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Introduction

The domestic guinea pig *Cavia porcellus* (also known as the cavy or cuy), is a small, stocky, tailless rodent commonly used in biomedical research. Guinea pigs are hystricomorph rodents related to the porcupine and chinchilla. They are not at all closely related to swine. Guinea pigs are easily handled and rarely bite; however, when excited they will stampede or circle their enclosure, and are likely to scratch. The males are called boars, and the females sows.

Guinea pigs originated in the Andes mountains of South America, where they are still of importance as a meat animal, and have a role in religious ceremonies and local medicine (MHller-Haye, 1981). They were first brought to Europe by the Spaniards following the conquest of Peru in 1532 (MHller-Haye, 1981).

Guinea pigs are popular as pets world-wide, and hobby breeders have selected animals for coat characteristics over the past 40 years (MHller-Haye, 1981). Varieties such as the English and American have smooth, short hair whilst the Abyssinian has short hair which forms whorls and rosettes. Long-haired varieties include the Angora (smooth-haired) and Peruvian (rough-haired) (Harkness and Wagner, 1989). As laboratory animals, the outbred Dunkin-Hartley line of English short-haired guinea pigs is the most common and has the most widespread distribution (Sutherland and Festing, 1987). Inbred strains of guinea pigs are less common, are used in studies of the genetics of immune function and have been reviewed by Festing (1979).

Uses

The guinea pig is commonly used in biomedical research for purposes such as a source of red blood cells, polyclonal antibodies, complement and tissues such as kidney. Guinea pigs have been used in a multitude of research roles including biochemical, physiological and pharmacological tests (e.g. assay for the presence of histamine). They are used as animal models for the study of disease conditions such as respiratory anaphylaxis, delayed-type hypersensitivity reactions, genital herpes and scurvy. For information on the uses of guinea pigs as animal models of human diseases, refer to the publications of the Armed Forces Institute of Pathology (see references and reading list). Guinea pigs are often used in hearing research. Much less commonly these days, the guinea pig is used for purposes of human disease diagnosis (e.g. tuberculosis, legionnaires' disease).

Sources of supply

Guinea pigs are available from research institutions, and ANZCCART publishes a list of strains maintained in Australia (ANZCCART, 1992). For sources of laboratory guinea pigs available world wide, refer to the publication by Festing (1993).

General biology

Wild guinea pigs inhabit a variety of environments including rocky and mountainous terrain, forest margins, swamps and grasslands (Sutherland and Festing, 1987). They avoid extremes of light intensity, preferring subdued light (Smallwood, 1992), and appear to have activity patterns described as either polyphasic or crepuscular. They shelter in burrows during the day and feed at nightfall (Sutherland and Festing, 1987). In the wild they have been observed to eat fresh green vegetation and wild fruits, and it is hypothesised that this choice of food is associated with their requirement for a nutritional source of vitamin C (Smallwood, 1992). In the laboratory environment, young animals readily adapt to the husbandry system and workday routine. However, as they mature, guinea pigs are less able to adapt to change; this gives rise to their reputation for being fussy eaters that will often refuse to eat or drink if changes in the feed, water or housing conditions occur (Harkness and Wagner, 1989).

Guinea pigs are social animals. In the wild they have been observed to live in small groups of five to ten in burrows dug by other species (Sutherland and Festing,

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1987). Vocalization is an important feature of the social interaction between guinea pigs living in groups, and also between guinea pigs and humans. Males housed in groups form dominance hierarchies, and subordinate animals are chewed and barbered. Hierarchies in grouped female animals are weak or non-existent. Males are most likely to fight each other in the presence of oestrous females (Sutherland and Festing, 1987).

The guinea pig has a number of notable anatomic features, which have been summarised by Smallwood (1992). The vertebral formula is C7, T13-14, L6, S3-4, Cd7; males have four sacral vertebrae and females three. Guinea pigs have three digits on the hind limb and four digits on the forelimb. The pelvic symphysis fuses in the male and females not bred before six months of age. In females bred before six months of age, the pelvic symphysis does not fuse and during pregnancy the ligamentous portion of the syndesmosis softens and proliferates to allow the wide separation necessary for the growth of large fetuses and their successful passage during parturition. The male has an os penis. The skull has very large tympanic bullae. The dental formula is 2(I 1/1 C 0/0 P 1/1 M 3/3), giving a total of 20 teeth. All teeth are open-rooted (hypodont) and erupt continuously. There is a normal 1 cm diameter hairless area caudal to the ear, which is not due to hair loss. Both the male and female have a single pair of inguinal mammae. The guinea pig has a gall bladder and a large colon, caecum and adrenal glands.

The fancy breeds of guinea pig vary considerably in colour and texture of the hair coat, and studies of the genetic control of these characteristics have been reviewed (Searle, 1968; Robinson, 1975). Colour is controlled by multiple alleles at six major loci (Sutherland and Festing, 1987) and non-colour characteristics by six genes (Robinson, 1975). The laboratory strains of guinea pigs used in Australia are most commonly based on the Dunkin-Hartley English short-haired, and are albino, monocoloured, bicoloured or tricoloured.

Genetic studies of histocompatibility and immune responses in the guinea pig have been reviewed by Robinson (1975) and Festing (1979).

Physiological data

Physiological parameters are shown in table one—useful references include:

*haematological data- Altman and Dittmar (1961, 1974); Williamson and Festing (1971)

*strain differences in relative organ weights - Strandkov (1939); Festing (1976)

*blood chemistry during aging- Rogers (1951)

*measurement of blood pressure, blood gases and other physiological responses in awake and anaesthetised guinea pigs- Brown *et al.* (1989)

*respiratory physiological data- Altman and Dittmar (1974).

Table 1 Guinea pig physiological values

Adult weight:	
male	900-1200 g
female	700-900 g
Birth weight	70-100 g
Body surface area (cm ²)	9.5 (wt. in g) 2/3
Body temperature	37.2-39.5 C
Chromosome no. (diploid)	64
Lifespan	4-5 y
Food consumption	6 g/100 g/d
Water consumption*	10-40 ml/100 g/d
Gut transit time	13-30 h
Breeding onset :	
male	600-700 g (3-4 months)
female	350-450 g (2-3 months)
Cycle length	15-17 d
Gestation	59-72 d
Pseudopregnancy (rare)*	17 d
Postpartum oestrus conception"	"fertile, 60-80%
Litter size	2-5 young
Weaning age (lactation duration)	150-200 g (14-21 d)
Milk composition *	"fat 4%, protein 8%, lactose 3%"
Peak milk production *	65 ml/kg (days 5-8)
Duration of breeding (not age)	18 months-4 y
Commercial breeding	4-5 litters
Reproductive performance	0.7-1.4
young/female/month	
Respiratory rate	42-104 breaths/min
Heart rate	230-380 beats/min
Tidal volume	2.3-5.3 ml/kg
Blood volume	69-75 ml/kg
Blood pressure	80-94/55-58 mm Hg
Red blood cells	4.5-7.0 X 10 ⁶ /mm ³
Packed cell volume	37-48 %
Haemoglobin	11-15 g/dl
White blood cells	7-18 X 10 ³ / mm ³
Neutrophils	28-44 %
Lymphocytes	39- 72 %
Eosinophils	1-5 %
Monocytes	3-12 %
Basophils	0-3 %
Platelets	250-850 X 10 ³ / mm ³
Serum protein	4.6-6.2 g/dl
Albumin	2.1-3.9 g/dl
Globulin	1.7-2.6 g/dl
Serum glucose	60-125 g/dl
Blood urea nitrogen	9.0-31.5 mg/dl
Creatinine	0.6-2.2 mg/dl
Total bilirubin	0.3-0.9 mg/dl
Serum lipids	95-240 mg/dl
Phospholipids	25-75 mg/dl
Triglycerides	0-145 mg/dl
Cholesterol	20-43 mg/dl
Serum calcium	5.3-12 mg/dl
Serum phosphate	3.0-7.6 mg/dl

Housing

Guinea pigs are messy. They kick food and bedding materials out of cages and pens, defecate and urinate in open food and water containers, and spit food up the nozzles of automatic watering nipples and sipper tubes. Water bottle bungs need to be protected with metal chew-guards, and sipper tubes or nipples should be made of stainless steel rather than brass (Sutherland and Festing, 1987). Guinea pigs often play with drinkers and waste more water than they actually consume. Urine is coloured off-white to yellow by the presence of phosphate and carbonate crystals (Harkness and Wagner, 1989). The urine tends to form an alkaline scale in the floor of pens and boxes, and occasionally an acidic solution needs to be incorporated in the cleaning program to remove it.

The guinea pig does not burrow, climb or jump to any great degree. This makes them relatively easy to contain in floor pens, battery enclosures, and metal or plastic boxes without lids; as long as the minimum height of the wall is 40 cm (Sutherland and Festing, 1987). Often wall heights of 18 cm will contain younger animals and most females, but not sexually active males (Harkness and Wagner, 1989).

Environmental enrichment should be considered when long-term caging of guinea pigs is planned. This can most simply take the form of hay or straw bedding materials in the pen. Animals enjoy chewing the bedding and make tunnels in piles of fresh hay or straw. Shallow ramps and plastic or ceramic pipe tunnels can be incorporated in larger floor pens without compromising the cleaning routine. Sometimes wood in the form of tree branches or logs is included for the guinea pigs to chew; However, care needs to be taken that the material is non-toxic, not a health and safety hazard to staff, and does not harbour disease organisms.

Floor pens are commonly used for harem mating systems and for maintaining large groups of 20-40 animals. The floor is generally concrete, with concrete or metal partitions for walls. The pens should be free of draughts, easily cleanable, and the floor surface kept dry. A pen with a gently sloping floor and floor drain is generally most successful. The watering system should be positioned close to the drain because guinea pigs are messy drinkers. The animals tend to congregate around the edges of the pen and avoid the centre. Bedding such as straw, sawdust and straw, or hay is often used. Sawdust used alone can be a problem with older males because it can cause impaction of the perineal sac. Bedding can be autoclaved if there are infection control concerns. Although relatively cheap to construct and maintain, floor pens can be an inefficient use of valuable floor space.

Battery-style caging usually consists of vertical rows of long, large metal cages held in a metal framework. The floor may be perforated plastic sheets, wire, or solid plastic or metal with bedding. This style of caging is a more efficient use of limited floor space, but is more difficult to maintain or keep clean due to the restricted vertical height between rows. The long, narrow design of the cage tends to result in animals crowding down one

end rather than being evenly distributed through the battery, and there is a danger of smothering if the animals become alarmed and stampede. Animals housed on wire floors should also be bred under similar conditions, since inexperienced animals placed on wire can fall through and break legs.

Metal or plastic cages are used to house small groups or individual animals. This style of housing is most suitable for animals maintained for experimental purposes, or for housing a sow and litter. It is also the most expensive form of caging. Lids are not necessary if the sides of the cage are high enough, as discussed above. Solid floor cages with bedding retain heat, which may be an advantage or disadvantage depending on the sophistication of ventilation and temperature control in the facility. This system is labour intensive, due to the more frequent need to clean the cage and change the bedding, and the tendency for guinea pigs to kick bedding materials out of the cage. Automatic watering systems for solid floor cages should be located outside the cage to minimize the danger of flooding. Wire floored cages reduce the labour requirement for cleaning, although there are more problems with leg and foot injuries and with draughts.

The environmental requirements of guinea pigs are similar to those of the other common laboratory species. Sutherland and Festing (1987) recommend the following conditions: temperature 18-22°C, 8-20 air changes/h, relative humidity 45-70%, 12-16 h light/day cycle. Group-housed guinea pigs provided with bedding withstand colder conditions, but neonates have reduced survival at temperatures below 17°C. Temperatures over 30°C are not well tolerated, particularly by pregnant sows.

Most guinea pigs are maintained under conventional conditions, but sometimes there is a need to house animals using barrier facilities. For further discussion of these terms refer to an earlier ANZCCART facts sheet (O'Brien and Holmes, 1993). Techniques for barrier rearing and maintaining these animals were described by Wagner and Manning (1975).

Nutrition

A well-formulated commercial pelleted guinea pig ration is the basis of a laboratory guinea pig diet. The National Academy of Sciences (1987) has published the nutrient requirements of guinea pigs. Australian commercially-produced guinea pig diets are subjected to nutrient analysis and results are published annually by the Nutrition Sub-committee of the Australian Society for Laboratory Animal Science in the ASLAS Newsletter.

The guinea pig is a herbivore, with a dietary requirement for ascorbic acid due to lack of the enzyme L-gulonolactone oxidase (Harkness and Wagner, 1989). The daily ascorbic acid requirement (5 mg/kg body weight for maintenance; 30 mg/kg during pregnancy) (Harkness and Wagner, 1989), can be supplied in the pelleted ration (800 mg/kg finished ration), or supplemented in the drinking water (1 g/litre), prepared fresh daily (Sutherland and Festing, 1987). If pelleted rations are to be autoclaved or irradiated, then higher

levels would need to be added, unless some of the newer heat-stable forms of ascorbic acid are used by the manufacturer. Feed containing ascorbic acid should be stored dry, cool and be used within three months of manufacture. Fresh fruit and vegetables can be used as vitamin C supplements and as a water source, but this practice is often not recommended for infection control reasons (Sutherland and Festing, 1987), unless the vegetables are first soaked in a bleach solution to remove potential pathogens.

Guinea pigs have a high dietary fibre requirement; approximately (35%; Smith, 1990), which is best met by supplying them with good quality lucerne hay. Hay can be autoclaved if this is considered necessary for infection control reasons.

Tap water is usually used, but will need to be autoclaved, filtered or chlorinated for barrier-maintained animals.

Reproduction

Guinea pigs are most commonly bred in a polygamous (harem) system. In this system one male is housed with four to 20 females (Sutherland and Festing, 1987). The size of the group is determined by a combination of production requirements and the facilities which are available. More than one male is usually placed with the larger groups of females in order to ensure that all oestrous females are covered. The males are changed at frequent intervals (every three or four months), and the pen of females has an economic breeding life of about two years. Productivity of the group is monitored rather than the individual animal.

Inbred strains of guinea pigs are produced using monogamous pairs. This necessitates a more labour intensive and costly breeding system. The record keeping required is more involved.

The oestrous cycle has an average length of 16 days (Müller-Haye, 1981; Smallwood, 1992). In the female, the vaginal opening is closed by a membrane except during oestrous, parturition, and days 20 to 25 of gestation (Smallwood, 1992). Oestrous is characterised by behavioural changes such as the lordosis posture of the female in the presence of the male (Sutherland and Festing, 1987), rupture of the vaginal membrane and mucus secretion. During oestrous, which usually occurs in the evening (Smallwood, 1992) and lasts six to eleven hours, the female is receptive to the male. Ovulation occurs spontaneously, approximately 10 hours after the onset of oestrous. Typically, two to four ova are released (Sutherland and Festing, 1987), however litters of up to eight have been recorded (Müller-Haye, 1981).

If mating occurs, the sperm transit time (vagina to oviduct) is 15 minutes. A copulatory plug forms in the vagina within minutes of mating, and is retained for one to two days (Smallwood, 1992). The gestation period is relatively long, being 68 days on average. Pregnancy can be detected by palpation of foetuses at four to five weeks. The weight of the female can double during gestation. Just prior to parturition, the pubic symphysis separates to a gap of 15 mm (Sutherland and Festing, 1987). On average, three young are born (Smallwood, 1992). Data

on litter size and perinatal mortality and neonatal growth rate are provided by Wright (1960). Approximately 8.5% young are stillborn, and the preweaning mortality of liveborn is 9.6%. The sow usually consumes the placenta and membranes. Cannibalism may occur, especially where there are stillbirths. Postpartum oestrous occurs at six to eight hours (Sutherland and Festing, 1987).

The new born is precocious, being fully developed, with body length up to 310 mm, hair coat, teeth erupted, and eyes open (Smallwood, 1992). Live birth weight ranges from 75-100 g. The neonate can eat solid food almost immediately and can be weaned within a few days. However, they are more successfully reared if weaning is delayed until 14-21 days or 180 g body weight (Sutherland and Festing, 1987). Milk production by the sow peaks at about seven days post partum, and declines by about four weeks (Southwood, 1992). The sow will often accept suckling by young other than her own, especially in the case of group housing (Sutherland and Festing, 1987).

Female offspring attain puberty and may come into oestrous at less than four weeks of age, and so should be weaned at 180 g or three weeks (Sutherland and Festing, 1987). Males reach puberty at 68-70 days. Mating should be delayed until the female weighs 400g (two to three months) and the male weighs 650 g (three to four months) (Harkness and Wagner, 1989).

Anaesthesia

Guinea pigs are considered to be difficult anaesthetic subjects, especially where surgical anaesthesia is required. They are very variable in their response to injectable agents; due partly to the variable gut content and its effect on body weight measurement. The dose rates for injectable agents below should be taken as a guide only. It is recommended that a pilot anaesthetic trial be used to determine dose response of the animals prior to the pain study. Volatile (gaseous) anaesthetics can be irritant to the respiratory tract and cause increased bronchial secretions, bronchospasm, initial breath-holding, then overdose from subsequent deep-breathing (Harkness and Wagner, 1989). When surgical anaesthesia is required, it is important to prevent hypothermia developing during and subsequent to the procedures. A heating pad or insulation such as aluminium foil or towelling should be used between the animal and the surgical table during the procedure and the recovery period (Sutherland and Festing, 1987). Any irrigation fluids used should be warmed to approximately 37°C using a water bath. Clipping of hair and application of skin disinfectants should be minimised.

Injectable agents are available, which can be administered intramuscularly or subcutaneously, or by intraperitoneal injection. Access to veins for purposes of blood sampling or intravenous injection (including injection of anaesthetics) is difficult in the guinea pig. Techniques have been described by Flecknell, 1987; Reuter, 1987; Sutherland and Festing, 1987 and Carraway and Gray, 1989.

The injectable drug mixture of xylazine and ketamine can be used for anaesthesia or sedation. Xylazine

(5 mg/kg) can be combined with ketamine (20-40 mg/kg) and injected intramuscularly as a pre-anaesthetic for subsequent methoxyflurane or halothane anaesthesia. The lower dose rates of ketamine produce sedative effects, whilst at higher dose rates light anaesthesia is produced. Recovery occurs in 5 to 30 minutes (Harkness and Wagner, 1989). To obtain surgical anaesthesia using the injectable mixture alone, xylazine (4 mg/kg) and ketamine (60 mg/kg) can be administered subcutaneously to give 15 to 30 minutes surgical anaesthesia (Harkness, 1990c). Sodium pentobarbital prepared as a 1% solution is another injectable anaesthetic which can be used. Intraperitoneal injection of the solution at the dose rate of 28-35 mg/kg body weight provides 30 to 100 minutes of surgical anaesthesia (Harkness and Wagner, 1989). Pentobarbital (20 mg/kg) combined with diazepam (8mg/kg) and injected intraperitoneally, produces surgical anaesthesia in 13 minutes (Harkness and Wagner, 1989).

Volatile anaesthetics are used most safely with an anaesthetic machine, in conjunction with a scavenger system. This requires the use of a different vapourizer for each particular type of volatile anaesthetic and as the anaesthetic is relatively expensive, this makes gaseous anaesthesia a relatively costly procedure. Induction can be performed using an anaesthetic chamber or a human paediatric face mask. For long procedures, anaesthetic gases can be administered using a face mask. Endotracheal intubation is difficult in this species (method described by Blouin and Cormier, 1987).

Methoxyflurane is considered to be the volatile anaesthetic of choice for guinea pigs. Where a closed or semi-closed anaesthetic machine is used, 1% methoxyflurane in oxygen is used for induction and 0.3% for maintenance. Induction and recovery occur very slowly (about 20 and 10 minutes respectively) (Harkness and Wagner, 1987). Halothane is a higher risk volatile anaesthetic: it is irritant, a cardiac and respiratory depressant, hepatotoxic and markedly hypotensive. The induction concentration of halothane is 5% (oxygen flow rate 1.5 l/min) and maintenance is 2 to 3% (Harkness and Wagner, 1987; Franz and Dixon, 1988). A closely related chemical, isoflurane, which is not flammable can be used as an alternative. Ether is no longer recommended to be used due to a combination of its irritant effects on the respiratory tract, and the safety hazard (highly flammable) to the operator (Sutherland and Festing, 1987).

For other anaesthetic preparations, a reference such as Flecknell (1987) should be consulted. Harkness and Wagner (1989) provide an extensive list of guinea pig anaesthesia references (pp 79-80). Brown *et al.* (1989) reported a comparison of injectable anaesthetic regimes, regarding their effects on physiological parameters such as mean arterial blood pressure, blood gases, heart rate and respiration in the guinea pig.

Euthanasia

The two most commonly recommended techniques are intraperitoneal injection of an overdose of sodium pentobarbital (90 mg/kg body weight) or inhaled carbon dioxide gas.

Euthanasia by carbon dioxide (CO₂) gas inhalation is commonly used where larger numbers of animals are required to be killed, or where tissue samples free of chemical residues are required to be collected after death. The procedure must be performed in a well-ventilated area. Using a plastic tube, CO₂ gas is supplied from a cylinder into a large plastic bag inside a plastic bin or box. Animals are then placed in the bag (do not overcrowd) and the bag is then loosely sealed. The tube is used to supply further CO₂ into the bag, (close to 100% CO₂ is required), and to flush out the air. The tube is then removed and the bag sealed. Once the animals become unconscious, they can be removed for exsanguination or left for 20 minutes to ensure death.

A comprehensive and critical summary of euthanasia methods can be found in Harris (1993).

Health monitoring

Good animal husbandry, combined with knowledge and understanding of the biology and behaviour of the guinea pig, are the keys to prevention of most animal health problems. Well-designed housing which is easy to maintain and caters for the comfort and well-being of the animal is essential. Animal care staff must be adequately trained, observant, and follow good animal husbandry principles. The day-to-day observations of the animal care staff are the first and most important part of a health monitoring program. Familiarity of the animal carer with the normal appearance and behaviour of healthy animals is essential; any deviation should be investigated promptly, since it may be the earliest sign that a problem exists. Hand-in-hand with good observation is good record-keeping. Production data can indicate changes in colony health status which might otherwise pass undetected.

Apart from investigation of any abnormality or change in the behaviour or health of the colony, production colonies should be tested for the presence of subclinical disease. Disease monitoring should involve routine submission of ex-breeders (or other adult animals) for autopsy, histopathology, parasitology, bacterial culture and virus serology. Details of sample size decision-making have already been discussed in some detail in a previous ANZCCART facts sheet (O'Brien and Holmes, 1993).

Disease agents

Ectoparasites such as lice and dermatophytes (ringworm) are a relatively common finding in conventional colonies. Although lice are usually controlled by grooming and rarely cause problems, ringworm fungal spores can infect other species including humans (zoonosis). With good husbandry practices, infectious diseases are relatively uncommon in a guinea pig colony. Guinea pigs are herbivores, and the relatively large caecum is notable. The normal gut flora consists of gram-positive and gram-negative micro organisms; administration of antibiotics can result in death or imbalance of the normal flora, with resultant severe disease and death of the guinea pig. Antibiotics can be safely used in guinea pigs as long as

care is taken to use a broad spectrum antibiotic, and not one which selectively kills only gram-positive bacteria. Penicillin kills guinea pigs.

Tables 2 and 3 summarise features of the most commonly encountered infectious diseases. Virus infections of guinea pigs do occur and can be detected by serological tests, although they rarely cause disease problems (Harkness and Wagner (1989), Harkness (1990b,c)).

Non-infectious diseases

Non-infectious diseases are relatively common in guinea pig colonies. They include:

Behavioural problems, such as fighting between males, barbering (hair chewing) and cannibalism of neonates. Avoidance of overcrowding, reducing group sizes, minimization of animal stress, and environmental enrichment can reduce the occurrence of these problems (Harkness and Wagner, 1989).

Dystocia and metabolic toxemias of pregnancy (ketosis), are commonly encountered in breeding sows, and are often associated with high numbers of stillbirths, neonatal mortality and death of the sow. Dystocia is more common if the female is first bred either too young (<350 g), too old (> 6 months) or if there foetopelvic disproportion due to excessive foetal size or obesity in the sow. Incidence of the problem can be reduced by breeding females at the correct age and by avoiding development of obesity in sows (Harkness and Wagner, 1989). Metabolic toxemia of pregnancy is commonly encountered in the last two weeks of gestation and the first week postpartum. It arises from a complexity of contributory factors including low energy/food intake in late pregnancy, obesity, inadequate

bloodflow to the uterus and placenta, foetal overload, endocrine imbalances and nonspecific environmental stressors. Death occurs suddenly or after a period of one to five days depression, dyspnoea or abortion. This disease can be minimised by supplying adequate fresh food and water and avoidance of stress and fasting in late pregnancy (Harkness and Wagner, 1989).

Hypovitaminosis C (scurbutus, scurvy) which can be present as a complicating and predisposing factor in other disease conditions. Ascorbic acid is involved in metabolism of cholesterol, amino acids and carbohydrates. It is also involved in formation of hydroxyproline and hydroxylysine, and therefore deficiency results in fragmentation of collagen and intercellular ground substance (Harkness and Wagner, 1989). The higher requirement for vitamin C in growing, pregnant and lactating animals makes them more susceptible to this disease. Clinically manifestations include rough hair coat, diarrhoea, lethargy, anorexia, weight loss, ocular and nasal discharges, enlarged painful long bone joints and costochondral junctions. On post-mortem, gut and tissue haemorrhages and bone deformities can be seen (Harkness and Wagner, 1989).

Weight loss can result from a number of causes, and is not necessarily due to the presence of infectious disease. Some of these causes include: malocclusion of cheek teeth; vitamin C deficiency; inadequate energy intake (due to lack of appetite, lack of access to food or water, neophobia due to change in food presentation, or late pregnancy restriction of intake); lactation (often hair loss is concurrent); chronic renal disease and urolithiasis (Harkness and Wagner, 1989).

Table 2 Parasitic infections of guinea pigs (Harkness 1990a, Harkness and Wagner, 1989)

Parasite	Clinical Signs	Diagnosis and Control
Lice: Gliricola sp., Gyropus sp.	Heavy infestations result in pruritis, alopecia, dermatitis.	Identify parasite (visible with naked eye) Predominantly head and neck affected. Ivermectin treatment 200-400 µg/kg injected s/c, with repeat at day 10; or bath in 1% lindane solution weekly for 3 weeks. Decontaminate environment.
Mites Trixacarus caviae (sarcoptid mite)	Severe pruritis, dermatitis (thick, scaly, crusty), matted hair, severe alopecia on head and neck, ears, back, outside legs.	Skin scraping. Histology: mites embedded in epidermal folds, tunnels and hair follicles. Principally on trunk. Ivermectin treatment 200-400 µg/kg injected S/C, with repeat at day 10; or bath in 1% lindane solution weekly for 3 weeks. Decontaminate environment.
Chirodiscoides caviae (fur mite)	Inapparent infection, pruritis, alopecia, dermatitis.	Skin scraping. Ivermectin treatment 200-400 µg/kg injected S/C, with repeat at day 10; or dust weekly with permethrin or carbaryl powder. Decontaminate environment.
Protozoa Cryptosporidium (human health hazard :zoonosis)	Inapparent infection -> lethargy, rough hair coat, failure to thrive, enteritis, watery diarrhoea, death.	Oocysts in faeces. Post-mortem: enteritis of caecum and small intestine. Organisms seen in gut mucosa epithelium. No effective specific treatment; treat dehydration, prevent transmission, decontaminate environment.
Eimeria caviae (intestinal coccidiosis)	Inapparent infection -> lethargy, rough hair coat, failure to thrive, enteritis, watery diarrhoea, death Does not commonly cause severe disease.	Oocysts in faeces. Post-mortem-enteritis of caecum and small intestine. Organisms seen in gut mucosa epithelium. Secondary bacterial enteritis. Sulphaquinoxaline 0.025% to 0.1% in water for 4-8 wks; or sulphamethazine 0.2% in water on alternate days. Treat dehydration, prevent transmission, decontaminate environment.

Table 3 Bacterial, rickettsial and fungal diseases of guinea pigs (Harkness, 1990b; Harkness and Wagner, 1989)

Infectious Agent	Clinical Signs	Diagnosis and Control
Fungi: (ringworm) (human health hazard: zoonosis) <i>Trichophyton mentagrophytes</i> <i>Microsporum sp.</i>	Inapparent infection common. Hair loss, dermatitis, crusts on back and face.	Skin scrapings:microscopic examination for fungal elements, spores. Culture on dermatophyte test medium. Histological sections stained with PAS. Ultraviolet fluorescence (some strains <i>M. canis</i>).Treat with topical ketoconazole cream (daily for 2-4 weeks);or griseofulvin (20 mg/kg food)for 25 days. Minimise stress.
Bacteria: <i>Streptococcus zooepidemicus</i>	Acute epizootics: septicaemia, abortions reproductive failure, pneumonia, death -> chronic: ocular and nasal discharges, nasal discharges, pneumonia, middleear infections, cervical and other lymph node abscesses. Inapparent infection	Clinical findings- cervical lymph node abscesses, head tilt. Culture abscesses, lungs. Surgical drainage of abscesses; Chloramphenicol palmitate 50 mg/kg orally, for 5-7 days.
<i>Streptococcus pneumoniae</i>	->carriers, upperrespiratory tract infections, ocular and nasal and inner ear infections, anorexia, weight loss, loss, head tilt, death. Variable morbidity and mortality.	Smear and culture exudate Oxytetracycline 0.1 mg/ml in water for 7 d, controls epizootic but no cure for carriers; use broad spectrum antibiotic such as chloramphenicol
<i>Bordatella bronchiseptica</i>	Inapparent infection ->carriers, ocular and nasal and middle ear infections, head tilt, pneumonia, anorexia, weight loss, abortion, stillbirth, death. High morbidity and mortality.	Culture organism from middle ear, lower respiratory tract. Chloramphenicol 50 mg/kg 6-hourly; or Sulphamethazine, 4 ml of 12.5% stock solution per 500ml water for 1-2 wks to suppress; or Tribriksen (trimethoprim/sulphadiazine) injections. Killed or attenuated bacterins help eliminate carrier state. Minimise stress; avoid contact with rabbits (subclinical carriers).
Other bacteria involved in respiratory disease: <i>Klebsiella pneumoniae</i> <i>Pasteurella multocida</i> <i>Pseudomonas aeruginosa</i> <i>Staphylococcus aureus</i> <i>Staphylococcus aureus</i>	A range of respiratory signs may be seen: nasal and ocular discharges, dyspnoea,pneumonia -> death. Chronic dermatitis, abscesses, especially feet.	Microbiological culture and sensitivity of exudates, post-mortem tissues. Antibiotic treatment. Minimise stress. Clinical signs. Prevention of foot abrasions and wounds essential since treatment by surgical drainage of abscesses is less successful. Antibiotic treatment treatment treatment be based on bacterial culture and sensitivity data.
<i>Salmonella typhimurium</i> (human health hazard)	Inapparent infection, carriers -> visceral abscesses especially liver and spleen, conjunctivitis, anorexia, abortion, death. Weaners and pregnant sows, most susceptible.	Microbiological culture of post-mortem tissues. Destock and decontaminate. Avoid use of green feed which may be contaminated.
<i>Clostridium difficile</i>	Use of penicillin or other antibiotics which selectively remove gram +ve gutbacteria. Animals drink less water, show lethargy,Animals \ Enteritis, death in 1-5 days.,	Post-mortem find fluid-filled, haemorrhagic cecum. Avoid use of antibiotics which selectively remove gram positive gut bacteria; although this organism is penicillin-sensitive.
Other bacteria involved in enteric disease: <i>Escherichia coli</i> <i>Salmonella sp.</i> <i>Yersinia pseudotuberculosis</i> <i>Bacillus piliformis</i> <i>Clostridium sp.</i> <i>Campylobacter sp.</i>	Inapparent infection -> acute to chronic diarrhoea, dehydration, weight loss, death.Carrier states. Weaners most commonly affected. Epizootics often associated with high mortality.	Post-mortem findings, fluid-filled, haemorrhagic gut. Other findings such as abscesses variable. Culture and sensitivity of organisms. Investigate causes/predisposing factors: poor sanitation, husbandry; prior use of antibiotics; contaminated food, bedding, water; introduction of new animals; stressors; dietary imbalance e.g. low fibre diet. Use of antibiotic treatments in disease is controversial:seek veterinary advice. enteric Supportive treatment such as fluids. Consider destocking destocking and decontamination depending on causati ve organism.
Rickettsia: <i>Chlamydia psittaci</i> (human health significance)	Inapparent infection -> conjunctivitis, ocular discharge; chronic genital infection. May be endemic in the colony.Mainly young animals 2-8 wks old are affected.	Conjunctival scrapings; intracytoplasmic inclusions stain with Giemsa. Immunofluorescence of scrapings. Infection often self-resolves by 28 days age. Chloramphenicol eye ointment for eye lesions.

Salivation/slobbering may be due to malocclusion of cheek teeth, vitamin C deficiency, heat stress or fluorosis (Harkness and Wagner, 1989).

Infertility/decreased breeding performance can result from high ambient temperatures, use of wire floors in breeding pens, presence of exogenous oestrogens or nutrient deficiencies in the diet or impaction of bedding materials in male genitalia (Harkness and Wagner, 1989).

Neoplasia is uncommon in guinea pigs less than 3 years of age. Older animals (> 3 years) show an increasing incidence of neoplasms (up to 30% of the population). The most common neoplasms are bronchogenic papillary adenoma (35%) and skin tumors (15%). The balance is composed of reproductive tract, mammary gland and haematopoietic tumors (Harkness and Wagner, 1989). At least one tumor is known to be induced by an RNA virus: acute, spontaneous lymphocytic leukaemia. This is a lymphoblastic leukaemia which is usually fatal within five days onset (Harkness and Wagner, 1989).

Rare genetic abnormalities such as corneal anomaly, dwarfism, congenital palsy, polydactyly, sexual hypogenesis, and abnormal tremor and waltzing behaviours have been described (Robinson, 1975).

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