Hand-Rearing Wild and Domestic Mammals

Laurie J. Gage, DVM
Hand-Rearing Wild and Domestic Mammals
Hand-Rearing Wild and Domestic Mammals

Laurie J. Gage, DVM

Blackwell Publishing
Laurie J. Gage, D.V.M., served as the Director of Veterinary Services concurrently at both Marine World Africa USA and The Marine Mammal Center from 1980 to 1994. She continued to hold that title at Marine World Africa USA until 1998, when the park became Six Flags Marine World. She also was the consultant veterinarian for Safari World in Bangkok, Thailand from 1992 to 1994, and has done consultant veterinary work for a number of private collections. She has been a lecturer at the University of California, Davis School of Veterinary Medicine since 1982 where she teaches marine mammal medicine and husbandry. She is presently the consultant veterinarian for Coyote Point Museum, and the Chief veterinarian for Six Flags Marine World in Vallejo, California.

The charts “Substitute Milk Formula For Opossum” and “Feeding Chart For The Modified Jurgelski Diet For Opossums” used by permission of Debbie Marcum.
To my teachers Mary, Murray, and Mishka
## Contents

**Contributors**  
ix

**Preface**  
xiii

**Acknowledgments**  
xv

**Introduction**  
xvii

### Part I  Domestic Mammals

1. Orphan Rabbits  
   *Karen Heller Taylor*  
   5

2. Puppies  
   *Valerie T. Barrette*  
   13

3. Domestic Kittens  
   *Laura Summers*  
   19

4. Critically Ill and Orphaned Foals  
   *K. Gary Magdesian*  
   24

5. Pigs  
   *Janet Fine and Rebecca Duerr*  
   30

6. Goat Kids  
   *Joan D. Rowe*  
   34

7. South American Camelids  
   *Robert J. Pollard and Susan D. Pollard*  
   39

### Part II  Wildlife, Zoo, and Marine Mammals

8. Opossums  
   *Paula Taylor*  
   45

9. Sugar Gliders  
   *Michele Barnes*  
   55

10. Macropods  
    *Rosemary Booth*  
    63

11. Hedgehogs  
    *Ian Robinson*  
    75

12. Sloths  
    *Judy Avey-Arroyo*  
    81

13. Ground and Tree Squirrels  
    *Dawn M. Smith*  
    90

14. Insectivorous Bats  
    *Susan M. Barnard*  
    96

15. Lemurs  
    *Cathy V. Williams*  
    104
16 Tamarins  
Laurie Hrdlicka and Cynthia Stringfield  
17 Macaque Species  
Laura Summers, Laurie Brignolo, and Kari Christe  
18 Great Apes  
Dawn Strasser  
19 Harbor Seals and Northern Elephant Seals  
Rebecca Duerr  
20 Sea Lions and Fur Seals  
Laurie J. Gage  
21 Walrus Calves  
Laurie J. Gage and Terry S. Samansky  
22 Fox Kits  
Jennifer Convy, Darlene DeGhetto, and Sophia Papageorgiou  
23 Black Bear Cubs  
Sophia Papageorgiou, Darlene DeGhetto, and Jennifer Convy  
24 Polar Bears  
Gail Hedberg  
25 Raccoons  
Darlene DeGhetto, Sophia Papageorgiou, and Jennifer Convy  
26 Ferret Kits  
Vickie McKimmey  
27 Exotic Felids  
Gail Hedberg  
28 Elephants  
Karen A. Emanuelson and Colleen E. Kinzley  
29 Nondomestic Equids  
Terry Blakeslee and Jeffrey R. Zuba  
30 Rhinoceros  
Terry Blakeslee and Jeffrey R. Zuba  
31 Black-Tailed and White-Tailed Deer  
Sophia Papageorgiou, Darlene DeGhetto, and Jennifer Convy  
32 Exotic Ungulates  
Kelley Greene and Cynthia Stringfield  

Appendix: Resources for Products Mentioned  
Index
Contributors

Judy Avey-Arroyo began working with sloths in Costa Rica in 1990. Finding no rescue centers for sloths, she developed a rescue/rehab/release protocol and opened an officially sanctioned rescue center in 1997. She has rescued, rehabilitated, and released injured adults and successfully released two hand-reared three-toed sloths using radio-telemetry.

Susan M. Barnard received her Bachelor of Science degree in 1983 from the University of the State of New York. She is assistant curator of herpetology at Zoo Atlanta, and executive director of Basically Bats, Inc. Barnard has served on the board of directors of the American Association of Zoo Keepers. She has authored numerous books and articles on aspects of reptilian husbandry, parasitology, and bat rehabilitation. As a licensed wildlife rehabilitator in the State of Georgia for over 20 years, Barnard pioneered bat rehabilitation in the United States. She makes routine television appearances and was featured in the National Geographic television special, “Keepers of the Wild.”

Michele Barnes began her career as a wildlife attendant at Koala Country, Dreamworld, in 1991. A specialist with mammals, she has also cared for birds, reptiles, and amphibians. She has been successful in raising animals such as bats, bandicoots, phascogale, possums, macropods, and gliders. Barnes is life sciences coordinator at The Australian Wildlife Experience, Dreamworld.

Valerie T. Barrette has worked in the veterinary field since 1982 as an assistant and client educator. Her canine behavior counseling service, The Right Steps, specializes in puppies. She is a lecturer at the San Francisco SPCA Dog Training Academy and writes a column for the Association of Pet Dog Trainers’ newsletter.

Terry Blakeslee became a keeper at the San Diego Wild Animal Park in 1972. As a member of the team of keepers at the Animal Care Center she has assisted in the hand rearing of approximately 2200 mammals, representing 116 species, mostly ungulates.

Rosemary Booth has worked as a veterinarian at Lone Pine Koala Sanctuary, Healesville Sanctuary, Melbourne Zoo, Currumbin Sanctuary, and the University of Queensland. Dr. Booth has broad experience in veterinary care and husbandry of Australian native species and has personally hand raised many Australian native species. She is an active lecturer and workshop host to volunteer wildlife carers, vets, and zookeepers. Dr. Booth obtained her veterinary degree in 1981 from the University of Queensland, and worked in private practice prior to her first zoo position.

Laurie Brignolo began working with infant monkeys as an undergraduate student. Dr. Brignolo has worked as a veterinarian at the California Regional Primate Research Center in Davis, California, for the last six years. She has monitored over five hundred nursery reared rhesus and cynomolgus macaque infants.

Kari Christe graduated from University of California, Davis, School of Veterinary Medicine, then completed a clinical residency at the California Regional Primate Research Center in 1998. She is a senior veterinarian at the center.
Jennifer Convy is wildlife rehabilitation manager at the PAWS Wildlife Department in Lynnwood, Washington.

Darlene DeGhetto received her DVM from Colorado State University in 1981. Dr. DeGhetto is presently employed by PAWS and has been a wildlife veterinarian since 1995. She has conducted research on marine mammals in Alaska, California, and Washington with the National Marines Fisheries Service, Alaska Department of Fish and Game and Washington Department of Wildlife; seabirds with U.S. Fish and Wildlife Service, Washington Department of Wildlife, and University of Washington; and wild ungulates and bears with Colorado Division of Wildlife.

Rebecca Duerr spent 14 years at the Marine Mammal Center in Sausalito, California, and worked extensively with many species of newborn marine mammals. In addition, she devoted many years to working in terrestrial wildlife rehabilitation facilities where she specializes in avian trauma care and hand-raising passerines for wild release.

Karen A. Emanuelson is director of veterinary services at the Oakland Zoo in Oakland, California. She assisted in the care of the small breeding herd of African elephants at the zoo included the hand raising of one male elephant calf, Kijana, in 1995–1996. Dr. Emanuelson was a private practitioner at Cottage Veterinary Hospital in Walnut Creek, California; taught in the Zoological Medicine Department at the University of California Davis; and interned with the Zoological Society of London, Whipsnade Park, United Kingdom.

Janet Fine operates the Piggypals’ Fine Sanctuary in Marysville California, where she cares for many pigs including potbellies, farm pigs, Yorkshires and hand-raised feral pigs. In 2000, she was awarded the National Sanctuary Owner of the Year award by the Pigs As Pets Association of America.

Laurie J. Gage served as director of veterinary services concurrently at Marine World Africa USA and the Marine Mammal Center from 1980 to 1994. Dr. Gage continued to hold that title at Marine World Africa USA until 1998, when the park became Six Flags Marine World. She has also done consultant veterinary work for a number of private collections domestically and abroad. Since 1982 she has been a lecturer at the University of California, Davis, School of Veterinary Medicine, where she teaches marine mammal medicine and husbandry. She is the consultant veterinarian for Coyote Point Museum and chief veterinarian for Six Flags Marine World in Vallejo, California.

Kelley Greene became an animal keeper at the Los Angeles Zoo in 1983. Greene is a specialist in hand rearing exotic infants with particular interest in hoofstock. She has successfully raised gerenuk, bushbuck, duikers, and pronghorn. She is lead animal keeper in the Los Angeles Zoo’s Children’s Zoo.

Gail Hedberg received her professional training at Colorado Mountain College in Glenwood Springs, Colorado, and became a registered veterinary technician in California in 1977. For the past 25 years she has hand raised over 150 neonatal species. She has held positions at Marine World/Africa USA and works today at the San Francisco Zoological Gardens and various consulting situations.

Laurie Hrdlicka became an animal keeper at Los Angeles Zoo in April of 1979, and began hand rearing infants in January of 1982. She currently works in the Animal Nursery hand rearing infants. She specializes in primates, carnivores, and marsupials.

Colleen E. Kinzley is general curator and elephant manager at the Oakland Zoo in Oakland, California, where she has worked since 1990. In 1995–1996, she was responsible for hand raising a male African elephant calf. She is the author of “The Elephant Hand-Raising Notebook.” She has been animal keeper at the Brookfield Zoo and animal keeper at the Phoenix Zoo.

K. Gary Magdesian received his DVM from University of California, Davis, School of Veterinary Medicine in 1993. He interned at Texas A&M and then completed a residency in large animal internal medicine at UC Davis in 1997. Dr. Magdesian received board certification in internal medicine in 1997 and in emergency/critical care in 2000. He has been on the clinical faculty at UC Davis School of Veterinary Medicine since 1997.

Vickie McKimmey started breeding ferrets in 1990 and is the proprietor of Just a Business of Ferrets. She also does limited rescue and adoption of ferrets. McKimmey is past president of the American Ferret Association and is director for the association’s Shows and Special Events Committee. She is a
Contributors

Sophia Papageorgiou earned her bachelor of science degree in animal science and zoology from the University of California at Davis in 1980. She then earned a degree in exotic animal training and management from Moorpark College in Southern California. After graduating from Tufts University School of Veterinary Medicine in 1996, Dr. Papageorgiou completed a small animal internship in Tucson, Arizona, and a wildlife internship at PAWS Wildlife Center in Lynnwood, Washington.

Robert J. Pollard graduated from UC Davis School of Veterinary Medicine in 1970, after having been one of the first students in Dr. Murray Fowler's zoo and wildlife medicine class. He and his wife Suzi moved to Sonora, in the Sierra foothills, and started a small animal practice. As llamas became more popular in the area in 1983, Dr. Pollard used his wildlife medicine experience to work on llamas, and to help the new llama owners. He and his wife own 59 llamas, with almost a dozen other llamas visiting their Valley of the Llama Ranch for breeding, birthing, or medical care.

Susan D. Pollard works together with her husband Dr. Robert Pollard to care for their personal collection of 59 llamas, as well as privately owned llamas that visit their ranch for breeding, birthing or medical care. Suzi also raises orphan wildlife for the California Department of Fish and Game.

Joan D. Rowe is an associate professor in the Department of Population Health and Reproduction, School of Veterinary Medicine, University of California, Davis. She holds DVM, MPVM, and PhD degrees from the University of California, Davis. Dr. Rowe completed a residency in food animal reproduction and herd health at UC Davis, and is a Diplomate of the American College of Veterinary Preventive Medicine. Dr. Rowe is chief of the Food Animal Reproduction and Herd Health Service at the UCD Veterinary Medical Teaching Hospital. She is a licensed dairy goat judge and on the American Dairy Goat Association Board of Directors.

Ian Robinson is veterinary manager of the RSPCA Norfolk Wildlife Hospital, which rehabilitates native British wildlife and treats thousands of casualties per year. The commonest species admitted is the hedgehog. He qualified as a veterinarian in 1975 and holds the RCVS (Royal College of Veterinary Surgeons) certificate in zoological medicine.

Terry S. Samansky has worked with marine mammals for over two decades. He was directly involved in the successful hand raising of six orphaned walrus calves. Samansky holds a bachelor of arts degree in biology and chemistry from California State University at Sacramento and has held positions as keeper, rehabilitation specialist, trainer, curator, and director at facilities such as Marineland of California, Active Environments, Marine World Africa USA, and Six Flags Marine World. He has published numerous papers and articles, and is a lecturer and teacher on the subject of marine mammal biology, care and husbandry. He is a biological consultant operating the educational website DolphinTrainer.com.

Dawn M. Smith became a registered veterinary technician in 1982. She taught classes for Wildlife Rescue, Inc., and she was director of animal care at the Marine Mammal Center for ten years. In Portugal, she set up the sea otter and marine bird exhibits at the Oceanario de Lisboa. In Los Angeles county, she helped in the opening of the California Wildlife Center, where she is now a consultant. She is a member of the Mediterranean Monk Seal Recovery Team.

Dawn Strasser holds a BS in business management from College of Mount Saint Joseph. She has been at the Cincinnati Zoo since 1979 where she has worked with birds for five years before transferring to the animal nursery. She has been the head keeper for six years, and has raised numerous mammals.

Cynthia Stringfield worked as a veterinary technician raising numerous species and large numbers of exotic mammals at Marine World Africa USA in Redwood City and Vallejo, California, from 1982 to 1990. She received her DVM from the University of California, Davis, School of Veterinary Medicine in 1990. Dr. Stringfield interned in small animal surgery and emergency medicine at the California Animal Hospital in 1991, and has been a staff veterinarian at the Los Angeles Zoo since 1993.

Laura Summers began raising orphan kittens before entering veterinary school. At University of California, Davis, she helped raise orphan kittens taken in by the Feline Medicine Club. After working
as a small animal private practitioner, Dr. Summers became a clinical veterinarian at the Oregon Regional Primate Research Center. She is currently a staff veterinarian at the California Regional Primate Research Center in Davis, California.

Karen Heller Taylor has been a laboratory animal veterinarian at North Carolina State University, College of Veterinary Medicine. She has worked with rabbits for many years as a laboratory animal veterinarian. She is a lecturer in the biology, care, and diseases of rabbits, and is a veterinarian in companion animal practice working with exotic pets and wildlife rehab.

Paula Taylor is a registered nurse with a degree from Golden West College in Huntington Beach, California. She has rehabilitated opossums since 1991. She has been a vice president and director of rehabilitation of the Opossum Society of the United States. She has published a manual and produced a video on opossum orphan care.

Cathy V. Williams is veterinarian for the Duke University Primate Center where she oversees medical care for 25 species of prosimian primates. Dr. Williams serves as the veterinary advisor for aye-ayes, sifakas, and bamboo lemurs to the Prosimian Taxon Advisory Group of the American Zoological Association, and is a representative on Duke University’s Institutional Animal Care and Use Committee. She obtained her veterinary degree in 1985 from the University of California at Davis and completed an internship in small animal medicine and surgery at North Carolina State University College of Veterinary Medicine in 1986. She worked in private practice prior to joining Duke University in 1996.

Jeffery R. Zuba completed a zoo animal medicine residency at the Zoological Society of San Diego. Dr. Zuba was an assistant professor of zoo medicine at Colorado State University from 1990 to 1991. He is an associate veterinarian at the San Diego Wild Animal Park and has worked there as a clinical veterinarian for many years. In this capacity, he has taken part in the institution's well-known program of captive propagation of hoofstock, especially "megavertebrate" species. His special interest is neonatology, which comprises a great portion of his veterinary duties.
When I started my career working with wild and captive nondomestic animals in 1980, my only experience raising any sort of mammal was at the University of California at Davis while I was in veterinary school. There I helped to raise a litter of pigs, a couple of goats, and a calf.

I owe my first real “exotic animal” hand-rearing experience to Dr. Marty Dinnes, my first employer after I completed an internship in equine surgery at Washington State University. One afternoon while working at Marty’s request on the set of the television show “Those Amazing Animals,” I met Mary Fleming, the head veterinary technician from Marine World Africa USA. She had brought a baby baboon down for the show. At the end of the day, Marty arrived on the set. Mary had a plane to catch and was getting ready to go back to northern California. Marty announced that I (and not Mary) would be taking the infant baboon home with me. This came as a complete surprise, and I frantically took notes as Mary gave me instructions about feedings and offered husbandry tips including how to cut a hole in the disposable diapers to pull the tail through. And then she was gone. I still thought Marty was kidding—that he was really going to take the infant primate to his home. But it quickly became apparent that he meant for me to take the baby baboon.

So I tucked little Jojo into his airline carrier, crammed it into the front seat of my Honda Prelude, and headed for my tiny trailer in Thousand Oaks.

And so my experience hand raising exotic animals had begun. I felt fortunate that Jojo thrived in spite of my lack of experience. He lived with me for a couple of months and then went on to a new home. I moved to the San Francisco Bay area to start my new position as Marine World Africa USA’s first resident veterinarian.

I felt great excitement my first day on the job at Marine World as I approached the animal nursery, where I again met Mary who was now raising two black leopard cubs. What could be cuter than leopards? Mary had allowed the cubs to run loose on the floor while she was cleaning their exhibit window. As I entered the nursery, one of the cubs, aptly named “Damien,” bounded over to me and embedded his canine tooth into my kneecap. My appreciation of cute wild neonates grew from that point forward.

Over the years I helped Mary raise dozens of species of infants. It seemed we had occasion to hand rear infants representing almost every order of mammals. We raised hoofed stock, such as nilgai, blackbuck, eland, and a rhinoceros—not to mention countless sheep and goats. We even helped an infant giraffe to survive his first week of life until his mother finally took over. We had a blind female camel whose calves we hand reared each year. I observed and, many times, helped Mary and the veterinary technicians raise dozens of tiger cubs, lions, cheetahs, leopards, cougars, servals, and bobcats. We raised kit foxes, river otters, wallabies, opossums, squirrels, a sloth, a koala, a zebra, a binturong, and even a hyena. And I thought leopards bit hard.

Mary had a special love for primates, and she and the Marine World team raised five chimpanzees, two orangutans, and a gibbon. For years we had an infant primate of one species or another running around our veterinary clinic.

My first “solo” experience as “Mom” after Jojo happened a couple of years after I assumed the clinical veterinary position at the then California Marine Mammal Center in early 1981. I did this job while also maintaining my veterinary position at Marine World. A very ill northern fur seal had
stranded with her tiny newborn pup. The mother died a few days after arriving at our center. The pup, who weighed barely 3 kg (7 lb), seemed healthy and very hungry. There were few volunteers back then, and no designated night crews, so I took the pup home with me. For lack of a better idea, I fed her our elephant seal formula, which was made with ground fish, whipping cream, and a number of other ingredients. I spent three days and nights encouraging the tiny pup to accept the bottle. Finally she figured it out, and began to thrive. I was flattered that she considered me to be Mom, and she vocalized in a special way whenever she saw me. I named her Mishka, and took her with me to work at Marine World each day where she had her own pool. At night she came home to my converted barn, which was located on an estate in Woodside.

Besides Mishka, I’ve had the opportunity to gain experience raising sea lions, harbor seals, elephant seals, walruses, a harbor porpoise, a Dall’s porpoise, and two infant beaked whales. While the pinnipeds did very well, none of the infant cetaceans lived over a month. However, the experiences and challenges working with them were memorable.

While there are dozens of chapters about hand rearing many species of neonates in a variety of texts, there was no one single text that held practical information about how to hand rear the more common domestic, wildlife, and zoo species. The AZA Infant Diet Care Manual is an excellent resource, but does not cover hand rearing domestic mammals or some of the more common wildlife species. Also, it is not readily available to those outside of the zoo profession.

Two years ago, at the American Association of Zoo Veterinarians annual conference, I bounced around an idea about compiling a practical book on hand rearing mammals. My colleagues not only embraced the idea, but also contributed their expertise to my project. This book could not have been done without the contributions of many. The chapter authors have contributed wonderful insights on how to rear the many species covered here, and the staff and volunteers of numerous wildlife centers, zoos, marine mammal rehabilitation centers, and wild animal parks have enriched the body of knowledge contained on these pages.

Hand rearing mammals is probably more art than it is science. There is no “right way” to successfully raise any of the species represented in this text. In some cases, only one method of raising a species may be mentioned, even though many methods have proven to be successful by many different individuals. Each of the authors of this book has had extensive experience raising the species represented in his or her chapter. They have given their best tips on the science and also, more important, the art of hand rearing mammals.
Acknowledgments

This book is a result of the efforts of 34 authors, several of whom contributed to more than one chapter. They are an international group of veterinary technicians, wildlife rehabilitators, and veterinarians. I am very grateful for their efforts and hard work to produce chapters that will certainly enhance the knowledge of hand rearing the various mammals mentioned in this book. Special thanks to Rebecca Duerr, Dawn Smith, Dr. Murray Fowler, Debbie Marcum, Jane Ewer, and Dr. Laura Summers for their editorial assistance and encouragement. Thanks to Bob Wilson, Lindsay Leonard, Kent Hedberg, and Jackie Wollner for their photographic assistance.

Thanks to my husband, Kenji Ruymaker, for his support and help. Thanks also to the veterinary team at Six Flags Marine World—Eric Calvo, Lisa Counts, and Lee Munro—as well as former Marine World employees Andy Goldfarb and Mary Fleming for their expertise in raising infant wild animals.
Introduction

Hand-Rearing Wild and Domestic Mammals is designed to help veterinary practitioners, technicians, wildlife rehabilitators, and zoo personnel to raise healthy infant mammals. It is a practical guide with resources and information to help the reader achieve success with each hand-rearing project.

This book is organized into two parts: Domestic Mammals, and Wildlife, Zoo, and Marine Mammals. The species represented here are, for the most part, commonly encountered species presented for hand rearing to wildlife centers, zoo hospitals, and veterinary practices. The eminently qualified contributors were encouraged to include helpful tips and resource information along with their advice on choices of formulas and equipment. In most of the chapters, tried and true “made-from-scratch” recipes are included in addition to the commercial diet recommendations.

There are many ways to hand rear mammals, and certainly we cannot present all of them here. While each chapter of this book is designed to stand alone, it may be worthwhile for the reader to explore other chapters written about similar species to gain different points of view. For instance, a reader seeking advice on how to best hand raise a zebra foal may consider looking at both Chapter 29 on hand rearing nondomestic equids and Chapter 4 on critically ill and orphaned foals.

It is the hope of the authors of this book that the information presented here will help all readers to achieve optimal success in hand raising wild and domestic mammals that are placed in their care.
Hand-Rearing Wild and Domestic Mammals
Part I
Domestic Mammals

1 Orphan Rabbits
2 Puppies
3 Domestic Kittens
4 Critically Ill and Orphaned Foals
5 Pigs
6 Goat Kids
7 South American Camelids
1
Orphan Rabbits
Karen Heller Taylor

NATURAL HISTORY
This chapter discusses both domestic and wild orphan rabbits and hares. The term “rabbit” will signify either a rabbit (wild or domestic) or a hare. Specific differences will be noted.

The family Leporidae includes three major genera: Lepus (hares), Sylvilagus (e.g., cottontail), and Oryctolagus (e.g., domestic or European). Because they are prey animals, members of these genera tend to be more active at night (nocturnal) or at dawn and dusk (crepuscular). Females (does) are generally larger than the males (bucks). Offspring in the nest are called pups or bunnies. The act of giving birth is called kindling.

Offspring of the genus Lepus (hares) are born with fur and eyes open. Depending on the species, the hare breeds either year-round or biannually (spring and fall). The average birth weight is 110 grams. Weaning occurs at one week.

The eastern cottontail (Sylvilagus floridanus) is the most numerous species of this genus in North America. The cottontail breeds February to September. The young are born naked with average birth weight of 30-40 grams and eyes closed but open by seven to ten days. Weaning occurs at three to four weeks.

The genus Oryctolagus is more similar to Sylvilagus and reproduces year-round. The average birth weight depends on the breed but ranges between 30 and 80 grams. The young are born naked and eyes are closed. Eyes open at about ten days of age. Weaning occurs at four to six weeks.

RECORD KEEPING
To the person who raises a single animal, paperwork appears trivial, but to the rehabber or the veterinary practice that sees many orphans during a concentrated period, good records are vital to success. The most important aspect of record keeping is the tracking of body weight in preweanlings to determine gain or loss. Other information includes:

Date of entry: Including information on the animal presenter (in case of zoonotic disease exposure and also helpful for release purposes)
Source: Physical location for wild animal or dam of domestic bunny
Age determination
Physical exam findings: On entry, including injuries, hydration status, and rectal temperature
Treatments: Fluids, antibiotics, other
Formula consumption
Urine and fecal production: At each feeding including fecal character (color and consistency)

EQUIPMENT
Equipment should be easily cleaned and disinfected. Low cost is also desirable for nonprofit facilities. The following items will be useful:

Rubber gloves: To prevent transmission of zoonotic disease and other diseases between different age and species groups
Gram scale (postal scale): To weigh the animal daily until weaned, then twice weekly until released. Use a lightweight box with a cover, a pillowcase, or a sock to contain high-spirited animals on the scale.
Enclosures: Need to be secure. A plastic or glass aquarium for animals less than one week old lined with newspaper and pine or aspen wood shavings is ideal. Because these animals are prey animals and nocturnal in activity, provide a burrow to reduce stress. Cardboard boxes with a cutout entry hole may be used but must be discarded when
soiled or between new animals. Plastic igloo-type burrows are available from many pet supply houses, which can be disinfected weekly or between animals. After 7 to 14 days, depending on species, the animal should be transferred to a wire cage to facilitate good air circulation and hygiene by allowing urine and feces to fall out the bottom. The wire openings should not be larger than 1 cm. Part of the surface area may be covered with straw and a burrow to provide a resting area. In the wild, a burrow is a small depression in the earth covered with dried vegetation or a nest within underlying brush. A burrow can be constructed from a clay pot turned on its side, upside-down plastic buckets with an entry hole cut out, or a small cardboard box.

**Heat source:** Electric heating pads should never cover the entire resting surface and should be set on the lowest setting to prevent skin burns and allow the animal to seek a cooler zone. Recirculating heat pads found in veterinary clinics are ideal, but are expensive. Hot-water bottles should be avoided because as they cool, they become a heat sink and actually pull body heat from the animal. Heat lamps may be used, but are hard to regulate. Like the electric heat pad, they should provide zones of coverage. If you place your hand on the enclosure floor under the heat lamp for a few minutes and your skin becomes uncomfortably hot, it is too hot for the animal and the lamp should be raised. Red heat-lamp bulbs are preferred to allow animals to sleep without the glare of white light.

**Disinfectant:** Household bleach at 1 oz per quart (33 ml per liter) mixed fresh works well and is inexpensive. Quaternary ammonia products or chlorine dioxide are recommended as well, but good ventilation and rinsing is required.

**White vinegar:** Rabbits produce alkaline urine with calcium crystals that form a scale on surfaces. Soaking in white vinegar before cleaning will help to remove scale.

**Measuring devices** such as spoons and cups
**Syringes:** 1, 3, and 5 cc Luer slip
**Feeding tubes** 3–5 French, red rubber

**CRITERIA FOR INTERVENTION**

Most wild bunnies that are presented as orphans are probably not orphans. The general public is not educated about the life cycles of rabbits and does not understand that a doe does not sit on or attend her nest like a domestic dog or cat would do with a litter. Bunnies are quite small when they are weaned and unless the animal is obviously injured, it should be left alone. If a pet or lawn mower has disturbed a nest, the nest should be recovered and pets removed from the area. Since the doe will only return one to two times a day to the nest to feed and care for the young, the bedding may be replaced in a pattern (e.g., checkerboard) that can be visually rechecked for disturbance the following morning.

If a bunny is presented that is determined to be healthy and weaned, a reasonable attempt should be made to return it to its home environment. If this is not possible, the bunny should be released in a similar environment with the knowledge that regardless of the location, the animal is a prey species and will most likely be preyed upon at some point. The life span of an eastern cottontail in the wild is approximately one year. A licensed rehabber should be able to help with the release, and be knowledgeable about “safe” release sites.

Most states have laws against keeping native wildlife as pets even if the animal has a permanent injury that would preclude its release. People who are interested in rehabilitation of wildlife should check with their state wildlife office to determine what permits are necessary.

If the animal is determined to be a true preweaning and/or is injured, an experienced rehabber, veterinary technician, or veterinarian should assess the animal as soon as possible to determine if the animal can be reasonably treated for injuries and to provide supportive care.

Domestic rabbit neonates may require hand raising due to death of the dam, poor mothering ability that may occur with a doe with her first litter, or discovery of orphan feral bunnies. In this last instance, a domestic rabbit has been released by negligent owners or escaped after being bred and is termed feral. These does may not be capable of coping in the wild (especially during extreme weather) and are either killed or abandon their litter. If possible, in a breeding operation, cross-fostering (finding a surrogate doe) would be more economical.

**ASSESSMENT OF THE NEONATE**

Evaluate the bunny at entry to determine body temperature and evidence of life-threatening wounds. Puncture wounds from animal bites may be difficult to locate and are frequently fatal. Rabies virus infection should be considered in many geographical regions as a contaminant of bite wounds unless a vaccinated household pet is known to be the predator.
INITIAL CARE AND STABILIZATION

Neonatal mammals are very susceptible to hypothermia. The normal body temperature for most hares and rabbits is 100–103°F (37.8–39.4°C). If the bunny is chilled by 54°F (3-4°C), the quickest way to warm it is to submerge it (head above water) in a warm-water bath (100°F/37.8°C) and massage gently. Remove the animal within five minutes and continue to warm/dry it under a heat lamp or dryer taking extreme care not to burn it. Animals with severe hypothermia will probably not return to “normal” after warming. Rapid warming of these animals may result in fatal metabolic changes.

Keep in mind that warming the animal may exacerbate dehydration. Fluid therapy should be considered after warming. If the animal requires more than oral hydration, subcutaneous injections of a balanced electrolyte solution (lactated Ringer’s or normal saline) for intravenous use can be used at a rate of 35–40 ml/kg/day. If the animal is weak and considered hypoglycemic, 2 1/2% dextrose in lactated Ringer’s solution (LRS) may be substituted.

FORMULAS

Recipes for milk replacer formulas are in Table 1.1. Rabbit milk is generally high in fat and protein and low in carbohydrates. High-carbohydrate diets have a negative effect on the bacterial flora and motility of the rabbit gastrointestinal tract. The problem with milk analysis is that no good studies have been done to look at how milk composition changes over the lactation period except in domestic rabbits used for production. Oryctolagus milk solids are reported to range from a high of 30% down to 25% over the lactation period. Sylvilagus and Lepus are approximately 35% and 40%, respectively, but data are not available to determine how these numbers change during lactation.

Species-specific milk is considered to be best but is generally not an available option with rabbits. Milk replacement for orphan rabbits commonly utilizes a combination of Esbilac or KMR (Kitten Milk Replacer) and MultiMilk. Esbilac is formulated for canine pups and has more fat but less carbohydrates and protein than KMR. KMR is formulated as a milk replacer for domestic felines, is higher in protein and carbohydrates than Esbilac, and therefore is not directly interchangeable with the Esbilac formula. The MultiMilk (or Milk Matrix 33/40) has the advantage of being able to increase the fat and protein when mixed with KMR or Esbilac without increasing the carbohydrates. All three products are manufactured by the same company and may be ordered. KMR and Esbilac are readily available from most pet stores and veterinarians. Heavy cream (36% milk fat, 0% carbohydrates) may be used to increase the milk fat of KMR or Esbilac formulas. Half-and-half should not be used because it will lower the protein and increase the carbohydrate content of the formula and may lead to digestive upset or poor weight gain.

Table 1.1. Recipes for Milk Replacer Formulas

<table>
<thead>
<tr>
<th>Recipe I</th>
<th>Recipe IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 parts Esbilac liquid</td>
<td>1 part Esbilac powder</td>
</tr>
<tr>
<td>4 parts Multi Milk (powder)</td>
<td>1/4 part heavy cream</td>
</tr>
<tr>
<td>(1.91 kcal/cc)</td>
<td>1 part water</td>
</tr>
<tr>
<td></td>
<td>(1.93 kcal/cc)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Recipe II</td>
<td>Recipe V</td>
</tr>
<tr>
<td>1 part Esbilac powder</td>
<td>1 part evaporated milk</td>
</tr>
<tr>
<td>1 part Multi Milk powder</td>
<td>1 part water</td>
</tr>
<tr>
<td>1 1/2 parts water</td>
<td>To each cup of this mixture add</td>
</tr>
<tr>
<td>(2.01 kcal/cc)</td>
<td>1 egg yolk</td>
</tr>
<tr>
<td></td>
<td>1 tablespoon corn syrup</td>
</tr>
</tbody>
</table>

Note: When mixing formulas a part equals a teaspoon or cup. For example, with Recipe I you would mix 6 teaspoons of Esbilac liquid and 4 teaspoons Multi Milk.

All formulas should be mixed in quantities that can be utilized within a two- to three-day period and be kept refrigerated. Only the amount of formula to be used at a single feeding should be removed and heated to reduce the probability of bacterial contamination and spoilage. Powdered formulas can be stored in airtight containers for up to six months and are generally more economical to use.

**WHAT TO FEED INITIALLY**

Once the bunny has been stabilized and is ready to be fed, it is best to start with an oral electrolyte solution. Gradually add in the milk replacer to avoid gastrointestinal upset. Rehydration should take place prior to starting the formula and should be corrected within a 24-hour period. A human oral electrolyte solution such as Pedialyte may be used to hydrate the animal and serve as its first meal. Calculate the fluid requirements for a 24-hour period and divide by the stomach volume limits to determine how many feedings need to take place (see below in Amounts to Feed). If hydration is corrected, mix formula and electrolyte solution 1:1 for the next meal. If the animal is doing well consider 100% formula. Depending on the degree of dehydration and the percentage of milk solids, the animal may take 24–48 hours to produce feces, but urine should be produced by the second feeding. The animal should also be content after it is fed and the abdomen should feel soft but full.

Neonatal rabbits, but not hares, require stimulation of the anogenital region to urinate and defecate. The doe will lick this region and frequently consumes the by-products. The rehabber must perform this stimulation task and can accomplish it by gently stroking this area with a warm moist cotton tip applicator or gauze. Remove urine and feces to maintain hygiene.

**NURSING TECHNIQUES**

Once the bunny is strong enough to nurse, syringe feeding is the method of choice. Excellent control of milk flow can be obtained with a 1 or 3 cc non-Luer lock (or slip tip) syringe placed in the corner of the rabbit's mouth. Placing a hand over the animal or laying a piece of cloth over the animal's head/eyes appears to increase the animal's comfort level and promote successful feedings.

Keep a warm moist clean cloth available to clean the bunny's face after nursing. Formula that is left to dry on the animal may cause hair loss and dermatitis.

Utensils that are used to feed the bunnies should not be shared between animals to reduce the chance of disease transmission. Between feedings, all utensils should be cleaned in hot soapy water, rinsed well, and allowed to dry. Dilute bleach (1 oz per quart of warm water) may be used as a disinfectant, but the utensils should be rinsed again before air-drying. Bleach will shorten the life span of the rubber plungers in the syringes.

**TUBE FEEDING**

If the animal has a poor suckling response, tube feeding is recommended for the first couple of feedings. A red rubber tube is attached to a 3 or 5 cc syringe. Starting with the tip of the catheter at the last rib, measure the tube against the side of the animal the distance from the last rib to the tip of the nose. Using indelible ink, mark the distance on the tube to the tip of the nose. This is the amount of tube to be passed into the animal's mouth and into the stomach. The syringe plunger is advanced until milk can be seen at the tip of the catheter (wipe off excess). Note that sufficient formula should be drawn up into the syringe to account for losses in the tube. It is also recommended to reduce the volume at each feeding by 25–30% when force-feeding and add an additional feeding to provide daily caloric requirements. With the animal restrained by the nondominant hand, the tube is passed into the back of the oral cavity and gently advanced in conjunction with swallowing. The length of tube if measured correctly can only be in the stomach as it would not be able to pass that distance if it were in the lungs unless it was advanced too roughly through the lungs and diaphragm. Administer the formula slowly, if you meet resistance, stop. The abdomen should be gently distended but not firm or hard.

**FREQUENCY OF FEEDING**

Does generally return to the nest to feed their young once a day to reduce the chance that a predator will follow her to the nest and prey upon her young. Because we are not feeding mother's milk, which resists spoilage in the stomach, it is best to divide the feedings into two to three a day to reduce bloat and be able to provide the estimated caloric requirements using artificial formula.

Once the bunny's eyes are open (or approximately seven days for hares) and the animal is nibbling on roughage, the number of feedings per day can be decreased. By two to three weeks of age (ten days
for hares), one feeding should suffice and in another five to seven days, the animal should be weaned to solids completely. Allow an additional two weeks for domestic rabbits. Continue to weigh the animal every two to three days in case substantial weight loss is noted. If weight loss occurs, wait one to two additional days to decrease the number of feedings and make sure to reassess the overall health of the animal.

AMOUNTS TO FEED

The neonatal rabbit stomach can hold up to 100–125 ml per kg of body weight at each feeding. Depending on the caloric density of the formula, the animal should be fed one to four times over a 24-hour period.

Example: A 30-gram bunny should be able to handle up to 3–3.75 ml of formula per feeding.

\[
30 \text{ g} \times 1 \text{ kg} / 1000 \text{ g} \times 100–125 \text{ ml/kg}
\]

To further expand the example, a 30-gram bunny would require

\[
(2 \times [70 \times (0.030 \text{ kg}^{0.75})]) = 10.1 \text{ kcal per day.}
\]

Using a milk replacement formula that provides 2.01 kcal/ml, the bunny would need to be fed per day

10.1 kcal/day \times 1 \text{ ml} / 2.01 \text{ kcal} = 5 \text{ ml of formula}

Since this amount (5 ml) is greater than the amount the bunny’s stomach can hold at one feeding, divide that number by two feedings per day and the bunny will need to be fed approximately 2.5 ml every 12 hours.

The amount to feed should be recalculated every two to three days. Construction of a feeding chart based on weight, kcal requirements, and use of a standard formula is helpful for quick reference of amounts to feed (see Table 1.2).

EXPECTED WEIGHT GAIN

Rate of gain is dependent on genus/species, adult target weight, genetics (domestic vs. wild), health of the neonate, and type of formula. For cottontails, weaning weight is somewhere between 150 and 200 grams depending on the age at weaning and successful transfer to adult diet (Fig. 1.1). Domestic rabbit weaning weights are very breed dependent since some meat breeds were founded specifically for high rate of gain. A domestic meat rabbit at 28-day weaning might weigh 550–650 grams and by day 70 reach 2.2–2.5 kg (deBlas and Wiseman 1998)!

Steady weight gain and good or average body-condition score are indicators of success. There may be instances when no weight gain is detected for 24–48 hours. This may be normal for the short term, but should not continue. Recalculate caloric requirements, assess the animal’s health, or consider changing to a different formula in the future if you continue to have repeated problems with weight gains.

HOUSING

Orphan rabbits do not need to be maintained for long periods of time due to their short maturation time to weaning. Housing does not need to change drastically from that described above in Equipment.

In the first week of life neonatal bunnies are at greater risk of hypothermia due to their age and lack of hair coat. Temperature in the nest area should be maintained at 80–85°F (26.7–29.4°C) and by week three can be reduced to 70–75°F (21–23.9°C). Neonatal hares are not at risk for hypothermia because they are more precocious and able to regulate body temperature at a younger age than the rabbit species.

Wild rabbits and hares have a very strong flight instinct and once they are able to move around may rush around the enclosure and injure themselves in an attempt to escape. Some may even vocalize with fear. As mentioned in the previous description of equipment, these animals should be provided a burrow to reduce stress. Handling should be kept to a minimum to reduce taming down prior to release. When catching an animal to feed or treat, the handlers should be deliberate but gentle in their actions to avoid chasing the animal around the enclosure. Use of small washcloths to cover the animal before picking up may simulate a burrowlike atmosphere and reduce stress. For animals that are extremely difficult, lowering the light level in the room may facilitate capture.

Domestic rabbit orphans have been tamed down through generations of breeding and do not have as great a fear instinct as their wild counterparts. Regular and frequent handling will improve the pet quality of these animals.

TIPS FOR WEANING FROM FORMULA TO SOLID FOOD

If provided the right foodstuffs at the right age, rabbits wean readily. Within a few days of opening their eyes (or within five to seven days for hares), bunnies should be provided a selection of clean
Table 1.2 Sample Feeding Chart

<table>
<thead>
<tr>
<th>Weight grams</th>
<th>Required kcal</th>
<th>Amount of formula in cc's per day*</th>
<th>Amount of formula in cc/feeding Feeding intervals in 24 hours</th>
<th>Stomach capacity: 100cc/kg**</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>0.9</td>
<td>8.81</td>
<td>4.4</td>
<td>2.2 1.5 1.1 2.5</td>
</tr>
<tr>
<td>30</td>
<td>1.1</td>
<td>10.09</td>
<td>5.0</td>
<td>2.5 1.7 1.3 3.0</td>
</tr>
<tr>
<td>35</td>
<td>1.2</td>
<td>11.33</td>
<td>5.7</td>
<td>2.8 1.9 1.4 3.5</td>
</tr>
<tr>
<td>40</td>
<td>1.4</td>
<td>12.52</td>
<td>6.3</td>
<td>3.1 2.1 1.6 4.0</td>
</tr>
<tr>
<td>45</td>
<td>1.6</td>
<td>13.68</td>
<td>6.8</td>
<td>3.4 2.3 1.7 4.5</td>
</tr>
<tr>
<td>50</td>
<td>1.8</td>
<td>14.80</td>
<td>7.4</td>
<td>3.7 2.5 1.8 5.0</td>
</tr>
<tr>
<td>55</td>
<td>1.9</td>
<td>15.90</td>
<td>8.0</td>
<td>4.0 2.7 2.0 5.5</td>
</tr>
<tr>
<td>60</td>
<td>2.1</td>
<td>16.97</td>
<td>8.5</td>
<td>4.2 2.8 2.1 6.0</td>
</tr>
<tr>
<td>65</td>
<td>2.3</td>
<td>18.02</td>
<td>9.0</td>
<td>4.5 3.0 2.3 6.5</td>
</tr>
<tr>
<td>70</td>
<td>2.5</td>
<td>19.05</td>
<td>9.5</td>
<td>4.8 3.2 2.4 7.0</td>
</tr>
<tr>
<td>75</td>
<td>2.6</td>
<td>20.06</td>
<td>10.0</td>
<td>5.0 3.3 2.5 7.5</td>
</tr>
<tr>
<td>80</td>
<td>2.8</td>
<td>21.06</td>
<td>10.5</td>
<td>5.3 3.5 2.6 8.0</td>
</tr>
<tr>
<td>85</td>
<td>3.0</td>
<td>22.04</td>
<td>11.0</td>
<td>5.5 3.7 2.8 8.5</td>
</tr>
<tr>
<td>90</td>
<td>3.2</td>
<td>23.00</td>
<td>11.5</td>
<td>5.8 3.8 2.9 9.0</td>
</tr>
<tr>
<td>95</td>
<td>3.4</td>
<td>23.95</td>
<td>12.0</td>
<td>6.0 4.0 3.0 9.5</td>
</tr>
<tr>
<td>100</td>
<td>3.5</td>
<td>24.89</td>
<td>12.4</td>
<td>6.2 4.1 3.1 10.0</td>
</tr>
</tbody>
</table>

* Caloric density is assumed to be 2 kcal/cc for this example.
** The amount of formula at each feeding should not exceed 100–125 cc/kg body weight.

Figure 1.1. Bunny on a scale (photo by Laurie J. Gage).

Leafy greens and good quality grass hay. Greens would include but are not limited to dark green lettuces, kale, broccoli, parsley, cilantro, other herbs, dandelion greens, and other greens (collards, mustard, turnip). Since these greens are not anchored in the ground by roots, it is recommended that the greens be chopped into smaller pieces initially to make them easier to consume by the young animal.

Fresh clean water should be provided daily as early as five days for hares. The water should be