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A Review of Rabbit and Rodent Production Medicine

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This review article outlines the essentials of production medicine (factors affecting production colony output) in rabbits and rodents, emphasizing the importance of routine management methods and record-keeping as well as disease control. Common management regimes and production diseases of the important rodent species are covered.

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Production medicine – the study of factors affecting breeding colony output – is a surprisingly broad topic; not only does it cover fertility and estrus cycle control, but any disease that can affect the numbers of animals being produced. This brief article will be concentrating on fertility but will also outline epidemiologically important diseases that can affect breeders’ output.

In the United Kingdom, there are few large “farms” of small mammals for the pet trade; the author’s personal experience is with smaller-scale breeders and their output in local pet stores. Most of the suppliers to the pet shops here are smaller-scale breeders with small colonies and range from experienced keepers to enterprising school children. These colonies are usually kept in one air space, for example a shed or a room in the house. This has implications both for the care of the animals and the epidemiology of disease. Many of these production animals are also show animals, exposing them to further dangers of stress and infectious disease, and are used in breeding programs (eg, as studs). It also means that diagnosis and treatment have a strict budget, related to their economic value.

This article summarizes the essential information and differential diagnoses for the majority of problems that can affect output when breeding these animals. There is discussion of “normal” breeding practices and the problems that can result from their use.

Rabbits

Basic Outline of Breeding

The rabbit is an induced ovulator, that is, ovulation is induced approximately 9 to 12 hours after mating. Luteinizing hormone is released in increasing pulses until a peak 90 to 120 minutes after copulation and returns to normal levels after a further 6 hours. The doe is receptive for periods of 7 to 10 days, after which she is nonreceptive for 1 to 2 days. Receptivity is indicated by a swollen red vulva, chin rubbing, standing for mounting, and restlessness. Ovarian activity is decreased by shortening days, and intensive breeding units can keep does breeding all year-round by using day lengths of 14 to 16 hours light, and 8 to 10 hours darkness. In such situations, however, close attention must be made to the body condition and health of the does because there would be no natural “recovery” period during which the doe would recover any body condition lost while raising the young.

The receptive doe is usually brought to the buck’s cage, whereupon they mate in the first few minutes. The doe is removed after 2 matings, or half an hour if there is no mating. In the latter case, she is reintroduced the next day.

Harkness and Wagner² describe an artificial insemination technique in the rabbit. The main advantage of this technique is that the semen can be diluted to the point of being able to inseminate up to 500 does, which is useful in selective breeding programs, in inseminating does at more than one site, and in conceiving offspring from genetically valuable stock without the risks associated with being housed together or “natural” mating (eg, venereal infections like Treponema). Disadvantages of artificial insemina-
tion include the increased observation of the female to ascertain the optimum insemination time, which is indicated by the color of the vulva; white has approximately 35% conception rate, pink has a conception rate of 55%, red is optimum with a 75% conception rate, and dark red is documented as a 40% conception rate.

Selection of doe and buck, as well as affected by breed standards, should be influenced by other factors such as medical history; rabbits with a history of dental malocclusion, for example, should not be bred from if there is a suspicion it could be caused by congenital malformation. While tempting to select for large litters, does should be selected for the number of kits weaned rather than numbers of kits born.

**Production Targets**

Richardson advises against having more than 3 litters per year. However, 8 litters per year with up to 9 young per litter are possible. At this level, colony stock selection has been for litter size and reliable conception, and diets with high protein and fiber (17% protein, 17% fiber). Metabolically this is a demanding target, and the formulation of the diet poses a risk of developing enterotoxemia. A more realistic target would be for 4 or 5 litters per year on a diet with a higher fiber content and lower protein, typically around 20% fiber and 14% protein.

Does are productively receptive again 3 to 9 days postpartum. After 9 days, and up to 4 weeks postpartum, conception rates are low, probably because of the metabolic demands of peak lactation. Does that have produced a poor litter can be remated in this first fertile week. However, those does with persistently small litters should be removed or investigated if they are part of a larger problem. Those with larger litters can be remated after this 3-week period.

Typical systems involve either mating at weaning, mating at 10 to 12 days after parturition (weaning at 30 to 42 days old), or mating at 2 days after parturition.

Pregnancy diagnosis is usually by abdominal palpation at approximately 2 and 4 weeks. Those rabbits pregnant at the first palpation but not at the second may be indicative of a husbandry problem, such as nutrition (low calorific or protein intake), stress, or disease.

**Causes of Low Conception and Live Birth Rates**

*Pasteurella multocida*, a common pathogen in rabbits, can cause orchitis in bucks and endometritis in does, lowering conception rates. *Staphylococcus aureus* is also a cause of endometritis and pyometra.

If does are aged over 2 years at their first mating, there is a much reduced likelihood that they will conceive with a mating.

Overweight does are prone to embryonic resorption. Increasing fiber and exercise while withdrawing most of the available concentrate will assist in weight loss. Exercise can be increased by housing in a large pen rather than a hutch or cage. Placing food, water, and bedding far apart will also contribute. When they are at the desired weight, concentrates are reintroduced and the doe is mated while her condition is increasing. She is then put back on to a maintenance ration. Her body condition should be monitored throughout pregnancy. On the other hand, insufficient calorific and protein intake reduces fertility (litter size) and can also result in early embryonic or fetal death and resorption.

*Treponema cuniculi* infection, which is venereally transmitted, can result in low fertility, stillbirth, and early neonatal mortality. Males and females in the colony should be regularly examined for signs of *Treponema* infection (crusting around the genitals), and newly brought-in stock should be examined and possibly screened or quarantined for infection if this is a problem. Colony elimination is by breeding from virgin does. Antibodies can be detected in infected or exposed stock. Diagnosis is usually by biopsy, impression smear, scraping, or flushing of lesions, and immediate examination using Giemsa stain or dark field and oil immersion.

Pregnancy toxemia/ketosis is uncommon in rabbits but most common in overweight primiparous does during the last week of pregnancy because of adipose tissue breakdown and subsequent hepatic lipidosis. The condition often results in abortion or premature parturition. The prognosis is guarded. Clinical signs include lethargy, salivation, hyperpnea, and respiratory distress, seizures, collapse, and an acid urine pH of
5 to 6. Treatment includes 5% glucose by parenteral or oral administration, steroids, and force-feeding of food containing complex polysaccharides. Prevention is primarily by making sure that does are not overweight (an approximate body condition score of 2.5 to 3 out of 5) and are fed on a diet with sufficient fiber. Anorexia in late pregnancy must be avoided (can be induced by stress) or treated quickly.

Dystocia is not a common problem in rabbits, but when seen it is usually caused by obesity, a large fetus (particularly in small litters), or malpresentation.

Persistently poorly performing does and bucks should be investigated and/or removed from the breeding program.

Causes of Neonatal Mortality

Mastitis is mainly seen in does kept in unhygienic conditions. The affected gland(s) are hot and hard, and the doe is often pyrexic and anorexic. The kits should be removed and hand-reared (because fostering may spread the infection) and antibiotics (such as enrofloxacin or trimethoprim-sulfonamide combination) and anti-inflammatories administered (such as carprofen) for analgesia. Culture and sensitivity should ideally be performed. If this is a problem affecting more than a very small number of does, consideration should be given to breeding house hygiene.

Cannibalism and desertion do occur in rabbits, primarily because of overcrowding in group-housed systems, but can also be seen in primiparous or stressed does. Bear in mind that does will only suckle once or twice a day, and so the absence of the mother from the nest is not a sign that she has deserted her young. Lactation may only start 24 hours after parturition, although longer than this is a sign of agalactia.

Coccidia (*Eimeria* spp) can cause diarrhea in young rabbits. Transmission is by the fecal-oral route, so hygiene in a breeding program is paramount. Diagnosis is by fecal examination. Treatment is by water or feed medication by a coccidiostat such as sulfamerazine, sulfadimethoxine, or amprolium.

Neonatal colibacillosis, caused by *Escherichia coli*, is seen as yellow fluid feces in rabbits under 2 weeks old. Postmortem findings include watery intestinal contents, and *E. coli* is cultured from the intestinal contents (not a normal finding in the flora in young rabbits). Improving management hygiene is the first step to preventing this condition. Treatment of suspected cases is with trimethoprim-sulfonamide combinations.

Causes of Adult Morbidity and Mortality

Viral hemorrhagic disease, caused by a calici virus, is thought to be endemic in the wild rabbit population of mainland Europe and Great Britain. There has been an isolated outbreak in early 2000 in the United States. The virus replicates in and damages hepatocytes, which, via the release of thromboplastins, cause disseminated intravascular coagulation. The virus is present in saliva and nasal discharges from affected rabbits. Transmission can be direct (eg, by mutual grooming or aerosol) or indirect (contact with soiled cage materials, on clothing, blood-sucking vectors, or food or water). The clinical syndrome of convulsions, epistaxis, lethargy, anorexia, dyspnea, pain (even vocalization) affects only rabbits over 6 weeks of age. Incubation is up to 3 days, and so in endemic areas, in the face of an outbreak, or with stock of unknown background, quarantine of new stock should be instituted. Diagnosis is by postmortem, histopathology, and virus isolation.

Pasteurellosis, otherwise known as “snuffles,” is an infection with *Pasteurella multocida* and is a common disease in pet rabbits. It is spread by aerosol transmission and becomes a problem in colonies kept together in the same airspace, although not all infected rabbits develop the clinical condition; some become carriers. Because of the still-developing nasal anatomy and the presence of maternal antibodies, the disease is not usually seen in young rabbits under the age of 3 months. When pasteurellosis is endemic in a colony, it is possible to take advantage of this resistance by weaning early (at about 5 weeks), establishing a pasteurellosis-free colony. Prevention is based on husbandry and management: good ventilation, quarantine of new stock whose status is unknown, and good nutrition of existing stock. Richardson reports that the ovine-killed *Pasteurella* vaccine (Pastacidin; Hoechst Roussel Vet Ltd, Milton-Keynes, UK) can be used in young rabbits (0.25 to 0.5 mL) and in adults (0.5 to 1 mL). This is given as a subcutaneous injection at weaning and repeated 2 weeks
later. Does can be vaccinated before mating, maximizing maternal antibodies in the colostrum. Bucks are vaccinated every 6 months. It is, of course, important to discuss and gain informed written consent from the owner before using an unauthorized vaccine in this way, but it provides an alternative strategy if a colony is infected.

**Estrus Cycle Manipulation**

*Induction of estrus.* When using artificial insemination, ovulation can be induced by a protocol developed by Parez and Chmitelin.\(^5\) An injection of 35 IU of PMSG (pregnant mare serum gonadotrophin) (Folligon; Intervet, Cambridge, UK) is given 10 days after parturition and 48 hours before estrus is desired, and then GnRH (gonadotrophin releasing hormone) (Fertagyl; Intervet; 0.2 mL) is injected at insemination. This protocol may also result in slighter increased litter sizes. It is not required when natural mating is used.

*Induction of parturition.* Oxytocin, given after 31 days at 0.15 to 0.2 IU intramuscularly, can induce parturition. There is an increased neonatal death rate reported.

Prostaglandins give good control and luteolysis with few side effects (eg, luprostiol 0.5 μg/kg, cloprostenol 1.5 μg/kg, and etiproston 50 μg/doe). In the United Kingdom, at least, there are no prostaglandins authorized for this use.

**Guinea Pigs**

**Basic Outline of Breeding**

Guinea pig boars and sows become mature at around 2 months old. For maximum efficiency and fertility, boars are usually not bred until they weigh 650 g (about 10 to 16 weeks old). Females must be bred before they are 6 months old, otherwise the pubic symphysis starts to fuse, which reduces the compliance of the pelvic canal and causes subsequent dystocia. Females are polyestrous all year round with an average 15- to 17-day cycle. Spontaneous ovulation occurs 10 to 12 hours after estrus start, and the sow is receptive to mating at night for a 6- to 12-hour period. Gestation is variable (larger litters have a shorter gestation period) but is between 59 and 72 days, with 63 to 69 the usual range. Litter size can range from 1 to 6, but is usually 3 to 4. There is a postpartum estrus 2 to 15 hours after birth, with a 75% fertility rate. This allows a potential target production of 15 young per year. However, pregnancy is demanding on the sow’s body and condition, and so Nakamura\(^6\) recommends that a sow be allowed a period of rest between pregnancies; therefore, the male should be removed before parturition. A sow’s breeding life is up to 4 years, and optimum fertility is obtained for the first 2 years.

Breeding systems can be monogamous or polygamous. Polygamous systems (1 male to 4 to 8 females) take advantage of communal rearing in which lactating females will suckle the kits from litters other than their own. This can, however, have the drawback that older pups from another litter can out-compete younger pups for their mother’s milk. The male is left in permanently to take advantage of the (usually) fertile postpartum estrus. The pups ought to be sexed and separated by 3 weeks of age because the females can have a fertile estrus at 4 weeks of age, which would result in a pregnancy with a high risk of complications such as abortion, still birth, or dystocia.

Sutherland and Festing\(^7\) recommend selecting breeding stock based on the success rearing total numbers of young to weaning, as opposed to selecting for litter size.

**Reaching Production Targets**

Infertility can be caused by the following factors: obesity; nutritional deficiencies; metritis; high environmental temperatures (>29°C); poor lighting (low intensity or <10 hours/day); disease (eg, respiratory infection, skin mites, gastrointestinal disease, cystic ovaries); overcrowding; aged boars or sows; and mechanical impediments (eg, sawdust or the waxy secretion boars accumulate in their groin and scrotal regions).

**Low Live Birth Rates and Neonatal Mortality**

Stillbirths and neonatal deaths are highest with primiparous or immature sows, which tend to have gestations less than 66 days or more than 72 days. Large litters and stressed sows (eg, loud noises, high temperatures, and exposure to predators like cats) also have short gestations. Exposure to nursing sows can induce premature birth. Ediger\(^8\) comments that pups weighing less than 50 to 60 g at birth do not usually survive.
Stillbirths can also be caused by aflatoxicosis (moldy hay), and septicemia from another infection such as *Bordetella* infection.

Early fetal death resulting in embryonic absorption is primarily caused by either infectious agents (eg, *Bordetella* spp, *Salmonella* spp, and *Streptococcus* spp), metabolic disorders (eclampsia or ketosis), or malnutrition (restriction of food intake during late pregnancy). Sows with severe mite infection (eg, *Trixacarus caviae*) often abort. Edward advises 2 months rest for aborted sows. Investigation of the reasons for abortion would include a full physical (including dermatologic) examination, hematology, and vaginal swab for culture. Richardson suggests supplementing with 4 mg/kg calcium per os per day during pregnancy. Exercise (eg, by having a large pen, with food, water, and bedding widely separated) is part of preventing obesity and can prevent ketosis. A target to aim for is less than 10% still births per colony.

**Adult Morbidity and Mortality**

Maternal death can be caused by uterine hemorrhage or dystocia. Pregnant sows at day 65 or above should be monitored closely for reduced appetite and onset of labor signified by straining and vocalization, and a green or bloody vaginal discharge signifying separation of the placenta. Forty-eight hours prepartum, the pubic symphysis separates leaving a palpable gap of 1.5 to 3 cm, under influence of relaxin. Note that guinea pigs do not display nesting behavior as with other rodents, and so this must not be used as an indication of impending parturition. If dystocia resulting in death of the fetus or sow occurs on a more than occasional basis, the clinician should consider obesity, late first breeding (after 6 months old), or a hereditary predisposition.

Ketosis or pregnancy toxemia usually occurs in the 1 to 2 weeks pre- and postpartum. It is caused by the energy requirements of the last stages of gestation and of increasing lactation, particularly in primiparous obese sows that become anorexic for any reason (eg, any stress or disease) or who have a low-energy diet in this critical month. There is also a "toxic" form where oversized fetuses compress the aorta in such a way as to cause uterine ischemia, fetal death, and disseminated intravascular coagulation. The sow requires more calories than can be eaten, and the subsequent rapid catabolism of adipose tissue can result in ketone production. The affected sow can die abruptly or deteriorate slowly over a week. Symptoms are nonspecific (including lethargy, adipsia, salivaition, incoordination, hyperexcitability, and dyspnea) but when seen in a sow in this critical period, there should be a high index of suspicion. Diagnosis can be confirmed by testing for protein or ketones in urine (which will be acidic) using a dip-stick, and/or finding hypoglycemia and hyperlipemia on blood sample (lateral saphenous vein is the best site). Nakamura describes treatment as unrewarding, but advises intravenous or intraosseous fluids, intravenous or oral dextrose, and calcium gluconate injection. Steroids can be used if the sow goes into shock.

Eclampsia or hypocalcemia occurs around parturition because of acute hypocalcemia brought on by lactation combined with inadequate resorption of calcium from bone and inadequate absorption from diet. Periparturient sows with eclampsia are depressed, have muscle twitches and spasms, and even convulsions. Treatment is with calcium gluconate injection. Hypocalcemia can be prevented with a good commercial diet or calcium supplementation around the risk period.

Mastitis can occur in guinea pigs kept in poor hygiene conditions and is usually caused by environmental bacteria such as *Proteus*, *Klebsiella*, *E. coli*, *Staphylococcus*, and *Streptococcus* spp (eg, *Streptococcus equi*). Swollen, hot, and hard mammary glands with decreased milk production, and even weight loss and death within a few days, are seen. A sample of mammary secretion should be taken if possible for culture and sensitivity, and the sow started on a broad-spectrum antibiotic such as a sulpha-trimethoprim combination (30 mg/kg). The administration of probiotic to the young especially may be warranted because some antibiotics will be secreted in the milk.

**Infectious Disease Affecting the Colony**

*Bordetella bronchiseptica* is the most common cause of pneumonia in guinea pigs. Adenovirus, *Klebsiella*, *Streptococcus pneumoniae*, and *S. pyogenes* can also be involved. The incubation period of bordetellosis can be up to a week, and many other animals including rabbits, dogs, and hu-
mans can carry *B. bronchiseptica*. The infection can result in a wide range of conditions and signs, including otitis media and deafness, conjunctivitis, abortion, and weight loss. Treatment with antibiotics, even if selected using culture and sensitivity, is reported to result in a carrier state or relapse of the disease. Huerkamp\(^\text{11}\) reports that using reduced dosages (0.2 mL, injectable) of canine Bordetellosis vaccine, with 6 to 12 monthly boosters, can be used to prevent infection and reduce spread.

Coronavirus diarrhea affects mainly weanlings that are stressed in some way (eg, transport or pet-shop display). Morbidity is reported to be as low as 5%, but subsequent mortality can be as high as 50% over the course of a week. Recovery is over the same period. Diagnosis is based on the clinical signs of acute anorexia, rapid wasting, and profuse watery diarrhea, and the lack of significant bacteria on culture. The final diagnosis may require postmortem and histopathology of the intestine. Treatment is supportive care with particular attention to fluids. Prevention requires quarantine of new additions to the colony for approximately 1 week and ensuring that nutrition and hygiene within the colony are of a high standard.

**Rats and Mice**

**Basic Outline of Breeding**

Rats reach sexual maturity at 6 to 8 weeks of age; males usually a week later than females. The females are polyestrous, coming in to heat every 4 or 5 days if they are exposed to male rats, or up to 6 days if they are kept in single-sex groups. The optimum light cycle is 12 hours light and 12 hours dark.\(^\text{12}\) Small groups of female mice kept together without any male influence (and pheromones can play an important part in the murine estrous cycle) can cause them to enter pseudopregnancy, an effect termed the "Lee-Boot" effect. Subsequent exposure to a male or his urine will then cause the females to enter estrus 3 days later in synchrony (the "Whitten" effect). These effects can be used to synchronize estrus and thereby parturition, which can be useful for management purposes and for batching the output. This effect can also be seen in rats but is not as pronounced or as reliable.

Breeding systems can be monogamous or polygamous. The most efficient in terms of record keeping and in numbers of young born is the monogamous pair system. The male is kept permanently with a single female throughout estrous, pregnancy, and lactation, taking advantage of the postpartum estrus, which is usually fertile. Good records can be kept easily of numbers born, numbers reaching weaning, and the parturition-to-parturition interval, which can be as short as 20 to 25 days. A pregnancy due to a postpartum estrus has a slightly longer gestation because the female is often still lactating when parturition is due. An average litter size is 10.

**Conception Rates**

The age of the parents affects the litter size, which increases with age until the fourth or fifth litter at about 6 to 8 months of age, when litter size starts to decline until 1.5 years of age. Estrous cycles stop around this time, and the doe must be retired. Bucks are usually fertile until 1.5 to 2 years old.

Overcrowding (eg, in a harem system with small cages) or poor nutrition can reduce or stop breeding. This is reversible upon improving conditions. Environmental factors such as high temperature and humidity can reduce fertility, particularly in males. As mentioned earlier, lighting should be 12 hours on and 12 hours off. Too little light or darkness can reduce fertility in females.

The protein content of the food should be between 14% and 24% during breeding. It is believed that a low vitamin E content in the food can result in reduced conception rates, and Richardson\(^\text{13}\) advises adding wheatgerm to the food.

An uncommon condition in rats is cryptorchidism, which results in lower male fertility. The condition is thought to be hereditary and affected males should not be bred.

**Neonatal Morbidity and Mortality**

The neonatal pups should not be handled unless necessary because leaving human or an unfamiliar scent on the pups will probably result in cannibalism. When handling is necessary, use impermeable gloves.
Poor nutrition, environmental stress, and infection can cause abortion and stillbirth. The doe commonly eats aborted or stillborn fetuses.

Neonatal mice with diarrhea usually have a viral cause, such as rotavirus or mouse hepatitis viruses (MHV). MHV is a group of coronaviruses causing severe enteritis in neonatal mice. Affected mice are smaller than usual and have profuse watery feces resulting in dehydration. On postmortem, MHV-affected mice usually have no milk in their stomach, in contrast to rotavirus-affected neonates, where so much milk accumulates in their stomachs that the abdomen is distended. Treatment of enteritis is primarily supportive with generous fluid administration.

Sendai virus infection in previously unexposed animals can prolong gestation, cause neonatal death, and retard development of neonates. In colonies in which the virus is endemic, neonates will be protected by maternal antibody until 1 to 2 months old. Enzyme-linked immunosorbent assay (ELISA) serology in the live patient, or autopsy and histopathology in the dead patient, can achieve diagnosis.

Infectious Disease Affecting the Colony

Respiratory infection is usually caused by *Mycoplasma pulmonis*, which can be found in the sinuses of asymptomatic rats. Other causes include *Streptococcus pneumoniae* (in rats and guinea pigs, but mice are usually asymptomatic), and Sendai virus causes respiratory distress and reproductive problems.

Sialodacryoadenitis virus causes sneezing, swollen salivary glands, eyelid porphyrin staining, keratitis, and conjunctivitis. Recovery is usual in about 2 weeks, and there is low mortality. Endemically infected colonies have neonates protected by maternal antibodies.

Syrian “Golden” Hamsters

Basic Outline of Breeding

After becoming sexually mature at 5 to 6 weeks old, females are seasonally polyestrous during summer (12 to 14 hours daylight), becoming receptive at night approximately every 4 days. Managed breeding starts at 8 to 10 weeks for females and 10 to 14 weeks for males. Before ovulation, there is a clear discharge visible on the vulva, which later becomes opaque white.

There are a few methods of managing planned breeding of hamsters, depending on the output required and the human supervision available:

1. The female to be mated is taken to the male’s cage just before dark, and the 2 are separated after mating, which occurs several times over the course of an hour. They can be left together until light. Aggression can be a problem, particularly if the male is taken to the female’s cage, or if the female is left with the male for too long. To avoid this, the male should be removed if mating has not occurred after about 5 minutes. If there are any signs of aggression between the 2, the female is removed and then mating can be reattempted after 24 hours. When successful, another mating can be attempted after 4 days to see whether the female is back in estrus or not, but if the female is pregnant her abdomen becomes noticeably swollen at about 10 days after mating. This method is very labor-intensive and is used in small-scale breeding.

2. Larger systems pair 1 premature male and female together permanently. Litters are produced approximately every 35 to 40 days. Fighting between the parents and pup cannibalism can occur with this system, particularly in small cages.

3. One male with 7 females rotate through his cage at weekly intervals. Males do need regular rest, however, overworked males can become exhausted and immunosuppressed (reduced splenic killer T-cell activity), which will reduce fertility leading to reduced conception rates.

4. Periodic harem system with 1 male to 2 females, or 3 to 5 males and 10 to 12 females, together for 7 to 14 days. The females are removed during pregnancy and lactation. Fighting can be a problem in this system.

The system used should be borne in mind when consulting on a production problem. For example, in the case of the second system, pup cannibalism is a potential problem. In the third system, it may be more straightforward to identify where the problem lies (eg, if the whole harem is affected, male infertility may be the cause). Whatever the system, female hamsters should not be kept together in all-female groups because when they are taken to a male they do
not show normal mating behavior, although their estrus cycles are normal. Gestation in hamsters is 16 to 18 days long, with an average litter size between 5 and 9 young. Birth usually occurs at night, and is preceded by a blood-stained discharge. If the pups have not been born by 18 days' gestation, then 0.5 IU of oxytocin intramuscularly can be used to induce parturition.

Infertility

There are many possible reasons for infertility, including:

1. immaturity when bred (female less than 5 weeks old).
2. senescence (older than approximately 15 months).
3. systemic disease, e.g., respiratory infection.
4. nutritional deficiency (e.g., low calorie or protein intake). Vitamin E has been reported as causing a fatal necrosis of the central nervous system in hamster fetuses. Richardson15 advises adding wheatgerm to the diet to increase dietary content of vitamin E.
5. a female first mated at over 6 months old will often be infertile on first breeding.
6. cold (environmental temperature <7.5°C for 2 weeks or more15).
7. environmental stressors.
8. pyometra or endometritis.
9. seasonal quiescence related to long darkness related to light (fertility will recover when the photoperiod is adjusted).
10. overworked male in multiple mating systems.
11. anestrus female removed from an all-female group; will recover when exposed to male for a time.

Neonatal Mortality

Cannibalism in hamsters is common, especially in group-housed systems, probably related to hamsters' territoriality. The causes of cannibalism are multifactorial, and include environmental factors (disturbing nest or mother, insufficient food, water, or nesting material, lack of privacy, or noise), management factors (handling when less than 10 days old, leaving the male in cage for more than 1 week after parturition, or a break in routine), or maternal and neonatal factors (primiparous females, agalactia or mastitis, ill or malformed young, or a very large litter).

Proliferative ileitis affects weanlings between the ages of 3 and 10 weeks old and can be an important cause of death. It is caused by Lactosia intracellularis. Clinical signs are of lethargy, anorexia, poor coat, weight loss, watery diarrhea, and a hunched posture caused by abdominal pain. Death occurs within 24 to 48 hours. Diagnosis is by signalment, clinical signs, and postmortem (thickened and edematous distal ileum, cecum, and proximal colon). Treatment is aimed at reducing mortality through the use of antibiotics (tetracycline at 400 mg/L of drinking water, enrofloxacin at 10 mg/kg twice daily per os, or trimethoprim sulphonamide combination 30 mg/kg twice daily per os), aggressive fluid therapy, and warmth.

Adult Morbidity and Mortality

Streptococci can be passed from humans (mainly children) to hamsters and result in pneumonia. Diploccoci are seen on stained preparations of the nasal secretions, and culture and sensitivity should be carried out if financially viable. Other organisms like Pasteurella pneumotropica, Staphylococcus aureus, and Bordetella can be found in the respiratory tracts of unaffected individuals. Chloramphenicol (50 mg/kg per os 4 times daily), enrofloxacin (10 mg/kg per os or subcutaneously twice daily), or a trimethoprim-sulfonamide combination can be used.

Sendai virus infects hamsters as well as rats and mice. Clinical disease often is complicated by secondary bacterial infection, and clinical signs will be similar to those of bacterial infection. ELISA testing of blood will reveal whether the individual has been infected with Sendai virus, but this may not be the cause of the clinical signs presented.

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**Suggested Reading**

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**On-Line Resources**

The Veterinary Information Network is an invaluable resource for research and discussion: http://www.vin.com

E-mail discussion groups on this topic include:

E-Vet Exotics. All vets are permitted, usually busy. Wide range of topics. All levels of experience. http://www.e-vet.com

Rabbit Vet Discussion Forum. All vets permitted. Low level of traffic, entirely in rabbit medicine and surgery. All levels of experience. http://www.rabbitvets.co.uk

ExoticDVM. All vets permitted, usually busy. All levels of experience. Run as a service of the Exotic DVM magazine. http://www.exoticdvm.com

EVDG. Previously UK-only, now opened up to exotics vets from all over the world. Managed by Sharon Redrobe, usually busy. Some of the leading vets in the field are subscribed. http://groups.yahoo.com/group/evdg

BVZS. Discussion list for the British Veterinary Zoological Society. http://www bvzs.org