INTRODUCTION

The risks associated with certain foods should be appreciated and assessed. Supplements, probiotics, vitamins and minerals may be necessary at times. Infectious diseases are less likely if mammalian rather than avian food is used as few pathogens cross between classes. A full discussion of the nutritional requirements of the orders ‘falconiformes’ and ‘strigiformes’ is beyond the scope of this article. As a basic principle, it is important to remember that each raptor species has evolved over millennia to fill a very specific ecological niche. In the absence of detailed nutritional data the dietary needs of any individual species will be met most fully by feeding a diet closely approximating to that which would be taken in the wild under ideal conditions1, although one should not loose sight of the fact that a natural diet is for a wild bird, by definition our captive birds have a different life style and hence have different nutritional requirements. The maintenance energy requirement of raptors is 110Kcal/kg^{0.75}/day.1 Thus the daily intake of a 100g bird is 25% of it’s bodyweight, a 700g bird 15% of it’s bodyweight, 1200g bird 10.7% of bodyweight, 4000g 6.25% of bodyweight, 7000g bird 3.5% of bodyweight.2 Larger birds eat more food but require a significantly smaller percentage of their body mass as daily food intake. The consumption of a prey animal by a raptor involves the bird eating casting (fur & feather), muscle, bone, viscera and the prey’s gut content. In supplying food to captive birds, all these elements should be considered. Any alteration to the birds diet, even from one prey species to another, in both captivity or free living individuals can result in a change to the relative proportions of these materials consumed.

FEEDING BIRDS OF PREY IN CAPTIVITY

Foods commonly available for feeding to captive raptors include day-old chick (doc) (i.e. hatchery waste males), “grown-ons” (chickens or turkeys of several weeks old), quail, rabbit, various rodents, beef, lamb and horsemeat. Over 50% of UK raptor keepers rely solely on feeding day old chicks.3 This is an unsatisfactory diet due to lack of a balanced diet, although recent analytical tests have demonstrated that chicks are in fact a much better central part to a diet, than had been previously considered4. (This booklet gives the must up to date analytical data on the nutritional composition of commonly fed raptor foods. It is being sold, to raise funds for the ‘Campaign for Falconry’ from the author). If the doc is fed with yolk included the fat content is high, but when the yolk sac is removed there is a significant deleterious reduction in the Ca:P ratio as well as the levels of vitamin A and E4. Whilst in the past one might have advised only feeding yolk sac once a week, the new recommendation is to feed yolk 5 times a week. The feeding of muscle (e.g. shin of beef) as a major part of the diet is unsatisfactory without supplementation. Birds flying on public display, are often fed beef as the public may
object to seeing fluffy chicks or mice fed. This can lead to calcium deficiency even in adult birds with central nervous signs or muscle cramps. There are marked inter species differences in nutritional requirement. European Kestrels (*Falco tinnunculus*) can breed successfully for several generations on an exclusive day old chick diet. In contrast merlins (*Falco columbarius*) fed on the same diet will not thrive. Free living merlins consume an insect based diet and for merlins a high fat diet may predispose to ‘Fatty Liver Kidney Syndrome of Merlins’. The diet of free living Secretary birds (*Sagittarius serpentarius*) is predominantly snakes, which are lower in energy and higher in Ca:P ratio than most commercial raptor diets. Young fast growing Secretary birds fed on a standard raptor diets may suffer a Ca:P:D imbalance with resultant metabolic bone disease and leg deviations. The essential point is to feed a varied diet, with supplements if appropriate, which as closely approximates to the natural wild diet as possible.

**Source and storage of food:** Irrespective of the food type, it is essential to be certain of the quality, source, method of killing, freezing and storage of the food. Food should be purchased from reputable sources, where the wholesomeness of the food can be assured. The method of killing should be ascertained and it should be certain that no toxic or noxious substances could be present in the food. Animals or birds fed to raptors must not have been on any form of medication, or medicated food prior to their death. Withdrawal times will depend on agents involved. The feeding of day old chicks hatched from antibiotic treated turkey eggs has led to infertility in the past. Once killed doc should be laid out on shelves and blast frozen, prior to packing. If chicks are boxed prior to freezing, the chicks in the middle of the box will take an excessive time to freeze, leading to proliferation of surface bacterial contaminants, toxin or spore formation. When frozen doc are purchased and transported, care must be taken to prevent thawing and subsequent re-freezing. Food should not be kept stored (frozen) for more than 3 months. The potential risks of zoonotic infections should always be considered when handling raptors or their food.

**CONTAMINATION OF FOODS**

**Microbiological:** any wild source of food (e.g. pigeon, game, road traffic kills) must be considered potentially contaminated. That animal failed the ‘fitness for life test’ and we do not know why. Such birds may be carrying organisms such as *Mycobacteria, Salmonella, Campylobacter, E. coli, Trichomonas, Paramyxovirus, Adenovirus, Falcon herpesvirus, Rotavirus* or alternatively may have been poisoned (e.g. alphachloralose, mercury, lead, mevinphos). Any wild sourced food should be in good body condition, have been caught and killed by physical means, and on examination the carcass should look in all respects to be thoroughly wholesome and free of disease. The abdomen should be opened and the surface of the liver examined. If lesions are detected the whole carcass must be rejected. Many infectious diseases (e.g. avian tuberculosis or viral disease) will cause gross liver lesions. Wild sourced foods may also be infested with internal (*Caryospora, Capillaria, Syngamus* etc.) or external parasites. Ectoparasites may act as vectors for haematozoa and other blood born infections. Viral diseases have been encountered (e.g. Adenovirus, Rotavirus) where healthy commercially sourced poultry (doc, turkey poults, quail), had been fed to healthy raptors which have then succumbed to disease. Apathogenic poultry viruses (of no commercial importance) may be pathogenic to raptors. Adenoviruses are commonly pathogenic to only one species (e.g. Mauritius kestrels (*Falco punctatus*)). Viruses which are apathogenic in a food species, especially those which may only be pathogenic to one target species (e.g. Adenovirus), cannot be predicted. The only precaution is to avoid feeding avian derived food. Pigeons form a particular risk to raptors due to their high sub clinical incidence of *Trichomonas* spp. (frounce / canker). Discarding the head, crop and oesophagus is insufficient as breast muscle and liver...
are often contaminated. Stressed, senile, juvenile or diseased raptors are most susceptible. Pigeon to be fed to raptors should be frozen completely and thawed prior to feeding. Other diseases commonly carried by pigeons include Falcon Herpes Virus, Owl Herpes Virus, Newcastle Disease Virus, Pigeon Paramyxovirus, Salmonellosis, Avian Tuberculosis and Chlamydiosis many of these are not eliminated by freezing. Raptors may consume parasite intermediate hosts. In both free living and captive raptors the consumption of Earthworms (e.g. *Eisenia foetidus* and *Allolobophora caliginosus*) and Arthropods (slugs, snails) which can act as intermediate, paratenic or transport hosts for parasites can lead to infestations e.g. *Syngamus* spp (gape or lung worm) and *Capillaria* spp.

**Toxic:** Many falconers feed ferreted, rifled or shotgun shot foods (especially rabbit and pigeon). Shotgun killed quarry should never be fed. Rifle bullets frequently fragment on impact, so even head rifle shot food should be discarded. Even newer ‘so called’ lead free bullets may in fact still contain lead (all be it coated on the outside by a alloy) or other toxic minerals e.g. zinc. Ferreted rabbits may contain lead pellets from a previous non fatal shooting incident. A single piece of lead shot is often sufficient to cause a bird’s death. Lead ingestion from the consumption of fallen shooters quarry is a major cause of mortality especially in wild eagles. Road traffic casualties may have been shot prior to vehicular collision. Keepers should be aware of the clinical signs of lead poisoning (see plate 1) (weakness of legs and wings, inability to stand, often grasping the feet each in the other, inco-ordination, poor appetite, green faeces, and weight loss).

![Plate 1. Northern Goshawk (*Accipiter gentilis*) suffering from lead poisoning]
Barbiturate poisoning has occurred in both wild and captive raptors after birds have been fed the carcasses of animals euthanased with pentobarbitone. Other possible toxic contaminants include alphachloralose, mercury, mevinphos and other pesticides.

COMMON DEFICIENCIES AND EXCESSES

Hypocalcaemia (lack of calcium), Ca:P:D^3 in balance, rickets and metabolic bone disease (MBD) (different names for the same condition) is the most important nutritional deficiency of raptors. Birds may present with slight or severe bowing of the legs (see plate 2), tibial head dyschondroplasia, longitudinal rotation of the tibiotarsus, major multiple folding fractures of the skeleton and even hypocalcaemic fits. MBD is most likely to occur in fast growing larger species.

Plate 2. Radiograph of the ricketic legs of a young Harris hawk (Parabuteo unicinctus)

Breeders should be advised not to feed such species ad libitum, but rather to restrain the potential growth rate. ‘Angel wing’ or ‘slipped wing’ (an outward rotation of the proximal metacarpal) has been experienced by the author in several fast growing larger raptors. This is readily controlled if diagnosed early by bandaging the primaries against the body, Ca, D^3 supplementation and a reduction of the growth rate. Dietary composition is more important in chicks than in adults. The diet must comprise whole carcasses, and not simply muscle (i.e. meat). The author has investigated calcium deficiencies in free living Golden eagle (Aquila chrysaetos) and European buzzard (Buteo buteo). In the former case the young were parent reared in an area with little ground game. The birds were feeding predominantly on fallen sheep carcasses. However, they were only consuming meat from the carcasses (as sheep bones were too large for young chicks to consume). The buzzards were rearing young in an area with
a significant rabbit die off due to myxomatosis. Food was plentiful and rabbit bones were too large for young buzzard chicks. A similar situation can arise when a breeder feeds a whole carcass diet of rabbit or pigeon for the parent rearing of young Harris’ hawks (*Parabuteo unicinctus*). Either the young are unable to consume the larger bones or the parents feed what is easiest. The result is severe MBD. It is a question of what food is available to the birds rather than what is consumed. Calcium deficiency may also be encountered in neonates produced by a hen with significant renal disease, or from one which has laid an excessive number of eggs (usually due to egg pulling or multiple clutching). Any multiple clutching hen should have her diet supplemented with Ca, D³ as soon as the first clutch has been completed. Calcium deficiency due to inadequate D³ levels is less common in raptors in comparison with parrots in view of the contrast in typical husbandry.

**Vitamin E / Selenium deficiency** is seen most commonly in chicks fed on high fat food which has been stored excessively. The condition presents as acute onset opisthotonus of neonates (commonly termed ‘star gazing’). Treatment is by injections of vitamin E and selenium and dietary supplementation.

**Vitamin B₂ (Riboflavin) deficiency** can also be seen in birds fed on excessively stored food or where a mixed diet has not been fed. Deficiency presents as an inward curling of the toes, typically seen within the first 14 days of life. Clinical signs respond rapidly to parenteral or oral B₂ supplementation.

**Secondary Thiamine ‘deficiency’** occurs when thiaminase containing fish are fed to fish eating species. Thiamine responsive fits are also seen in certain breed lines of captive Harris’ Hawks. These cases are not related to a dietary deficiency, although supplementation does control clinical signs.

**FEEDING METHODS AND HUSBANDRY**

Aviary birds are often fed excessively. Excess food may not only lead to fat build up in the, hardening of the arteries and other health problems, but also increases the risk of vermin infestation. If birds do not come down to feed as soon as the food is provided, they are either ill or they do not need as much. When feeding aviary birds, food is best supplied in a drawer system, rather than a chute. If excess food is given (if not cached) it can be removed rather decomposing on the aviary floor. The food drawer should be positioned to avoid direct sunlight or access by vermin. Atherosclerosis may occur in over fed, poorly exercised birds, especially if on a high fat diet. Old spent laying quail; mature fat laboratory rats/mice are a particularly risk. The condition is commonest in older breeding female birds, in view of the increased mobilisation of fats, during egg laying. A heritable tendency toward the condition has been demonstrated in quail.⁹ There is usually no indication that the bird is ill; it is simply found dead in the aviary, or dies during some other stressful event (handling, anaesthesia). Serum cholesterol screening maybe of value in predicting which birds are at risk. Nutritionally induced atherosclerotic lesions in quail have been shown to regress after dietary correction,¹¹ or with exercise. If possible at the end of the breeding season all breeding birds should be taken out and flown free even if it is only for a few weeks.

**Water:** Although raptors typically acquire their daily water intake via their food, if the weather is hot, they are unwell or laying, or if they are anorectic, their dietary water intake may be inadequate. This can be particularly relevant during training, when a bird may be kept on the fist until it will eat from the glove. In this way some birds can go up to three days without eating, leading to dehydration and kidney disease. Raptors should have access to fresh water at all
times. Water containers must be easily disinfected. Water should be changed regularly, especially in hot weather, as *Pseudomonas* sp. (a very dangerous bacteria) often grow in warm water infecting the bird and leading to severe and often fatal disease. In hot weather, it may be necessary to sanitise the drinking water with a diluted disinfectant (e.g. chlorhexidine or virkon) to control this problem. Water baths should be carefully designed to minimise the possibility of birds drowning. In the UK, during the months of October to April, birds should be prevented from bathing in the afternoon, as birds still wet at night are more prone to ‘wing tip oedema an dry gangrene syndrome’. This applies particularly to first year birds of susceptible (warm climate) species tethered within 18 inches of the ground overnight.

**Supplements**

There is a large range of supplements available for addition to birds’ diets. If the birds are fed a good diet, supplements will only be required at times at additional stress (if at all) e.g. training, breeding or mouling. Supplements should not be used as an alternative to a well balanced diet. A good diet should be varied, and differs depending on the size, type and current activity of the bird being fed. Day old chicks (with most yolk removed) may offered as up to 70% of the weekly in take as long it is balanced with another food to give a balanced diet with variety. Whole carcasses should be fed; never remove meat from the carcass and feed that alone. In temporary situations of poor availability, it may be necessary to rely on chick or beef, and at these times, it is sensible to use a supplement. Supplements should have been designed with specific regard to raptor nutrition, and the manufacturers recommended dosages should be followed. Over dosage is not uncommon and can be extremely dangerous. The commonest problem is vitamin D toxicity, which leads to calcification of the kidney and subsequent renal failure.

**Obstructions**

**Casting:** is the indigestible parts of the carcass, which are consumed and then regurgitated as a pellet by raptor. This includes hair, feathers and in some cases (e.g. Owls) skeletal elements. Casting should not be given to any chicks under 12 days of age, and for some species (e.g. the Merlin) not until 20 days of age. This applies in particular to ‘hard’ casting such as rodent fur, whilst chick down is considerably easier to deal with. Young chicks are often unable to cast such material; leading to a proventricular obstruction and death. Clinically a firm swelling may be palpable caudal to the edge of the sternum. Treatment using gut muscle stimulating drugs, oral and parenteral fluid therapy, antibiosis and cautious use of oral liquid paraffin is often effective. If this is unsuccessful, surgery could be attempted, but success rates of gut surgery on neonates are often poor. Breeding females with developing ovarian follicles and a swollen active oviduct may have difficulties with excessive casting due to lack of abdominal space. A normal raptor will produce a casting 8 – 16 hours after a meal. Birds cannot be fed again until they have cast. If this does occur, a small intestine obstruction can arise.

**Inadvertent ingestion of indigestible matter:** On occasions organic material may be consumed with food (e.g. peat, wood shavings or vegetable material) from nest ledges, which the bird is unable to cast. In such cases a gut blockage will occur. Harris’ hawks are the most intelligent of the common captive raptor species. They will at times ‘play’ with materials in their surroundings and can ingest various foreign bodies. One example is that they can learn to untie the knot tethering their leash to the perch. The leash can be pulled free of the swivel and the bird can then swallow the leash which may be later cast or it may necessitate an ingluviotomy. Large foreign bodies may be safely left 24 hours, in the expectation that they will be naturally cast by the bird. Owls, both in captivity and in the wild, occasionally eat very long twigs (on occasions 6 - 8 inches long). The bird may appear inappetant, uncomfortable and miserable.
Sometimes the twig is 'cast', but on other occasions, it may perforate the crop or proventriculus with a grave prognosis. Endoscopic or surgical removal may be necessary. Another form of obstruction seen especially in the larger owls is the ingestion of pea gravel. The bird is presented with a history of having a good weight but marked loss of body condition. Gastric distension by the gravel reduces the bird's appetite and little or no food is ingested. The condition is often advanced by the time of presentation.

**Ingestion of over size food items:** the feeding of rabbit or hare carcasses with intact femurs can cause problems. The bone may pass directly into the proventriculus and be digested. However, in larger raptors the bone may rotate into a transverse position in the crop or stomach. The bone may form an obstruction in the crop or perforate the gut leading to a terminal peritonitis. If the bone is broken (preferably without sharp ends) before feeding the problem does not arise. A similar situation can develop when pheasant or poultry necks are fed whole. The neck usually passes down straight, but occasionally will double over in the crop or distal oesophagus becoming. On occasions, birds will eat uncommon prey items. The most unusual obstruction encountered by the author was a female Red Tailed Hawk (*Buteo jamaicensis*) which had caught and eaten a hedgehog (*Erinaceus europaeus*). Initially the bird was fine, but after 18 hours with no casting, she was presented for examination. Barium contrast radiography confirmed the presence of multiple spines and fur lodged in the proventriculus. The obstruction was successfully removed via abdominal surgery.

**Decreased motility:** Decreased gastrointestinal motility can occur due to gastrointestinal obstructions and infections but also many other diseases. It may occur following over-eating, especially if the bird is in low condition or suffering from any illness. This occurs most commonly when a bird has made it's first kill. The bird may have been reduced in weight to encourage it to 'enter'. Having killed it is rewarded by allowing it to eat a large part of the kill. 'Sour Crop' is a common and rapidly serious manifestation of this decreased motility. Ingested meat is held within the crop being maintained at 38 - 40°C, with no gastric acid or enzymes present to prevent bacterial multiplication. Initial treatment by the falconer for a slow emptying crop is the administration of 5 - 10ml/kg of saline by crop tube. The additional lubrication will often speed the passage of the food from the crop. If this is not effective and the crop is still unmoved after 6 - 8 hours, the bird will require urgent veterinary intervention. Intravenous fluids, antibiotics and non-steroidal anti inflammatory drugs are given. The most urgent action required is to empty the crop. With the bird anaesthetised and the wind pipe entubated, the crop contents may be 'milked back' to the mouth from the crop and removed. However this may be time consuming and traumatic to the patient. It is considered that surgically opening the crop is a more rapid, complete, and lower risk procedure, which also facilitates lavage of the crop with warm saline to remove all unabsorbed toxins. In a critical patient, it may be prudent to close the ingluviotomy on a subsequent day. Every effort should be made to identify possible underlying conditions. Following surgery the bird is given intra venous and oral fluid replacement therapy, gradually moving over to liquid foods once the crop is emptying normally, and finally solid food without casting once the bird is begging for it.

**Feeding in abnormal circumstances**

**Neonates:** chicks are "immune incompetent" for the initial days of their lives. Hygienic food preparation is imperative. In our experience, the best preventive action is to feed a probiotic, for the first ten to fourteen days of life. The probiotic will colonise the gut with helpful organisms thereby reducing the chance of an over growth with pathogenic organisms.
Feeding the bird which is low in condition: casting is not required on a daily basis. If a bird is low in condition, withhold casting, feed half crop of food this may be repeated as soon as the crop is empty, rather than waiting hours for the bird to cast, in this way the bird’s weight and condition can be rapidly corrected.

Feeding the Vomiting Bird: vomiting may arise in raptors because of a whole range of different conditions, all of which require veterinary attention. A bird, which is vomiting, should not be immediately offered more food, even if it is loosing weight fast. The bird should be anaesthetised, diagnostic test performed, an indwelling intra venous catheter placed, and antibiotics, gut motility drugs and fluid therapy administered. If vomition ceases, an hour later 5ml/kg warm oral electrolytes may be administered. If the fluid is kept down, it should be repeated once more two hours later. If that is retained then a further two hours later, a feed with the same volume of a liquidised food (e.g. Hills A/d. Hills UK. Hatfield) should be given by crop tube. This liquidised food is repeated every 2 hours, increasing to 10ml/kg on at least 3-4 occasions. Meat is only offered when the bird recognises it from a distance and demonstrates it is keen to eat it. The first solid food offered should be easy to ‘put over’ and digest e.g. skinned doc.

Feeding the inappetant bird: often one is presented with a bird, which is low in condition, but is inappetant. There are many causes for this scenario. Any mouth (e.g. trichomoniasis, capillariasis, candidiasis), oesophagus/crop (e.g. local irritant, bacterial infection, sour crop, pox virus), stomach (e.g. impaction, infection), air sac (e.g. aspergillosis, air sacculitis, egg peritonitis), major organ failure or septicaemia is likely to lead to a depressed appetite. Some birds do not want to eat on other occasions the bird attempts to eat, but then head flicks and brings the food back. A specific diagnosis must be made and the condition treated. In the authors opinion more birds are saved by appropriate fluid therapy and nutritional support than any other medical or surgical therapy. In cases of oral or cervical trauma a tube placed through the skin of the neck, straight into the crop may be the least traumatic method of maintaining food intake. Care should be taken in maintaining hygiene of the tube.

The bird who is not maintaining weight on it’s normal food intake or not gaining weight on an increased food intake: this is common reason for presentation of a bird by a falconer. As the falconer is weighing his bird daily, minor changes in metabolic efficiency are readily apparent. Frequent cast free meals should be given to increase the bird’s weight, whilst a diagnostic work up is performed.

Feeding birds and travelling: birds should not be fed directly before travelling, in particular if they are not used to travelling. If considering an experienced flying bird, which is used to travelling, known not to suffer from travel sickness, then feeding up after a kill travelling home is acceptable. In other situations, a bird should not be travelled with food in the crop or proventriculus. The bird should have cast prior to travelling. If a bird casts whilst hooded or closely confined in a travelling box it may choke on the casting.

REFERENCES
3. Forbes NA, Parry-Jones J. Management and Husbandry (Raptors) In: Beynon PH, Forbes