# NUTRITIONAL CONSIDERATIONS FOR HAND-REARING POSSUMS

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## POUCH LIFE

Possums and gliders, like other marsupials, are born extremely undeveloped, and reside in the mother's pouch for much of their early development. Mother's milk provides all the essential nutrients for the growth of pouch young (PY). Milk-dependent possums have two major stages of development:

Phase 1 is the early lactation stage and relates to PY that are entirely confined to the pouch. Physically these animals are furless (or with very fine fur), with eyes closed to just opened and ears drooped.

Phase 2 is the late lactation stage which corresponds to joeys emerging from the pouch, eyes opened and thick hair growth. These animals have increased activity levels and growth demands.

Pouch exit occurs once young are able to control their own body temperature (thermoregulate) and have a well-established immune system. At this time the digestive system has advanced to the stage where the young can begin to eat solid food and start the process of being weaned off milk and onto an adult-type diet.

Different species of possums and gliders achieve full pouch emergence at different times as outlined in Table 1 below.

Table 1. Pouch emergence age for various species of possums and gliders.

| Species, common name | Species, scientific name | Age when fully emerged from pouch |
|---|---|---|
| Eastern Pygmy Possum | Cercatetus nanus | 42 days |
| Feathertail Glider | Acrobates pygmaeus | 60 days |
| Sugar Glider | Petaurus breviceps | 75 days |
| Squirrel Glider | Petaurus norfolcensis | 85 days |
| Yellow-bellied Glider | Petaurus australis | 100 days |
| Common Ringtail Possum | Pseudocheirus peregrinus | 130 days |
| Greater Glider | Petauroides volans | 150 days |
| Common Brushtail Possum | Trichosurus vulpecula | 150 days |
| Mountain Brushtail Possum | Trichosurus caninus | 180 days |

The stage of development of a PY can be expressed by how much of its pouch life it has completed. This gives rise to the concept of Age Factor (AF):

$$\text{Age Factor (AF)} = \frac{\text{Age of Pouch Young (PY)}}{\text{Age when fully emerged from the pouch}}$$

For example a Common Brushtail is normally fully out of the pouch by 150 days, therefore a PY at 120 days of age has an AF of 120/150

= 0.8. By definition, a young animal that spends any time in the pouch has an AF of less than 1. Initial pouch emergence begins for larger species (e.g. Brushtail and Ringtail Possums) around an AF of 0.7 to 0.8. Smaller species (e.g. pygmy possums & gliders) may emerge at an earlier AF and be deposited in the nest while the mother forages at night. For these species full emergence from the nest at night time is equivalent to emergence from the pouch in the larger possums.

The concept of Age Factor helps us standardise the nutritional requirements of PY for related species. All species of possums and gliders develop at roughly the same rate when compared using AF so that a Sugar Glider at 60 days, a Ringtail at 100 days and a Brushtail at 120 days all have similar nutritional requirements (All have an AF of 0.8). In terms of the two main stages of young possum development, Phase 1 (early lactation) corresponds to AF < 0.8, while Phase 2 (late lactation) relates to AF > 0.8. PY with an Age Factor < 0.5 are very immature in development and may not be viable candidates for hand-rearing.

**MILK COMPOSITION**

Several studies have been conducted on the nutritional composition of possum milk, particularly that of the Brushtail1,2 and Ringtail Possums3 and to a lesser extent the Sugar Glider4. This research shows that possum milk undergoes significant changes in composition and energy content over the course of lactation, as demonstrated in Figures 1 and 2.

The changes in milk composition outlined in Figure 1 cater for the widely differing nutritional requirements of the developing joey from furless “pinkie” to fully-emerged from the pouch. During early lactation (Phase 1: AF < 0.8) possums obtain much of their energy from carbohydrate and have low fat levels in the milk. However approaching pouch emergence (Phase 2: AF > 0.8) the situation is reversed, with milk becoming more concentrated with fat, and carbohydrate dropping rapidly. Fat contains twice the kilojoules per gram as carbohydrate, so the later lactation milk provides higher energy levels to the fast-growing and increasingly active emerging

joey. The increasing energy content of the milk as seen in Figure 2 is therefore largely driven by the increase in fat content.

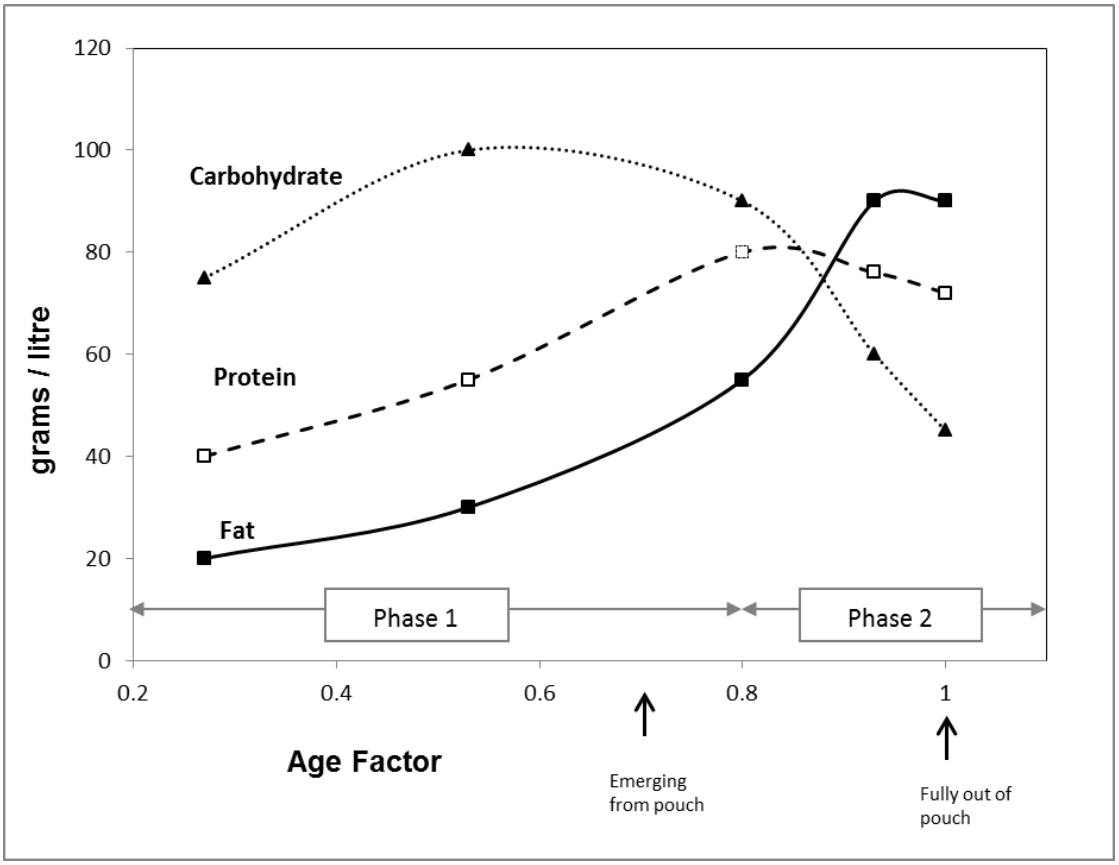


Figure 1. Changes in milk composition with age for a typical possum joey 1,2.

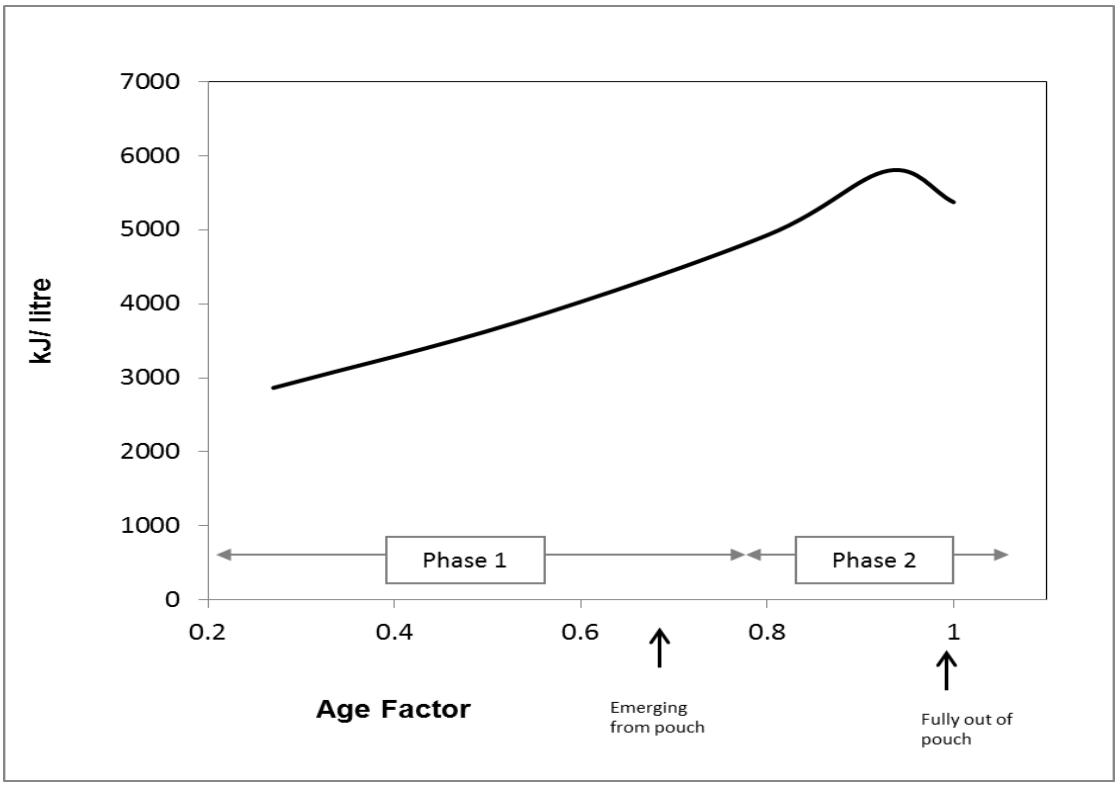


Figure 2. Change in energy content in possum milk up until pouch emergence (as calculated by the author from references 1 and 2).

Protein content in possum milk gradually increases throughout pouch life, peaking at around an AF of 0.8, before declining again after pouch exit. The composition of proteins also change, with varying amounts of immunoglobulins, iron-binding proteins (lactoferrin) and amino acids. For example the mid lactation milk (AF = 0.5–0.8) has high amounts of the amino acid cysteine, which is essential for healthy hair growth. A lack of cysteine in the milk during this period is likely to result in poor hair growth and problems with thermoregulation.

Possum milk differs from that of other marsupials in that it contains significant amounts of the carbohydrate lactose in later lactation. There is evidence to indicate that the lactose-hydrolysing enzymes (lactase) are extracellular to the intestinal mucosa, allowing a higher threshold of lactose assimilation from the gut5. This suggests that after pouch emergence possums do not necessarily exhibit the same effects of lactose intolerance that is seen in suckling macropods. This possibly explains why, historically, some carers have been able to

feed late lactation possums on cow's milk- based formulas, without acute digestive upset.

Another difference seen in possum milk is that after pouch emergence (AF>1), the concentration of nutrients and total solids in the milk tends to reduce. Many other marsupials such as macropods and wombats show a continual increase in milk solids, particularly fat. This difference may be a result of fully-emerged possums being able to increase their intake of solid foods relatively quickly, such that the nutritional importance of milk declines accordingly. The reduction in milk solids coincides with the regular consumption of caecal pellets (caecotrophy) in Ringtails, suggesting that foliage can be digested3.

Munks et al. (1991) found that the levels of fat remained lower throughout lactation in captive Ringtail Possums3. Some people have concluded that because of this, all possums should be maintained on a low fat milk throughout lactation. However in this study, the milk of wild Ringtails was found to be significantly higher in fat than that of captive animals. This was attributed to a difference in diet between wild and captive animals in the study. It is therefore likely that, as with other species of possums, young Ringtails also require a higher fat milk in late lactation (AF > 0.8) to ensure they are provided with sufficient energy to deal with the metabolic rigours of pouch emergence.

## POSSUM DEVELOPMENT WITH AGE

The physical changes in a developing possum occur at set times over the course of lactation. Developmental milestones such as eyes opening, first hair growth and full emergence from the pouch can all therefore be related to Age Factor.

As previously mentioned, development of possums can be broadly categorised into 2 phases:

- Age Factor <0.8 for younger joeys not yet emerged from the pouch

- Age Factor >0.8 for older joeys emerging from the pouch

These stages of development have associated nutritional considerations which are outlined in Table 2.

Table 2. Developmental milestones for possums

| Age Factor | Stage of Development | Nutritional Considerations |
|---|---|---|
| <0.8 | • Fully pouch bound.<br>• Eyes closed to just open.<br>• Ears flat to drooped.<br>• Furless to fine fur.<br>• Unable to properly thermoregulate.<br>• Immune system not fully developed.<br>• Faeces yellow custard to toothpaste consistency. | • Low energy milk, with a low fat content.<br>• Digestive system is not well developed - milk contains easily digested carbohydrates and proteins.<br>• Immunoglobulins present in milk to boost immune system.<br>• No gut flora<br>• Protein contains sufficient levels of sulphur-containing amino acids (e.g. cysteine) for the onset of hair growth. |
| >0.8 | • Joey starting to emerge from the pouch; feeding, urinating, defecating outside the pouch.<br>• Eyes fully open (may be closed for longer in smaller species).<br>• Ears erect.<br>• Short soft to dense long fur.<br>• Able to thermoregulate.<br>• Developed immune system | • Higher energy milk with an elevated fat content - coincides with increased activity levels and growth demands of joey.<br>• Fall in carbohydrate content of milk with decrease in associated gut enzymes.<br>• Increasing levels of “body-building” proteins to coincide with peak growth rate.<br>• Gut flora developing for digestion of solid food. |

- Faeces toothpaste consistency to soft, then firm green pellets.

**IMMUNITY**

Pouch young receive passive immunity from immunoglobulins present in the mother's milk. Immunoglobulins are proteins that provide immunity against pathogenic micro-organisms such as bacteria and viruses. Pouch young that do not receive immunoglobulins are likely to have a weakened immune system and increased risk of infection and mortality. In possums, intestinal absorption of antibodies occurs well into in pouch life, and immunoglobulins are present in the milk throughout much of lactation6. The two main classes of immunoglobulins present in the milk are Immunoglobulin A (IgA) and Immunoglobulin G (IgG). Ingested IgA protects against pathogens in the gastrointestinal tract, whereas IgG is transported across the gut epithelium into the circulatory system of the young.

In Brushtail possums there are two main periods of immune transfer via the milk7.

- The first is a colostrum phase, which occurs immediately after birth and includes both IgA and IgG. This helps protect the PY from common organisms found inside the pouch. Any viable PY that come into care would have already received this initial transfer of antibodies from the mother.
- The second period of immune transfer consists mainly of IgG and occurs at the transition of milk composition at an Age Factor of around 0.6-0.8. This protects the young when they

first leave the pouch and become exposed to new pathogens in the external environment.

Provision of a colostrum supplement (e.g. Impact™, Wombaroo Food Products) to hand-reared possums at this stage of development may be particularly beneficial. Colostrum is ideally fed to pouch-bound marsupials within a week of first coming in to care, as immunity from the mother's milk can deplete significantly after seven days and may be completely gone by 4-6 weeks6. Most commercially available colostrum supplements derive from bovine origin, however this is still effective against a wide range of pathogens that are common in the environment (e.g. rotavirus, which can cause acute diarrhoea8). Bovine colostrum has therefore been successfully used to boost the immune response in a diverse range of animal species.

## NUTRITIONAL DEFICIENCIES IN CARE

When hand-rearing orphaned marsupials it is ideal to mimic as closely as possible the nutrition supplied by mother's milk 9.

Despite the published research about milk composition, many carers do not necessarily cater for the changing nutritional needs of the developing possum joey. In particular, hand-reared possums are often maintained on a single composition, low protein/low energy formula throughout lactation. This does not allow for the changing nutrient requirements over time, particularly the increased needs for protein and energy in later lactation. Table 3 below compares the composition of Brushtail Possum milk in later lactation, to the manufacturer claims of three commercially available milk replacer formulas.

Table 3. Milk replacer comparisons for a 135 day old Common Brushtail Possum (AF =0.9)

| Milk | Solids (g/litre) | Protein (%) | Fat (%) | Carbohydrate (%) | Energy (kJ/litre) |
|---|---|---|---|---|---|
| Mother's Milk* | 280 | 8.0 | 9.0 | 6.0 | 5800 |
| Biolac™ M100 | 160 | 5.0 | 5.0 | 5.0 | 3900 |
| Divetelact™ (Dilution B) | 200 | 4.8 | 6.0 | 7.6 | 4200 |
| Wombaroo™ Possum Milk Replacer >0.8 | 250 | 7.5 | 9.0 | 5.0 | 5700 |

* Mothers milk from Cowan 1 with energy content calculated by the author, ™ Product info from McCracken 9.

This highlights a significant shortfall in protein, fat and energy for some formulae, compared to mother's milk. These deficiencies are usually compensated for by feeding at much higher volumes than mother-reared possums. However excess feed volumes may limit the uptake of nutrients or induce diarrhoea in possums. Smaller species in particular (e.g. gliders, pygmy possums) are limited by the volumes they can comfortably ingest.

Another potential deficiency of some formulas for late lactation possums is the high sugar content (glucose & galactose), compared to the very low levels found in the natural milk at this stage. These sugars may inhibit the establishment of the correct gut flora required for the digestion of foliage, thus delaying the weaning process onto natural solid foods 9, 10.

Any signs of nutritional deficiency should be actively monitored throughout the hand-rearing process. This is best achieved by regular measurement of body weight, and correlating this against growth charts for the species in care. The prolonged effects of nutritional deficiency may include:

- Slow growth rate;
- Poor body condition;
- Poor hair growth;
- Reduced ability to thermoregulate;
- Weaker immune system;
- Later weaning.

Any of these problems may ultimately lead to a delayed time line for release and a poor prospect for long-term survival of animals when returned back to the wild.

**WEANING FOR RELEASE**

Once a possum leaves the pouch it begins to eat solid food and becomes less reliant on milk. When weaning, careful consideration needs to be paid to the species' natural diet. Animals being prepared for release need to be familiar with wild-type dietary items naturally found in their release area.

The length of time to weaning depends on the species. As a guide, young are weaned at about 1.3 times their pouch life. For example a Common Brushtail pouch life is about 150 days, so should be fully weaned by about 195 days.

Weaning age is important for possums that are being released back into the wild. This is because species such as the Common Ringtail and Brushtail can reach sexual maturity within their first year (up to 90% of females have a pouched young by 12 months of age). A typical time line for a hand-reared Common Brushtail is outlined in Figure 5. It is important that weaning occurs as soon as possible, to ensure that this developmental time line is not unnecessarily delayed.

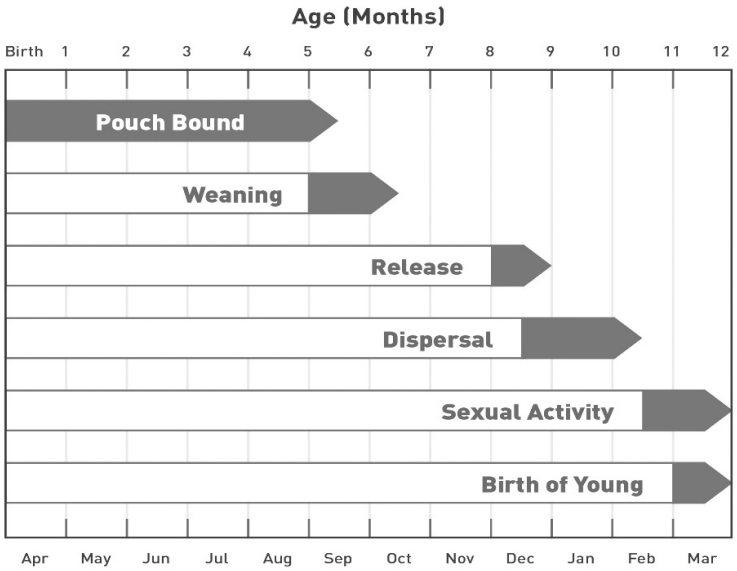


Figure 5. Time Line for hand-reared Common Brushtail Possum (Trichosurus vulpecula).

The critical period for possum survival occurs after release, when there may only be another 2-3 months before the onset of sexual activity. This is the minimum amount of time required for dispersal, establishing a territory as well as finding food resources and nesting sites. Timing of release should therefore be based on the dispersal age of the animal, and not necessarily body weight. However, providing optimum nutrition throughout the hand-rearing process will help achieve a good weight for age and ultimately assist in survival. On the other hand, if hand-reared animals are underweight for their age, it is common practice for carers to hold on to possums for longer than their dispersal age. This may compromise individuals at the point of release if stressed by competition with resident populations and the onset of sexual activity.

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