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Specialist information

From the Committee for Laboratory Animal Nutrition

Feeding concepts and methods in the laboratory animal facility and in animal experiments

- Ferrets -

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Preliminary remarks

Ferrets (*Mustela putorius furo*) belong to the order *Carnivora* (meat eaters) and the family of mustelids (*Mustelidae*). It is descended from the polecat through selective breeding.

More than 2000 years ago, ferrets were already being used for combating rodents and hunting wild rabbits (Fox 1998). Later, they were kept for their fur and eventually gained importance also as laboratory animals in biomedical research. Here the ferret is mainly used for research into respiratory diseases, because it possesses a relatively long trachea and is very susceptible to various human influenza viruses (Wolf and Hebeler 2001, 2006; Ball 2006; Lewington 2007). Ferrets are also used to address questions concerning the metabolism of carotinoids (Gugger et al. 1992; Ledermann et al. 1998) as well as in toxicological and cardiovascular research (Hebeler and Wolf 2001; Ball 2006; Lewington 2007).

Ferrets show marked sexual dimorphism (Shump and Shump 1978; Wolf and Hebeler 2001, 2006; Ball 2006; Lewington 2007; Marshall Bio Resources 2010). Females are about half the weight of males (Table 1, Fig. 1). Corresponding differences are seen in the length of the body. Females grow to a length of about 20-40 cm and males to 40-60 cm (Weiss et al. 2014). In both sexes, the length of the tail is 10–15 cm and body height 12–16 cm (Weiss et al. 2014). In terms of nutritional physiology, ferrets are a carnivorous species. They only eat plant food to a limited extent.

Peculiarities of nutritional physiology

Like all carnivores, ferrets have a simple digestive system. The monogastric stomach of this species possesses a large capacity for stretching. As a result, ferrets can consume large amounts of food in a very short time. The digestive tract is relatively short. At 1.8-2.0 m, the small intestine is the longest section of its digestive tract (Wolf and Hebeler 2001). Ferrets possess a straight large intestine, about 10 cm in length, with a stable microflora system showing little differentiation (Wolf and Hebeler 2001, 2006). As a result of the short digestive tract, the rapid intestinal transit time and the simple, but relatively stable intestinal flora, the digestive capacity for complex carbohydrates and fibre is limited (Hebeler and Wolf 2001; Wolf and Hebeler 2006).

In terms of nutritional physiology, ferrets and cats are similar in many respects (Kamphues et al. 2004; Fekete et al. 2005). Unlike other animal species, they are unable to synthesize taurine from the two sulphur-containing amino acids cysteine and methionine. This means that taurine always has to be provided in adequate quantities through the food (NRC 1982; Wolf and Hebeler 2001, 2006). It is also the case that arginine is essential for both species (NRC 1982; Hebeler and Wolf 2001).

One difference from the cat is that ferrets can use provitamin β-carotene from plants to some extent for the synthesis of vitamin A. But the conversion is inefficient, so ferrets cannot satisfy their vitamin A requirements through the nutritional intake of β-carotene alone (Gugger et al. 1992; Ledermann et al. 1998; Wolf and Hebeler 2001).

Table 1: Ferret data relevant to feeding (Fox, 1998; Hebeler and Wolf, 2001; Kamphues et al., 2004)

Live mass	♀ 450–1000 g, ♂ 1300–2000 g
Sexual maturity	♀ 4-5 months, ♂ 9 months
Breeding maturity	♀ 9 months, ♂ 12 months
Oestrus cycle	Seasonally polyoestrous (March – August); Mating seasons dependent on light conditions, among other factors; 1-2x per year; ovulation is triggered by the mating act and occurs 30–40 h later.
Gestation	40–46 days
Litter size	2–12 pups
Live mass at birth	6–12 g
Weaning age	6–8 weeks
Live mass when weaned	300–450 g
Life expectancy	5–11 years (max. 13)
Food intake	100–200 g wet feed/animal and day 25–50 g dry feed/animal and day (depending on age and sex, and also on the energy density of the feed)
Water intake	15–40 mL/animal and day when fed on wet feed 75–100 mL/animal and day when fed on dry feed

Life phases

Pregnancy

The live mass of ferrets in both sexes is to a large degree subject to seasonal fluctuations. The animals lose weight during the rutting season in spring and put on weight again in the autumn (Weiss et al. 2014). This weight loss is primarily due to a marked loss of appetite. In breeding females, therefore, the diet should already be switched to a feed with a higher protein and fat content before or at the latest at the start of pregnancy to avoid an insufficient supply of energy or nutrients (Hebeler and Wolf 2001; Wolf and Hebeler 2006).

It must be borne in mind that a feeding frequency of several meals a day or *ad libitum* feeding corresponds more closely to natural feeding behaviour than a single large meal (Hebeler and Wolf 2001).

Lactation

Lactation is a physiologically demanding process for female ferrets. There is a significant increase in the energy requirement, especially with large litters, because the energy cost of lactation is high (NRC 1982; Hebeler and Wolf 2001; Wolf and Hebeler 2006). If the quality and quantity of feeding is insufficient, there is a risk of nursing sickness (lack of milk). Dry feed should be available ad libitum to lactating females. Suckling kits need an average of 4.1 g of milk per gram of increase in live mass (Tauson et al. 2004).

Table 2: Reference values for the composition of ferret feed; dry-matter percentage (Hebeler and Wolf 2001)

	Maintenance	Pregnancy	Lactation, growth
Raw protein (% DM)	> 30	35–40	35–40
Raw fat (% DM)	> 18	18–20	25–30

Growth

In the first three weeks of life, the young feed exclusively on their mother's milk, during which they reach a live mass of about 80-100 g (Shump und Shump 1978). At the start of the fourth week, the animals begin taking in solids in addition to milk. The young must be offered fresh, chopped, mushy feed several times a day (Hebeler and Wolf 2001). In week seven, sex-specific differences in bodyweight development begin to appear. The males now grow faster than the females, who are fully grown earlier than the males because of their much lower final weight. The growth phase is completed after about 20–28 weeks (Weiss et al. 2014). Fig. 1 plots the average development of live mass up to week 24 according to data from Marshall Bio Resources.

Growing ferrets are fed twice to three times daily up to week eight and thereafter once or twice a day. As regards the acceptance of feed, ferrets go through a kind of conditioning phase up to week twelve. Feed mixes, especially dry feed, which are not offered up to this age are often poorly accepted later on.

Husbandry

With regard to the specific nutrient requirements of ferrets, there are no values available on the basis of scientific nutritional studies. Most data is based on empirical values or extrapolated from the nutrient requirements of the mink and the cat (Hebeler and Wolf 2001; Kamphues et al. 2004; Riechert 2005; Wolf and Hebeler 2006).

Therefore, complete feed (dry or wet feed) is frequently used for ferrets and cat (Table 3). As carnivores, ferrets have high protein and fat requirements (Kamphues et al. 2004; Riechert 2005; Wolf and Hebeler 2006; Ball 2006;). The protein content in complete feeds for adult animals amounts to 30-40% of dry matter. The protein must be of high quality and easily digestible.

Crude fat is an important energy source in the feed. It should amount to not less than 18% of dry matter (Wolf and Hebeler 2006).

The carbohydrate and raw fibre content of the feed is correspondingly low. Plant products in the form of complex carbohydrates serve as natural carbohydrate sources.

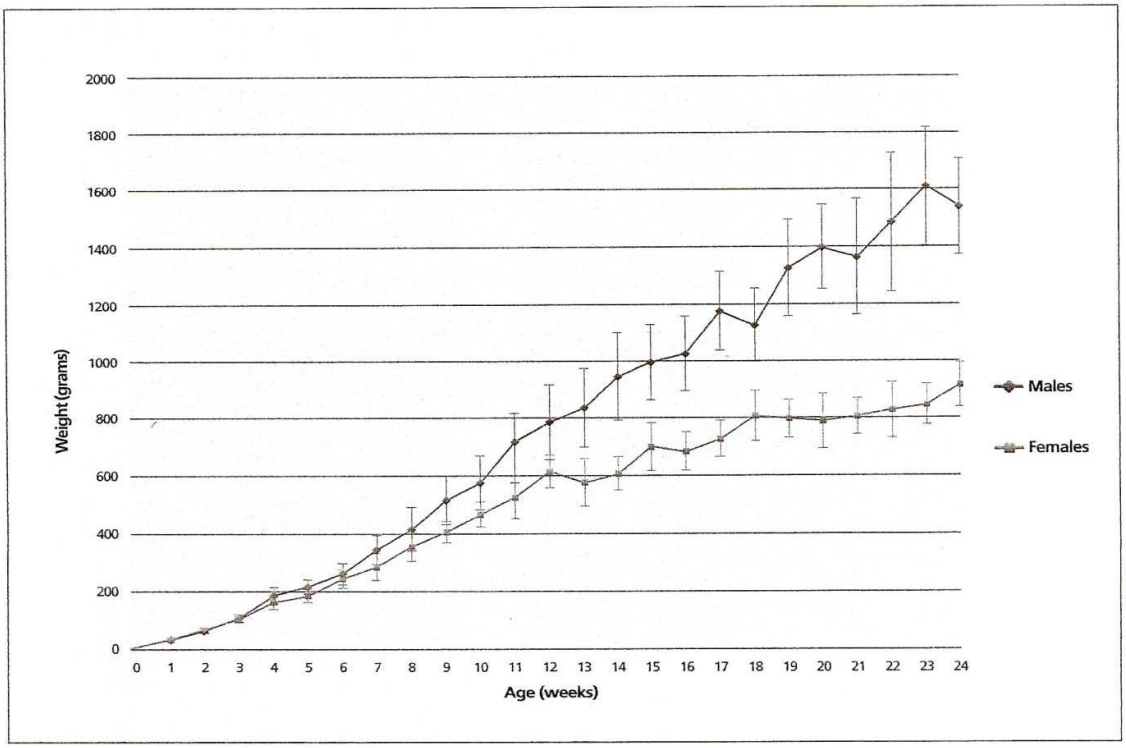

Fig. 1: Average development of live mass in males and females up to the age of 24 weeks (Marshall Bio Resources, 2010).

The daily energy requirement in the maintenance phase is based on the energy requirement of the mink of about 500 kJ ME/kg LM 0.75 (Kamphues et al. 2004). The daily food intake during the maintenance phase varies between 25 and 50 g dry feed or about 100–200 g wet feed, depending on the body mass, sex, and the energy density of the feed (Wolf and Hebeler 2001, 2006). In general, feeding is energy-constant in ferrets (Hebeler and Wolf 2001; Wolf and Hebeler 2001; Riechert 2005).

Table 3: Raw nutrient contents[1] of commercially available complete feed for ferrets (n=19) and cats (n=27)[2] as dry-matter percentages (modified according to Hebeler and Wolf, 2001).

	Ferret feed $\bar{x}$	Ferret feed min. – max.	Cat feed $\bar{x}$	Cat feed min. – max.
Raw protein (% DM)	39.2	31.1 – 55.6	36.7	30.4 – 47.9
Raw fat (% DM)	19.8	8.9 – 27.8	18.3	8.8 – 36.1
Raw fibre (% DM)	3.3	1.1 - 5.7	3.2	0.7 – 10.0
Raw ash (% DM)	7.7	6.6 – 11.1	7.1	3.1 – 15.4
NFE (% DM)	30.0	4.4 – 47.2	34.9	7.9 – 45.1

[1] According to manufacturer's data
[2] Selection of commercially available products without any claim to completeness

Water supply

Fresh drinking water should be available ad libitum as a rule. An adequate supply of drinking water is particularly necessary when using dry feed. If water intake is inadequate, there is an increased risk for the formation of urinary stones, especially struvite stones (Hebeler and Wolf 2001; Wolf and Hebeler 2006; Wolf et al. 2009). If dry feed is provided, water consumption is about 75–100 mL per animal per day (Wolf and Hebeler 2006). Water can be supplied in bowls or bottles with long drinking tubes as well as automatic drinking systems.

If dry feed is used, the option of soaking the feed in water may be considered. This will improve not only the ferret's water supply, but also its food intake (Wolf and Hebeler 2001, 2006). In this case, however, it must be borne in mind that the feed deteriorates more quickly.

Presentation of feed and feeding technique

Complete feed for ferrets is useful for increasing the level of standardization in the laboratory animal facility. When the animals are fed on complete feed, they also receive an adequate supply of vitamins and minerals (Hebeler and Wolf 2001; Kamphues et al. 2004). Mixtures made up of small rodents, day-old chicks, entrails and organs from slaughtered animals supplemented with noodles, rice, boiled potatoes etc., as well as mineral and vitamin mixes, are just as unsuitable for experimental husbandry as so-called treats (e.g. sweets, biscuits or raisins). The latter are very rich in carbohydrates and can result in an insufficient supply of protein if they make up a high proportion of the daily ration (Hebeler and Wolf 2001; Kamphues et al. 2004; Wolf and Hebeler 2006). Dry feed is usually provided ad libitum. The animals then feed about 9–10 times per day, which corresponds to natural feeding behaviour (Hebeler and Wolf 2001; Wolf and Hebeler 2001). When wet feed is provided, the ferrets should receive 2–3 meals per day (Hebeler and Wolf 2001). It is important to maintain impeccable feeding hygiene. Each day, any left-over feed must be removed, the feeding bowls cleaned, and the cages checked for possible food caches.

Ferrets arriving at the new animal facility from the breeder or from other facilities should be fed the same way as in the facility they came from, especially in the initial phase, in order to avoid an abrupt change in the feeding pattern. The original facility should therefore supply the animals' customary feed (enough for about 2 weeks) together with the animals, so that they can be gradually accustomed to the new feed.

Feeding in experiments

Fasting before operations should be brief and not last longer than 4–6 hours. Nutrition-related hypoglycaemia can already occur after six hours of fasting (Hebeler and Wolf 2001; Wolf and Hebeler 2006).

Nutrition-related disorders

- Feeding on poorly digestible protein (inadequate supply of amino acids; NRC 1982)
  → weakened immune system
  → urolithiasis
  → small litter size
  → low growth rate of new-borns
- Taurine deficiency (Kamphues et al. 2004)
  → hypertrophic and dilated cardiomyopathy
- Arginine deficiency (Hebeler and Wolf 2001)
  → Hyperammonaemia
  → Encephalopathy
- Vitamin E deficiency (NRC 1982)
  → Yellow fat disease, fatty tissue necrosis
- Thiamine deficiency in ferret kits (NRC 1982)
  → Apathy
  → Anorexia
  → Weakness of hind limbs
  → Convulsions
- Calcium deficiency (NRC 1982; Hebeler and Wolf 2001; Kamphues et al. 2004)
  → Loss of teeth
  → Bone deformations
  → Spontaneous fractures
  → Coordination disorders
- Calcium and phosphorus deficiency (NRC 1982)
  → Osteomalacia
- Excess supply of calcium and vitamin D (NRC 1982)
  → Renal failure
  → Calcification

Transport

Transport cages for cats and other small animals are suitable for transporting ferrets. The side walls must be perforated to ensure there is sufficient air circulation. The transport cages should be easy to clean and escape-proof. For journeys lasting more than four hours, it is recommended that the animals be provided with wet feed and drinking water in bottles. Wood granules have proved suitable as bedding material (Ball 2006; Dammann 2012; Papadopulos 2012; Wolf 2012; TVT 2014).

Enrichment

Bearing in mind the minimum dimensions of the cage (EU Directive 2010/63) the ferret cage must be divided into

- a run with a feeding area,
- a sleeping area and
- a toilet

(EU Directive 2010/63; TVT 2014).

In addition, the new EU Animal Welfare Directive calls for

- sufficient complexity of the cage installation,
- stimulation of locomotor and cognitive skills, and
- certain manipulability of the cage installation by the animal,

which is only ensured with relevant enrichment (EU Directive 2010/63; Dammann und Tsai 2011).

The following enrichment materials, among others, are suitable for ferrets:

- non-slip climbing opportunities and
- plastic tubes (Dammann 2012; Papadopulos 2012).

Examples of social enrichment:

- group housing if possible and
- regular examples and handling by the animal technicians (EU Directive 2010/63; Dammann und Tsai, 2011; Dammann, 2012; Papadopulos, 2012).

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