CHAPTER

28

Management, Husbandry, and Colony Health

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OUTLINE

INTRODUCTION

This chapter provides a review of the management, husbandry, and colony health requirements of the Syrian or golden hamster, *Mesocricetus auratus*, utilized in biomedical research. Hamsters are rodents belonging within the family Crecetidae. Members of the Crecetidae family are characterized by large cheek pouches, relatively thick bodies, and a short tail. Additional publications that provide comprehensive descriptions of hamster husbandry and care are Hankenson and Van Hoosier (2002) and Hoffman et al (1968).

HOUSING

Caging Systems

Hamsters are generally housed in cages that are appropriate for housing other laboratory rodents. Contemporary cages are generally made of commercially manufactured rigid plastic materials (i.e. polycarbonate, polysulfone, and polypropylene) or stainless steel. Hamsters are agile and have considerable ability to escape by means of chewing or gnawing on the cage material and by dislodging the cage lid. To reduce the

The Laboratory Rabbit, Guinea Pig, Hamster, and Other Rodents
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TABLE 28.1 Cage Space Requirements for Hamsters[a]

Body Weight (g)	Minimum Floor Area/Animal in^2 (cm^2)[b]		Height[c] in (cm)
<60	10	(64.5)	6 (15.2)
60–80	13	(83.8)	6 (15.2)
80–100	16	(103.2)	6 (15.2)
>100	19	(122.6)	6 (15.2)

[a]*Summarized from CFR (rev. 2008) and ILAR (2011).*
[b]*A nursing female hamster with litter must be housed in a cage without other adult hamsters and that provides at least 121 in^2 (780.5 cm^2).*
[c]*Measured from cage floor to cage top.*

opportunity for escape by chewing, caging should not be manufactured with wood or soft metals such as aluminum. Hamsters may also chew plastics, around the hole in the cage for the water bottle, and escape. Caging must also be equipped with secure, tight and close-fitting doors and lids to prevent escape of animals. Plastic shoebox-style cages with tight-fitting wire bar lids are commonly employed in research institutions and commercial breeding operations. Hamsters may be housed successfully in solid-bottom cages with contact bedding. Excluding breeding colonies, hamsters may be housed in suspended cages with raised floors, i.e. caging with stainless steel wire-mesh, slatted, or perforated suspended floors over catch pans. Suspended wire floor caging is not recommended for breeding colonies as smaller animals may fall through or become entrapped in the wire mesh flooring. Preference testing has indicated that hamsters generally prefer solid floor caging with contact bedding over stainless steel suspended floor caging, but the preference for solid floor caging decreased with increased duration of exposure to suspended wire flooring (Arnold and Estep, 1994).

Requirements for both floor space and cage height for hamsters are defined in the Animal Welfare Regulations (CFR, rev. 2008). The Institute of Laboratory Animal Resources (ILAR, 2011) provides similar non-regulatory recommendations for cage size and height for hamsters (see Table 28.1). Nursing female hamsters, together with a litter, must be housed without other hamsters and provided a minimum of 121 sq. in. (780.6 sq. cm.) of floor space (CFR rev., 2008). Cage size has been shown to affect core body temperature and febrile response in hamsters (Kuhnen, 1999). Housing hamsters in small cages was associated with increased baseline rectal temperature when compared with hamsters housed in large cages. Febrile response to lipopolysaccharide injection was greatest in hamsters housed in large cages and smallest in animals housed in small cages.

The cage sanitation practices applied to the common laboratory rodents also apply to hamster caging. Soiled bedding material should be removed and replaced with clean material, or animals transferred to a clean bedded cage, as often as necessary to keep the cage occupants clean and dry. Unlike most common laboratory rodents, hamsters tend to defecate and urinate in one corner of the cage and, because they are desert-adapted animals, hamsters produce relatively scant amounts of urine. U.S. Animal Welfare Regulations (CFR rev. 2008) prescribe that, at a minimum, hamster cages must be sanitized at least once every 2 weeks (14 days).

Bedding

A variety of contact bedding materials can be used with hamsters, including processed wood shavings and chips, corn cob, pelleted wood, as well as virgin and recycled paper products. Preference testing of bedding materials with hamsters is limited. Lanteigne and Reebs (2006) showed that without nesting material, hamsters have a preference for pine shavings over aspen shavings, corn cob over wood pellets, pine shavings over corn cob, and aspen shavings over wood. The preferences were eliminated, however, when animals were provided a piece of paper towel as nesting material. Provision of long-term access to running wheels can result in development of foot lesions in hamsters, but the development of lesions was not affected by use of pine shavings or hard wood chip bedding (Beaulieu and Reebs, 2009). Hamsters build nests, and, for breeding animals, the addition of nesting material (i.e. tissue paper, cotton wool) is recommended. It is not recommended to use cedar and untreated (non-kiln-dried) soft wood bedding, such as pine, as it contains aromatic hydrocarbons capable of inducing hepatic microsomal enzymes and cytotoxicity in rodent species, including hamsters (Harkness, 1994; Vesell, 1967).

ENVIRONMENTAL CONDITIONS

Ventilation

Specific ventilation rates for the primary enclosure (cage) and the secondary enclosure (room) housing hamsters have not been described and ventilation rate recommendations for housing other research rodents are acceptable. Animal Welfare Regulations (CFR rev. 2008) require that facilities housing hamsters be adequately ventilated to provide for the health and comfort of the animals and to minimize the development of drafts, odors, and moisture condensation. In contrast, ILAR (2011) provides a general recommendation of 10–15 air changes per hour (ACH) for the secondary enclosure housing research animals, including hamsters. The use of individually ventilated caging systems, which provide intra-cage ventilation rates in excess of 10–15 ACH, may

allow decreased air exchange rates in the rooms housing the caging system, while preserving an acceptable cage environment for the animal (Reeb et al., 1998).

Illumination

Recommendations for acceptable illumination levels within vivaria are generally based on providing levels sufficient to allow safe working conditions for personnel, good housekeeping, adequate observation of animals, and to preserve circadian cycles (ILAR, 2011). The level of illumination required for optimal maintenance and health of hamsters has not been described and light intensity levels of approximately 325 lux measured approximately 1 m (3.3 ft) from the floor are generally acceptable to allow adequate illumination for husbandry purposes and observation of animals (ILAR, 2011).

Hamsters are strictly nocturnal in captivity, whereas females in the wild are primarily diurnal (Gattermann et al., 2008). Hamsters are seasonal breeders that in a natural setting will modulate reproduction in association with photoperiod, the duration of light and dark contributing to a 24-hour cycle. In a natural setting, hamsters restrict reproduction to the long days of spring, summer, and fall. In captivity, hamsters can be maintained under a 12:12 light cycle (12 h light:12 h dark) for general research purposes. For reproductively active animals, such as breeding colonies, a long 14-hour light cycle is recommended and thus breeding colonies are maintained under 14:10 light:dark cycle (Brainard et al., 1986). Alterations of photoperiod in hamsters have been shown to affect circulating levels of luteinizing hormone (LH) and follicle stimulating hormone (FSH) and to produce altered testicular development and spermatogenesis (Ellis and Follett, 1983). Alteration in the photoperiod during pregnancy of hamsters has been shown to affect the timing of parturition (Viswanathan and Davis, 1992).

Temperature

The Syrian hamster originates from an arid, desert environment and their thermoneutral zone, the temperature range associated with minimal metabolic expenditure, is approximately 82.4–86°F (28–30°C) (Gordon, 1993). Unless required for scientific purposes, hamsters are commonly housed and maintained in research institutions at temperatures appropriate to other common laboratory rodents. The Animal Welfare Regulations specify that hamsters maintained within an indoor housing facility must be provided ambient temperatures that neither fall below 60°F nor rise above 85°F (CFR rev. 2008). ILAR (2011) recommends that hamsters be maintained in a range of 68–79°F (20–26°C). Hamsters are adaptable to cooler temperatures, and short-term hibernation can be induced in hamsters by exposure to cold temperatures, approximately 3–5°C, and a shortened light cycle (Hoffman, 1968). A study by Gumma et al. (1967) showed that pre-hibernation hamsters may show a preference for 8°C whereas post-hibernation hamsters show a preference for higher temperatures (24°C).

Humidity

As with previous recommendations for ambient temperature, hamsters are commonly housed and maintained at relative humidity levels generally acceptable for other common research rodents. Recommendations are that relative humidity be maintained between 30–70% for most research species, including hamsters (ILAR, 2011).

Environmental Enrichment

A primary goal of environmental enrichment is to provide animals with the opportunity to perform species-specific behavioral patterns (Hutchinson et al., 2005). Numerous enrichment devices have been described for use with hamsters including tubes, pipes, shelters, nest material, and deep bedding. In the wild, hamsters are solitary, living either singly or as mothers with nursing pups in burrow systems. Burrow systems include a nest chamber, a chamber for urination, and a chamber for food storage (Gattermann et al., 2001; Sorensen et al., 2005). Because hamsters spend considerable time underground in the wild, it is generally recommended that some form of burrow, pipe, tube, and shelter be provided to hamsters (Arnold and Westbrook, 1998; Baumans, 2005). McClure and Thompson (1992) showed that aggression in hamsters housed in suspended wire cages was diminished after the addition of a polyvinyl chloride (PVC) pipe. Provision of nesting material, or bedding that provides the ability for nest building, is generally recommended as both wild and captive-bred hamsters will create nests (Gattermann et al., 2001; Lanteigne and Reebs, 2006); and female nest-building behavior has been shown to increase during pregnancy (Richards, 1969). Hamsters that were provided deep bedding (i.e. 40 and 80 cm deep) showed significantly less gnawing of cage wire bars, a possible indicator of sub-optimal housing conditions, and increased the construction of burrows used for sleeping than did animals provided shallow amounts (10 cm) of bedding (Hauzenberger et al.. 2006). Hamsters readily utilize exercise wheels (i.e. running wheels), and the use of exercise wheels has been proposed as a method of environmental enrichment as well as a means to measure activity in chronobiology research (Beaulieu and Reebs, 2009; Gattermann et al., 2004). Hamsters naturally forage and hoard food and they

should be provided with food pellets inside the cage, preferably on the cage floor (Baumans, 2005; Sorensen et al., 2005).

NUTRITION

Feed Type

Hamsters are generally provided commercially produced pelleted rodent diet intended for mice and rats, and animals raised on such diets show normal growth and reproduction (Hankenson and Van Hoosier, 2002; Slater, 1972). Hamsters can also be raised and maintained successfully on purified and semi-purified diets. Colocolic intussusception has been described in hamsters following a change in diet from a standard pelleted rodent chow to a semi-purified diet with sucrose as the primary carbohydrate (Cunnane and Bloom, 1990). Although once common, when fed a nutritionally adequate diet formulated for mice and rats, dietary supplementation with grains, fruits, and vegetables is generally considered unnecessary (Slater, 1972). Additionally, dietary supplementation with grains, fruits, and vegetables may increase the risk of exposure to unwanted microbiologic agents and contaminants (Coates, 1991).

The method of feed presentation to hamsters differs from that for mice and rats, in that hamsters are generally provided food on the cage floor. Harkness et al. (1977) observed that when a hamster colony originally provided pelleted rodent food from feed hoppers with 7/16-inch slots were fed from feed hoppers with narrower 5/16-inch slots morbidity and mortality of animals in the colony increased significantly. Adult animals showed cachexia, delayed weight gain, broken incisors, and an inability to obtain food from the feed hopper. Nursing hamsters demonstrated agalactia resulting in pup mortality and decrease in conception rate. Upon feeding hamsters from the cage floor, animals regained a normal pattern of weight gain. It was postulated that because hamsters have a relatively broad muzzle compared with similarly sized rodents, they have difficulty accessing adequate food from narrow-slotted feed hoppers. Consequently, providing food solely from feed hoppers is not recommended and hamsters are commonly provided food on the cage floor. In addition, young hamsters will begin to eat solid food at 7–10 days of age and nursing hamsters with litters may become preoccupied with hopper-bound food and neglect their young (Harkness and Wagner, 1995).

Nutritional Requirements

Hamsters maintained on commercially produced rodent diet show normal growth and reproduction. General nutrient levels associated with acceptable rates of growth and reproduction have been reported with diets consisting of 15–25% protein, 35–40% carbohydrate, 4–5% fat, and 5% crude fiber (Arrington et al., 1966, 1979; NRC, 1995; Newberne and Fox, 1980; Newberne and McConnell, 1979). Feed consumption in hamsters is similar in males and females, with published ranges between 5.0–8.9 g per day for growing and adult animals (Arrington et al., 1979; Banta et al., 1975; Newberne and McConnell, 1979).

Although hamsters are commonly maintained on laboratory diets formulated for mice and rats, relatively little has been published on the specific nutritional requirements of hamsters, and the nutritional requirements of hamsters are not identical to those of other rodents (NRC, 1995; Newberne and McConnell, 1979). Hamsters possess a distinctly compartmentalized stomach consisting of a forestomach and a glandular stomach. The forestomach shares physical characteristics with a rumen, contains microorganisms similar to those found in a rumen, is a source of volatile fatty acid production, and has been postulated to allow fermentation, prior to passage of ingesta into the gastric stomach (Hoover et al., 1969; Warner and Ehle, 1976). It has been proposed that the apparent rumen-like functions of the hamster forestomach may allow the animal to digest and utilize lower-quality protein in comparison to other rodents such as the rat (Newberne and McConnell, 1979). The forestomach, however, is not required for maintenance of proper nutrition, survival, or growth of the hamster fed a nutritionally adequate diet, as surgical removal of the forestomach was shown not to affect growth and feed utilization in the animal (Ehle and Warner, 1978).

Published requirements for amount of protein in the hamster diet are variable. For hamsters fed semipurified diets utilizing casein as the sole source of protein, satisfactory growth rates have been reported for diets containing 12–24% casein; satisfactory weight gain has been associated with natural-product diets containing 5–25% protein (Newberne and McConnell, 1979). Soybean meal as a protein source has been shown to promote increased weight gain and improved protein utilization (i.e. increased protein efficiency ratio) compared with diets containing wheat gluten and fish protein concentrate (Banta et al., 1975). Nutritional studies have also shown increased survival of hamsters fed a diet containing 20 g lactalbumin/100 g diet (Birt et al., 1982). Cornstarch has been shown to be a good carbohydrate source for hamsters, promoting satisfactory growth, reproduction, and longevity and it is generally provided in the range of 30–40% as a source of dietary energy (Newberne and McConnell, 1979). Dietary carbohydrates can affect circulating glucose

and lipid metabolism in hamsters. Hamsters fed a diet containing 60% fructose showed increased food consumption and development of obesity, hyperinsulinemia, and hypertriglyceridemia (Kasim-Karakas et al., 1996). The dietary fat requirement for hamsters has been described for growing hamsters as 5%; commercially prepared rodent diets with 4% fat also appear adequate for growth, reproduction, and maintenance (Knapka and Judge, 1974; Newberne and McConnell, 1979). Requirements for fiber have not been described for the hamster and 4–5% fiber found in commercial rodent diets appears appropriate for normal growth, reproduction, and maintenance. Diets containing high levels of refined sugars and no fiber have been associated with high mortality, and the substitution of cornstarch for glucose or sucrose or the addition of 12–20% alfalfa to the diet increased survival (Ershoff, 1956). There is a paucity of information regarding mineral and vitamin requirements of hamsters. It has been recommended that levels for copper, magnesium, potassium, and zinc should be increased in comparison to dietary requirements of the rat; recommended levels in semipurified diets are 12 ppm copper, 0.12% magnesium, 20 ppm potassium, and 0.6% zinc (Newberne and Fox, 1980; Newberne and McConnell, 1979). Studies have described minimal levels of dietary vitamin A for the hamster as 1.1 mg/kg retinol and 2 mg/kg retinyl palmitate/kg in semi-purified diet (Newberne and McConnell, 1979; Rogers et al., 1974). The hamster does not require a dietary source of vitamin D when provided a calcium–phosphorus ratio of 2:1 (NRC, 1995; Newberne and McConnell, 1979). Hamsters are coprophagic and it is presumed that a considerable amount of vitamin K is provided by ingestion of feces (NRC, 1995). Minimal dietary requirement for vitamins B_6, B_{12}, E, biotin, choline, folic acid, niacin, pantothenic acid, riboflavin, and thiamin have not been described for the hamster and sufficient dietary levels for growth and reproduction are provided in diets formulated for the rat. Satisfactory dietary levels for vitamins and minerals for the hamster are provided in Table 28.2.

TABLE 28.2 Satisfactory Vitamin and Mineral Dietary Levels for the Hamster

	Natural Product Diet (mg/kg)	Semi-purified Diets (mg/kg)	
Vitamin/Mineral	Banta et al. (1975)	Arrington et al. (1966)	Rogers et al. (1974)
A	15.3	90.0	2.0
C	–	900.0	–
D_2	–	5.0	62.1
E	1100.	100.0	600.0
K	5.2	45.0	4.0
Choline	2000.0	150.0	2000.0
p-Aminobenzoic acid	100.0	100.0	6.0
Inositol	100.0	100.0	200.0
B12 (µg/kg)	32.0	28.0	50.0
Niacin	93.0	90.0	100.0
Pantothenate	54.0	60.0	40.0
Riboflavin	12.0	20.0	15.0
Thiamin	14.0	20.0	25.0
Pyridoxine	10.1	20.0	6.0
Folic acid	3.1	1.8	4.0
Biotin	0.9	0.4	0.6
Calcium, %	0.54	0.59	0.41
Phosphorus, %	0.58	0.30	0.39
Magnesium, %	0.13	0.09	0.06
Potassium, %	0.79	0.82	0.61
Sodium, %	0.19	0.15	0.21
Iron	180.0	140.0	154.0
Manganese	15.9	3.65	9.0
Copper	12.6	1.6	7.0
Zinc	9.4	–	9.2
Iodine	0.02	1.6	1.7
Cobalt	–	0.2	–
Fluoride	–	–	0.2

Hydration

Hamsters should be provided access to clean, potable water at all times. Water can be provided via water bottles with stainless steel sipper tubes or automatic water systems with stainless steel lixits. Hamsters have been reported to consume, on average, 8.5 ml water per 100 g body weight. Consumption of water can vary significantly; male consumption ranges from 4.5–5 ml/100 g body weight and female consumption ranges from 13.6–14 ml/100 g body weight (NRC, 1995).

Nutrition-Related Disease

Nutrition-related diseases are uncommon in hamsters fed commercially produced rodent diets. Numerous nutritional deficiencies have been induced in the hamster by feeding diets formulated to be deficient in specific nutrients, minerals, and vitamins. For a comprehensive review see NRC (1995). Hamsters fed a diet deficient in vitamin E, starting at weaning,

develop testicular degeneration, muscular dystrophy, and experience decreased growth, which is reversible by treatment with dietary vitamin E (Granados, 1968). Supplementation of vitamin E has been shown to reduce aortic fatty streak accumulation in hypercholesterolemic hamsters (Xu et al., 1998). Deficiency of vitamin E, possibly combined with oxidative stress, may be important in development of clinical disease in cardiomyopathic hamsters (Sakanashi et al., 1991). Spontaneous hemorrhagic necrosis (SHN) of the central nervous system of fetal hamsters has been described when pregnant dams are fed vitamin-E-deficient diets, and the syndrome is alleviated by intraperitoneal administration of vitamin E (Keeler and Young, 1979). Vitamin A deficiency, similar to other rodent species, can lead to abnormal development, alopecia, a course hair coat, xerophthalmia, and altered morphology of tracheal epithelium (Chopra et al., 1990; Keeler and Young, 1979).

BREEDING

Reproductive Biology

Sexual maturity in the hamster generally occurs at approximately 6 weeks (42 days) of age, although copulatory activity can begin as early as 4 weeks of age. Sexual maturity can be verified in the male hamster by performing the penile smear technique to identify the presence of spermatozoa on the glans penis (Vandenbergh, 1971). Female hamsters generally begin estrus between 6–8 weeks of age. It is recommended that breeding animals be allowed to mature to 90–100 g body weight before breeding to achieve maximum production. Females are generally 8–10 weeks of age and males 10–12 weeks of age prior to initial breeding. The use of slightly older and larger males appears beneficial when placing males with more aggressive females (Slater, 1972). Reproductive senescence occurs at approximately 14 months of age in both sexes.

Female hamsters have a regular 4-day estrous cycle. The end of ovulation, typically day 2 of the 4-day estrous cycle, is identifiable by the presence of a readily observable postovulatory vaginal discharge. The vagina, and often the vaginal orifice, is filled with an opaque, white, viscous discharge. The postovulatory discharge is indicative of the animal having reached estrus the day before and it is predictive of the next estrus 3 days after the appearance of the discharge, followed by estrus on days 7, 11, and so forth. Female hamsters can be successfully mated in the evening of the third day following the postovulatory discharge. In commercial breeding operations, large groups of hamsters can be selected based on the postovulatory discharge and mated with a resulting 90% breeding success rate (Balk and Slater, 1987). Females may show pseudopregnancy lasting 9–10 days following non-fertile copulation, with return of a postovulatory vaginal discharge on postcopulatory days 10–11 (Richards, 1966). Pregnant animals are identifiable by rapid weight gain and abdominal distension at 10 days post mating. Implantation occurs on day 6 of pregnancy. Postpartum estrus in hamsters is generally anovulatory (Harkness and Wagner, 1995).

The female hamster is tolerant of the presence of a male only during estrus, and females will readily attack males if paired together outside of estrus. When in estrus and receptive to males, the female will display lordosis upon approach of a male and maintain the posture while the male remains in the vicinity. When copulation occurs, males will mount the female multiple times. Females in estrus will accept males beginning approximately 1 hour before start of the dark cycle (i.e. lights out) and end receptivity to the male approximately 15 hours later (Ciaccio and Lisk, 1971).

As mentioned earlier, hamsters are seasonal polyestrus breeders that will modulate reproduction in association with photoperiod. For reproductively active animals, such as those in breeding colonies, a long 14-hour light cycle is recommended and thus breeding colonies are maintained under 14:10 light:dark cycle (Brainard et al., 1986). Alterations of photoperiod in hamsters have been shown to affect circulating levels of luteinizing hormone (LH) and follicle stimulating hormone (FSH) and to produce altered testicular development and spermatogenesis (Ellis and Follett, 1983). Alteration in the photoperiod during pregnancy of hamsters has been shown to affect the timing of parturition (Viswanathan and Davis, 1992).

The gestational period for the hamster is approximately 15.5 days. Parturition is preceded by the female displaying an increase in activity and restlessness with alternating bouts of eating, grooming, and nest building. Immediately prior to parturition, an increase in respiration rate and a bloody vaginal discharge are observed. Litter sizes range from 4–16 pups, with average litter sizes reported as 5–9 (Harkness and Wagner, 1995) and 11 (Slater, 1972). The first litter from a primiparous female is generally smaller than subsequent litters.

Common Breeding Systems

Multiple breeding schemes have been described for hamsters including hand-mating, pair mating, and polygamous mating (Harkness and Wagner, 1995). A common method for breeding hamsters utilizes hand-mating of the animals. On the third day following a post-ovulatory discharge, the female hamster is placed into a male hamster's cage 1–2 hours prior to the start of the dark cycle. Animals are then observed for fighting, and the female removed if she shows aggression towards the male. If the female is receptive, she will

show a posture of lordosis with tail erect and hindlimbs spread apart. Animals will often mate within 5–10 minutes of being placed together, at which time they may be separated; or animals may be left paired overnight and separated the following morning. Hamsters may also be bred by polygamously pairing one male with 1–2 females for 7–14 days, followed by separation of the animals and housing of the females individually for parturition and until pups are weaned. Monogamous pairing of one male with one female continuously has also been described. This breeding scheme requires placing a prepubital male and female together, and allowing them to remain together throughout breeding and parturition. Sequential monogamy mating of hamsters involves rotating seven females through a male's cage in series, with each female paired with the male for 7 days. Using this breeding system, after a female weans a litter at 3 weeks of age, the female is rotated back to the male's cage every 7th week. Because female hamsters can be aggressive, breeding pairs of hamsters must be checked daily for fight wounds and animals separated if needed.

Care of Young

Approximately 2 days prior to parturition, females should be transferred to a clean cage and provided with nesting material. Sufficient food should be added to the cage to allow the female to remain undisturbed with a newborn litter for 7–10 days following parturition. Disturbing a dam, especially a primiparous dam, with a newborn litter can lead to litter abandonment and cannibalism by the dam. During the first 7–10 days following parturition, food and water may be added to a cage if needed, but bedding should not be changed. If it is necessary to disturb a dam with a young litter, the dam should be provided with fresh food with which she may fill her check pouches reducing the likelihood of cannibalism of the new pups (Hankenson and Van Hoosier, 2002). When moving neonatal hamsters between cages, care should be taken to transfer the neonates within their nest to minimize the disturbance as much as possible.

Hamsters are born hairless, with teeth, and with eyes and ears closed. Ears open at 4–5 days of age, eyes open at 14–16 days of age, and hamsters begin to eat solid food at 7–10 days of age. Consequently, water should be available by 10 days of age when the young hamster begins to ingest solid food. Care should be taken to ensure that if animals are provided water via a bottle that the sipper tube is appropriately sized to provide accessibility to the neonates from the floor of the cage. Hamsters can be weaned as early as 15 days of age, but it is suggested that young be left with the mother until at least 19 days of age (Slater, 1972), and it is common to wean hamsters at 21–28 days of age. At weaning, animals are generally separated and housed in groups by age and sex.

COLONY HEALTH

Preventive Medicine

A preventive medicine program for hamsters is contingent upon selection of a high-quality source of hamsters. A quality source of hamsters should have a well-defined health-monitoring system in place to allow periodic assessment of the breeding colony for common infectious agents of hamsters. As with other rodents, infection by adventitious microbial agents can adversely affect animal health, alter the physiology of animals, introduce experimental variables that can alter experimental outcomes (i.e. data) generated from the use of animals, and pose a zoonotic risk to the people working with the animals. For a summary of natural pathogens of hamsters and the effects of those organisms on research, see Baker (2003). If hamsters intended for research originate from a non-commercial source without adequate health monitoring information for the colony, animals should be placed into quarantine and microbiologic testing performed to identify infectious agents that may compromise the health of the animals or their usefulness in research. A rigorous biosecurity program, defined as all measures taken to prevent the introduction, contain, and when necessary eradicate adventitious infections, is also required to protect the microbiological integrity of hamsters maintained and used in research and breeding facilities (Shek and Gaertner, 2002). Maintenance of healthy hamsters within a research facility is also contingent upon providing adequate husbandry and care, including provision of a nutritionally complete diet formulated for laboratory rodents, continuous access to clean water, appropriately designed and maintained caging, proper sanitation of cages, equipment, and facilities supporting the hamsters, and appropriate environmental conditions as outlined earlier in this chapter.

Colony Health Monitoring

Infection of rodents, including hamsters, by adventitious agents can negatively affect animal health and interfere with research outcomes derived from the animals (Baker, 2003). Health monitoring of research rodent colonies involves subjecting animals to a battery of assessments, including macro- and microscopic pathology, bacteriology, parasitology, and serum and microbiologic diagnostic tests with a goal of identifying whether the test animal, a surrogate for the source colony, is infected with specific microbiological agents considered important for

the particular rodent species under study. Although this process is often referred to as health monitoring, microbiologic monitoring may be the more appropriate term (Hansen, 2003) and is used as a synonymous term. Shek and Gaertner (2002) describe the components to be considered when designing and implementing a microbiologic monitoring program for rodents, including detailed discussions on diagnostic methodologies, design and implementation of a surveillance program, and interpretation of results. Important parameters that must be defined when developing a microbiologic monitoring program are the number of animals to test, the frequency of testing, the agents for which to screen, and the diagnostic methodology that is most appropriate for each agent. Selection of the appropriate testing methodology for hamster infectious agents is beyond the scope of this chapter and the reader is referred to the relevant literature (Livingston and Riley, 2003; Shek and Gaertner, 2002; Waggie et al., 1994). Frequency of testing is dependent upon many variables, including historical contamination rates, general health quality of the colony, i.e. gnotobiotic health status versus specific pathogen-free status, financial resources, and sensitivity of the research to contamination by common hamster infectious agents. Many organizations develop schedules whereby samples are submitted for serologic testing relatively frequently, i.e. quarterly, in conjunction with submissions of live animals that combine serologic testing with more comprehensive testing including bacteriology, parasitology, and pathological exam less frequently, i.e. once to twice yearly.

Selection of agents to include in a microbiological testing program for hamsters should be based on selection of agents that pose a risk to human health (i.e. zoonotic agents), cause disease in hamsters (i.e. primary pathogens), and interfere with research outcomes. When possible, decisions regarding frequency of testing and the selection of specific agents to include in a monitoring program should also involve a risk-based approach that requires knowledge of the general prevalence of infectious agents found within the research population of interest (Pritchett-Corning et al., 2009; Shek and Gaertner, 2002). The prevalence of infectious agents in research mice and rats has been well-documented (Jacoby and Lindsey, 1997; Livingston and Riley, 2003; Poiley, 1970; Pritchett-Corning et al., 2009; Schoondermark-van de Ven et al., 2006), whereas prevalence rates of infectious agents in research hamsters is limited (Suzuki et al., 1982). In general, prevalent agents are more likely to contaminate a facility and such agents should be tested for more frequently than agents that are rarely found in research colonies. Table 28.3 provides a summary of positive test results for hamster samples, excluding samples from commercial rodent vendors, submitted from 2003–2008 to a commercial diagnostic laboratory (Charles River Research Animal Diagnostics Service, Wilmington, MA), unpublished data (Cosentino, 2009). The Federation of European Laboratory Animal Science Associations (FELASA) has provided recommendations on microbiologic agents to include in a hamster health monitoring program (Nicklas et al., 2002).

The following agents are commonly included in hamster microbiologic monitoring programs. The primary zoonotic concern associated with research hamsters is infection with lymphocytic choriomeningitis virus (LCMV), a virus of the family *Arenaviridae*, genus *Arenavirus*. Human cases of LCMV have been reported after exposure to infected research and pet hamsters (Baum et al., 1966; Bigger et al., 1975; Lewis et al., 1965). Additional viral agents for which colonies are routinely screened are pneumonia virus of mice (PVM) and Sendai virus. PVM is a *Pneumovirus* in the family *Paramyxoviridae*. Infection of hamsters with PVM is clinically silent, and experimental infection has produced interstitial pneumonia in hamsters (Baker, 2003). Sendai virus (*parainfluenza 1*) is a *Paramyxovirus* within the family *Paramyxoviridae*. Sendai virus infection in hamsters can produce respiratory disease including tracheitis, bronchitis, and interstitial pneumonia and it may alter renal potassium flux (Genovesi and Peters, 1987). The prevalence of LCMV, PVM, and Sendai virus in research hamster colonies is considered to be low (Baker, 2003).

A limited number of bacterial agents are generally included in hamster microbiologic monitoring programs. Infection with *Clostridium piliforme* (i.e. Tyzzer's disease) can cause disease and mortality in hamsters (Motzel and Gibson, 1990), although reports of disease in research colonies are rare. Screening for *Salmonella* spp. is recommended by FELASA (Nicklas et al., 2002) and practiced by many commercial hamster breeders; reports of salmonellosis in research hamsters appear rare, although outbreaks have been reported (Innes et al., 1956). A number of bacteria, including *Pasteurellaceae* and *Streptococcus pneumoniae* that were associated with pneumonia in a survey of hamster diseases (Renshaw et al., 1975) and *Corynebacterium kutscheri*, which can colonize the upper respiratory tract of hamsters (Amao et al., 1991), are frequently also reported on hamster health monitoring reports. Their importance in producing clinical disease in hamsters is unclear. A number of *Helicobacter* spp. have been isolated from research hamsters, and infection by several species of *Helicobacter* has been associated with clinical disease (Whary and Fox, 2004). Hamsters are an established host for *H. cinaedi*, although the prevalence in research colonies has not been described, and hamsters have been proposed as a reservoir species for zoonotic helicobacteriosis (Gebhart et al., 1989; Orlicek et al., 1993).

Hamsters can also serve as hosts for a variety of parasitic agents. Acariasis is a common finding during

TABLE 28.3 Prevalence of Common Rodent Infectious Agents in Hamsters, 2003–2008[a]

Agent	Assay Method[b]	No. of Samples Tested	No. Positive	Prevalence (%)
VIRUSES				
Lymphocytic choriomeningitis virus (LCMV)	ELISA	7445	2	0.027
Parvovirus genus (NS-1)	ELISA	5928	0	–
Pneumonia virus of mice (PVM)	ELISA	7437	1	0.013
Reo-3 virus	ELISA	7426	0	–
Sendai virus	ELISA	7446	3	0.040
BACTERIA				
Bordetella bronchiseptica	Culture	207	0	–
β-hemolytic *Streptococcus* spp.	Culture	207	1	0.48
Campylobacter jejuni	Culture	413	2	0.48
Corynebacterium kutscheri	Culture	207	0	–
Klebsiella oxytoca	Culture	207	1	0.48
Klebsiella pneumoniae	Culture	207	0	–
Helicobacter genus	PCR	84	55	65.5
Helicobacter hepaticus	PCR	84	1	1.19
Mycoplasma pulmonis	Culture	146	0	–
Pasteurella multocida	Culture	207	0	–
Pasteurella pneumotropica	Culture	207	55	2.42
Pseudomonas aeruginosa	Culture	415	8	1.93
Staphylococcus aureus	Culture	207	37	17.9
Streptococcus pneumoniae	Culture	207	0	–
ECTOPARASITES				
Demodex spp.	Direct	431	52	12.1
INTESTINAL PROTOZOA				
Entamoeba spp.	Wet mount	215	22	10.2
Giardia spp.	Wet mount	215	39	18.1
Hexamastix spp.	Wet mount	215	40	18.6
Reortamonas spp.	Wet mount	215	3	1.40
Spironucleus spp.	Wet mount	215	33	15.4
Trichomonas spp.	Wet mount	215	169	78.6
INTESTINAL NEMATODES				
Aspicularis tetraptera	Direct	215	3	1.40
Syphacia spp.	Direct	215	6	2.79

[a]*Samples originated from pharmaceutical, biotechnology, academic, and government institutions in North America and were submitted to Charles River Animal Diagnostic Services (Wilmington, MA) from 2003–2008, unpublished data (Cosentino, 2009).*
[b]*ELISA (enzyme-linked immunosorbent assay of serum), PCR (polymerase chain reaction of feces), Direct (examination of pelt under a stereomicroscope for ectoparasites; examination of macerated cecum and colon with stereomicroscope for nematodes), Wet mount (high-magnification phase-contrast microscopy of wet mount of duodenal and cecal mucosa scrapings for protozoal agents).*

colony health screening of hamsters; the two common mites identified are *Demodex criceti* and *D. aurati*. Prevalence of *Demodex* infestation in research colonies is high, although clinical signs are uncommon (Baker, 2003). A number of protozoal organisms have been identified in the intestinal tracts of hamsters, but their association with enteric disease is unclear, as their presence is common in both healthy and ill animals (Hankenson and Van Hoosier, 2002). The primary nematodes found in the intestinal tract of hamsters are pinworms of the genus *Syphacia*; hamsters may be infected by *S. mesocriciti, S. criceti, S. obvelata,* and *S. muris* (Baker, 2003; Hankenson and Van Hoosier, 2007). The prevalence of pinworm infections in hamsters has not been described.

RECORD KEEPING

Use of Records

Record keeping is an important aspect of any scientific endeavor and fundamental to good science. Records show what data have been collected and under what conditions the data were collected. Accurate records provide accountability and are necessary for a laboratory to replicate earlier experimental procedures and research outcomes. In animal studies, the requirement for accurate and full record keeping extends to the care and husbandry provided to the animals. Minimal animal identification records for hamsters are often satisfied by a cage card with the following data: source of animal, strain or stock, name(s) of responsible individual (i.e. investigator), pertinent dates (i.e. purchase date, date of birth, dates of experimental procedures), and Institutional Animal Care and Use Committee protocol number, when applicable. If animals are bred for research, accurate records must be maintained to document items such as parentage of animals, litter size, and age of animals as these parameters are important for proper management of breeding colonies and may provide information on the health of the colony. Health records are necessary to accurately treat and evaluate the response of treatment of ill and injured animals and medical records provide valuable information on the general health of research animal colonies.

Breeding Records

The maintenance of accurate breeding records is essential for proper management of breeding and production colonies. For ongoing breeding programs, such as in a commercial breeding operation and for research efforts that rely on multi-generational breeding of hamsters, a computer database is helpful for maintenance of records. For small-scale breeding programs, typical in research settings breeding small numbers of hamsters, breeding records may be maintained on paper such as in a laboratory notebook or by retention of animal cage cards. Minimal information that should be recorded and maintained in breeding records includes animal identification (i.e. unique animal identification numbers for males and females), the date a breeding pair or breeding group is established, the date of birth of the litter, total number of pups born, the number of pups by sex, the number of surviving animals at weaning, segregated by sex, and the date of weaning. If ongoing breeding of females is planned (i.e., multiple litters from the same female), it is recommended to routinely evaluate the litter size for each female. A decrease in litter size is commonly observed as an animal ages and this information is used as criterion to retire breeders. For a detailed discussion on management and design of breeding colonies, including development of foundation colonies and breeding colony structure, see White (2007).

Husbandry Records

Records documenting the environmental conditions within the vivarium as well as the activities of animal facility staff provide important information to animal facility management staff, veterinary care staff, and researchers. Common environmental records maintained within animal facilities include documentation of housing room temperature, humidity, and light cycle. These parameters can be recorded automatically via electronic building management systems or manually via paper records. Electronic building management systems are beneficial as alarm parameters can typically be programmed to detect when environmental parameters exceed predetermined limits (i.e., high and low temperature limits), and the building management system will automatically notify personnel that can then take action to rectify the problem before animal welfare is adversely impacted. If using a paper-based documentation system, animal husbandry staff can be tasked to record temperatures and humidity levels daily within each animal holding space. Under this system, it is recommended to utilize a thermometer that registers both the peak (high) and low temperature over a set period of time, typically daily, and record both temperatures. This allows assessment of temperatures within the space during periods when staff are not present. Relative humidity in an animal housing space can be measured using a hygrometer or sling psychrometer. If housing room light cycles are not controlled though a centralized system, individual room light timers

must be routinely assessed to insure that timers are working properly and that animals are not exposed to alterations in light cycle. Husbandry activities that are important to maintaining animal health and wellbeing should also be recorded. Such records include dates when animals are provided clean food and water, cages are cleaned, and when animal rooms are cleaned and sanitized. Sanitation records are also useful for tracking key aspects of the cage sanitation process. For example, facilities utilizing mechanical cage washers routinely maintain records indicating that rinse water temperatures reach prescribed minimums to achieve adequate sanitation. Recording this information provides animal care management, research personnel, and regulatory officials the ability to regularly review key aspects of animal care, husbandry, and housing environment provided to the animals to insure they meet acceptable standards.

Health Records

Health records, also referred to as clinical records, can be maintained as group records for large populations, such as commercial breeding colonies, or as individual animal records. Health records should include pertinent clinical observations and diagnostic information, history of surgical procedures, postoperative care, and information on experimental use as it pertains to clinical care of the animal. For rodents, this information may be relatively simple and maintained on the cage card accompanying an animal or extensive and maintained as a stand-alone record.

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