). The group found that although initial training was adequate for all of the airlines, continuing education and education of contractors were inconsistent. The group recommended the establishment of a formal training program that would incorporate:

- A time line for recurrent training;
- A consistent standard and frequency of training for ground handling staff, especially for outside contractors that are used more frequently by smaller airports; and
- A standard training program to minimize the amount of informal on-the-job training and thereby avoid omission of important considerations for safe animal care and transportation; this would also minimize delays in training during staff turnovers.

# 4

# Biosecurity

Biosecurity, for the purposes of this report, is defined as the policies and measures taken to minimize the risk of introducing an infectious pathogen into the human, agricultural animal, and research animal populations. Animals have long been recognized as hosts of zoonoses (infectious diseases that can be transmitted to humans or other species of animals). Biosecurity should be a consideration when transporting research animals because of the close contact that can occur between research animals and human handlers or other transported animals. This creates the potential for unintentional or intentional transmission of a zoonosis into the human or agricultural animal populations. Many zoonoses, including potential (agro)bioterrorism agents, are difficult to detect in an infected animal because they cause asymptomatic disease in the host species. However, the effect of zoonoses can be significant in humans and agricultural animals, causing severe disability or death and negatively affecting the capacity of the agricultural sector.

Another biosecurity concern is transmission of an infectious pathogen to a research animal during transportation and introduction of the pathogen into the colony that receives the animal. Infectious pathogens can negatively affect the health of the research animal and colonies, confounding research utilizing the infected animals.

## PROTECTING PUBLIC HEALTH AND AGRICULTURAL RESOURCES

### Minimizing Risks Associated with Transporting Research Animals with Experimentally Introduced Zoonoses

Increased efforts to improve the biosecurity of human populations and the agricultural sector have resulted from passage of the USA Patriot Act (2001), the Bioterrorism Preparedness and Response Act (2002), and enforcement of three parts of the *Code of Federal Regulations* (42 CFR 73, 7 CFR 331, and 9 CFR 121). These regulations establish lists of agents and toxins that have been deemed threats to humans, animals, and plants (see Table 4-1). The regulations require research laboratories that possesses any of the aforementioned agents to register its facility with the Centers for Disease Control and Prevention (CDC), designate a responsible official, perform background checks of persons who have access to the agents (conducted by the Department of Justice), and have a security plan for containment of the infectious agent. When infected animals must be transported, a plan for secure transportation must be in place. That plan would normally require:

- close communication between shipper and recipient;
- presence of responsible officials at the originating and receiving institutions;
- transfer of health records and assurances;
- identification of a carrier registered by the US Department of Agriculture;
- documentation of safety and security training of animal care personnel;
- notification of the appropriate institutional or CDC officials in case of emergency, loss, or theft;
- existence of emergency procedures (see Table 4-2); and
- good record maintenance.

Institutions are also required to have the appropriate level of laboratory biocontainment as outlined by CDC and the National Institutes of Health in the *Biosafety in Microbial and Biomedical Laboratories Manual* (BMBL). Although many shippers meet some of the requirements for laboratory biocontainment, not all meet all of the requirements, the result of which is a lack of uniformity in biosecurity during transportation. The characteristics of a good shipper are outlined in Table 4-3. Further, biocontainment requirements for transportation of infected animals (Appendix C, BMBL) are not as clearly defined as laboratory biocontainment

TABLE 4-1 Agents and Toxins That Require Registration of the Facility with CDC

**Bacteria**
*Bacillus anthracis*
Botulinum neurotoxin producing species of *Clostridium*
*Brucella abortus, Brucella melitensis, Brucella suis*
*Burkholderia mallei, Burkholderia pseudomallei*
*Cowdria ruminantium* (Heartwater)
*Coxiella burnetii*
*Francisella tularensis*
*Mycoplasma capricolum/M.F38/M. mucoides capri(contagious caprine pleuropneumonia), Mycoplasma mycoides mycoides (contagious bovine pleuropneumonia)*
*Rickettsia prowazekii, Rickettsia rickettsii*
*Yersinia pestis*

**Fungi**
*Coccidioides immitis, Coccidioides posadasii*

**Toxins**
Abrin
Botulinum neurotoxins
*Clostridium perfringens* epsilon toxin
Conotoxins
Diacetoxyscirpenol
Ricin
Saxitoxin
Shigatoxin and Shiga-like ribosome inactivating proteins
Staphlococcal enterotoxins
Tetrodotoxin
T-2 toxin

**Prions**
Bovine spongiform encephalopathy agent

**Viruses**
African horse sickness virus
African swine fever virus
Akabane virus
Avian influenza virus (highly pathogenic)
Bluetongue virus (exotic)
Camel pox virus

**Viruses (continued)**
Cercopithecine herpesvirus 1 (Herpes B virus)
Classical swine fever virus
Crimean-Congo haemorrhagic fever virus
Eastern Equine encephalitis virus
Ebola virus
Foot-and-mouth disease virus
Goat pox virus
Hendra virus
Influenza virus (reconstructed replication competent forms of the 1918 pandemic influenza virus containing any portion of the coding regions of all eight gene segments)
Japanese encephalitis virus
Lassa virus
Lumpy skin disease virus
Malignant catarrhal fever virus (Alcelaphine herpesvirus type 1)
Marburg virus
Menangle virus
Monkeypox virus
Newcastle disease virus (velogenic)
Nipah virus
Peste des petits ruminants virus
Rift Valley fever virus
Rinderpest virus
Sheep pox virus
South American haemorrhagic fever viruses (Junin, Machupo, Sabia, Flexal, Guanarito)
Swine vesicular disease virus
Tick-borne encephalitis (flavi) viruses (Central European tick-born encephalitis, Far Eastern tick-borne encephalitis [Russian spring and summer encephalitis], Kyasanur Forest disease, Omsk hemorrhagic fever)
Variola major virus (Smallpox virus)
Variola minor virus (Alastrim)
Venezuelan equine encephalitis virus
Vesicular stomatis viruses (exotic)

TABLE 4-2 Elements of an Emergency Plan

- Containers must be labeled clearly with the appropriate biohazard labels and identification of contents to inform transportation workers of package contents.
- Package documentation must identify potential biohazards in the package and 24-hr contact information for a responsible official from the consignor institution.
- The responsible official must be knowledgeable about the contents of the shipment and the potential hazards that it may pose and monitor the shipment in transit until receipt and confirmation by the consignee.
- The responsible official will assist in the coordination of responses of emergency officials or transportation-worker safety officers in case of accident or theft.

TABLE 4-3 Characteristics of a Good Shipper[a]

A good shipper of research animals:

- finalizes the method of shipment, route, and special care required for a shipment before accepting it;
- obtains all required federal, state, and regulatory-agency permits and documents;
- ensures that the carrier is US Department of Agriculture (USDA)-certified for live-animal shipments or meets International Air Transport Association (IATA) and Department of Transportation (DOT) regulations for dangerous goods;
- provides the carrier with information about the shipment, including type of animal (scientific and common name), sex, physical conditions, number of animals per container, medication given, and whether the shipment is a dangerous good;
- provides containers that adhere to current IATA regulations for live animals or dangerous goods;
- provides suitable bedding and food for the animals;
- obtains all documentation and correct information required by IATA, by national and carrier regulations, and for the shipper's certification;
- provides special feeding and watering instructions on the outside of each container and provides the carrier with a respective copy;
- develops an emergency plan and a 24-hr contact number for a responsible official to coordinate responses; and
- maintains records for each shipment—including such information as the species and number of animals, dates of shipment and receipt, carrier, and name and address of consignee—for at least 3 years.

[a]Adapted from Section 1.2 of the Live Animals Regulations (IATA, 2005).

requirements. However, Appendix C of the BMBL, as well as Chapter 2 of this report, contains comprehensive information on which agencies must be contacted when transporting animals with human and agricultural animal zoonoses and can provide assistance in development of appropriate biocontainment plans for transportation.

### Minimizing Risks Associated with Transporting Research Animals with Unknown Zoonoses

Though research animals may be experimentally infected with agents, many zoonoses of concern are endemic in research animals or may be naturally acquired. A list of zoonotic diseases communicable from research animals to humans is presented in Table 4-4. Because many of those zoonoses cause asymptomatic disease in animals, it may not be apparent that the animal is infected. The challenge is to identify the zoonoses that animals potentially harbor, consider the likelihood that the animal is a carrier and potential for exposure, evaluate the likely severity of an adverse event, and take steps to mitigate the risk.

TABLE 4-4 Examples of Zoonotic Diseases Transmissible from Research Animals to Humans

| Disease | Potential Animal Vectors | Potential Route of Transmission |
|---|---|---|
| *Bacterial* | | |
| Anthrax | Contaminated herbivores | Cutaneous, inhalation |
| Brucellosis | Cattle, goats, swine, dogs | Inhalation, ingestion, direct contact |
| Leptospirosis | Cattle, dogs, horses, swine, rodents, reptiles, amphibians | Inhalation of contaminated fluids, direct contact |
| Salmonellosis | Birds, swine, reptiles, turtles, tortoises | Direct contact, fecal-oral |
| Tuberculosis | Domestic and wild animals | Droplets |
| Q fever | Cattle, sheep, goats | Inhalation, direct contact with infected animals, their birth products, or infected materials such as bedding |
| *Viral* | | |
| Influenza | Birds, horses, swine | Aerosol, physical contact |
| Hantaviruses | Rodents | Aerosol, direct contact with mucous membranes, animal bites |
| Ebola | Unknown | Direct contact with infected materials, possibly droplets |
| Monkey B virus | Old World monkeys | Animal bites, direct contact with mucus membranes |
| Monkeypox | Ground squirrels, gambian rats | Droplets |
| Rabies | Dogs, cats, wild carnivores, bats, foxes, raccoons | Animal bite, possibly airborne |
| *Fungal* | | |
| Ringworm | Bovine, birds | Direct contact |

There are reports of zoonotic disease transmission from pet hamsters, rabbits, and rodents to humans (CDC, 2001, 2005a, 2005b). Since companion animals are often transported in unfiltered containers and are transported along with research animals (particularly during air transport), the potential for cross contamination during transport must also be considered.

In general, contact between animals and people during transportation should be restricted to prevent exposure to or transfer of zoonoses. When possible, human contact should be limited to trained animal handlers who are knowledgeable of good sanitation practices, biosafety and biocontainment, and precautions for protection against zoonoses.

*Special Considerations When Transporting Nonhuman Primates*

The transportation of nonhuman primates requires special consideration because the risk of zoonotic disease transmission is greater with nonhuman primates than any other species of research animal due to the close phylogenetic relationship between humans and nonhuman primates (NRC, 2003b). Macaques imported for research have been implicated in the transmission of B virus and Ebola virus to laboratory workers, both potentially fatal diseases in humans (Cohen *et al.*, 2002; Palmer, 1987). B virus (also known as *Herpesvirus simiae*) is of particular concern as it is endemic in some populations of macaques and infected animals are generally asymptomatic. B virus and Ebola virus can be transmitted through aerosols, animal bites, scratches, contact with body fluids or tissue material, or equipment that has been contaminated with body fluids (NRC, 2003b).

Due to the risks associated with zoonotic diseases transmitted from nonhuman primates, a common standard for personal protective equipment (PPE) has been established for workers who come into contact with nonhuman primates or equipment that has been exposed to nonhuman primates (NRC, 2003b). This standard recommends that dedicated clothing, gloves, and masks be utilized when in contact with nonhuman primates and that eye and face protection be mandatory for individuals who come into contact with macaques. Eye and face protection are also highly recommended for individuals who come into contact with other Old World monkeys.

Ensuring public safety and maintaining public confidence in the shipping process should be concerns of both regulatory agencies and carriers. Public confidence is difficult to maintain when airline passengers observe transportation workers wearing PPE boarding their plane. However, the development and use of overshippers (a closed, environmentally controlled container into which a standard primary enclosure would be loaded in order to prevent a zoonotic exposure) would mitigate the need for some types of PPE (please refer to Chapter 5 for further discussion).

*Special Considerations When Transporting Specimens and Tissues*

Diagnostic specimens and tissues that are used for research are usually isolated from animals that are suspected of having an infectious disease or that are from an endemic area, and they should be treated as potentially infectious and hazardous materials. Those materials should be handled according to guidelines in BMBL (5th edition, Section VI and Appendix C). All diagnostic and tissue samples should be packaged according to IATA regulations as dangerous goods (Chapter 2). Depending on the suspect sample, it may be necessary for only persons who have IATA training to handle the sample. Access to the packages should be limited. If the sample potentially contains a select agent, both the shipper and the recipient must have all pertinent clearances and permits required by CDC and USDA and must have notified all appropriate agencies.

## PROTECTING THE BIOLOGICAL INTEGRITY OF RESEARCH ANIMALS AND COLONIES

In recent years, greater attention has been paid to maintaining the microbial status of research animals and animal colonies. Scientists have rapidly expanded the use of immunocompromised rodents, such as nude mice and transgenic animals with immune deficits. Preventing exposure to infectious agents is necessary to maintain the health of these animals. In addition, scientists have discovered infectious agents, such as mouse and rat parvoviruses and *Helicobacter* species, that cause subclinical infections but can significantly alter research results (Jacoby and Lindsey, 1998). A list of viral, bacterial, and parasitic organisms found in commonly used species of research animals is presented in Table 4-5. Many of these organisms can infect multiple species, increasing the potential for intraspecies and interspecies disease transfer.

The most common routes of disease transmission between animals are infectious aerosols, close contact, and fomite (an inanimate object, such as clothing, capable of transmitting infectious organisms) transmission. Each of these routes poses a risk during shipping; however, there are methods to prevent the transmission of diseases among research animals, including barrier containment, specific-pathogen diagnosis, disinfection of vehicles and shipping containers, use of personal protective equipment (PPE), and segregation of animals. Though research animal vendors generally have well-established procedures to minimize biosecurity concerns, the typical researcher may need guidance in addressing biosecurity concerns

TABLE 4-5 Infectious Agents and the Susceptible Species of Research Animals

| | **Mice** | **Rats** |
|---|---|---|
| **Viruses** | | |
| Sendai | X | X |
| PVM (Pneumonia virus of mice) | X | X |
| MHV (Mouse hepatitis virus) | X | |
| MVM (Minute virus of mice) | X | |
| GD-VII (Theiler's murine encephalomyelitis virus strain) | X | |
| REO 3 (Reovirus type 3) | X | X |
| EDIM (Group A rotavirus) | X | |
| Lymphocytic choriomeningitis vVirus | X | X |
| Polyoma | X | |
| MCMV (Murine cytomegalovirus) | X | |
| Ectromelia | X | |
| MPV (OPV) (Mouse parvovirus – Orphan parvovirus) | X | |
| MAD (Mouse adenovirus) | X | X |
| K virus | X | |
| MTLV (Mouse thymic virus) | X | |
| Hantavirus | | |
| Adenovirus | | |
| Parainfluenza | | |
| Rotavirus | | |
| PI-1 (Parainfluenza-1) | | |
| PI-2 (Parainfluenza-2) | | |
| RHD (Rabbit haemorrhagic disease) | | |
| LCM (Lymphocytic choriomeningitis) | | |
| H1 (Toolan's H1 virus) | | X |
| KRV (Kilham Rat virus) | | X |
| SDA/RCV (Sialodacryoadentitis virus/Rat corona virus) | | X |
| HANT (Hantaan) | | X |
| RRV (Ross River virus) | | X |
| Foamy virus | | |
| Dengue | | |
| Yellow fever | | |
| Pox viruses | | |
| Ebola | | |
| SIV (Simian immunodeficiency virus) | | |
| B virus | | |
| Rat picornarvirus | | X |
| RPV (OPV) (Rat parvo virus – Orphan parvo virus) | | X |

| | Guinea Pigs | Gerbils | Rabbits | Hamsters | Nonhuman Primates |
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| | | | | | |

*continued*

TABLE 4-5 Continued

| | Mice | Rats |
|---|---|---|
| **Bacteria** | | |
| *Streptococcus zooepidemicus* | | |
| *Pasteurella multocida* | | |
| *Pasteurella* spp. | | |
| *Treponema cuniculi* | | |
| *Bordetella bronchiseptica* | X | X |
| *Citrobacter rodentium* | X | |
| *Corynebacterium kutscheri* | X | X |
| *Clostridium piliforme* | X | X |
| *Salmonella* spp. | X | X |
| *Mycoplasma pulmonis* | X | X |
| *Streptobacillus moniliformis* | X | X |
| *Helicobacter hepaticus* | X | X |
| *Campylobacter* spp. | | |
| *Yersinia* spp. | | |
| *Mycobacterium* spp. | | |
| *Burkholdria* | | |
| CAR bacillus | X | X |
| **Parasites** | | |
| Ectoparasites | X | X |
| Gastrointestinal helminths | X | X |
| Gastrointestinal protozoa and sporozoans | X | X |
| *Encephalitozoon cuniculi* | X | X |
| Hepatic coccidia | | |
| Metazoa | | |
| Intestinal coccidia | | |
| Other protozoa | | |
| Demodex | | |

| Guinea Pigs | Gerbils | Rabbits | Hamsters | Nonhuman Primates |
|---|---|---|---|---|
| | | | | |
| X | | | | |
| | | X | | |
| | | X | | |
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| X | X | X | X | |
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| | | X | | X |
| | | | X | |

TABLE 4-6 Recommendations for Shipment of Research Animals Between Institutions

- Shipments of research animals between institutions should be coordinated between responsible persons at the sending and receiving institutions. They should ensure that all documentation is in order, including federal (CDC, USDA, and DOT), state, and local permits.
- Shipments should be prepared by persons who have documented training in animal handling procedures and the proper use of PPE.
- Animals should be placed in shipping containers that will provide protection to them and the receiving colony from microbial contamination.
- Animals should be packaged according to regulatory-agency (IATA, USDA, and DOT) standards.
- Shippers should provide documentation and assurances to recipients that the animals are healthy. If the recipient requires a more extensive health report, including testing for specific pathogens, the costs of the diagnostic tests should be covered by the consignee.
- Only USDA-certified carriers should be used for transportation of research animals.
- On receipt, the consignee should place the research animals at the appropriate level of biocontainment and quarantine before introduction into the laboratory colony.

when shipping animals to a colleague. Recommendations for shipment of animals between research institutions can be found in Table 4-6.

## Barrier Containment

Most small-animal vendors have designed shipping containers that incorporate spun polypropylene filters to provide a physical barrier to the transfer of microbial contaminants into or out of each container, thus protecting research animals, colonies, and animal handlers from pathogen exposure during transportation. For gnotobiotic animals (animals whose microfauna and microflora are known in their entirety) and immunocompromised animals, microisolation shipping containers are also available. Although the sturdy construction of the vendor containers may tempt researchers to reuse them to transfer research animals to other researchers, this practice is not recommended. Most vendors sterilize or disinfect the animal containers, food, and water before loading animals. Once a container has been opened at the recipient's facility, its sterility has been compromised. Some facilities autoclave shipping containers for reuse; however, this may increase the air resistance of the polypropylene filters, restricting air flow (White, 2004). Until it can be established that autoclaving does not restrict air flow below acceptable levels, the committee suggests that the prudent course of action is to avoid autoclaving shipping containers for reuse. To ensure the biosafety of their animals, individual researchers who wish to transfer animals to other researchers should purchase presterilized shipping containers from animal vendors.

## Specific Pathogen Diagnosis

Normally, when major vendors communicate with clients, they identify the pathogens for which their animals have been tested to assure recipients that the animals sent to them are free of pathogens that could disrupt their colonies or experiments (for example, introduction of a respiratory infection would disrupt and invalidate an experiment on respiration). People shipping a few animals to colleagues do not always know the pathogen status of their animals and therefore cannot assure colony supervisors that the imported animals can be introduced safely into their colonies. To avoid inadvertent introductions of diseases, some colony supervisors quarantine incoming animals until they can gather the data required to ensure the health and safety of incoming animals (Otto and Tolwani, 2002). If facilities do not have the space and testing facilities required for that precaution, then it may be necessary for testing to be conducted at the institution of origin. Unfortunately, testing in such instances does not monitor for disease transmission during transport. Arrangements for testing and provision of assurances before introduction of shipped animals into a new colony require communication between responsible and knowledgeable officials of the institutions involved. Such officials can help to arrange safe and secure shipment of animals and arrange for the most efficient assurance of colony security.

## Disinfection

Transportation protocols should have standardized procedures for disinfection of animal cages, transportation vehicles, and holding areas that conform to IATA, USDA, DOT, and CDC standards. Disinfection prevents transmission of pathogens from one shipment of animals to the next shipment transported in the same vehicle. Bedding, food, and water may be sterilized by autoclaving or gamma irradiation before and after shipment to prevent contamination of research animals and the receiving colony. Disinfection by sterilization or irradiation is not feasible for such items as transfer-vehicle cargo holds, large cages, and transportation-company holding areas. In these cases, however, chemical disinfection should be conducted after each transfer event. To ensure maximal efficiency of the disinfection process, disinfection should be applied using concentrations of chemical disinfectants and application times should be optimized according to manufacturers' instructions.

Disinfection of the outside of the shipping containers should also be considered. As discussed above, companion animals are often transported in unfiltered containers and may be transported along with research animals. Therefore, the potential for cross contamination of shipping containers is present and must be considered. Another situation that may result in cross contamination is the entry of wild mice infected with lymphocytic choriomeningitis virus or mouse hepatitis virus into an animal holding area along the transportation route, such as an airport or cargo transfer station. The infected wild mouse can shed virus, thus contaminating the outside of the shipping container. Transmission of pathogens to research animals or colonies can then occur if the container is brought into a facility or animals are removed from the container without disinfection of the outside surfaces. Since such infections occur during transportation, diagnostic testing by the source provider does not ensure the biosecurity of either the animals or the receiving colony.

## Personal Protective Equipment

The appropriate use of PPE can also protect research animals from human pathogens and cross contamination from other animals. For example, macaques are susceptible to human infections such as measles and tuberculosis. The use of PPE will not only prevent the transmission of B virus from a macaque to a human, but also can prevent the inadvertent transmission of measles or tuberculosis to the macaque. People who handle animals should cover their street clothing and exposed body surfaces with PPE to reduce the risk of pathogen introduction through direct contact or aerosol. In some instances, it may be appropriate to provide handlers with a shower-based entry system. The appropriate disposal of PPE is also necessary so that the PPE does not act as a fomite for transmitting pathogens. For example, if PPE is worn while disinfecting incoming shipping containers, the PPE should be disposed of before moving on to other tasks.

## Segregation of Animals

Separation of different shipments of animals is also a method for preventing intra- and interspecies transmission of pathogens presented in Table 4-4. The committee suggests close adherence to the recommendations in the LARs regarding segregation of species and separation of animals of the same species of different origins (LARs Sections 5.3 and 10.3.2). Briefly, these regulations state that:

1. animals in quarantine must be segregated from those which are not;
2. animals known to be for laboratory use must not be stored adjacent to other animals in order to reduce any risk of cross-infection or contamination;
3. nonhuman primates from different continents must be isolated from each other in aircraft holds, airport cargo warehouses, animal holding facilities, and during all phases of ground transportation; and
4. animals that are natural enemies, e.g., cats and dogs, may be loaded in the same hold provided they are not in sight of one another.

Situations in which some aspects of these recommendations are not feasible may arise. For example, an airport may not have containment facilities to separate nonhuman primate species. In these cases, other measures must be employed to prevent disease transmission. An effective means of overcoming this problem would be the development of self-contained overshippers, as recommended in Chapter 5.

# 5

# Recommendations

Preceding chapters have provided background regarding the laws, regulations, and regulatory agencies responsible for animal transportation (Chapter 2); principles that underlie good practices of animal handling, management, and care essential to maintaining animal comfort, health, and well-being during and immediately after transportation (Chapter 3); and concepts and principles related to preventing exposure of the general public, transported animals, animal handlers, and animal colonies to infectious organisms (Chapter 4). These factors provided the foundation for the following four recommendations.

**Recommendation 1: The National Institutes of Health (NIH), through the National Center for Research Resources, should update and reimplement the National Primate Plan to ensure a stable means for transporting nonhuman primates into and within the United States. In addition, research institutions that use nonhuman primates should encourage the development of reliable ground transport for nonhuman primates to protect against the possibility that domestic transportation of nonhuman primates on commercial airlines may one day become unavailable.**

For US research institutions, there are several sources for obtaining nonhuman primates for use in biomedical research. Sources include overseas breeding colonies, National Primate Research Center (NPRC) breeding colonies, breeding colonies at academic institutions, and US commercial breeding colonies, with overseas breeding colonies supplying the majority of nonhuman primates (Robinson and Beattie, 2003). Therefore, the majority of nonhuman primate resources in the United States must be transported by air, both into the United States and generally to their final destination (see Figure 5-1 for the locations of research facilities, importation sites, and vendors of nonhuman primates). Currently, few foreign airlines will consistently transport nonhuman primates into the United States, and no US domestic airlines will transport nonhuman primates into the United States. For the purpose of transporting nonhuman primates once they are already in the United States, research institutions may use the one US domestic airline that currently transports nonhuman primates nationally (Kemnitz, J. personal communication, August 4, 2005).

The paucity of carriers that transport live animals is due, in part, to the often unprofitable nature of live-animal transportation in the air-transportation industry. For typical passenger/cargo-configured network carriers, such as the major airlines present in the US market, cargo contributes only 2 to 5% of total operating revenues. The contribution of live-animal transportation is even less significant and involves costs for personnel training and environmental controls to comply with federal regulation. In addition to the economic disincentives discussed above, several other reasons have been identified for the declining number of commercial airlines that will transport nonhuman primates, including the following:

- concern regarding zoonoses between nonhuman primates and humans;
- the high cost of training personnel and acquiring protective equipment;
- potentially higher insurance rates due to liability issues;
- required disinfection of cargo areas after holding nonhuman primates;
- pressure from animal rights activists; and
- the potential danger associated with escapes (DePoyster, 2003).

There is no clear solution to the foreign commercial airline situation. Some organizations have started chartering private jets to import shipment of nonhuman primates to the United States (DeMarcus, 2003). This option increases the cost of transportation (DeMarcus, 2003), and private chartering companies are not immune to the pressures that led the commercial airlines to refuse to transport nonhuman primates. Though corporate research institutions have some ability to cover the cost of private charters, academic researchers utilizing nonhuman primates have no mechanism for absorbing the increased cost of transportation by private charters. In the committee’s judgment, the practical approach is to pre-


**FIGURE 5-1** Locations of research facilities using nonhuman primates, major importation sites, and vendors of nonhuman primates in the United States.

pare for the eventuality that all nonhuman primates may have to be transported into the US by private charter. To prevent the financial impact of private charters from restricting research involving nonhuman primates, it is imperative for agencies that fund research using nonhuman primates to ensure that allowances are made for the increased costs associated with private chartering.

In some ways, the domestic air transportation system is more likely to reach a crisis point because currently only one domestic airline will transport nonhuman primates within the United States. A similar situation arose several years ago, when US airlines refused to carry day-old chicks and adult avian species via airmail transport. As a result, Congress enacted Public Law 107-67, the Treasury and General Government Appropriations Act of 2002. Section 651 of this law amended Section 5402(c) of Title 39 so that "the Postal Service may require any air carrier to accept as mail shipments of day-old poultry and such other live animals as postal regulations allow to be transmitted as mail matter." While legislative action by Congress would virtually eliminate the domestic air transportation problem, that solution is perhaps the least likely to occur, and the committee felt it imperative to provide other pathways to improve the transportation of nonhuman primates.

Some individuals in the academic research community believe that the NPRC breeding colonies will eventually be able to meet the domestic need for nonhuman primates, eliminating the need to transport nonhuman primates into the United States in large numbers. The source of this assumption is the National Primate Plan (DHEW, 1978). The National Primate Plan was published in 1978 by the Interagency Primate Steering Committee, which included representatives from the National Science Foundation, Department of Defense, Environmental Protection Agency, Veterans Administration, and Department of Health, Education, and Welfare. The National Primate Plan was developed to ensure adequate supplies of primates to meet research needs by coordinating the various federal program activities. One of the recommendations of the National Primate Plan was that domestic primate production be sufficiently expanded to ensure a continuous, stable, and long-term supply of primates and that domestic production must provide for all of the nation's need for commonly used species, specifically rhesus and cynomolgus macaques. At the time, the Plan's authors estimated that domestic production was fulfilling about 50% of the domestic need. Since 1980, imported nonhuman primates have comprised, on average, 26% of the nonhuman primates used in research. However, the percentage of nonhuman primates used in research that are imported has steadily increased over the last seven years and, in 2004, imported nonhuman primates comprised 35% of nonhuman primates used in research.[1] This is a cause for concern, as the NPRC's facilities are limited and being utilized to the maximum (Robinson and Beattie, 2003).

Considering that reliance on imported nonhuman primates is increasing and that the NPRCs are functioning at maximum capacity, it is unlikely that the US research community's demand for imported nonhuman primates will decrease. Moreover, the mission of the NPRCs is to provide researchers with access to nonhuman primates, not to supply nonhuman primates directly to researchers. Any research using NPRC animals must be conducted at an NPRC, and NIH-funded research projects take precedence over activities funded by other resources (NIH, 2002). The NPRC breeding colonies are not intended to supply nonhuman primates to other academic or corporate research institutions and there is no indication that their mission will be revised. In the committee's judgment, the most promising solution for permanently addressing the declining availability of transport services is to update and reimplement the National Primate Plan. *An updated National Primate Plan could ensure allowances for increased costs associated with domestic private chartering where necessary and relaunch the nation's efforts to develop domestic production of the most commonly used nonhuman primates to meet national needs.*

**Recommendation 2: NPRCs and research institutions utilizing nonhuman primates should work jointly, perhaps through professional societies, to encourage the development of reliable ground transportation for nonhuman primates.**

Most producers of small research animals have reacted to the declining availability of economical domestic airline services by developing systems for ground transport of their research animals either by utilizing their own personnel and vehicles or by contracting with independent ground transport companies. Ground transport of nonhuman primates does seem to occur, but is not a widespread occurrence, possibly due to economic constraints and because most ground transport companies are geared toward the transportation of rodents and other small mammals. It would be prudent for the NPRCs and individual research institutions to work jointly, perhaps through professional societies, to encourage the development of reliable ground transport for nonhuman primates to protect against the possibility that domestic transportation of nonhuman primates on commercial airlines may one day become unavailable.

[1]Estimates of the percentage of imported nonhuman primates used in biomedical research in the United States were generated from US Department of Agriculture (USDA) data on the number of animals used in research (USDA, 2004) and data from the US Fish and Wildlife Service and Centers for Disease Control and Prevention (CDC) on the number of nonhuman primates imported into the United States for research purposes (DeMarcus, 2003).

**Recommendation 3: Federal agencies that fund nonhuman-primate research and the commercial shipping community should coordinate an initiative to develop a self-contained overshipper to ship non-human primates and other animals that pose a significant risk of zoonotic exposure.**

Recommendation 3 is directed to the possibility of cost-effectively shipping nonhuman primates and other infectious animals in standard primary enclosures that would be loaded into closed devices (overshippers). Overshippers could be built in such a fashion as to incorporate HEPA filters, temperature and humidity controls, viewing windows, and outside access. An overshipper with these characteristics would minimize or eliminate exposure to or contact between humans and animals, as well as between animals in the same conveyance, while providing an escape-proof and safe environment. Government agencies, shippers, inspectors, handlers, and carriers alike might prefer the limited human intervention, reduced zoonotic exposure, and convenience this method would provide. Because it is unlikely that the airline industry itself would be in a position to pay for the development of such units, the cost must be borne by the shipping and animal research communities at large. The resulting improvements in terms of safety, security, and convenience may encourage more airlines to transport nonhuman primates and other species that pose similar problems.

**Recommendation 4: An interagency working group should be established to coordinate all federal inspection and permitting activities related to transportation of animals and animal products under one entity. In addition, the individual agencies should move to clarify the language of federal regulations or issue guidance documents to increase the readability and understanding of those regulations.**

As discussed in Chapter 2 (and diagrammed in Table 2-1), five different federal agencies oversee various aspects of the transportation of research animals and their products. The USDA provides inspection oversight to ensure the welfare of animals during transportation, the Fish and Wildlife Service issues permits and inspects shipments to control the movement of wildlife and conserved species, the CDC registers and inspects shipments to control the introduction of zoonotic disease through imports, the Food and Drug Administration (FDA) performs similar functions to control the intrastate and interstate spread of zoonotic diseases, and the Department of Transportation issues permits to control hazards presented by the transportation of materials such as infectious live animals or radioactive animal products. Due to overlapping regulatory authority, it is possible for one shipment of animals to be inspected by two different agencies and be required to register or obtain permits from three or more agencies. This overlap presents a significant regulatory burden to individual investigators trying to navigate this complex network of regulatory authority. Establishing one federal entity that can be consulted would greatly reduce regulatory burden for shippers, whether they are individual investigators or large commercial operations. Such a working group also has the potential to centralize and reduce the number of redundant inspections and permits that must be issued for each shipment.

There is also substantial room for improving the comprehensibility of the various federal regulations. The committee was particularly concerned with areas of inconsistency and obscurity in the Animal Welfare Act (AWA) regulations, which are the federal regulations that establish standards for animal welfare that apply to most species of research animals during transportation. The AWA regulations are organized by groups of common species: 9 CFR 3 subpart A details standards for the transportation of dogs and cats, subpart B covers guinea pigs and hamsters, subpart C covers rabbits, subpart D covers nonhuman primates, etc. In this way, species with similar physiology and behavioral characteristics are regulated by the same standards. While differences between species account for the majority of differences in standards between species groupings, there are several cases of inconsistencies that have no apparent underlying scientific reason. For example, the regulations pertaining to dogs and cats state that the cargo area must be pressurized when flying above 8,000 ft (9 CFR 3.15(d)). There is no similar requirement for nonhuman primates, rabbits, guinea pigs, or hamsters. Another example involves acclimation of guinea pigs. For all species besides guinea pigs, there is a provision in the AWA regulations for transporting animals in temperature conditions that fall below the minimum allowed temperature if the animal has been acclimated to lower temperatures as certified by a USDA-accredited veterinarian (e.g., 9 CFR 3.13(e)). However, no such provision exists for guinea pigs, though there is literature suggesting that guinea pigs can be successfully cold-acclimated (Sobel *et al.*, 1960, 1965; Vapaatalo *et al.*, 1984).

There are also a number of inconsistencies in standards that apply to the same animal. For example, for nonhuman primates, the temperature in a terminal facility cannot fall below 45°F for more than *four consecutive hours* (9 CFR 3.91 (d)), but the temperature during handling (movement into or out of a terminal facility or conveyance) cannot fall below 45°F for more than *45 minutes* (9 CFR 3.92(a)(3)). During air transport, the ambient temperature inside the plane must be maintained at a level that ensures the welfare of the nonhuman primate (9 CFR 3.88(d)); however, during surface transportation, the temperature must be maintained between 45°F and 85°F (9 CFR 3.88(e)).

There are also instances in the Animal Welfare Regulations where there are inconsistencies in reporting and documentation. For example, the certification that must accompany dogs, cats, and nonhuman primates must include the name, address, and telephone number of the consignee (9 CFR 3.13(b) and 9 CFR 3.86(b)); however, this information does not have to be included in the certification that must accompany rabbits, guinea pigs, or hamsters. While inconsistencies in reporting and documentation are unlikely to affect the welfare of the animal directly, they make compliance with AWA regulations onerous, thus diminishing their effectiveness.

Though the committee had greater concerns about the AWA regulations because they directly impact the welfare of the animals, the committee found that all of the federal regulatory language lacked clarity. This makes it difficult to determine which federal agencies would oversee a particular transportation situation. In particular, it is exceedingly difficult to determine which federal regulations apply to the transportation of animals or animal products that contain a known or suspected zoonotic/infectious agent, whether naturally occurring or experimentally induced (see Table 2-1). Federal agencies should work to clarify these issues, either through the development of an interagency working group or the issuance of guidance documents by the individual agencies.

**Recommendation 5: Shipments of research animals between institutions should be coordinated between responsible individuals at both the sending and receiving institutions.**

In the committee's judgment, instances of mortality, morbidity, and adverse effects on animal health occur most frequently when individual investigators unfamiliar with the vagaries of the research animal transportation system ship animals to investigators at other institutions. Such problems can be avoided if each institution designates a single individual responsible for ensuring the safe shipment and receipt of research animals. This designated individual would ensure that communication between institutions is effective at all stages of the transport process; that all documentation including health certifications required by the receiving institution and all federal, state, and local permits are in order; and that animals are placed in shipping containers according to the appropriate standard. This designated individual would further ensure that USDA-certified carriers are utilized and that, upon receipt, the consignee is notified and places the animals in the appropriate level of biocontainment/quarantine before introduction into the laboratory colony. Though institutional animal care and use committees are not required to directly review each instance of animal transport, transport activities should be reviewed during the semiannual program evaluation to ensure that appropriate procedures are being followed (Silverman *et al.*, 2000).

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# Appendix A

# Summary of the Animal Welfare Act Regulations Pertaining to Transportation

This summary of Animal Welfare Act (AWA) standards is divided into three sections. The first and second cover regulations that pertain to the transportation of dogs and cats and of nonhuman primates, respectively. The third section covers AWA regulations that pertain to the transportation of guinea pigs, hamsters, rabbits, and animals defined as other animals by the US Department of Agriculture. *Other animals* would include any species of warm-blooded animal other than dog, cat, guinea pig, hamster, rabbit, nonhuman primate, marine mammal, or bird. AWA regulations pertaining to marine mammals are not included in this summary but can be found in 9 CFR 3.112-3.118. This summary is not meant to be exhaustive. For example, specific directions on water temperatures and detergents that should be used to sanitize transportation enclosures are not included. However, each section refers to the original AWA regulation if further specifics are required.

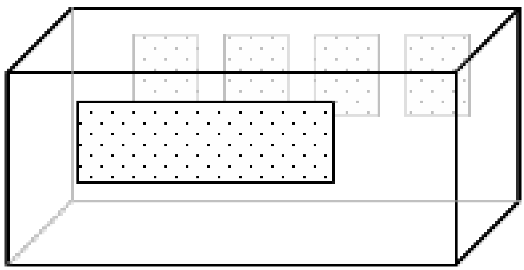
## DOGS AND CATS (9 CFR 3.13 – 3.19)

### Enclosure

1. The primary enclosure must be strong enough to contain the animals securely and comfortably and to withstand the normal rigors of transportation.
2. Enclosures must be large enough that each animal has enough space to turn around normally while standing, to sit and stand, and to lie in a natural position.

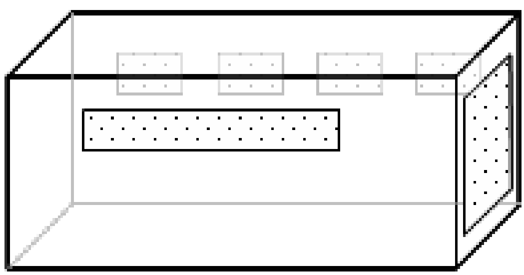
3. Interior has no sharp points, edges, or protrusions that could injure an animal.
4. Each animal is securely contained in the enclosure and cannot put any part of its body outside the enclosure in a way that could result in injury to itself, handlers, or other persons or animals.
5. The openings of the enclosure are easily accessible at all times for emergency removal of the animals.
6. Unless the enclosure is permanently affixed to the conveyance, adequate handles or handholds should be present so that it can be lifted without tilting and ensure that anyone handling the enclosure will not come into physical contact with an animal that is inside.
7. Unless the enclosure is permanently affixed to the conveyance, labeling on the top and at least one side with the words "Live Animals" in letters at least 1 in. high and arrows indicating the correct upright position of the enclosure must be present.
8. Any material or treatment in or on the enclosure must be nontoxic.
9. A solid, leakproof bottom or removable leakproof tray under a slatted or mesh floor that prevents seepage of waste products from the enclosure is required. The slatted or mesh floor must be constructed so an animal cannot put any part of its body through the raised floor. Unless it is on a raised floor, the enclosure must contain enough unused, nontoxic litter to absorb and cover excreta.
10. Food and water receptacles must be attached inside the enclosure and placed so that they can be filled from outside the enclosure without opening the door.
11. The primary enclosure must be cleaned and sanitized before each use. If an animal is in transit for more than 24 hr, the enclosure must be cleaned and litter replaced or the animal moved to another clean and sanitized enclosure. If moving an animal from the enclosure is necessary, this procedure must be completed in a way that safeguards the animal from injury and prevents escape.
12. Projecting rims must be on the exterior of walls that contain ventilation openings and provide a minimal air circulation space of 0.75 in.
13. The size and arrangement of ventilations openings must comply with one of the following options:

Option A: Two ventilation openings



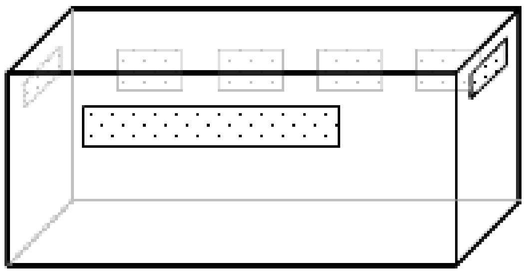
Surface area of each opening is at least 16% of wall surface area.
Total surface area of openings is at least 14% of total surface area of all walls.
One-third of surface area of openings must be in upper half of enclosure.

Option B: Three ventilation openings



Total surface area of openings on opposing walls is at least 8% of those walls' total surface area.
Surface area of openings on third wall is at least 50% of surface area of that wall.
Total surface area of openings is at least 14% of total surface area of all walls.
One-third of surface area of openings must be in upper half of enclosure.

Option C: Four ventilation openings



Surface area of each opening is at least 8% of surface area of that wall.
Total surface area of openings is at least 14% of total surface area of all walls.
One-third of surface area of the openings must be in upper half of enclosure.

14. If the enclosure is permanently affixed to the conveyance so that there is only a front ventilation opening, the opening cannot be blocked, must open directly to an unobstructed aisle, must be at least 90% of the total surface area of the front wall, and must be covered with bars, wire mesh, or smooth expanded metal that has air spaces.

**Compatibility**

1. Dogs or cats transported in the same enclosure must be of a single species and be maintained in compatible groups.
2. Puppies or kittens 4 months old or younger cannot be transported in an enclosure with adult animals other than their dams.
3. Animals that are overaggressive or exhibit a vicious disposition must be transported individually.
4. A female in estrus may not be transported in an enclosure with a male animal.
5. When transportation is by air,
   a. No more than one animal 6 months old or older or weighing over 20 lb may be transported in the same enclosure.
   b. No more than two puppies or kittens 8 weeks to 6 months old, of comparable size, and weighing 20 lb or less each may be transported in the same enclosure.
   c. Weaned animals less than 8 weeks old must be of comparable size or must be littermates and be accompanied by their dam.

6. When transportation is on the ground or by privately owned aircraft,
   a. No more than 4 animals 8 weeks old or older and of comparable size may be transported in the same enclosure.
   b. Weaned animals less than 8 weeks old and of comparable size or animals less than 8 weeks old that are littermates and are accompanied by their dam may be transported in the same enclosure.

### Food and Water

1. Each animal 16 weeks old or older must be offered food at least once every 24 hr.
2. Animals less than 16 weeks old must be offered food at least once every 12 hr.
3. Each animal must be offered water at least once every 12 hr.
4. Those periods start when an animal was last offered food and water before transportation began.
5. Each animal must be offered food and water within 4 hr before being transported or within 4 hr before delivery to a carrier or intermediate handler.
6. It is not acceptable to withhold food or water unless withholding is directed by a veterinarian.

### Documentation

1. Certifications must be securely attached to the outside of the primary enclosure in a manner that makes them easily noticed and read.
2. For surface transportation only, the operator of the conveyance may hold documents. Certification must include
   a. Consignor's name, address, and dated signature.
   b. Consignee's name, address, and telephone number.
   c. Each animal's tattoo or tag number.
   d. Time and date when each animal was last fed and watered (not to occur more than 4 hr before delivery to carrier or intermediate handler).
   e. Instructions for satisfying in-transit food and water requirements for a 24-hr period, administration of drugs or medication, or other special care.
3. Certification of acclimation (required only if temperature of animal holding area is less than 45°F) must include
   a. Consignor's name and address.
   b. Each animal's tattoo or tag number.
   c. Signed statement from veterinarian, dated no more than 10 days before delivery, that each animal is acclimated to temperatures

lower than 50°F, and the specific minimal temperature that the animal is acclimated to.

### Delivery to Carriers and Handlers

1. Carriers and handlers cannot accept an animal for transportation more than 4 hr before departure time; this can be extended by 2 hr by agreement of the carrier and consignor.
2. Carriers and handlers cannot accept an animal for transportation unless the enclosure meets the requirements described above, the enclosure is free of obvious defects, the appropriate written certifications listed above are attached to the enclosure, and the carriers' holding area meets the minimal temperature requirements described below under "Terminal Facilities" unless the animal is accompanied by a certificate of acclimation (see "Documentation" above).

### Terminal Facilities

1. Shipments of animals cannot be comingled with inanimate cargo in animal holding areas of terminal facilities.
2. All holding areas must be cleaned and sanitized as often as necessary to prevent an accumulation of debris and to minimize disease hazards; an effective program must be implemented for the control of insects, ectoparasites and birds and mammals considered pests.
3. Ventilation must be provided to minimize drafts, odors, and moisture condensation; auxiliary ventilation must be used when the ambient temperature is 85°F or higher.
4. Temperature must not be below 45°F or above 85°F for more than 4 consecutive hours; temperature must be measured at a point not more than 3 ft away from the outside of the enclosure and halfway up the side of the enclosure.
5. The facility must provide shelter from sunlight, extreme heat, rain, and snow.
6. Upon arrival at a facility, if a consignee cannot be notified with 24 hr of arrival, the handler must return the animal to the consignor; if the consignee is notified but does not accept delivery within 48 hr of arrival, the handler must return the animal to the consignor.

### Handling

1. When an animal is moved to or from a facility or conveyance, it must be sheltered from sunlight, extreme heat, rain, and snow.

2. The animal cannot be exposed to temperature above 85°F for more than 45 min.
3. Transporting devices must be covered when the temperature falls below 50°F; the animal cannot be exposed to temperatures below 45°F for more than 45 min unless it is accompanied by a certificate of acclimation; temperature is measured from a point not more than 3 ft from the outside of the enclosure and halfway up the side of the enclosure.
4. Handlers must avoid causing physical harm or distress to the animal.
5. The enclosure cannot be placed on an unattended conveyor belt or on an elevated conveyor belt or tossed, dropped, needlessly tilted, or stacked in a manner that results in its falling.
6. The enclosure must be handled in a manner consistent with written instructions attached to it.

## Primary Conveyance

1. The cargo space of conveyances to transport animals must be designed, constructed, and maintained in a manner that protects the health and well-being of each animal and ensures its safety and comfort.
2. The cargo space must have a supply of air that is sufficient for normal breathing of all animals, and entry of engine exhaust must be prevented.
3. Enclosures must be positioned in the cargo space in a manner that provides protection from the elements, allows each animal enough air for normal breathing, and allows for the removal of the animals in the event of an emergency.
4. During surface transportation, auxiliary ventilation must be used in the cargo space when the temperature reaches 85°F. The temperature may not exceed 85°F or fall below 45°F for a period of more than 4 hr.
5. During air transportation, cargo areas must be heated or cooled as necessary to maintain a temperature that ensures the health and well-being of each animal. The cargo area must be pressurized in flights above 8,000 ft.
6. The cargo space must be kept clean and animals may not be transported with any items that may be expected to cause harm to them.

## Care in Transit

1. During surface transportation, the operator of the conveyance must observe the animals at least once every 4 hr to ensure sufficient air and acceptable ambient temperatures. If an animal is in obvious physical distress, the operator must obtain appropriate veterinary care at the closest available facility.

2. During air transport, animals must be observed at least once every 4 hr unless the cargo area is not accessible during flight, in which case the animals must be observed whenever they are loaded or unloaded to ensure sufficient air and acceptable ambient temperatures. If an animal is in obvious physical distress, veterinary care must be provided as soon as possible.
3. During transportation, animals shall not be removed from their enclosure unless placed in another enclosure or facility that conforms to the appropriate AWA regulations.

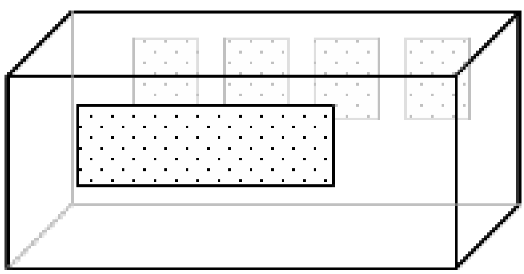
## NONHUMAN PRIMATES (9 CFR 3.86-3.92)

### Enclosure

1. The primary enclosure must be strong enough to contain the animals securely and comfortably and to withstand the normal rigors of transportation.
2. The enclosure must be large enough that each animal has enough space to turn around normally and to sit without its head touching the top of the enclosure. Larger species may be restricted in their movements when freedom of movement would be dangerous to the animals or people.
3. The enclosure interior should not have sharp points, edges, or protrusions that could injure the animal.
4. The animal must be securely contained in the enclosure and unable to put any part of its body outside the enclosure in a way that could result in injury to it, handlers, or other persons or animals.
5. Openings of enclosures must be easily accessible at all times for emergency removal of animals.
6. Openings of enclosure must be secure with animalproof devices that prevent accidental opening, including opening by nonhuman primates.
7. Unless the enclosure is permanently affixed to the conveyance, adequate handles or handholds must be provided so that it can be lifted without tilting and to ensure that anyone handling it will not come into physical contact with the animal in it.
8. Ventilation openings should be covered with bars, wire mesh, or smooth expanded metal having air spaces.

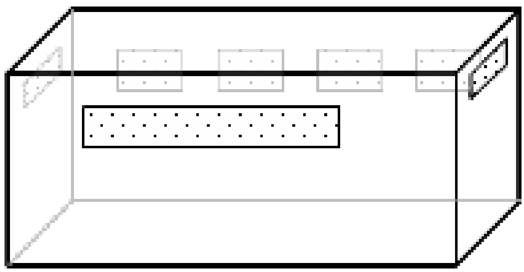
9. All enclosures must be marked on the top and at least one side with the words “Live Animals” or “Wild Animals” in letters at least 1 in. high and with arrows indicating the correct upright position of the enclosure.
10. Any material or treatment in or on the enclosure should be nontoxic.
11. A solid, leakproof bottom or removable leakproof tray under a slatted or mesh floor that prevents seepage of waste products outside of the enclosure is required. The slatted or mesh floor must be constructed so that the animal cannot put any part of its body through the raised floor. The enclosure must contain enough unused, nontoxic litter to absorb and cover excreta.
12. Food and water receptacles must be attached inside the enclosure and placed so that they can be filled from outside the enclosure without opening the door. Food and water receptacles must be designed and installed so that a nonhuman primate cannot leave the primary enclosure through the food or water opening.
13. The primary enclosure must be cleaned and sanitized before each use.
14. Projecting rims must be on the exterior of walls that contain ventilation openings and provide a minimal air circulation space of 0.75 in.
15. The size and arrangement of ventilations openings must comply with one of the following options:

    Option A: Two ventilation openings



Surface area of each opening is at least 16% of wall surface area.
Each opening must be above midline of enclosure.

Option B: Four ventilation openings



Surface area of each opening is at least 8% of surface area of that wall.
Each opening must be above midline of enclosure.

16. If the enclosure is permanently affixed to the conveyance so that there is only a front ventilation opening, this opening cannot be blocked, must open directly to an unobstructed aisle, must be at least 90% of the total surface area of the front wall, and must be covered with bars, wire mesh, or smooth expanded metal having air spaces.

## Compatibility

1. Only one animal may be transported in a primary enclosure, except for
   a. A mother and her nursing infant.
   b. An established male-female pair or family group (but a female in estrus cannot be transported with a male nonhuman primate).
   c. A compatible pair of juveniles of the same species that have not reached puberty.
2. Nonhuman primates of different species cannot be transported in adjacent or connecting enclosures.

## Food and Water

1. Each animal 1 year old or older must be offered food at least once every 24 hr and water at least once every 12 hr.
2. Animals less than 1 year old must be offered food and water at least once every 12 hr.
3. Those periods start when an animal was last offered food and water before transportation began.
4. Each animal must be offered food and water within 4 hr before being transported or within 4 hr before delivery to a carrier or intermediate handler.

## Documentation

1. Certifications must be securely attached to the outside of the primary enclosure in a manner that makes them easily noticed and read.
2. For surface transportation only, documents may be held by the operator of the conveyance. Certification must include
   a. Consignor's name, address, and dated signature.
   b. Consignee's name, address, and telephone number.
   c. Species of nonhuman primate.
   d. Time and date when animal was last fed and watered (not to occur more than 4 hr before delivery to carrier or intermediate handler).
   e. Instructions for in-transit food and water requirements for a 24-hr period, administration of drugs or medication, or other special care required.
3. Certification of acclimation (required only if the temperature of the animal holding area is less than 45°F) must include
   a. Consignor's name and address.
   b. Species of nonhuman primate.
   c. Signed statement from veterinarian, dated no more than 10 days before delivery, that the animal is acclimated to temperatures lower than 50°F and the specific minimal temperature the animal is acclimated to.

## Delivery to Carriers and Handlers

1. Carriers and handlers cannot accept an animal for transportation more than 4 hr before departure time. This can be extended by 2 hr by agreement of the carrier and consignor.
2. Carriers and handlers cannot accept an animal for transportation unless the enclosure meets the requirements described above, the enclosure is free of obvious defects, the appropriate written certifications listed above are attached to the enclosure, and the carriers' holding areas meet the minimal temperature requirements described below under "Terminal Facilities" unless the animal is accompanied by a certificate of acclimation (see "Documentation" above).

## Terminal Facilities

1. Shipments of animals cannot be comingled with inanimate cargo in animal holding areas of terminal facilities. Nonhuman primates must not be placed near any other animals, including other species of nonhuman primates, and must not be able to touch or see any other animals, including other species of nonhuman primates.

2. All holding areas must be cleaned and sanitized as often as necessary to prevent an accumulation of debris and to minimize disease hazards. An effective program must be implemented for the control of insects, ectoparasites, and birds and mammals considered pests.
3. Ventilation must be provided to minimize drafts, odors, and moisture condensation. Auxiliary ventilation must be used when the ambient temperature is 85°F or higher.
4. The temperature must not fall below 45°F or rise above 85°F for more than 4 consecutive hr. Temperature must be measured at a point not more than 3 ft away from the outside of the enclosure and halfway up the side of the enclosure.
5. The facility must provide shelter from sunlight, extreme heat, rain, and snow.
6. Upon arrival at a facility, the carrier or handler must attempt to notify the consignee immediately and once every 6 hr thereafter. The time, date, and method of attempted notification, actual notification of consignee, and name of the person who notified or attempted to notify the consignee must be written either on the carrier's copy of the shipping document or on the copy that accompanies the primary enclosure. If a consignee cannot be notified with 24 hr of arrival, the handler must return the animal to the consignor. If the consignee is notified but does not accept delivery within 48 hr of arrival, the handler must return the animal to the consignor.

## Handling

1. When an animal is moved to or from a facility or conveyance, it must be sheltered from sunlight, extreme heat, rain, and snow.
2. The animal cannot be exposed to a temperature above 85°F for more than 45 min.
3. Transporting devices must be covered when the temperature falls below 45°F; the animal cannot be exposed to temperatures below 45°F for more than 45 min unless it is accompanied by a certificate of acclimation; temperature is measured from a point not more than 3 ft from the outside of the enclosure and halfway up the side of the enclosure.
4. Handlers must avoid causing physical harm or distress to the animal.
5. The enclosure cannot be placed on an unattended conveyor belt or on an elevated conveyor belt or tossed, dropped, needlessly tilted, or stacked in a manner that results in its falling.
6. The enclosure must be handled in a manner consistent with written instructions attached to it.

## Primary Conveyance

1. The cargo space of conveyances to transport animals must be designed, constructed, and maintained in a manner that protects the health and well-being of each animal and ensures its safety and comfort.
2. The cargo space must have a supply of air that is sufficient for normal breathing of all animals, and entry of engine exhaust must be prevented.
3. Enclosures must be positioned in the cargo space in a manner that provides protection from the elements, allows each animal enough air for normal breathing, and allows for the removal of the animals in the event of an emergency.
4. During surface transportation, temperatures inside cargo areas must be kept at between 45°F to 85°F at all times.
5. During air transportation, cargo areas must be maintained at a level that ensures the health and well-being of each animal at all times.
6. The cargo space must be kept clean, and animals may not be transported with any items that may be expected to cause harm to them.
7. Enclosures containing nonhuman primates must be placed far enough away from animals that are predators or natural enemies. Regardless of whether the other animals are in enclosures, the nonhuman primates should not be able to touch or see them.

## Care in Transit

1. During surface transportation, the operator of the conveyance must observe the animals at least once every 4 hr to ensure sufficient air and acceptable ambient temperatures. If an animal is in obvious physical distress, the operator must obtain appropriate veterinary care at the closest available facility.
2. During air transportation, animals must be observed at least once every 4 hr unless the cargo area is not accessible during flight, in which case animals must be observed whenever they are loaded or unloaded to ensure sufficient air and acceptable ambient temperatures. If an animal is in obvious physical distress, veterinary care must be provided as soon as possible.
3. During transportation, animals shall not be removed from their enclosure unless it is to be placed in another enclosure or facility that conforms to the appropriate AWA regulations. Only persons who are experienced and authorized by the shipper, consignor, or consignee may remove a nonhuman primate from its enclosure during transportation, unless it is required for the health or well-being of the animal.

## GUINEA PIGS AND HAMSTERS, RABBITS, AND OTHER ANIMALS (9 CFR 3.35-3.41, 9 CFR 3.60-3.65, 9 CFR 3.136-3.142)

### Enclosure

1. The primary enclosure must be strong enough to contain the animals securely and comfortably and to withstand the normal rigors of transportation.
2. The enclosure must be large enough that each animal has enough space to turn around normally while standing and to stand and lie in a natural position. Some species may be restricted in their movements when freedom of movement would constitute a danger to the animals or people.
3. Enclosure interiors must have no protrusions that could injure the animals.
4. For guinea pigs and hamsters, inner surfaces of fiberboard, cardboard, or plastic enclosures must be covered or laminated with wire mesh or screen where necessary to prevent escape.
5. Openings of the enclosures must be easily accessible at all times for emergency removal of animals.
6. Unless the enclosure is permanently affixed to the conveyance, adequate handles or handholds must be provided so that the enclosure can be lifted without tilting and to ensure that anyone handling it will not come into physical contact with animals in it.
7. Projecting rims must be on the exterior of walls that contain ventilation openings and provide a minimal air circulation space of 0.75 in.
8. Unless the enclosure is permanently affixed to the conveyance, it must be marked on top and on at least one side with the words "Live Animals" or "Wild Animals" in letters at least 1 in high and with arrows indicating the correct upright position of the enclosure.
9. A solid, leakproof bottom that prevents seepage of waste products outside the enclosure is required. Unless it is on a wire or other nonsolid floor, the enclosure must contain enough unused, nontoxic litter to absorb and cover excreta.
10. The primary enclosure must be cleaned and sanitized before each use.
11. The interior height and space per animal of each enclosure must comply with the following minimal standards for guinea pigs and hamsters (there are no minimal requirements for rabbits and other animals):

**Guinea Pigs**

| *Weight* | *Minimal Interior Height of Enclosure* |
|---|---|
| <500 g | 15.2 cm |
| >500 g | 17.8 cm |

| *Weight* | *Minimal Enclosure Space per Animal* |
|---|---|
| <350 g | 193.6 $cm^2$ |
| 350 to 600 g | 290.3 $cm^2$ |
| >600 g | 354.8 $cm^2$ |

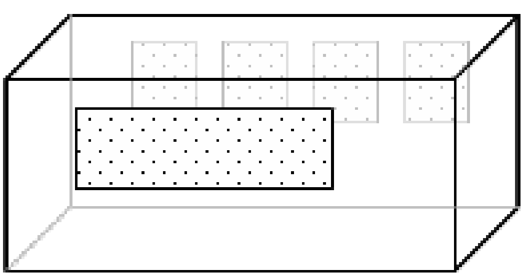
**Hamsters**

| | *Minimal Interior Height of Enclosure* |
|---|---|
| Dwarf Hamsters | 12.7 cm |
| All Other Hamsters | 15.2 cm |

| | *Minimal Enclosure Space per Animal* | |
|---|---|---|
| *Age* | *Dwarf Hamsters* | *All Other Hamsters* |
| Weaning-5 weeks | 32.2 $cm^2$ | 45.2 $cm^2$ |
| 5 to 10 weeks | 48.3 $cm^2$ | 71.0 $cm^2$ |
| >10 weeks | 58.1 $cm^2$ | 96.8 $cm^2$ |

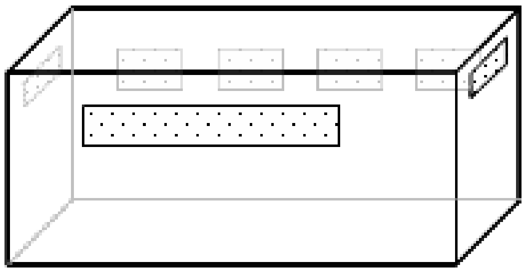
12. The size and arrangement of ventilations openings must comply with one of the following options:

    Option A: Two ventilation openings



Surface area of each opening is at least 16% of surface area of that wall.
One-third of surface area of openings must be in lower half of enclosure, and at least one-third of surface area of openings must be on upper half of enclosure.

Option B: Four ventilation openings



Surface area of each opening is at least 8% of surface area of that wall.
One-third of surface area of openings must be in lower half of enclosure, and at least one-third of surface area of openings must be on upper half of enclosure.

13. If the enclosure is permanently affixed to the conveyance so that there is only a front ventilation opening, this opening cannot be blocked, must open directly to an unobstructed aisle, must be at least 90% of the total surface area of the front wall, and must be covered with bars, wire mesh, or smooth expanded metal.

**Compatibility**

1. Animals transported in the same enclosure must be of the same species and be maintained in compatible groups.
2. No more than 15 rabbits, 15 guinea pigs, or 50 hamsters can be transported in the same enclosure. For all other animals, animals that have not reached puberty shall not be transported in the same enclosure with adult animals other than their dams; socially dependent animals (such as sibling, dam, and other members of a family group) must be allowed visual and olfactory contact. A female animal in estrus shall not be transported in the same enclosure with a male animal.

**Food and Water**

1. For guinea pigs, hamsters, and rabbits when transported for a period of more than 6 hr, food and water or a type of food that satisfies the requirement for food and water must be provided in the primary enclosure.
2. For all other animals, water must be offered within 4 hr before transportation and at least once every 12 hr after initiation of transporta-

tion. Consigned animals must be provided with water at least once every 12 hr after acceptance for transportation. Exceptions are allowed for animals that require water more frequently, are hibernating, or are under veterinary treatment.

3. Each animal must be fed at least once every 24 hr; exceptions are allowed for animals that require food more frequently, are hibernating, or are under veterinary treatment.

## Documentation

1. Certifications must be securely attached to the outside of the primary enclosure in a manner that makes them easily noticed and read.
2. For surface transport only, documents may be held by the operator of the conveyance. Certification must include
   a. Consignor's name, address, and dated signature.
   b. Number of animals in enclosure.
   c. A statement that enclosure complies with US Department of Agriculture standards.
   d. 24 hr feeding instructions for animals other than guinea pigs, hamsters, and rabbits (whose enclosures should already contain sufficient food and water for the duration of transportation).
3. Certification of acclimation (required only if the temperatures of the animal holding area is less than 45°F) must include (it is important to note that the AWA does not recognize that guinea pigs can be acclimated to temperatures below than 45°F):
   - Consignor's name and address.
   - Number of animals in shipment.
   - Signed statement from veterinarian, dated no more than 10 days before delivery, that the rabbit or hamster is acclimated to temperatures lower than 45°F and the specific minimal temperature the animal is acclimated to.

## Delivery to Carrier and Handlers

1. Carriers and handlers cannot accept an animal for transportation more than 4 hr before departure time. This can be extended by 2 hr by agreement of the carrier and consignor.
2. Carriers and handlers cannot accept an animal for transportation unless the enclosure meets the requirements described above or the consignor furnishes the carrier with a certificate stating that the enclosure complies with the standards set forth in the AWA, the enclosure is free from obvious defects, the appropriate written certifications listed above are attached to the enclosure, and the carriers' holding

areas meet the minimal temperature requirements described below under "Terminal Facilities" unless the animal is accompanied by a certificate of acclimation (see "Documentation" above).

### Terminal Facilities

1. Shipments of animals cannot be commingled with inanimate cargo in animal holding areas of terminal facilities.
2. All holding areas must be cleaned and sanitized as often as necessary to prevent an accumulation of debris and to minimize disease hazards. An effective program must be implemented for the control of insects, ectoparasites, and birds and mammals considered pests.
3. Ventilation must be provided to minimize drafts, odors, and moisture condensation. Auxiliary ventilation must be used when the ambient temperature is 75°F or higher.
4. The temperature must not fall below 45°F or rise above 85°F ever or for more than 4 consecutive hr. Temperature must be measured at a point not more than 3 ft away from the outside of the enclosure and halfway up the side of the enclosure.
5. On arrival at a facility, the carrier or handler must attempt to notify the consignee at least once every 6 hr following arrival. The time, date, and method of each attempt at notification, final notification, and name of the person notifying the consignee shall be recorded on the copy of the shipping document retained by the carrier or intermediate handler and the copy accompanying the animal shipment.

### Handling

1. When an animal is moved to or from a facility or conveyance, it must be sheltered from sunlight, extreme heat, rain, and snow.
2. The animal cannot be exposed to a temperature above 85°F for more than 45 min.
3. Transporting devices must be covered when the temperature falls below 50°F; the animal cannot be exposed to temperatures below 45°F for more than 45 min. Temperature must be measured from a point not more than 3 ft from the outside of the enclosure and halfway up the side of the enclosure.
4. Handlers must avoid causing physical harm or distress to the animals.
5. The enclosure cannot be tossed, dropped, needlessly tilted, or stacked in a manner that results in its falling.

## Primary Conveyance

1. The cargo space of conveyances for transport of animals must be designed, constructed, and maintained in a manner that protects the health and well-being of each animal and ensures its safety and comfort.
2. The cargo space must have supply of air that is sufficient for normal breathing of all animals, and entry of engine exhaust must be prevented.
3. Enclosures must be positioned in the cargo space in a manner that provides protection from the elements, allows each animal enough air for normal breathing, and allows for the removal of animals in the event of an emergency.
4. During transport, auxiliary ventilation must be used in the cargo space when the temperature reaches 75°F. The temperature may not exceed 85°F or fall below 45°F except when rabbits are being transported and a certificate of acclimation to lower temperatures has been provided.
5. The cargo space must be kept clean, and animals may not be transported with any items that may be expected to cause harm to them.

## Care in Transit

1. During surface transportation, animals must be observed at least once every 4 hr to ensure sufficient air and acceptable ambient temperatures. If an animal is in obvious physical distress, the operator must obtain appropriate veterinary care as soon as possible.
2. During air transportation, animals must be observed at least once every 4 hr unless the cargo area is not accessible during flight, in which case animals must be observed whenever they are loaded and unloaded to ensure sufficient air and acceptable ambient temperatures. If an animal is in obvious physical distress, veterinary care must be provided as soon as possible.
3. During transportation, animals shall not be removed from their enclosure unless it is to be placed in another enclosure or facility that conforms to the applicable AWA regulations.

# Appendix B

# Patterns in the Ground Transportation of Research Animals in the United States

## BACKGROUND

This appendix focuses on inventorying the locations of institutions that use animals for research and the locations of the vendors that breed research animals for research in order to visualize the movement of research animals in the United States.[1] In addition, the appendix presents the results of a quantitative modeling effort directed towards locating additional supply points "optimally" and assessing the potential benefit of the additional supply points. All of the analyses in this appendix are focused on the transportation of research animals by truck from US breeding vendors to US research institutions; they do not consider transportation of research animals by other modes (air, sea, etc.) and transportation of research animals between research institutions or from abroad.

The next section discusses data-preparation efforts. The following two sections present a brief overview of the quantitative analysis and the empirical results of the analysis.

[1]The transportation model was limited to those species for which the vendors/breeders supplying research animals were clearly identifiable. Livestock and some other species were excluded because animals of these species used in research can be obtained from a number of sources, some of which the committee could not identify.

## DATA PREPARATION

### Data Sources

The three primary data sets used in this analysis are the National Institutes of Health (NIH) academic institution data from 2003, the US Department of Agriculture (USDA) species and facilities data from 2003, and data on research animal vendors. The first set, which is referred to as the NIH grants data, consists of 1020 research institutions (academic and nonacademic) in the United States that receive grant awards for research utilizing research animals. For each institution, the data include the location (city and state), the number of NIH grant awards that utilize animals in 2003, and the award amount received in 2003. This data set was used as a proxy for rodent (rats and mice) use in the United States. Unlike other species of research animals, rodent use is not reported to any federal agency, so there is no census of rodents used in biomedical research. However, it has been estimated that rodents comprise approximately 95% of the animals utilized in research (Trull and Rich, 1999). Therefore, the total dollar amount of the NIH grants awarded to each institution was used as a proxy for the relative magnitude of rodent use at that institution.

The second data set, which is referred to as the USDA data,[2] contains information on 985 research institutions (academic and nonacademic), their locations, and the numbers of animals utilized in research or breeding programs, by species (cats, dogs, rabbits, guinea pigs, hamsters, pigs, sheep, other farm animals, and nonhuman primates). Those two sets of data include all warm-blooded vertebrates (with the exception of rats, mice, and birds) used in research in the United States, and those vertebrates (including rats, mice, and birds) utilized in research supported by NIH funding. The one subgroup of research animals not described in those data sets are rats, mice, and birds utilized at research institutions not supported by NIH funding. This would include most commercial research institutions, such as pharmaceutical and biotech companies. Rodent vendors have estimated that 45% of shipments are to for-profit customers, suggesting that a large portion of the facilities that utilize rodents are not represented in the data sets used for this model.

The third data set, which is referred to as the vendor data, includes the major vendors that supply research animals in the United States, the locations of production facilities, and the species they supply. Of the 45 vendors in this data set, four vendors supply cats, 16 supply dogs, 20 supply rodents (rats and mice); some vendors supply multiple species.

[2]This data was obtained from the USDA through a Freedom of Information Act request.

In addition to the three primary data sources listed above, the US Cities Geographic Information System (GIS) file provided by TransCAD® (Caliper, Inc.) was used in the analysis. The US Cities GIS file locates US cities on the basis of latitude and longitude.

### Geocoding Procedure

Geocoding of research institution and vendor locations from the primary data sources was accomplished using TransCAD®. Specifically, data on the location of the institutions were matched with the city and state data fields in the US Cities GIS file to determine the geographic coordinates (latitude and longitude) of the institution or vendor locations. A TransCAD® macro was written to automate the process. Some 80% of the research institutions and all of the vendor locations were geocoded using the automated procedure. However, the US cities GIS file did not have city data fields corresponding to the remaining 20% of research institutions. For these, we used internet websites to manually determine geographic coordinates of the cities in which the research institutions were located.

### Computation of Distances Between Utilization Points and Supply Locations

The geocoding of the locations of utilization points and supply locations was followed by an overlay procedure in TransCAD® in which the geocoded locations were overlaid on the TransCAD® highway file and mapped to the nearest highway network node. A TransCAD® shortest-path routine was then run to obtain distances between utilization points and supply locations.

## QUANTITATIVE ANALYSIS

The objective of the quantitative analysis was to locate additional supply points optimally, with an assessment of the potential benefit of doing so. The fundamental motivation was to answer the following questions: If one additional breeding facility is being considered in the United States, where should it be to make the new total distance in the animal transportation system lowest? By how much is the new total transportation distance shorter than the former total distance? The questions could then be extended to more than one additional breeding facility. The facility-location model is thus a minimization model that considers various alternative location possibilities and determines the ones that provide the shortest transportation distance.

An important issue is that the solution space for identifying the best locations for new facilities is the entire United States. However, it is computationally infeasible to enumerate the objective function over all possible locations in the United States. Furthermore, for the scale of the transportation problem under study, there is no need to consider two closely spaced cities (such as Dallas and Fort Worth) as separate candidate locations. In the current analysis, the United States is divided into 40 grids, and the centroids of the grids are considered as the candidate solutions for the facility-location problem (see Figure B-1). The distances from all of the research centers to those potential facility locations are calculated with the procedure discussed above.

The minimization function in the facility-location problem is weighted to ensure that a new facility is located closer to high-utilization demand points. In the NIH grants file, the weighting was based on the total dollar amount of NIH grants. In the USDA file, the weighting for each species category was based on the total number of each species used at each utilization point.

A couple of points should be noted about the results of the quantitative modeling effort presented in the next section. First, because a spatial system that identifies 40 grids of the entire United States is used to identify candidate location sites, the city locations identified in the next section as optimal location points for additional facilities must not be taken literally. The spatial resolution adopted for the quantitative analysis implies that any location within 100-200 miles of the city locations identified in the next section would be appropriate and reasonable. Second, the locations of additional supply points are based solely on the criterion of reducing total transportation distance. Clearly, there are other factors that this model does not take into consideration, e.g., all stocks and strains of any given species are not maintained at each production facility and some vendors have established truck routes that determine which production facility will supply certain research institutions. Therefore, the locations suggested by the model in the next section should be considered in light of these complexities.

## EMPIRICAL RESULTS

Three facility location models were estimated, one each for the NIH grants data set (rodents), the USDA cats data set, and the USDA dogs data set. For each of the three analyses, the optimal locations for one and two additional supply points were determined. In the analyses, the solutions for additional supply points were incremental and are not included here.

The results from the NIH grants data set (rodents) are provided in Figure B-2 and Table B-1. The current supply points are represented in the

**FIGURE B-1** Candidate set for the facility-location problem. Dots indicate the centroids for the 40 grid segments used in the analysis.

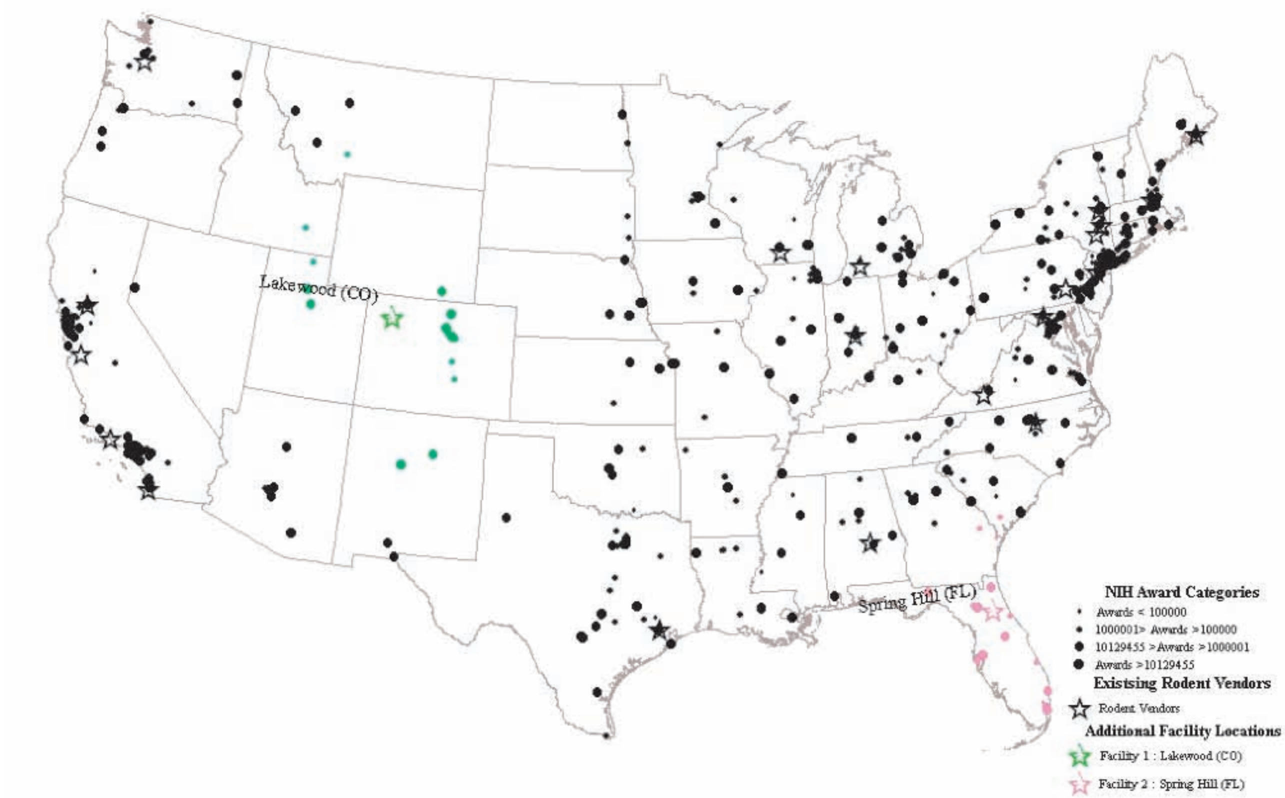



**FIGURE B-2** Solution set for the facility location problem for the NIH grants data set (rodents).

shape of stars in Figure B-2, and the current demand points (i.e., research institutions) are represented by dots, with the diameter of the dot indicating the total amount of funding received by the research institution in 2003. The "new" supply points are identified by a colored star and labeled. The figure indicates that the optimal location for one additional supply point would be Lakewood, CO, and for two additional supply points would be Lakewood, CO, and Spring Hill, FL. Table B-1 indicates the estimated reduction in total weighted travel distance in the research animal transportation system due to the addition of supply points. The reductions are substantial and show, as expected, the decreasing marginal returns with the number of additional supply points.

The corresponding results for the USDA cats data set are provided in Figure B-3 and Table B-2, and for the USDA dogs data set in Figure B-4 and Table B-3. In the figures, the diameters of the dots representing research institutions indicate the number of animals utilized at the research institution. As can be observed from Tables B-1 through B-3, the reductions in total weighted travel distance are substantial for each species.

TABLE B-1 Total Weighted-System Travel-Distance Reduction with Increase in Supply Points for NIH Grants Data Set (Rodents)

| No. of Facilities | Optimal Supply-Point Locations | Total Weighted-System Travel Distance (miles) | Incremental Percentage Change |
|---|---|---|---|
| 0 (base case) | — | 13,651,385 | — |
| 1 | Lakewood, CO | 12,198,700 | 10.64 |
| 2 | Lakewood, CO and Spring Hill, FL | 11,714,939 | 3.96 |

TABLE B-2 Total Weighted-System Travel-Distance Reduction with Increase in Supply Points for USDA Cats Data Set

| No. of Facilities | Optimal Supply-Point Locations | Total Weighted-System Travel Distance (miles) | Incremental Percentage Change |
|---|---|---|---|
| 0 (base case) | — | 13,101,225 | — |
| 1 | Chico, CA | 9,108,974 | 30.47 |
| 2 | Chico, CA and Spring Hill, FL | 6,915,744 | 24.08 |

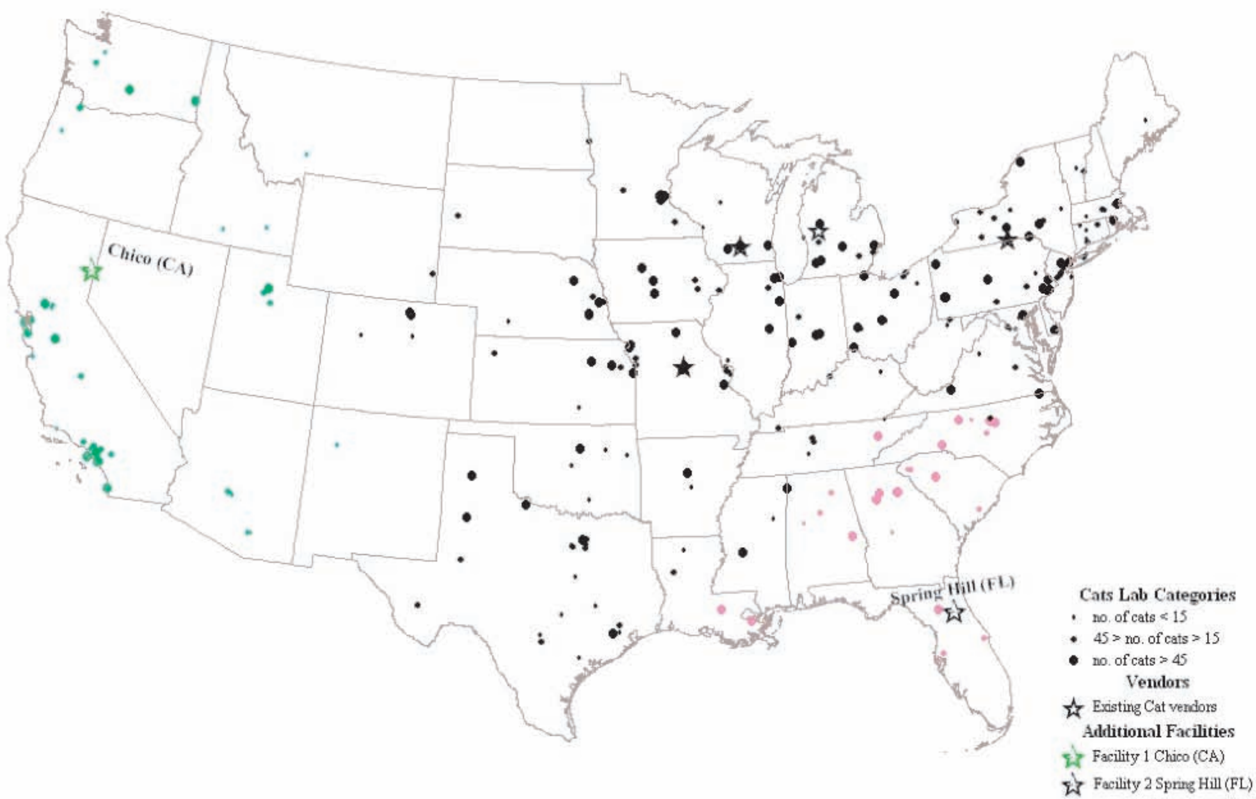



**FIGURE B-3** Solution set for the facility location problem for the USDA cats data set.

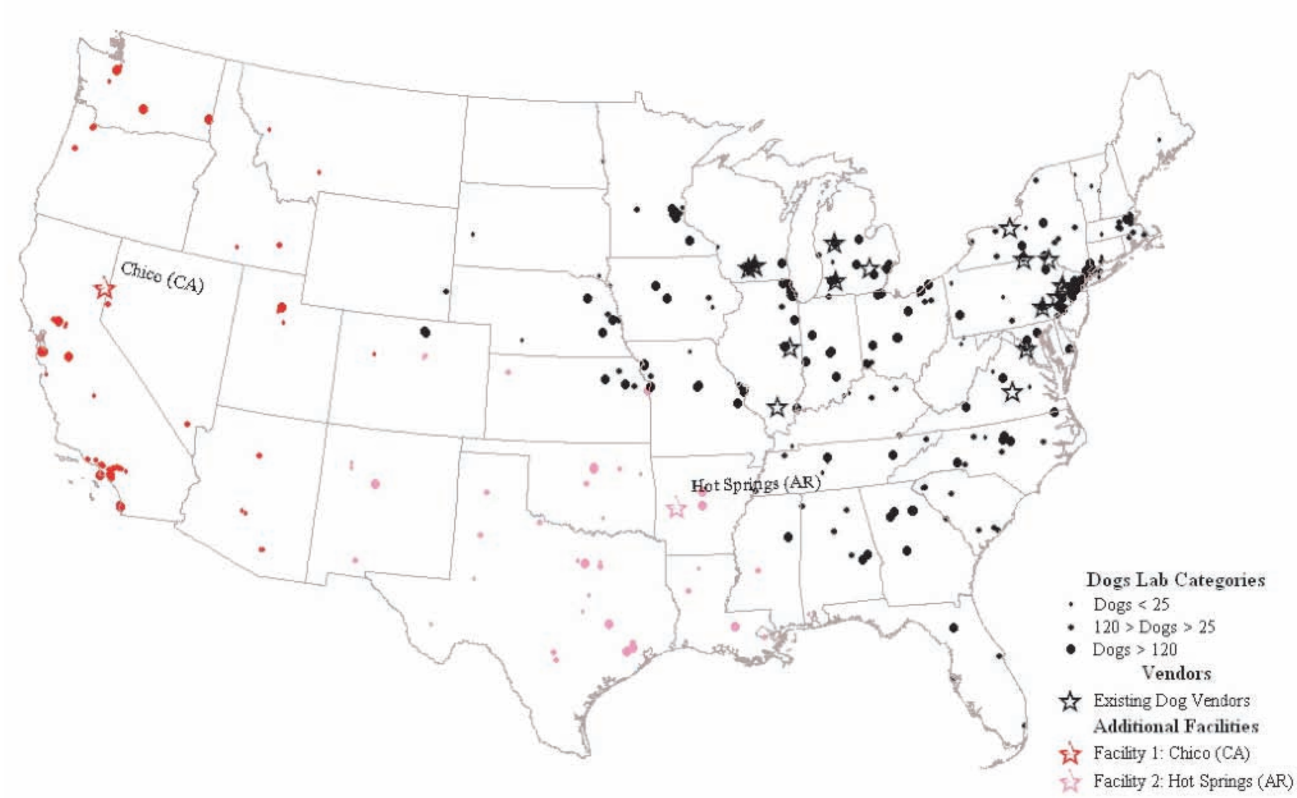



**FIGURE B-4** Solution set for the facility location problem for the USDA dogs data set.

TABLE B-3 Total Weighted-System Travel-Distance Reduction with Increase in Supply Points for USDA Dogs Data Set

| No. of Facilities | Optimal Supply-Point Locations | Total Weighted-System Travel Distance (miles) | Incremental Percentage Change |
|---|---|---|---|
| 0 (base case) | — | 25,387,410 | — |
| 1 | Chico, CA | 18,110,828 | 28.66 |
| 2 | Chico, CA and Hot Springs, AR | 14,765,449 | 18.47 |

## SUMMARY

This chapter has described the committee's efforts to inventory and visualize the "utilization" points of research animals (the locations of institutions that use research animals) and the "supply" points of research animals (the locations of the vendors that breed research animals). Such an effort provides a qualitative sense of the patterns of transportation of research animals. In addition, the chapter presents the results of a quantitative modeling effort to locate additional supply points "optimally" and an assessment of the potential benefit of the additional supply points.

It is important to again emphasize that the locations for additional supply points developed from the quantitative analysis are based solely on the criterion of reducing total weighted travel distance in the research animal transportation system. Furthermore, because a grid system was used to identify candidate location sites and because of the scale of the research animal transportation system, any location within 100 to 200 miles of the locations identified in the analyses would be reasonable.

# About the Authors

**Ransom L. Baldwin**, PhD (Chair), is professor and session chair of the Department of Animal Science of the University of California, Davis. He is known for his research on nutrient use and energetics in ruminant animals. Dr. Baldwin has extensive National Research Council committee experience, including involvement on the Committee to Revise the Guide for the Care and Use of Laboratory Animals (1996) and his role as chair of the Subcommittee on Input-Output Relationships in Animal Production. He is a member of the National Academy of Sciences.

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