The Domestic Cat

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Sandra Mccune
ANIMAL MATTERS

31 The domestic cat

Sandra McCune

Biological overview

General biology

The domestic cat *Felis silvestris catus* used in laboratories is the same species that is commonly kept as a companion animal and which exists in substantial numbers in a feral state. Cats are intelligent, highly specialised mammals that have evolved a range of morphological adaptations and sensory abilities to suit their exclusively carnivorous lifestyle (reviewed by Bradshaw 1992). A cat's perception of the world is therefore different from ours. Hunting by sight at night means they see in lower light intensities than we can and are particularly sensitive to rapid movement. They are not, however, able to see in fine detail or to discriminate clearly between shades of colour (Bradshaw 1992). They also hunt by sound and are very sensitive to the ultrasonic frequencies that rodents use to communicate. Their sensitive sense of smell helps them to locate prey although, in the final stages of a kill, touch is the dominant sense. Smell is also used to select food while a second olfactory system (the vomeronasal organ) is used in social communication. Sebaceous glands are located throughout the body, especially on the head and the peri-anal area, and between the digits. Scratching, which deposits scent from the interdigital glands, is a marking behaviour which leaves visual and olfactory signals, and helps to maintain the claws in good shape (Rochlitz 2005). The deposition of urine and faeces, and rubbing of the body against objects, may also be used in olfactory signalling. Allo-rubbing, where cats rub their face and body against each other and intertwine their tails, serves to exchange scent profiles between cats.

Standard biological data are listed in Table 31.1.

Size range and lifespan

Average domestic cats weigh between 2 and 5 kg. Males are significantly heavier than females. There are breed differences; American Ragdolls or Maine Coons can be three times heavier than the average, whilst the small Singapura weighs a mere 2–3 kg. Well cared for domestic cats can, on average, expect to live for about 12 years and many cats live into their twenties.

Social organisation of free-ranging cats

Cats can adapt to a wide range of population densities. Feral cat populations range from densities of 1–2000/km^2 (Izawa *et al*. 1982; Izawa 1984; Kerby & Macdonald 1988). The social system feral cats adopt depends upon the distribution and availability of resources. The home ranges of breeding males are usually much larger than those of females. The sizes of their home ranges are determined by both food supply and social considerations (including availability of breeding females, whether females are solitary or social and the degree of competition for females). Male home ranges encompass the territories of several breeding females. The home ranges of females are determined by the needs for shelter and food both for themselves and for any dependent young. Where cats have to support themselves solely by hunting, they are often solitary as their prey is unlikely to be sufficiently abundant to sustain a social group. If food is more common but patchily distributed, then the home ranges of cats may overlap though they would rarely hunt in the same area at the same time.

Social groups exist where food is locally concentrated; usually as a result of human activities (Kerby & Macdonald 1988). These groups are basically matrilineal, consisting of females, usually related, and their offspring (including immature males). The size of the groups is very variable and seems to be determined largely by food availability, mortality amongst kittens from a range of infectious diseases and extermination by humans. Females are tolerant of other members in the group but defend their communal core area (containing their den and major source of food) aggressively against intruders. Their aggression intensifies if there are young kittens in the group. This exclusion of outsiders makes it difficult for females to move between groups. Males tend to disperse away from their mother's home range when they are 2 or 3 years old. Initially they avoid contact with all other cats but as they mature and get stronger they will challenge other males for access to females. Mature males are only loosely associated with any group but in areas where most females are group-living, a particular male may concentrate his mating efforts within a single group. Further information on cat behaviour can be found in Thorne (1992); Beaver (2003) and in the American

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Table 31.1 Standard biological data for the cat (after Hurni & Rossbach 1987).

Parameter	*Value*
Age of replacement of deciduous dentition (months)	3.5–6
Life expectancy (years)	9–14 (over 20 has been recorded)
Body weight:	
Female (non-breeding) (kg)	3–4
Male (kg)	3–7
Birth (g)	110 ± 20
Respiration rate (/min)	16–40
Volume (ml)	12–15 (0.3–0.4l/min)
Arterial blood pressure (mmHg)	120/75
pH	7.35
Blood volume:	
Total (ml/kg body weight)	75
Maximum single sample (ml/kg body weight)	7
Pulse rate (/min)	150–200 (range 120–220)
Body temperature (°C)	38–39.5
Dental formulae:	
Deciduous	$2\ (I^3_3 C^1_1 Pm^3_2) = 26$
Permanent	$2\ (I^3_3 C^1_1 Pm^3_2 M^1_1) = 30$
Oestrous cycle (days)	14 (anovular)
Gestation (days)	65.5 ± 1.7
Litter size	3–6 (range 1–10)
Lactation (weeks)	7
Weaning (weeks)	4–7

Association of Feline Practitioners Feline Behaviour Guidelines[1].

Reproduction

Under optimum conditions, females become sexually mature at around 9 months (range 4–18 months). Males (toms) are sexually mature by 8 months though some may be fertile earlier. Cats are normally seasonal breeders in temperate climates. Toms are most sexually active in spring though they can sire kittens at any time of the year. Females will breed all year round if they are kept indoors with no exposure to sunlight and with a 12:12 hour light–dark regime. Most oestrous cycles last between 18 and 24 days. Oestrus lasts about 4 days if mating occurs but otherwise between 5 and 10 days. Cats are induced ovulators (although see Lawler *et al.* 1991), with foreplay and coitus stimulating ovulation. Sterile copulation may result in pseudopregnancy which lasts about 36 days. Successful pregnancies last about 63 days (range 58–72 days). Females are capable of coming into oestrus 3–4 weeks after a litter is weaned.

The average litter size is 4 (typical range 3–10), with 104 males born to every 100 females. Maximum litter size is usually reached by the third litter. Females are optimally fertile between the ages of 1 and 8; subsequently their oestrous cycles may become irregular and litters are fewer and smaller. Although sperm quality declines with age, males can remain fertile into their twenties.

Breeds, strains and genetics

A recent genetic assessment of 979 domestic cats and their wild progenitors – *Felis silvestris silvestris* (European wildcat), *F. s. lybica* (Near Eastern/north African wildcat), *F. s. ornata* (central Asian wildcat), *F. s. cafra* (southern African wildcat) and *F. s. bieti* (Chinese desert cat) – indicates that each wild group represents a distinctive subspecies of *Felis silvestris* (Driscoll *et al.* 2007). As *F. s. lybica* and domestic cats fall into the same genetic clade (a group of species with the same ancestor), it is likely that the *lybica* subspecies gave rise to the genetic lineage that eventually produced all domesticated cats. Cats were domesticated in the Fertile Crescent of the Near East and north Africa, probably coincident with the development of agricultural villages where cats fed on the rodents that infested the grain stores of the first farmers. The first evidence of cat remains buried together with human remains was found in Cyprus, and determined to be 9500 years old (Vigne *et al.* 2004). The earliest evidence for domestication comes from Egypt in the third millennium BC (Linseele *et al.* 2007)

Cats have not been subject to intensive selective breeding programmes with most breeds originating in single gene mutations or a few combinations. The concept of cat breeds dates from the nineteenth century. Breeds are classified into British (European or American) and Foreign on the basis of head shape, body conformation and coat quality. British types are stocky with a heavier coat. Foreign types are slender and smooth coated. Breeds are also classified by hair length; Short-hairs and Long-hairs. The difference is due to a single gene, the allele for long coat being recessive. A more recent hair mutation has resulted in three new breeds; the Cornish Rex, the Devon Rex and the American Wire-hair. Colour varieties are caused by less than a dozen mutations. Most seem to affect only pigmentation but that producing blue-eyed white cats is linked with timidity, deafness, elevated mortality and poor mothering ability. Breeders are now producing breeds in several colours; blurring the distinction between breeds and varieties (a full account of breeds and varieties is provided by Vella *et al.* 1999).

Sources of supply

It is good practice, and a legal requirement in some countries (eg, in the European Union), for cats to be bred and obtained from approved establishments. Many laboratories use specific pathogen free (SPF) cats which will need to come from recognised SPF sources. These cats should be free from viral and chlamydial upper respiratory disease, FeLV (feline leukaemia virus), FIV (feline immunodeficiency virus), coronavirus and both ectoparasites and endoparasites. Cats should be quarantined for at least 3 weeks before joining the colony. Cats from random sources would need a 6 week quarantine

[1] http://www.aafponline.org/resources/guidelines/Feline_Behavior_Guidelines.pdf

as their disease status would be unknown. They might also have behavioural and handling problems.

Management and breeding

General husbandry

Husbandry systems should use best health care practices, which emphasise good welfare and meet the animals' behavioural needs. Systems should provide safe, comfortable, animal-friendly conditions, environmental choice for the animal, sensory stimulation, physical and mental exercise and should minimise disease. Detailed recommendations for cat housing exist (eg, Home Office 1989; European Commission 2007) and provide guidelines on the design, construction and security of animal facilities; and on the environmental conditions within the facility, encompassing guidelines for temperature, relative humidity, ventilation and lighting). There are examples of innovative design incorporating elements intended to meet cats' behavioural needs (Loveridge 1994; Loveridge *et al.* 1995).

Housing

Cats can be kept outdoors or indoors. Considerations of environmental control, costs and disease transmission mean most colonies are kept in closed indoor accommodation. Housing needs to be easy to clean and maintain, and compatible with the requirements of laboratory studies. Using several individual buildings reduces the potential for disease to spread throughout a colony (Hawthorne *et al.* 1995).

Group housing

Groupings should take account of density recommendations. In the UK for group-housed cats, recommended minimum floor area per cat is 3300 cm^2 for cats weighing up to 3 kg and 5000 cm^2 for cats weighing over 3 kg (Home Office 1989). This rises to 5000 cm^2 and 7500 cm^2 respectively when cats are housed singly. The revised guidelines of the European Convention for the Protection of Vertebrate Animals used for Experimental and Other Scientific Purposes (ETS 123), Appendix A (Council of Europe 2006), and the revised Annex II to the European Directive 86/609 (European Commission 2007) require a minimum floor area of 1.5 m^2 and shelving of 0.5 m^2, with another 0.75 m^2 of floor space and 0.25 m^2 of shelf space for every additional cat; and that the cage should be 2 m high.

A critical minimum cage size has not been established for cats. Some cats will show behaviour problems when confined in cages with the dimensions given above. Indeed, some free-ranging cats will show behaviour problems. However, cats with restricted access to outdoors are more commonly presented with behaviour problems than free-ranging cats so it appears that space is limiting to some individuals even in relatively enriched home settings. The response of the individual to confinement varies widely and is based on many factors. The most important of these is likely to be quality of the confined space and the cat's previous experience. Investing in the quality of the space rather than the quantity may often result in a better outcome for the cat.

The cat, having originated from a largely solitary-living species, has not developed the complex visual signalling that is typical of species that have had a long evolutionary history of social living, such as the domestic dog. As a result, lacking or having limited signals for avoiding conflict such as appeasement (Casey 2007b), and post-conflict mechanisms such as reconciliation (van den Bos 1998), they do not form distinct dominance hierarchies. Usually, cats will avoid physical confrontation by using behaviours to maintain distance, such as olfactory marking, posturing and vocalisation. Alternatively, they may try to evade threats from other cats by hiding or fleeing to elevated locations. If housing conditions in the laboratory do not provide for these responses, cats may end up in aggressive encounters with each other.

The maintenance of groups is influenced by factors that include familiarity, stability, socialisation to other cats and availability of resources. Sibling pairs of cats have more amicable relationships than unrelated cats living together (Bradshaw & Hall 1999), and close social bonds may also develop between unrelated kittens that are raised together. Attention to the socialisation of cats with other cats at a young age will make them more tolerant of others in adulthood. Optimal socialisation to humans occurs if kittens are handled between the second and seventh week of life (Karsh & Turner 1988), and it is generally accepted that the period of socialisation of kittens to other cats also occurs during this time (Rochlitz 2005).

Housing cats at high densities increases the likelihood of their being stressed. While housing in groups provides opportunities for complex social interactions and so increases mental and physical stimulation (Figure 31.1), group composition should be kept fairly constant to avoid disrupting established group dynamics. Social cohesion is maintained through behaviours such as allo-rubbing, which involves tactile communication and the mixing and exchange of scent, such that all individuals in the group have a shared scent profile. The frequent addition of new cats into a group disrupts relationships and introduces new olfactory profiles that interfere with social cohesion.

When cats are housed in groups, attention should be paid to the availability of resources (food, toileting sites, resting and hiding areas). Resources should be distributed in a number of places to prevent certain animals from monopolising one area, and to enable them to avoid conflict with others when accessing these resources. Cats which fail to adapt to a particular social group, for example those which avoid contact with all other group members, should be rehoused, either with a smaller group or singly.

Individual housing

Sometimes cats need to be housed individually. For instance; post-/pre-parturition females; mature males; sick, injured or quarantined individuals; or as a necessary part of a specific research programme. The most specialised or extreme form of single housing is probably the metabolism cage which is used, for example, to facilitate the reliable collection and assessment of faeces. These cages are usually made of metal

Figure 31.1 Enriched housing provides opportunities for play, social contact and privacy.

(often stainless steel) with mesh floors. They can be stressful to the cats confined in them in many ways. The accommodation may be unfamiliar to the animal if it is normally group-housed. The cages are usually small and so lack space for normal movement. They provide only a barren environment; devoid of comfort and facilities providing physical and mental stimulation. The enforced social isolation may also cause stress to cats that are used to social contact with others. These cages should be made as appealing as possible with the addition of resting boards with covers, toys and visual observation of other cats and should be used for as short a time as possible.

In response to the need to improve upon such cages, Loveridge and co-workers (1995) developed a system of two-roomed lodges which provide individually housed cats with an enriched environment, freedom of choice, mental and physical stimulation and conditions as similar as possible to those in the main colony (Figure 31.2). Extensive use of glass throughout the building allows the individually housed animals to be visually stimulated by those on either side, by human and cat activity within the colony, and by activity in the grounds outside the colony building. Individually housed cats should have access to a larger exercise area space and be given some personal attention every day (Figure 31.3). Even more recently, an organisation has developed a mechanical litter tray system that allows urine and faeces to be collected from specific cats housed in their normal group housing. Users should explore the possibilities of these techniques before resorting to metabolism cages.

Environmental provisions

An important objective of good housing is to improve welfare by giving the animal a degree of control over its environment and the opportunity to make choices (Broom & Johnson 1993). Good laboratory housing for cats should include a range of shelving at different heights, and a choice of resting and hiding places. Timid cats and those less well integrated into the social group will occupy the higher shelves (Rochlitz *et al.* 1995), particularly those in corners as they provide the best vantage points and protect the cat from being approached from behind. Cats spend a large portion of their day either resting or sleeping, so it is important that there are plenty of rest areas with comfortable surfaces.

Figure 31.2 Lodges for singly housed cats (in the background) can be built around central areas of activity to provide visual stimulation.

Hiding is a coping behaviour that cats often show in response to stimuli or changes in their environment (Rochlitz 2005). It is commonly seen when cats want to avoid interactions with other cats or people, and in response to other potentially stressful situations. A recent study investigated the effect of hiding enrichment on stress and behaviour of kennelled cats (Kry & Casey 2007). The hiding enrichment

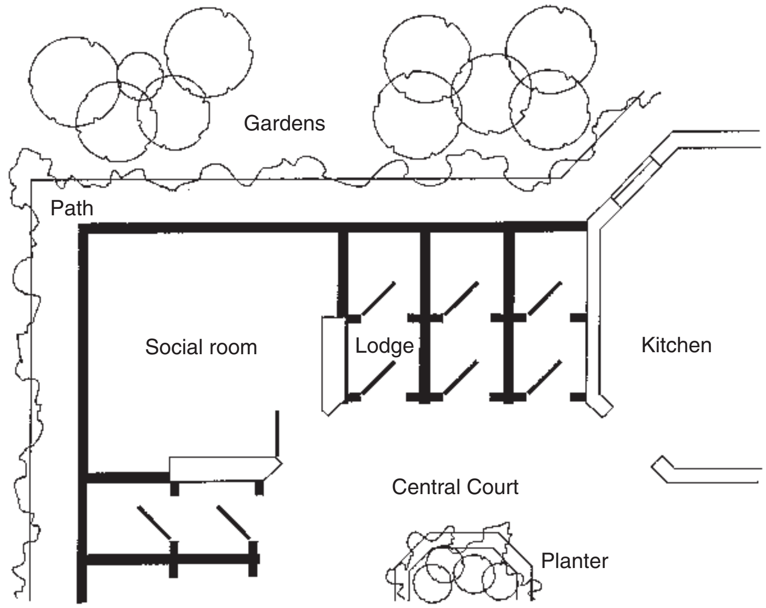

Figure 31.3 Section through a facility providing single and group housing for cats (from Loveridge *et al.* 1995). Reproduced with kind permission of Waltham Centre for Pet Nutrition.

consisted of a cardboard box (Hide, Perch and Go® box, British Columbia SPCA), whilst control animals were provided with an open bed. A significant reduction in stress was noted in the enriched group: these cats were more likely to approach humans and displayed relaxed behaviours much more frequently.

Visual barriers can be useful, to enable cats to get out of sight of others and also to break up the three-dimensional space into sections or compartments, making it more complex and giving the cat more choice about where it wants to be (Rochlitz 2005). Housing should incorporate features to provide opportunities for stimulation, and for environmental and social choice. For example: provision of internal windows to enable cats to watch other cats and human activity; internal arrangement of pens incorporating different levels to increase usable space and give opportunities for climbing, for example by imaginative use of shelving, climbing poles and ropes; semi-hidden spaces to explore or to withdraw from the group, for example, plastic hollow cubes, large children's toys etc which can be moved from group to group; experience of the natural environment either by direct access (which may not be possible in a minimal disease system) or through glass.

Olfactory enrichment is relatively underused in animal housing, perhaps because of the relatively poor sense of smell of humans compared with many other species. Surfaces for the deposition of olfactory and visual signals and for claw abrasion, such as scratch posts, rush matting, pieces of carpet and wood, should be provided.

Presentation of food and water

Fresh water should always be available and, ideally, replenished constantly from a chlorinated mains supply. Some cats prefer to drink from a water fountain. Food should be kept fresh. Removing food for a period each day seems to renew the cats' interest.

Identification and sexing

In small colonies cats can be identified by their markings and other characteristics. Microchip implants provide a secure, safe and permanent method of identifying individuals. Insertion of the microchips is less painful than tattooing. Collars can be used but their fit needs to be checked regularly and they are unsuitable for very young kittens. Cats can be sexed at birth from the ano-genital distance (about 6 mm in females and 13 mm in males).

Physical environment and hygiene

The physical environment should be monitored, and ambient temperature and humidity adjusted for comfort (15–24 °C and 55% ± 10% relative humidity are recommended by the UK Home Office (1989)). Rather than having a homogeneous environment, creating a range of microenvironments is preferable as this provides a cat with some choice, for example: heated beds; sun-warmed ledges; and shaded lying areas. Even in single metabolism cages, a single shelf at least provides some choice of location for the individual. Good ventilation is important to dilute and remove air-borne pathogens and to disperse heat produced by animals and equipment. Cats need protection from extremes of heat and housing will need extractor fans, blinds or solar-absorbing glass and reflective film.

The combination of good design and an effective cleaning regimen will minimise disease transmission. All rooms and litter trays, 'furniture' and other surfaces within, need daily cleaning with detergent and disinfectant. Cleaning materials need to be chosen carefully as cats are particularly sensitive to phenolic compounds. Aerosolisation of phenolics can result in corneal lesions if the cats remain in the room during cleaning. Chlorhexidine appears to be a safe and effective disinfectant for cat rooms (suggestions in Hawthorne *et al.* 1995). Bedding should be disposable or washable. Only small quantities of food should be stored within the buildings to avoid attracting vermin and this should be kept in vermin-proof containers. Every care should be taken to avoid any wild, stray or pet animals entering the animal facility. Particular care needs to be taken with drains and other services that penetrate the fabric of the building and so allow a potential route into the animal rooms.

Health monitoring, quarantine and barrier systems

Cats should be handled frequently and checked daily; handling and restraint techniques were reviewed by Wills, J. (1993). Every week they should have a specific health check (ears, eyes, nose, genitalia and general body condition), be groomed and weighed (Figure 31.4). Twice a year they should have a dental examination and a haematology and biochemistry screen. Colonies should be screened for viruses, bacteria and parasites. Viral screening should occur on an epidemiological basis. Assuming a low incidence of disease a large number of cats may need to be screened to find a problem. Any unexpected death should be thoroughly investigated.

The probability of cats contracting an infectious disease depends on a number of factors, including: age; genetic predisposition; nutritional status; levels of stress; concurrent illness; level of infectious disease challenge and virulence of the infectious organism.

Separate facilities should be provided for the isolation of suspected infected cats and for those in quarantine. Isolation facilities should be completely self-contained and, ideally, in a separate building from the main colony. Disease transmission can be limited further by housing all cats according to their susceptibility. Preferably each susceptibility group should be handled by different personnel, otherwise the sequence in which they are handled should be on a susceptibility basis from most to least susceptible, eg: early-weaned kittens; queens with kittens; older cats; quarantine cats; and finally sick cats. Further details are given by Hawthorne *et al.* (1995).

Transport

Cats are not good travellers. Travel causes stress in many individuals and therefore should be kept to a minimum (McCune 1994). Journeys of over 10 h duration appear to be especially stressful (Bradshaw & Holloran 2005). Preferably cats should be accompanied to ensure their safety and welfare. If cats are to travel unaccompanied, across borders, or by air, sea or rail then special regulations will probably apply. Each country and carrier will have its own regulations regarding animal transport. Cats appreciate being able to look out of their carrier. SPF cats will need to be protected from infection during transit. Cats travelling by air will require containers approved by the *International Air Transport Association* (*IATA*) who revise their regulations annually (see also Chapter 13 and Laboratory Animal Science Association (LASA) 2005).

Breeding

For general advice see Wills, M.B. (1993).

Condition of adults

Cats are sexually mature at 8–9 months of age. Cats that begin to cycle and are not bred are likely to develop uterine pathology that decreases reproductive performance. Therefore, if the colony has reproduction as a goal, queens should be placed into a harem in their first year. At the Waltham Centre for Pet Nutrition queens are retired at 8 years and toms are retired at 10 years, but other breeders may continue to use their breeding animals for longer than this if they remain in good health.

Figure 31.4 Regular health checks and grooming are essential to ensure the well-being of individuals.

Identifying the fertile state

Anoestrous females will respond aggressively to any sexual approach by a male. Females in pro-oestrus show subtle changes in their behaviour; they tend to be rather restless and rub up against objects. They allow males to approach but prolonged contact is not tolerated. Over the next 24 h the females rub their head and flank against objects with increasing intensity, they roll on the floor, stretch, purr and rhythmically open and close their paws, flexing their claws. At this stage they will tolerate grooming by the male but not mounting. Full sexual receptivity is indicated by females adopting the lordosis position; the female crouches with her head close to the ground, her hindlegs treading and partly extended, and her tail laterally displaced to expose the perineum (UK Cat Behaviour Working Group 1995).

Mating systems

In the harem or group mating system, ideally one male cat is kept in a group of females. The dominant male will usually mate with more than 80% of the females. A potential difficulty with this system is that the exact date of mating is not known and pregnancy is determined by the female gaining weight (Figure 31.5). The female should be moved to kittening accommodation 10–14 days before birth is due to allow her to habituate to the new surroundings.

A second, but perhaps less welfare friendly, system is to house females together in groups and to accommodate the males in individual housing. When signs of oestrus are observed, the female is taken to the chosen male and mated a number of times. Males need to be replaced regularly to avoid inbreeding. The advantage of this system is that parentage and date of mating are known. The disadvantage for the singly housed males is they have relatively little social contact with other cats.

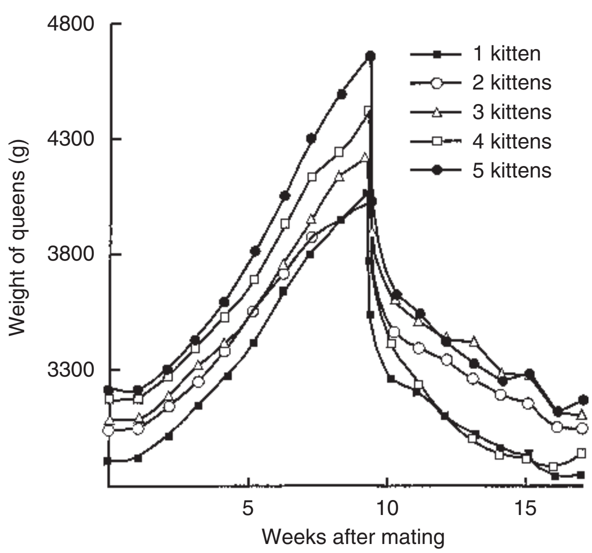

Figure 31.5 Weight changes during gestation and lactation in queens with different litter sizes (group size = 15) (from Loveridge & Rivers 1989). Reproduced with kind permission of Waltham Centre for Pet Nutrition.

Conception and pregnancy

Ovulation is triggered by mating, possibly from the stimulation of the tom withdrawing his barbed penis. After copulation both cats wash their urinogenital area, the female continues to roll for about 30 minutes before they mate again. Multiple copulations are normally required to trigger ovulation. Females may mate many times and with different males. Pregnancy can be reliably diagnosed by palpation at 21–28 days, by ultrasound after 21 days and by radiography after 40–45 days. Pregnancy can be assessed by monitoring weight gain, and weight gain also gives some indication of the size of the litter (Loveridge 1986).

Nesting

Cats do not usually build nests but make use of whatever protective shelter is available; they will usually make use of boxes, newspaper, cardboard or other forms of bedding if provided. They like to choose where to give birth, and may visit suitable sites several times before coming to a decision. Some cats prefer dark, quiet places; a box provided in the breeding area will generally be used. Occasionally cats will transfer their kittens to a new nest site.

Parturition

Group-housed pregnant cats are moved to separate accommodation about 10 days before parturition to protect the newborn kittens from attack. Feral queens living in social groups do use communal dens and collaborate to nurse each other's offspring; in large groups it tends to be mothers and daughters co-operating but in small groups all adult females may nurse each other's offspring, (Bradshaw 1992). Confined females have been known to kill newborn kittens. Infanticide by tomcats has also been recorded.

Before giving birth the queen cleans herself thoroughly, particularly her ventrum around the nipples, and her anogenital area. Parturition is usually uneventful. The kittens are born at 2–30-minute intervals. After the birth the queen removes the amniotic sac from around the kitten, severs the umbilical cord, eats the placenta and licks the kitten clean which stimulates its breathing. After delivery of the last kitten, the queen then encircles her litter and encourages them to suckle by nuzzling and licking them. Kittens find the nipple and suckle spontaneously using innate reflexes. Suckling must be established promptly as neonatal kittens cannot withstand even short periods without food and need to acquire maternal antibodies from the milk. The mother will remain in contact with the kittens for at least the first 24 h. For the first month the queen spends about 70% of her time in the nest caring for her kittens; initiating feeding bouts, grooming, and stimulating their perineal area to encourage urination and defecation (this must be done until they are about 7 weeks old).

Development of the young

Sensory development

Sensory systems are not fully operational in the newborn kitten. They are born blind, virtually deaf and completely dependent. They have a fully developed sense of touch, and can detect and respond to temperature gradients. Olfaction is fully developed by 3 weeks and hearing by 4 weeks. Kittens' eyes open at about 6 days. They can follow visual cues by 3–4 weeks. Thereafter their visual acuity improves and is fully developed by about 16 weeks. Internal control of body temperature is not fully developed until 7 weeks.

Physical development

Motor skills develop in parallel with sensory abilities. Newborn kittens can only move by wriggling against a substrate but by the third week they can stand, though their balance is poor, and by 5 weeks they are attempting complex movements. Motor control is fully developed by 11 weeks. Predatory behaviour is observed in cats with no experience of prey but they require experience to become efficient hunters. Feral kittens learn by interacting with prey brought to the nest by their mothers. Pet kittens learn by interacting with toys, litter mates and their mothers.

Kittens' milk teeth begin to appear about 14 days after birth. Initially they are not very interested in solid food but by week 5 are consuming substantial quantities. Kittens can be weaned at 8 weeks. Sensory and physical development are reviewed in Robinson (1992a).

Behavioural development

In the first 2 weeks, kittens mainly sleep and eat. The sensitive period for socialisation to people lies between the end of the second and seventh weeks. This is the period when contact with people has the greatest influence on a kitten's development of friendliness to people. Kittens should be given plenty of opportunity to socialise with other cats and humans, to play and experience colony routines. Older kittens should continue to be given a wide range of experiences as this will help them to accept novel events as adults. Cats that are handled from birth show more rapid physical development and, as adults, are more responsive to humans and to novel events (McCune 1992). Their friendliness to people is affected by the quality and quantity of handling they receive (reviewed in McCune *et al.* 1995) but is also dependent on their parent's temperament (McCune 1995a). Kittens from confident fathers are more confident themselves and cope better when faced with unfamiliar situations such as being handled by strangers or being caged (McCune 1992). Consequently, it is important to consider temperament when selecting individuals for a breeding programme.

Weaning and rearing

The queen begins weaning by spending more time away from her kittens and by adopting postures which make her nipples inaccessible. Weaning can be encouraged by providing shelving to which queens can retreat and by removing queens for increasingly longer periods. The kittens are encouraged to eat solid food from approximately 3 weeks of age, which helps to reduce their dependence on mothers' milk. Weaning is usually complete at 8 weeks of age.

In breeding colonies, weaned kittens are usually housed separately from their mothers. Housing kittens aged 8–18 weeks together widens their social experience and increases their sociability to other cats. Young toms can be allowed supervised socialisation with groups of kittens. This provides stimulation and activity for the tom and teaches kittens how to interact with adults. Older kittens are usually grouped with others of a similar age.

Selection of breeding stock

Cats used for breeding should be free from detectable abnormalities, have a good temperament, and be fastidiously clean. Breeding females should be good mothers and have produced good-sized litters with an even sex ratio and good-sized offspring. Immunodeficiencies may occur in inbred lines.

Special systems – barrier colonies

A successful barrier colony can be established using simple and straightforward procedures (Loveridge 1984). The colony is set up using SPF cats and accommodated away from existing non-SPF catteries. Access is limited, and personnel shower and dress in a separate set of clean clothing before entering and only handle the barrier colony cats. Goods and equipment are disinfected by immersion in a tank containing aldehyde-based disinfectant, delicate items are wiped with disinfectant.

Feeding

Cats are solitary hunters and tend to take prey that is considerably smaller than themselves. Although their natural feeding behaviour is to eat small meals through the 24 h day, cats are opportunistic feeders and will adjust their patterns of activity to suit the frequency with which food becomes available. Adult cats at maintenance can adapt to being fed once or twice a day but growing kittens and lactating queens require more frequent feeds. Confined cats are generally given food *ad libitum* and eat small quantities at frequent intervals. Cats are highly selective feeders and require their food to be highly palatable and fresh. Odour and texture play an important part in diet selection by cats. Careful observation is required to establish individual preferences and the correct level of feeding. Most cats seem to be able to monitor, and therefore adjust, their own calorie intake to match their energy requirements quite accurately. Good nutrition during pregnancy and lactation will give kittens the best start in life.

Natural and prepared diets

Cats are obligate carnivores: they must eat meat products. Free-living cats eat most parts of their prey (small vertebrates and insects) including skin, bones and viscera. Most confined cats are fed solely on commercially prepared canned or complete dry cat foods. These diets have been designed to supply all the key nutrients and energy needed and have been tested for digestibility and palatability. Many come in a range of types and flavours since cats are known to appreciate variety in their diet (Bradshaw 1992). Canned food is a heat-sterilised moist food and, as such, is a safe product with a very long storage life and so requires no special storage conditions. Good-quality complete dry food made specifically for cats can also be used as the sole source of nutrition. Dry food can be kept for many months providing it is stored in dry cool conditions. Offering some dry food maintains oral hygiene in cats. Its natural abrasive action helps to prevent build-up of plaque and reduces gum disease. Another advantage is that it can be left out longer than canned food, which allows the cats to adopt a more natural feeding pattern of many small meals throughout both the day and night. However, in general, most cats find dry foods less palatable than moist foods like meat or canned foods.

Diets can be made directly from raw ingredients. The National Research Council (NRC) (2006) gives dietary guidelines for cats, both minimum requirements and maximum tolerable levels, and lists the composition of a wide range of ingredients from which diets can be formulated to meet the cat's nutritional requirements. Further information can be found in Burger (1993) and Markwell (1994).

Water

The requirement for fresh clean water is at least as important as that for other nutrients. The water content of the diet affects the amount of water cats drink.

Dietary requirements

Dietary requirements are listed in Tables 31.2 and 31.3. These will change with life stage as does the way in which the food should be presented.

The NRC (2006) estimate energy requirements in normal adult cats using an exponential equation of $100\,BW^{0.67}$ kcal per day (BW = bodyweight in kg), which is based on data from lean cats using indirect calorimetry (Nguyen *et al.* 2001). For overweight cats the suggested equation is $130\,BW^{0.4}$ kcal per day (Table 31.2).

Pregnant and lactating queens

Pregnant and lactating queens should be fed *ad libitum* on a balanced diet (Figure 31.6). Specially formulated diets are available and supplements should be avoided as they can result in nutritional imbalances (reviewed by Legrand-Defretin & Munday 1993). The NRC (2006) recommends the equation for energy requirements for gestation to be $ME = 140\,BW^{0.67}$ kcal/day (Table 31.2).

Cats increase their food intake from the first day of pregnancy and, on average, gain about 39% of their pre-mating weight during pregnancy (reviewed in Loveridge & Rivers 1989). Weight gain varies with the size of the litter (according to the equation: weight gain (g) = 888.9 + 106.5 N, where N is the number of kittens in the litter) (Loveridge & Rivers 1989). Some of the weight queens accumulate is lost at parturition, the rest acts as an energy reserve for lactation (Loveridge 1986). In the first 4 weeks of lactation queens expend more energy than they can take in. They continue to

Table 31.2 Energy requirements of growing cats (from the NRC Guidelines 2006).

Lifestage	*Energy measurement*	*Notes*
Adult maintenance		
Normal	100 kcal/kg $BW^{0.67}$/day	
Overweight/low activity	130 kcal/kg $BW^{0.4}$/day	
Pregnancy	ME $140\,BW^{0.67}$ kcal/day	
Lactation		
<3 kittens	ME kcal = maintenance + 18 × BW x L	L = stage of lactation from week 1 to week 7 where *Week 1* = 0.9 *Week 2* = 0.9 *Week 3* = 1.2 *Week 4* = 1.2 *Week 5* = 1.1 *Week 6* = 1.0 *Week 7* = 0.8
3–4 kittens	ME kcal = maintenance + 60 × BW × L	As above
>4 kittens	MEkcal = maintenance + 70 × BW × L	As above
Growth[+]	$100 \times BW_a^{0.67} \times 6.7 \times (e^{(-0.189p)} - 0.66)$	where *p* = BWa/BWm *BWa* = actual body weight (kg) *BWm* = expected mature bodyweight *E* = base of natural log ~2.718

[+] The age at which a cat's energy requirement settles to the adult level is around 40 weeks, although actual bodily development may continue to 12 months – especially for a large male cat.

Table 31.3 Nutrient requirements of cats (From the NRC Guidelines 2006). Nutrient requirements/1000 kcal.

Nutrient	*Units*	*Cat requirement*
Protein	g	50.00
Arginine	g	1.93
Histidine	g	0.65
Isoleucine	g	1.08
Leucine	g	2.55
Lysine	g	0.85
Methionine and cystine	g	0.85
Phenylaline and tyrosine	g	3.83
Threonine	g	1.30
Tryptophan	g	0.33
Valine	g	1.28
Taurine	g	0.10
Fat	g	22.50
Linoleic acid		1.40
Arachidonic acid		0.015
Minerals		
Calcium	g	0.72
Phosphorus	g	0.64
Potassium	g	1.30
Sodium	mg	170.00
Chloride	mg	240.00
Magnesium	mg	100.00
Iron	mg	20.00
Zinc	mg	18.50
Copper	mg	1.20
Manganese	mg	1.20
Iodine	µg	350.00
Selenium	µg	75.00
Vitamins		
Vitamin A (retinol)	µg	250.00
Vitamin D (cholecalciferol)	µg	1.75
Vitamin E (α-tocopherol)	mg	10.00
Vitamin K (phylloquinone)	mg	0.25
Thiamin	mg	1.40
Riboflavin	mg	1.00
Pantothenic acid	mg	1.44
Niacin	mg	10.00
Pyridoxine	mg	0.625
Folic acid	µg	188.00
Vitamin B_{12}	µg	5.60
Choline	mg	637.00
Biotin	µg	18.75

need extra energy whilst they suckle and rebuild body reserves. The amount of energy required depends on the number and age of the kittens. The NRC (2006) recommendation for ME in lactating cats is based on the maintenance requirement increased by a factor determined by the number of kittens in the litter and the stage of lactation (Table 31.2).

Growing kittens

Nutrition is one of the major determinants of kittens' growth rate, along with freedom from disease, good husbandry, maternal weight and the kitten's sex (Loveridge 1987). During a kitten's first few weeks it is entirely dependent on its mother's milk to achieve the desired growth rate of nearly 100 g a week. If the queen's milk is insufficient, or kittens are being hand reared, specially manufactured milk replacers should be given at frequent intervals. Milk replacers mimic the composition of queen's milk, are highly digestible and may include a probiotic to help establish a healthy gut flora. NRC (2006) recommends a factorial equation to estimate the energy requirements for kittens (Table 31.2).

Although deciduous teeth appear about 14 days after birth, very young kittens are not very interested in solid food. From about 3–4 weeks, they become increasingly interested in the solid food that their mother is eating. By week 6, kittens are eating for 50 minutes a day (Robinson 1992a) and should be given finely chopped or moistened food. Commercial food specifically formulated for kittens is available; it has a higher concentration of energy and some nutrients than food formulated for adult cats. The amount of food kittens can ingest at one meal is limited and, ideally, they should be fed *ad libitum*. Weaned kittens do not need milk and become less able to digest lactose as their gut matures. At 6 months of age most kittens have gained 75% of their final adult weight and can be given food formulated for adult cats.

Older cats

Most colony cats are retired when they are around 8 years old. If studies require geriatric cats some changes in feeding regimens may be required. Geriatric cats require small but regular feeds of a high-energy, highly palatable and digestible diet (feeding frequently rather than *ad libitum* allows food intake to be monitored). Recent research has shown that their ability to digest fat, protein and energy declines with

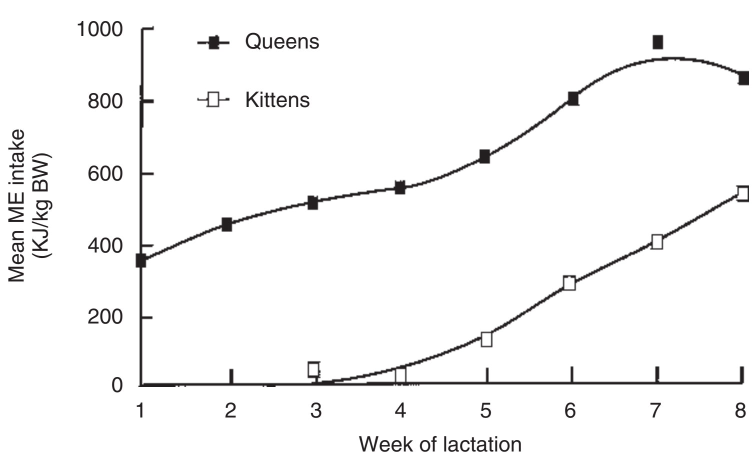

Figure 31.6 Energy intakes of queens and kittens during lactation (mean of three kittens/litter).

age (Taylor *et al.* 1995), whilst energy requirements remain constant. It may be necessary to offer finely chopped or moistened food if they have poor dentition. It is particularly important that elderly cats have easy access to a supply of fresh clean drinking water. They are inclined to become dehydrated because they are less sensitive to thirst and are less efficient thermoregulators (Markham & Hodgkins 1989).

Laboratory procedures

Handling and training

Cats that have been handled and well socialised as kittens are much easier to handle and train as adults. Good handling techniques help cats feel comfortable and secure. Grown cats can be picked up with one hand under the chest, just behind the front paws, and the other under the hindquarters (Wills, J. 1993). Once picked up, the cat will probably be most comfortable sitting in the crook of the handler's arm, with its forepaws either leaning against the handler's shoulder or held in the handler's other hand. Most of the cat's weight should be taken on the handler's arms. Young kittens should be picked up with one hand under the chest and the other under the hindlegs. A young kitten will be small enough to sit on a palm as long as the handler supports its head with the other hand.

Manual restraint

The usual method of restraining a calm cat is to sit the cat on a surface and hold its front legs. The jaw can be gently but firmly held in the other hand to control its head. Alternatively, it can be wrapped securely in a blanket (reviewed by Wills, J. 1993). Further restraint may be necessary for agitated or nervous cats, for example the use of an extending collar on a rod or crush cages. Sedation is the preferred method of restraint for any cat with a history of being fractious. In the case of blood parameters, it greatly diminishes the effect of stimulating the fight or flight response on blood values.

A handling technique called 'clipnosis' or 'clipthesia' has been described (Pozza *et al.* 2008), which is used to immobilise cats for nail clipping, blood sampling and other minor procedures. The application of spring paper clips or clothes pegs that gently grasp the skin along the dorsal midline of the neck and cranial thorax renders the cat immobile. Although the technique's effectiveness varies between individuals, it appears to be useful for providing gentle restraint in most cats (Pozza *et al.* 2008). Based on their behavioural responses, the application of the clips does not appear to be aversive to most cats.

Training

Kittens will learn from their mother to use a litter tray. Hand-reared kittens need to be trained to use one by putting them on the tray frequently, particularly when they look ready to urinate or defecate. Consideration should be given to exposing kittens to minor procedures that will be part of the routine in the future (eg, use of clippers and being gently restrained on an examination table).

Physiological monitoring

To maximise welfare and data reliability, monitoring methods should be as non-invasive as possible. Procedures are easier with two experienced handlers; one restrains the cat while the other performs the procedure. The more relaxed the handlers and the cat are, the easier and less distressing the procedure.

Recording body temperatures

Most cats can simply be held while their rectal temperature is taken. Cats that do object will need to be restrained.

Collection of specimens

Blood

Samples of 1–2 ml are most easily obtained from the front leg: from the antebrachial cephalic vein. For smaller samples, blood can be collected directly by letting it drop out through the needle into the collection vessel rather than being drawn out by syringe. Larger samples are easier to obtain from the jugular veins. See Joint Working Group on Refinement (JWGR) (1993) for general guidance, and limits to blood volume that can be acceptably withdrawn.

Urine

Many of the methods used to collect urine (cystocentesis, catherisation, manual transabdominal expression) are invasive and may be traumatic, particularly when testing is repeated or long-term. They also interfere with the cat's normal urination pattern (as can keeping cats on mesh floors through which urine drains). Most cats can be trained to urinate in a clean tray: cats accustomed to urinating and defecating in a litter tray can be trained to use decreasing amounts of litter until the tray is empty. The outlet of the tray can be connected to a collection vessel outside the pen, enabling urine to be collected separately from faeces. Markwell and Smith (1993) describe a non-invasive collection system whereby urine can be continuously monitored (Figure 31.7).

Milk

Milk can be manually expressed with some difficulty from lactating queens by gentle massaging of the teats after the administration of 5 IU of oxytocin (im) to stimulate milk flow (Keen *et al.* 1982).

Administration of medicines

General advice on the administration of substances can be found in JWGR (2001). Most cats will detect drugs mixed in their food and will refuse to eat.

Dosing and injection procedures

Oral dosing is best carried out with two handlers, one restrains the cat while the other gives the medicine. To give

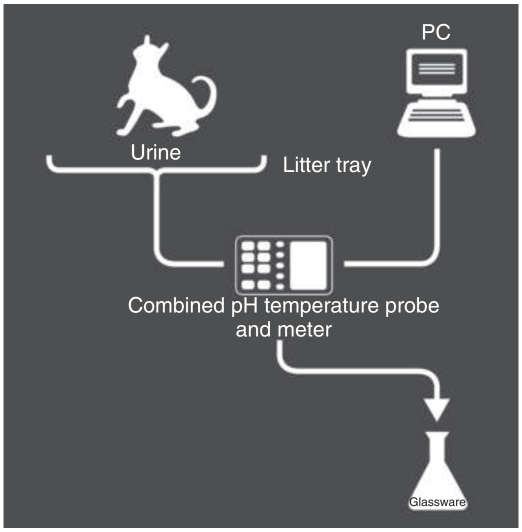

Figure 31.7 Non-invasive collection system for urine (after Markwell & Smith 1993). Reproduced with kind permission of Waltham Centre for Pet Nutrition.

a tablet grasp the cat's head from above, at the points where the jaws meet, with forefinger and thumb, tip the head back and press in with thumb and finger. Push on the lower jaw with the index finger of the other hand to open the animal's mouth and drop the tablet far back on the middle of the tongue. Push it quickly and gently so it moves over the back of the tongue. Close the mouth and gently stroke the throat to encourage swallowing. Large tablets have to be broken into smaller pieces. When giving liquid medicines let the liquid run down the tongue drop by drop, allowing the cat to swallow after every two to three drops or it may choke.

Cats need to be restrained for the application of eye and ear drops. To give ear drops hold the cat's head to one side and put the drops in, externally massaging the ear canal helps the drops to penetrate. Apply eye drops to the inner corner of the eye and keep the head back for a while to allow the drops to cover the eye's surface.

Injections are given when the cat is restrained. Subcutaneous injections are usually given into the scruff of the neck, intramuscular injections into the muscle (quadriceps) overlying the femur of the hindleg or, for small volumes, into the paralumbar (epaxial) muscles. Absorption can be accelerated by gentle massage. Cats which require routine subcutaneous injections (eg, diabetics) can be trained to accept injection without restraint by associating the procedure with a highly palatable food treat.

Anaesthesia and analgesia

General advice can be found in Hall and Taylor (1994) and Flecknell (2009).

Pre-anaesthesia

Preparation
Prior to administering an anaesthetic, food should be withheld for 12 h (there is no need to withhold water). This will reduce the risk of vomiting during induction or during the recovery period.

Cats object to aggressive restraint, particularly if they are not sedated. It is always better to give them the benefit of the doubt by first handling them with the minimum restraint. If stronger restraint is required, then premedication and anaesthesia may be used.

Premedication
Agents and dosages are given in Table 31.4. Premedication with a sedative is advisable, even in placid cats, as it reduces struggling during induction. A less stressful induction has several advantages: a reduced dose of induction agent and maintenance agent is required; recovery is smoother; and analgesia is more effective.

Pain

Pain can be difficult to recognise in cats, as their behavioural responses may not be as overt as in other species such as the dog. Behaviours indicating pain can be subtle and easily overlooked, and there may be individual variation. Several studies have examined the behavioural indicators of post-operative pain; these indicators include the inhibition or loss of normal behaviour (such as decreased grooming or failure to eat), the expression of abnormal behaviours (such as altered posture or aggression) (Waran *et al.* 2007) and increased reaction or sensitivity to touch (Taylor & Robertson 2004). Chronic long-term pain, such as that caused by degenerative joint disease, is likely to have a more significant impact on the welfare of cats than is currently recognised. Typical signs of chronic pain include reduced activity, hiding, decreased interest and decreased response to surroundings; there may be inappetance leading to weight loss. Proper assessment of pain in cats will require the development and validation of behaviour-based, multidimensional pain measurement tools. These are available for dogs (Holton *et al.* 2001) but are in their infancy for cats. Guidelines on pain management in cats have recently been published (Hellyer *et al.* 2007).

Analgesia

Safe and effective methods of analgesia are now available. Pain should be prevented whenever possible. Pain can be managed more effectively if analgesia is given before the pain occurs. It is particularly important to consider any requirements for analgesia in sedated cats as they may be unable to demonstrate in any observable way the true level of pain they are experiencing. If a procedure or a disease is known to cause pain in other species, or it seems probable that it might be painful, then analgesia should be given. Analgesics should not be given 'as needed', rather they should be administered on a fixed schedule which can be re-evaluated and changed as necessary. There should be a scale of assessment that all workers can use.

There are two approaches to analgesia:

1. Non-pharmaceutical (see Post anaesthesia section);
2. Pharmaceutical:
    - Opioids – morphine, oxymorphone, buprenorphine, fentanyl;

Table 31.4 Sedatives, tranquillisers, analgesics, pre-anaesthetic and anaesthetic medication for use in cats (derived from BSAVA Small Animal Formulary 2005, National Office of Animal Health 2006, Flecknell 1996). See also Flecknell (2009). Data sheets should be consulted for the various drugs, combinations with other drugs and their dosages and route of administration.

Drug	*Dosage*	*Route*	*Comments*
Atropine sulphate	0.03–0.05 mg/kg	sc	
Acepromazine	0.03–0.125 mg/kg	sc, im	
Diazepam	0.1–0.3 mg/kg	iv	
	0.2–0.4 mg/kg	im	
Opioids			
Buprenorphine	0.01–0.02 mg/kg	sc, im. or sublingually	Lasts 6–8 h
Morphine	0.1–0.2 mg/kg	sc, im	Lasts 6–8 h
Oxymorphone	0.02–0.1 mg/kg	im, sc	Lasts 2–6 h
Fentanyl: skin patch	0.025 mg/h patch for cats weighing 3–5 kg; in smaller cats only half the protective liner should be removed	Applied to clipped and shaved chest wall, and covered with a light dressing	Replace every 2–3 days
Non-steroidal anti-inflammatory drugs (NSAIDs)			
Carprofen	4 mg/kg	sc or iv	Lasts 24 h, given as a single dose; one single further dose at 2 mg/kg may be given
Meloxicam	0.3 mg/kg	sc	Lasts 24 h, given as a single dose
	0.05 mg/kg	Orally	Once daily, following initial 0.1 mg/kg loading dose orally
Ketoprofen	2 mg/kg	iv, im, sc	Every 24 h for up to 3 days
	2 mg/kg	iv, im, sc	Given once, followed by 1 mg/kg orally every 24 h for 4 further days
	1 mg/kg	orally	Every 24 h for up to 5 days
Local anaesthetics			
Bupivacaine 0.5%	Up to 1 mg/kg	Perineural	Duration 2–6 h
Lidocaine 2%	Up to 4 mg/kg	Perineural	Duration 1–2 h
Sedatives and anaesthetics			
Ketamine	1–2 mg/kg	im	Analgesia
	11 mg/kg	im	Minor restraint (in lower doses and with fewer side effects if combined with other drugs)
	22–33 mg/kg	im	Minor surgery (in lower doses and with fewer side effects if combined with other drugs)
	2.2–4.4 mg/kg	iv	
Ketamine	5–10 mg/kg	im	Sedation
Midazolam	0.2 mg/kg		
Ketamine	100 mg/kg	im	Anaesthesia; xylazine and atropine are administered first, followed by ketamine 20 minutes later
Xylazine	1.1 mg/kg		
Atropine	0.03 mg/kg		
Ketamine	5–20 mg/kg	im	Sedation or anaesthesia depending on dose
Medetomidine	40–100 µg/kg		
Ketamine	5 mg/kg	im	Anaesthesia
Medetomidine	80 µg/kg		
Butorphanol	0.4 mg/kg		

- Local anaesthesia – lidocaine, bupivacaine;
- NSAIDs (non-steroidal anti-inflammatory drugs) – carprofen; meloxicam, ketoprofen.

Prolonged, effective analgesia is best achieved by using a combination of these drugs with non-pharmaceutical techniques. The effect of opioid analgesia can be optimised by sedatives.

Anaesthesia

For procedures lasting 20 minutes or less, or for minor surgery (eg, suturing small skin wounds), cats are often given intravenous general anaesthetics or heavy sedation with analgesia (xylazine, medetomidine or ketamine). For longer procedures or major surgery, general anaesthesia is usually induced with intravenous agents and then maintained with a gaseous anaesthetic. The preferred route for intravenous administration is into the cephalic vein in the foreleg (using a 0.6 mm or 0.5 mm (24–25 G), 16 mm needle). If this is not possible, the injection can be made into the medial vein of the hindleg or jugular veins.

For intubation, a selection of endotracheal tubes, from 3.0–5.5 mm, should be available. Cats have a very sensitive laryngeal reflex. To prevent laryngeal spasm, the larynx is sprayed with 2% lidocaine and the endotracheal tube is lubricated with lidocaine gel. The formulation of some local anaesthetic sprays can cause laryngeal oedema in cats, and the spray should be checked before use to ensure it is safe for use in cats. A semi-rigid wire in the lumen of the endotracheal tube can facilitate tracheal intubation. The end of the tube should not pass further than the point of the shoulder.

Intravenous agents and dosages
Agents used routinely for intravenous induction of anaesthesia are: 2.5% thiopental (10 mg/kg iv) or propofol, 10 mg/ml emulsion (6 mg/kg iv for a premedicated cat).

Gaseous agents
Gaseous agents include isoflurane, sevoflurane and halothane. Isoflurane is considered to have several benefits over halothane. Sevoflurane is relatively new to the veterinary market, but appears to have benefits over halothane and to be similar to isoflurane (Hammond 2007).

Muscle relaxants
With modern anaesthetics, muscle relaxants are not usually necessary. Their use is not recommended unless the anaesthetist is very experienced with feline anaesthetics.

Anaesthetic protocol – best practice
A best practice protocol for routine surgery would be: acepromazine; buprenorphine; carprofen or meloxicam; intravenous propofol; isoflurane; and with application of local anaesthetic into the wound.

Post anaesthesia
A variety of non-pharmaceutical techniques can be used to create the optimum conditions in the cat's external and internal environments. Cats should be allowed to recover from anaesthesia in a quiet warm room. They should be nursed on soft bedding and kept clean and comfortable. A semi-enclosed box or high-sided soft bed where the cat can feel secure and still be monitored can be useful. Cats that are used to contact with humans can be given plenty of reassuring verbal and physical contact. Frightening noise and smells should be excluded from the recovery area. Any painful tissues should be immobilised using splints or bandages. The cat should be carefully monitored throughout the post-anaesthesia recovery period, as it is during this time that complications are most likely to occur.

Euthanasia

Euthanasia should be performed in a dignified manner, minimising any mental or physical suffering to the cat, (see also Chapter 17). The method of choice is injection of an anaesthetic agent sufficient to cause rapid unconsciousness and a certain death. A common method is to give a high overdose (about 200 mg/kg) of pentobarbital by intravenous injection. This results in an immediate loss of consciousness, rapidly followed by deep narcosis and respiratory and cardiac arrest. The cat dies within a few seconds apparently without pain or distress. If a cat is difficult to handle, it may need to be sedated before being euthanased.

Common welfare problems

Disease

This section summarises the diseases that most commonly threaten laboratory cats. More detailed reviews are provided by Chandler *et al.* (2007) and Sherding (2008). See also King and Boag (2007).

Prophylaxis

Cats are susceptible to a number of viral, bacterial and parasitic diseases. Colony cats should be vaccinated from the age of 9–12 weeks against feline viral rhinotracheitis, feline calicivirus and feline infectious enteritis. It is important to use a killed vaccine in an SPF-derived cat to minimise the risk of experiencing full-blown disease. Closed colonies are unlikely to be exposed to the feline leukaemia virus. Cats entering the colony should be treated to eliminate all parasites; in a closed colony reinfestation is unlikely.

Signs of diseases

A cat's behaviour and appearance reflect its state of health. A healthy cat will have an alert bearing and move easily and confidently about its accommodation. It will be interested in its surroundings and its food, and groom frequently. It will have clean ears, eyes, mouth and skin. Animals that show any deviations from these signs should be observed and examined carefully to investigate the cause. Any cat exhibiting watery lacrimation, purulent discharges from eyes, nose, or ears, excessive salivation, vomiting or diarrhoea should be isolated immediately.

Viral diseases

Feline immunodeficiency virus (FIV)
FIV is a lentivirus that shares many characteristics of other lentiviruses, such as human immunodeficiency virus. FIV is transmitted primarily by parenteral inoculation of virus present in saliva or blood, via bite and fight wounds. This accounts for the higher prevalence of the virus in adult male cats. Occasional transmission of virus *in utero* and post parturition via the milk may occur.

FIV infection progresses through several stages: an acute phase; a clinically asymptomatic phase of variable duration; and a terminal phase of infection often referred to as feline acquired immunodeficiency syndrome (Sellon & Hartmann 2006). The hallmark of FIV pathogenesis is progressive disruption of normal immune function. During the last stages of infection, clinical signs are often a reflection of opportunistic infections, neoplasia, myelosuppression and neurological disease. However, with proper care some FIV-infected cats can live for many years with a good quality of life, and may die in old age from causes unrelated to FIV infection.

Diagnosis of FIV infection is made most commonly by detection of FIV-specific antibodies in blood by either enzyme-linked immunosorbent assay (ELISA) or rapid immunomigration-type assays (Sellon & Hartmann 2006). An FIV vaccine is available commercially (Fel-O-Vax®, Fort Dodge); because the vaccine contains whole virus, cats respond to vaccination by producing antibodies that are indistinguishable from those produced during natural infection.

Feline leukaemia virus (FeLV)

The prevalence and importance of FeLV as a pathogen in cats are decreasing, primarily because of testing and eradication programmes and the routine use of FeLV vaccines. FeLV, a retrovirus and member of the Oncornavirus subfamily, causes clinical illness related to the haemopoeitic and immune systems and neoplasia. The three most important FeLV subgroups are FeLV-A, FeLV-B and FeLV-C; only FeLV-A is contagious and passed horizontally from cat to cat in nature. Subgroups FeLV-B and FeLV-C evolve *de novo* in an FeLV-A-infected cat by mutation and recombination between FeLV-A and cellular or endogenous retroviral sequences contained in normal feline DNA (Hartmann 2006).

FeLV spreads between susceptible cats primarily via saliva, where virus concentration is higher than in plasma. Vertical transmission can also occur: kittens can be infected transplacentally or when the queen licks and nurses them. Susceptibility to infection is highest in young kittens. The outcome of FeLV infection mainly depends on immune status and age of the cat, but is also affected by virus pathogenicity, infection pressure and virus concentration. Guidelines for testing cats for FeLV have been published (American Association of Feline Practitioners and Academy of Feline Medicine (AAFP/AFM) 2001). While persistently viraemic cats have a decreased life expectancy, treatments for the many clinical syndromes that accompany infection are available. A discussion of FeLV infection and outcome, testing and treatment can be found in Hartmann (2006).

FeLV vaccines are available but the relative efficacy of the vaccines is controversial. Vaccine efficacy testing protocols vary widely between studies and are complicated by the natural resistance of cats (especially older cats) to FeLV infection; none of the licensed vaccines are 100% effective.

An epidemiological association exists between FeLV (and rabies) vaccination and the later development of soft tissue sarcomas at the injection site, referred to as injection site sarcomas, vaccine-associated sarcomas and vaccine site-associated sarcomas (Hartmann 2006).

Feline infectious peritonitis (FIP)

FIP is an infrequent virus infection, which is almost invariably fatal. It is caused by feline infectious peritonitis virus (FIPV), which is generally accepted to be a mutation of feline enteric coronavirus (FECV) (Addie & Jarrett 2006). The latter is common in the domestic cat population, particularly in multicat households or where cats are kept in crowded conditions. Transmission is primarily indirect through contact with virus-containing faeces or fomites, for example contaminated litter trays.

The mutation enables FIPV to infect macrophages and monocytes, and spread throughout the body. The damage caused by the virus is due to the intense immune reaction, localised inflammatory response and vasculitis at the site of virus colonisation.

Two basic forms of FIP, effusive (wet) and non-effusive (dry) are recognised. Approximately half the cats with FIP are less than 2 years of age, although all age groups can be affected (Addie & Jarrett 2006). The risk factors for FIP development are age and crowding, with young cats in crowded catteries being most at risk. Good husbandry is particularly important in controlling FIP. When establishing a colony a decision must be made on whether to focus on FIP or the coronavirus family. If it is the broader family, then the goal should be to maintain the cats free of antibodies to coronaviruses. This would require a different level of surveillance and then the use of vaccines.

An intranasal vaccine, given to cats over 16 weeks of age, has been developed but it is not effective if the cat has already been exposed to the virus. Definitive diagnosis of FIP is by *post-mortem* examination or by using DNA sequencing to detect FIP virus genes in blood, peritoneal fluid or tissue biopsy.

Feline infectious enteritis or panleucopenia (FIE)

Feline panleucopenia is a parvovirus; it is shed in all body secretions during acute stages of disease, but mainly in the vomitus and faeces. It has a short shedding period but long survival in the environment (Greene & Addie 2006), where it is resistant to heat and to many disinfectants. FIE is a highly infectious disease with a high mortality rate. The virus is usually transmitted by indirect contact of susceptible animals with contaminated premises; *in utero* transmission does occur, and may cause early foetal death and resorption or result in the birth of live kittens with varying degrees of neurological damage.

Subclinical cases of infection, more common in older cats, may go unrecognised, while severe clinical illness is the rule in young kittens; sudden death may occur. A presumptive diagnosis is usually made based on clinical signs and the presence of leucopenia. With appropriate symptomatic therapy and nursing care, cats may recover from infection. Immunisation has been very effective at reducing the incidence of this disease.

Feline viral upper respiratory infection (cat 'flu)

Between 85% and 90% of cases are caused by either feline herpesvirus (which causes feline viral rhinotracheitis) or feline calicivirus. Feline herpesvirus (FHV) generally causes more severe disease than feline calicivirus (FCV), but FCV appears to be relatively more common. The viruses are shed mainly in ocular, nasal and oral secretions, and transmission is largely by direct contact from infected to susceptible cat.

After FHV infection virtually all recovered cats become latently infected carriers, with intermittent episodes of virus shedding, particularly after periods of stress. FCV carriers shed virus more or less continuously; in some cats the carrier state appears to be lifelong, but most cats at some point spontaneously recover and appear to eliminate the virus.

Bordetella bronchiseptica is also recognised as a primary pathogen to the feline respiratory tract, although its precise contribution to disease in the field is not yet fully established (Gaskell *et al.* 2006).

Although immunisation cannot guarantee complete protection from upper respiratory infection nor from the development of latent infection, routine vaccination of kittens using a modified live or killed bivalent vaccine, and regular booster vaccination, is recommended.

Cats can carry zoonotic diseases that may be a risk to people (reviewed by Greene & Levy 2006).

Reproductive problems

Major causes of infertility in both toms and queens include inbreeding, poor husbandry, disease, anatomical or reproductive defects and social stress. Investigation should first eliminate any non-reproductive disorders by a thorough physical, haematological and biochemical examination, followed by a thorough evaluation of the reproductive system and semen.

Prolonged anoestrus is usually a management problem. The cats' general health and nutrition should be optimised, and they should be exposed to 14–16 h of light per day and to reproductively active cats. Some queens cycle but do not show any oestrous behaviour (silent heat). They may breed if housed with a male.

Failure to mate may be caused by inexperience. Virgins should be partnered with an amenable, experienced mate. Immature toms can lack libido, some may respond after visual exposure to breeding males, others may need more time to mature. Toms should mate in familiar surroundings otherwise they may concentrate on territory marking instead of mating. Mating may fail because the cats are incompatible; the cats may have definite mating preferences, or some physical incompatibility may prevent intromission.

Queens may not conceive after mating. Failure to conceive following breeding is occasionally caused by vaginal or, more commonly, by uterine disease. Ovulation may fail because of inadequate vaginal stimulation or hormonal insufficiencies. Toms may fail to inseminate; their fertility declines if they are mated too frequently. Failure to carry a pregnancy to term has been associated with environmental stress, dietary insufficiencies, or failure of extraovarian progesterone.

Effects of neutering

Neutering eliminates sexual behaviour in males and females, and maternal behaviour in females. It reduces the incidence of behaviours such as urine marking in both sexes, and increases tolerance towards cats from outside the social group (Bradshaw 1992). However, neutering predisposes to obesity by causing a reduction in energy expenditure. While a cat may adapt its food intake in accordance with this, the adaptation may take 9–10 weeks, by which time its body weight would have increased. The risk of obesity is greatly increased if the cat is confined in a small enclosure and is inactive.

Abnormal behaviour

Specific problems associated with confinement include boredom, aggression to people and cats, fearfulness, behavioural inhibition, withdrawal, escape behaviour, hiding, poor reproductive success, anorexia, weight loss, tail chasing, stereotypies, fabric eating and self-mutilation (reviewed in McCune 1995b). Introducing a new cat into a stable colony produces conflict in the group until both newcomer and residents habituate to the new social hierarchy. Studies of stray cats housed communally at a shelter have shown that most overt aggression occurs within the first 4 days and that mutual toleration is established after 2 weeks (Bradshaw 1992). However, although many of these cats will appear to have behaviourally habituated to confinement at this stage, a recent study has shown that cats were still showing abnormally high urinary cortisol levels (indicative of increased stress) up to 5 weeks after entry to a quarantine cattery (Rochlitz *et al.* 1995). Behavioural inhibition is commonly the response of cats to confinement. Unlike the more overt forms of distress like vocalising, spitting, hissing and growling, behavioural inhibition is easy to miss unless detailed observation is made of the cat (McCune 1992).

Preventing problems

Research animals without behavioural problems are likely to have better welfare and be better for research purposes. Many problems associated with confinement can be prevented by adequate early socialisation and careful selection of cats for suitable temperament (Robinson 1992b; McCune *et al.* 1995). Siegford *et al.* (2003) developed and validated a test to evaluate temperament in cats. These authors found that cats could be ranked, using an easily scored feline temperament profile (FTP), as being more or less sociable toward people, and that FTP scores were fairly consistent over time and circumstance and correlated positively with responses of cats to animal care staff and unfamiliar humans. Cats with timid temperament, extremes of age and restricted experience are more likely to have problems adjusting to confinement and responding to novelty.

There are three approaches to preventing stress in confined cats: (1) selective breeding of the most suitable individuals; (2) an investment of time and effort in the early development phase of kittens; and (3) maintaining a varied and stimulating environment which offers cats choices about what they do and where they do it.

All these approaches have been touched on earlier in this chapter. The benefits of breeding from healthy, confident, well socialised, unrelated parents will help preserve the quality of a cat colony. Early socialisation is a critical time in the development of kittens and, if handled sensitively, will produce cats that are more tractable and pleasant to work with. The quality of the environment is also critical to a cat's well-being. With a little imagination, there can be many opportunities for providing variety and reducing stress (reviewed in McCune 1997). Enriching the environment through the provision of social contact, toys and food presented in novel ways will help to ensure good welfare.

Keeping groups stable reduces conflict. Where cats cannot be group-housed they can be given visual, olfactory and auditory contact by using glass partitions with nose-height holes drilled between adjacent pens. They can be given access to a communal room on a rota basis, each cat leaving olfactory and sometimes visible messages for the next occupant. Likewise, scratch posts can be moved from one pen to another (these posts carry interesting olfactory information).

Although cats normally spend a large part of their day asleep or resting, they can become bored. They should be given opportunities for play, exercise and predatory behaviour. Food is often used as an enrichment device. Dry food is particularly suitable for hiding in pens or for placing inside containers which the cat has to work at to extract individual pieces. Puzzle boxes are now commercially available and can extend the handling time of the food. Small pieces of dry food (or toys) can be pawed through irregular openings in the lid of the box (Figure 31.8).

Cats socialised to humans find human company stimulating and have been found to show signs of stress when the caretaking style becomes less interactive (Carlstead *et al.* 1993). A range of activities can be engaged in, from talking quietly to interactive play with a range of toys. Activities can be selected to suit the personality and response of the individual cat. Cats will play with toys. They show most interest in toys that mimic prey but toys need to be changed frequently and offered in randomised rotation to sustain long-term interest. Rods attached to toy fish that can be jiggled to stimulate play seem particularly popular with younger cats.

In addition to providing an enriched environment, fearfulness can be significantly reduced by consistent, positive handling (Gourkow & Fraser 2006). Animal care staff should handle the cats under their care daily, at times that are not part of routine caretaking procedures such as feeding or cleaning (Rochlitz 2000). Hoskins (1995) examined the effect of human contact on the reactions of cats in a rescue shelter: cats that received additional handling sessions, where they interacted closely with a familiar person, could subsequently be held for longer by an unfamiliar person than cats that did not receive additional handling sessions.

Older cats

A range of medical and behavioural conditions is recognised in older cats. Common medical conditions associated with aging include renal disease, dental disease, hyperthyroidism, diabetes mellitus and osteoarthritis. Sensory loss, such as deafness, and signs of cognitive impairment may become evident (Bowen & Heath 2005). Signs of cognitive impairment may include disorientation, altered interaction with others, sleep problems (usually associated with vocalisation), house soiling and failure of appetite. A number of treatment approaches may be used. Environmental modification, by making the environment more accessible to the cat (for example, providing additional, lower resting and hiding places), exposure to play and increased social contact, will stimulate and maintain mental processes. Dietary supplementation with a range of antioxidants, essential fatty acids and other additives has been shown to improve neuronal metabolic function and boost central nervous system antioxidant reserve. While environmental enrichment and dietary modification should be the mainstay therapies to delay progression of cognitive decline, and where euthanasia is not indicated because of the nature of the research, some psychoactive drugs may also be useful (Bowen & Heath 2005).

Figure 31.8 Presenting part of the food ration in a puzzle can provide a rewarding challenge.

Feline facial pheromones

A range of pheromones has been isolated from feline facial secretions (Mills 2005), and two fractions are available commercially: F3 and F4. The F3 fraction can be used to have a calming effect on cats and facilitate their adaptation to new environments, such as new housing or hospitalisation for veterinary treatment (Griffith *et al.* 2000), or during transport. It is also used in the treatment of behavioural problems such as urine marking and spraying, and scratching of objects. It is available as a spray for application onto cages, tables and blankets and as a plug-in diffuser for rooms or treatment areas. The F4 fraction reduces the cat's wariness of unfamiliar people, and is used to reduce the risk of aggression due to handling in the veterinary hospital. It is available as a spray that is applied to the environment or to the person's hands prior to handling the cat.

Monitoring welfare

The effect of changes made to relieve stress and enrich the captive environment can be assessed by looking for a decrease in abnormal behaviours associated with long-term stress (Bradshaw 1992) and for a behavioural repertoire which more closely resembles that of free-ranging cats (UK Cat Behaviour Working Group 1995; see also Chapter 6). Changes over time can be assessed quickly by using a scoring system. A composite behavioural scale for quantifying stress in confined cats was devised by McCune (1992) and had 10 levels, which were later reduced to seven (McCune 1994). This scale was refined by Kessler and Turner (1997) by adding more postural elements to form the cat stress score (CSS), still with seven levels. This behavioural score correlates well with many indicators of stress (McCune 1992), although there is not always agreement between it and some physiological measures of stress (McCobb *et al.* 2005). Casey (2007a) found a negative correlation between the rate of decline of the CSS and the rate of decline of urinary cortisol to creatinine ratios for cats newly admitted to an animal shelter. This implies the presence of different 'coping styles' in cats, where some actively respond to stress and adapt to the unfamiliar surrounding physiologically, while others appear to be more passive but change little physiologically.

All workers in an establishment should ensure they are using the score in the same way and are being consistent over time in their scoring. Although such a score does require training, once learnt it is a powerful means of assessment as it summarises so much fine detail and can be quickly applied.

A combination of good innovative design and thoughtful husbandry enables confined cats to be kept in conditions where the demands on their welfare and the laboratory's work schedule can be harmoniously balanced.

Quality of life

Quality of life is an abstract construct that has been formally recognised and widely used in human medicine. In recent years there has been much discussion about the concept of quality of life and its application to companion animals. While it is generally accepted that quality of life has to do with the animal's feelings, how it can be defined, measured and reported in animals is currently being explored (McMillan 2005; Scott *et al.* 2007). Approaches include the observation and interpretation of the animal's behaviour, and the use of questionnaires directed at the person most closely involved with the animal's care (see also Chapter 6).

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