Key Words: raptor, bird of prey, falcon, hawk, breeding, reproduction

'Raptor' is a collective term used to describe both diurnal birds, mainly of the order Falconiformes and those which are generally nocturnal, the Strigiformes (owls). Legislation relating to the keeping of birds of prey in captivity varies from country to country and state to state. Any veterinarian treating raptors should be familiar with the local legislative requirements.

The Falconiformes are divided into families that include vultures, the secretary bird and ospreys as well as the more commonly encountered falcons and hawks. It is useful for the clinician to be aware of the difference of life style between the families as this will often determine the correct method of management.

**MANAGEMENT OF RAPTORS IN CAPTIVITY FOR BREEDING**

Enclosures need to be built for the comfort of the birds, and to enable ease of monitoring and management by technicians prior to and during the breeding season. Proper observation allows the use of techniques such as, egg pulling, double clutching, artificial incubation, returning of young to own or other parents, and such other management processes that can be used to achieve successful breeding of birds. Some species will not breed if able to see adults of their own species and many will partake in aggressive territorial disputes with birds in adjacent aviaries if these are too close. Raptors are susceptible to disturbance during the breeding season and may fail to breed or injure themselves in their aviary if there is excessive disturbance. Some birds are aggressive when nest sites are approached. Some pairs will not share a perch until a pair bond has formed, this may take a long time and may only persist for a short period of time (hours or days) immediately surrounding the mating period. Most raptors (see Table 1) demonstrate reverse sexual dimorphism (the female is typically 30% larger than the male), in some species the female is aggressive towards the male. In such cases the male may need to be kept in a separate aviary adjacent to her aviary, and only permitted together at the
receptive period, and then immediately separated again (e.g. Northern goshawk Accipiter gentilis)

**Choice of species**: - The right native or non-native species, with the ability to cope with local regional climates, will survive and breed better. Enclosures should take into account the natural climate of the species they house. For example, African vultures are very susceptible to frostbit, as are the tropical species of New World Vultures. Enclosures should be designed to give more than adequate shelter for each individual bird, and for young on nest sites. Most breeding raptors, require individual territories, i.e. separate aviaries for each potential pair. Breeding aviaries should be designed to avoid extremes of weather (wind, rain, and sun). **Pinioning or wing clipping is totally unacceptable for raptors, it is outdated and inappropriate.** Raptor aviaries must have an enclosed top. Enclosures should be roofed with weatherproof material so that birds have more than adequate shelter and nest areas are completely covered far enough out to prevent rain or snow blowing in. Roofing material used should prevent excessive build up of heat in the summer or condensation in winter - steel, tin and large areas of transparent roofing material are not suitable. Concrete fibre roofs, or bitumus sheets both have good insulating properties and cut down condensation to a minimum. Transparent sheeting may need to be used to give extra light; these sheets are better placed away from nesting areas. Enclosures should be designed to encourage good ventilation without permitting drafts. Air vents in the roof of the service passage can help if designed correctly, make sure they are not large enough for birds to escape. Chicken wire is a highly unsuitable medium for raptors and does them physical damage if they fly into it. Chain link as roofing material has been known to kill birds that have managed to catch a flight feather in one of the twisted links. Welded mesh is the most suitable, with a hole diameter of 2" being suitable for all but the small raptors, such as Kestrels, in which case 1" x 1" is small enough. Very small mesh (1/2 inch) should only be used for the tiny raptors such as Merlins, American Kestrels or Pygmy Falcons, as larger birds can catch a talon and become entangled on the wire, or injure toes.

Raptors settle better if they are able to perch at height. High enclosures should also be long enough for birds to manoeuvre. When designing aviaries one must remember the necessity to catch birds on occasions in an atraumatic manner.

Breeding aviaries should have at least two solid sides, preferable with a service passage. This enables monitoring and feeding without disturbance. Nest ledges or boxes should be placed on these solid walls with permanent access ladders, upper corridors/passageways in place, access doors, viewing panels, spy holes or CCTV to enable observation to enable breeding management techniques. Access doors should be large enough to allow easy access for wheelbarrows and keepers - 1m x 2m makes for safe and comfortable entrance for keepers. There should always be a double door system.
If birds become nervous or territorial during the breeding season or at any other time windbreak material stretched taut (be careful a bird cannot get caught up or stuck in or behind it), or vertical battens (e.g. electrician conduit piping) applied parallel inside the wire, to create an additional barrier inside the wire to avoid self trauma.

**Substrate:** plants in aviaries can provide useful cover for birds which are being chased or bullied. These are planted in pots and either buried in the substrate or placed where they can be watered from outside. Aviary floors should be as clean and dry as possible. Birds, which have to constantly land on cold, wet, muddy floors will eventually suffer health problems. This is especially relevant to vultures, caracaras and Secretary birds, which spend much of their time on the ground.

For breeding enclosures, a concrete base, sloping for drainage, covered in at least four inches of sand stops vermin from digging, is easy to clean and keep hygienic. In case of infectious disease, sand can be removed, concrete disinfected prior to sand replacement.

Wood chips or bark (unless sterile) are not recommended as they can support *Aspergillus* spp growth.

Aviaries should also be furnished with a range of perches, nest areas, retreats for some species, baths and feed ledges.

**Perches:** Perches need to be suitable for the species in residence. Secretary Birds unless housed in huge enclosures are unlikely to perch other than on the ground, so low tree trunks, large rocks and stumps are sufficient. Vultures, both Old World and New World do not have feet that grip well, so they require large, non-slip perches with plenty of space for landing. As vultures tend to squabble, sufficient high perches are recommended. There should be sufficient space round the perches for very big birds to land safely from a height. Eagles require large branch type perches, with space well in excess of their wingspan to land on such perches, in order to avoid feather and wing damage. Large falcons need forgiving surfaces, ledges of rock, large diameter branches, half round wooden ledges covered in cocoa matting or artificial grass matting will all assist in making the birds comfortable and minimising the risk of foot problems. Swing perches (which move when a bird lands on them), minimises the force of impact and hence reduces foot trauma. The buzzards, hawks and small raptors will all do well with a mixture of low and high tree type perching, including rope swing perches.

Perches of differing diameters, from wide to narrow, with a variable surface texture will provide valuable gripping exercise for the birds as well as reducing the chances of plantar pedal pressure necrosis (which leads to bumblefoot). Perch surfaces require regular attention, replacement and cleansing. Changing of the perches appears to give mental stimulus to raptors. When considering the sighting of perches, the ease of cleaning, as well as the potential to soil food and water supplies should be considered. Wooden branch type perches placed across corners is poor practice, apart from the
build up of droppings on walls, flight feathers can be damaged as birds fly into
the corner. Perches sited away from walls make for better visibility, cleaner
enclosures and better feather condition. Good perches with plenty of branches
should be placed close to nest areas so that young birds have a place to hop
to once they become active.

**Nest areas:** some raptors prefer to nest on ledges, some in trees, others in
holes or cavities, a very few nest on the ground. By checking the nesting
requirements of individual species in good reference texts, it is easy to provide
for specific breeding needs. The tree nesters will usually use a nest located on
a ledge in place of a tree. In captivity, the size of the nest area is important
and optimism should be taken into account when building a ledge or box.
There should be sufficient area to house both parent birds and the highest
likely number of young with ease. Extensive nest ledges allows pairs to
choose a nest area at different points on the ledge, room for adults to display
without getting too close to one another in the early, sensitive stages of
courtship. It gives sufficient space for developing young to grow, practise wing
flapping and play. It also gives room for keepers to get onto the ledges out of
season and clean them properly.

Nest boxes are a minimum of 18" square for small birds, with an access panel
at the back for monitoring, egg removal, replacement of young birds, ringing of
young birds etc.

All nest areas should be easily monitored with the minimum of disturbance and
easily accessible to facilitate the removal or replacement of eggs and young.
Spy holes or one way glass are essential if captive breeding is a serious
intent, access doors should be incorporated in any nest area.

Nest substrate should be soft in view of the inherent fragility of eggs. Some
groups of raptors, (e.g. falcons), do not build a nest, but like the owls, dig a
scrape (depression) in the substrate on the nest ledge and lay their eggs in the
hollow. As some individuals can dig quite a deep ‘scrape’ the substrate needs
to be at least 15-20cm deep. The ledge supports must be capable of safely
supporting the weight of the substrate, nest and family. Sand or pea gravel is
the best nest substrates. Wood chips, peat, hay, straw or other vegetation are
all dangerous in terms of harbouring infection (*Aspergillus* spp) or for
accidental ingestion by adventurous inexperienced young feeders. Even for
those other species that build their own nests, a soft under carpet of sand will
stop eggs being broken if nests are poorly constructed by the birds. Nest
ledges must have raised edges as eggs are unforgiving when dropped from a
height or used for football practice. With species, that prefers nest boxes (e.g.
kestrels), a choice of nest boxes (size, position and opening) is advantageous.

**Baths:** although birds of prey do not regularly drink, they all do at times, in
particular when young, in hot weather or if ill, so there must always be clean
fresh drinking and bathing water available. Baths should be easily accessible
for cleaning and maintenance preferably from outside the enclosure. Baths
should be large enough to enable bathing, but shallow with a non-slip surface.
Baths need to cleaned out at least once a week and up to three times per
week during the summer months. In hot weather or climates, disinfectant may be added to the water to prevent bacteria or algae blooms.

**Feed Ledges:** it is preferable to feed birds from a service passage. A ledge, or sliding drawer for food, out of the sun and weather and easily removable for cleaning is recommended. If food is not consumed, this is readily apparent and can be easily removed. Dropping food onto enclosure floors encourages vermin and should be avoided. If food drawers are placed underneath nest areas, they are less likely to be soiled. More over youngsters will only see food arrive when delivered by the parents.

**Maintenance:** for birds of prey to breed successfully in captivity a certain amount of privacy should be provided. Cleaning enclosures on a daily basis can cause disruption, disturbance and stop birds from 'owning' their territory, which may result in breeding failure. Before the breeding season, a twice-weekly cleaning routine is well tolerated. Once egg laying commences, enclosures are not entered until the young have hatched. The removal of a nest area after breeding and replacement (or provision of building materials) prior to breeding season can act as a stimulation for breeding.

**Aviary Sizes:** although it is surprising that some species have bred in captivity in relatively small enclosures, it is generally accepted that sufficient space to exercise as advantageous. Shown in Table 1 below are advised aviary sizes.

<table>
<thead>
<tr>
<th>Bird Type</th>
<th>Wing Span</th>
<th>Aviary size</th>
<th>Aviary height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eagles / large vultures</td>
<td>2-3m</td>
<td>8m x 8m</td>
<td>6m</td>
</tr>
<tr>
<td>Buzzards, kites, large falcons, small eagles, hawks</td>
<td>1-1.75m</td>
<td>7m x 7m</td>
<td>4m</td>
</tr>
<tr>
<td>Small falcons, small buzzards, small kites, small hawks</td>
<td>0.5-1m</td>
<td>4m x 4m</td>
<td>3m</td>
</tr>
</tbody>
</table>

**NUTRITION OF BREEDING RAPTORS**

Birds of Prey are carnivorous and are generally content on a diet of dead meat. A varied food intake (rather than a single food type) is recommended, it may be more stimulating for the birds and less reliance on one food type reduces problems should that food type become unavailable. A varied diet reduces the chance of mineral or trace element deficiencies.

The main food fed to birds of prey in the UK is hatchery waste - (dead day old cockerels of either chickens or turkeys). These are culled as they are not needed and are available, sold frozen from several suppliers. Although these are fine for the birds and give a nice sized food parcel for most, they are inadequate as a sole food source. Any avian derived food (day old chicks, quail, pigeon) carry a greater risk of food borne infection (e.g. Adenovirus, rotavirus, _E coli_, _M avium_, falcon herpes virus, _Salmonella_ spp. etc.) than if mammalian derived food is used\(^1,2,3\). Although many species bred happily on this diet, it must be appreciated any diet different from that normally consumed...
in the wild, could have a negative effect on breeding performance. It is shown that by changing the source of food, (or even just changing the diet that the normal food species has been fed on), changes the essential fatty acid content of the egg yolk produced by the breeding hen, which can have a negative effect on breeding. Studies show that breeding female raptors have a significantly higher protein, higher mineral but lower fat content than non-breeding females. Raptors may be defined as 'capital breeders' (those who fuel reproductive expenditure from foods eaten before laying) in relation to protein and minerals (especially calcium), but 'income breeders' (cover reproduction expenditure by feeding during breeding) in relation to energy requirements. For this reason if 'egg pulling' or 'multiple clutching' are to be used, (as methods of maximising reproduction - see later), as soon as the first clutch is completed, captive bird diets should be supplemented with increased mineral (especially calcium and vitamin D) and protein levels in order to prepare them for the additional (unplanned by the bird) egg laying. Quail, rats, mice, guinea pig, rabbit, beef or horse, may all used in a mixed diet for birds of prey. If meat (beef or horse) is used for more than 10% of the birds diet, unless a calcium (+ vitamin D) supplement is provided the diet will be calcium deficient. At all times a 'complete carcass' diet should be fed. Food should always be as fresh as possible, even if from frozen stock. Much supplied frozen food has already been in store for several months prior to supply, frozen stocks must be rotated to limit storage times.

Wherever possible the food fed to captive raptors should as closely resemble that consumed in the wild. Even so a diet consumed in the wild will always tend to be more varied although there is an argument that a captive bird's life style differs greatly from a wild bird and that the diet should be adjusted accordingly. Tiny species such as Pygmy falcons (Polihierax semitorquatus) should be fed predominantly insects, if larger food items are used, these should be skinned and cut in half. Although fresh food is generally more palatable, pigeon should always be frozen and thawed prior to feed to eliminate any Trichomonas spp. Freezing will not destroy falcon herpes virus, which is often carried by pigeons. Gyr falcons and merlins appear particularly prone to falcon herpes virus, and feeding pigeons to these species should be avoided. There are many other risks associated with specific foods, which are beyond the scope of this paper.

Vultures, when given a large feed may well take longer than 24 hours to put over their crop. Under normal circumstances, it is beneficial to give them a couple of days per week where they are not fed. However when birds are rearing young, food cannot be withheld so smaller regular meals are preferable.

Birds of prey should be fed once daily (preferably in the morning), in very cold weather it is beneficial to feed smaller raptors twice a day. Some species, such as the falcons, fed an increasing protein level prior to breeding appear to gain a higher fertility. Increased levels of dietary vitamin E prior to the breeding season may be beneficial to male fertility. The highest levels of vitamin E are found in day old chicks (40.7 IU/100g DM), compared with 10.1 in vitamin E enhanced quail, 5.9 in 12 week mouse or 21 in weaner rats.
Care must be taken leading up to the breeding season, that excessive casting (indigestible fur or feather) material is not fed to raptors, in particular females. Birds will cope with 'casting' as found on hatchery chicks, but not necessarily a sudden switch to larger volumes of courser casting such as rodent fur. In view of the increasing coelomic space occupancy by the swollen oviduct and follicular development on the ovary, casting can build up in the proventriculus and the bird is unable to be safely regurgitate it.

During courtship smaller feeds given more often (4-8 x daily) can lead to increased food passes between the male and the female. As the female recognises the male as an improved food provider, so an enhanced pair bonding and breeding follows. Reducing a pairs body condition prior to the breeding season, then gradually increasing it also seems to lead to an improved breeding performance. Feeding parent birds at least twice a day once young are hatched is vital. Probiotics may be fed not only to hand reared chicks but may also be given to birds feeding their own young, reducing disease and possibly enhancing growth rates.

To maintain aviary cleanliness, it is best to gut rabbits, rats and quail before feeding them to raptors. The wings and feet are cut off dead quail, the feet from rabbits and the tails from rats, which also helps keep avaiaries clean. Uneaten food should be removed except where there are growing young. Old food should be removed from aviaries daily in a manner to avoid disturbance.

With the exception of insect feeders, live food should not be fed to birds of prey. In the UK it not only unnecessary but also illegal.

**SOCIAL STRUCTURE**

A few species of birds of prey are colony nesters such as some of the vultures, Sooty Falcons (*Falco concolor*), Lesser Kestrels (*Falco naumanni*) and so on, and some will feed in-groups, (e.g. the vultures and some eagles). Nevertheless birds of prey generally are not gregarious and do not tolerate other species of their own kind with any degree of ease. Birds of prey do not have much of a social structure, other than single birds pairing up either just for breeding or for a life mate. Some species, such as the harriers are polygamous during the breeding season, with males pairing with up to three different females and providing for three families, however to achieve this in captivity would require very spacious enclosures. Apart from Harris Hawks (*Parabuteo unicinctus*) who do have a social structure in the wild and older young will often assist in the rearing of siblings; the American Black Vultures (*Coragyps atratus*) who appear to have a social role in roosting and feeding habits; and the Daptrius Caracaras who hunt in groups and also breed in groups; most other raptors have no bond to hold them together once young are considered independent of parents. Some species do not even stay together as a pair for the whole year, but instead split up after the breeding season and pair up again, barring accidents, the following spring. Many of the smaller species may not even be mate faithful.
Changing Group Structure.
Once young birds are fledged they should be caught up quickly and either dispersed to their new homes or put in groups in a separate aviary. In captivity, juvenile birds can sometimes be left in groups until they reach adult plumage, although they should be monitored for signs of bullying. Some parents will tolerate juveniles they have reared for some time, even up to the young achieving adult plumage, however this may prevent further breeding by the parents. Stress can cause bullying and even injury to one or other of the birds, often resulting in a speedy despatch and cannibalism.

Imprinting: if totally natural breeding is intended, then it is very important that youngsters to be used later for breeding should be reared naturally by parents of their own species. If not they will not react (pre-courtship behaviour) correctly with their intended mate and breeding will not occur. If the breeders chosen breeding methods will involve significant human intervention during the breeding season, young birds (intended for breeding), are best reared by an 'imprint female' (i.e. one who thinks she is human, such that she is not phased by close human contact, and passes on her experiences to the young. Alternatively 'social imprinting' or 'crèche rearing' of young may be used, where chicks are hand reared as a group (hence maintain their normal bird behaviour, do not become imprinted and still relate normally to others of their own species), but are not upset by regular human handling.

If you want to breed hybrids naturally, the chicks should be reared together from hatch.

On the death of one of a pair, new mates should be introduced well outside the breeding season and the bereft mate should be given time to recover from the loss. Some birds will never find the right replacement mate; others will pair up with the first option offered.

For the keeping and breeding of the true Accipiters specialist reading is suggested prior to building enclosures and structuring management plans, as their requirements are very different and complex.

BREEDING

Mating: some raptors are aggressive, to extremely aggressive, when in breeding condition. Aviaries should be entered with great care and feeding carried out from outside especially if pairs are showing territorial or breeding behaviour. In most species the female will stop going to collect her own food and will allow the male access to food first. She may call to him for food, she may chase him begging for food, she may, if he does not get the idea, or is unresponsive, take food from him whether he wishes it or not. This is when pair bonds can be seen to form. If males are not giving the responses that the females expect, she may turn on the male and start chasing him, terrorising him, even injure or killing him. If a male is showing signs of fear, injury or unacceptable levels of stress he should be immediately removed. If the male bird is always seen to in a low perching position in the aviary, a problem
should be considered. Although, in view of her larger size the female is usually the more aggressive, it does not follow that the female is always dominant. On occasions she can be the one showing signs of stress and needs to be rescued. Considerable experience is required in assessing pair behaviour. Food passing, nest building, copulation, calling, all of these are a fair indication that breeding attempts may be made. Mating can occur at anytime, it may be very obvious to the onlooker, it may never be seen, even by those monitoring the enclosures, unless CCTV is used. There is little that can be done to encourage mating except putting the birds in the right surroundings, preventing disturbance and hoping for compatibility. Some birds breed readily, others never breed in captivity. Higher quality food (increased mineral and protein levels) prior to the breeding season may stimulate breeding activity.

In the wild state falconiformes breed at greatly differing times of the year depending on the species, food availability, altitude and weather conditions. Similarly in the captivity different species come into breeding condition at different times of year. Monitoring of newly paired birds should continue throughout the year until breeding seasons are established.

Diurnal birds of prey mature at various differing ages (see Table 2). Placing younger birds in with older birds (especially experienced breeders) can bring a younger bird into breeding condition at an earlier age than anticipated.

### Table 2. Biological Data

<table>
<thead>
<tr>
<th>Species</th>
<th>Fennec</th>
<th>Goshawk</th>
<th>Common Buzzard</th>
<th>Cooper's Hawk</th>
<th>Ferruginous Hawk</th>
<th>Northern Harrier</th>
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**Breeding Methods**

Historically birds of prey, required for the sport of falconry, were caught from the wild. Birds were often released back to the wild at the end of the flying season. This continues in some areas of the world, but in many other countries this is illegal and birds must instead be bred commercially. The captive breeding of raptors has evolved over several decades, such that greater numbers, of improved quality of pure bred and hybrid birds of prey are now produced. The development of expertise has been catalysed by conservationists as well as commercial producers supplying birds to the lucrative Middle East market.
Natural Egg Laying and Incubation.

**Eggs:** all falcons lay brown speckled eggs, the caracara’s (being closely related) do similar. Other raptors lay varying colours of blotched white, buff, or greenish blue eggs. The colour tends to become paler to non-existent as each subsequent egg is laid. The last egg in larger clutches of falcons eggs may be almost white. Most birds of prey lay an egg every other day (every 48-50 hours), although larger birds such as eagles can have an extended interval (72 hours). Egg lethargy (females become lethargic and may look ill just before egg laying is considered physiological - (interference can be very detrimental) must be carefully differentiated from egg binding (a pathological condition requiring rapid intervention). Females seen sitting on the ground for an excessive period, rather than perched or on the nest area, should rouse suspicions. Handling of females that are imminently to lay as well as those suffering from egg binding should be undertaken with extreme care. Sudden bouts of cold weather (particularly in aviaries exposed to prevailing winds), disturbance, stress or shocks may result in egg binding. In the event of a clinician treating an egg bound bird, it should be remembered that the application of any lubricant oil to the egg will render it infertile, as does any form of trauma. There are situations where the 'bound' egg alone is of considerable value. In such circumstances, the egg may be removed by salpingohysterotomy, if naturally delivery following medical intervention is unsuccessful. Keepers should start to monitor nest sites some time before egg laying is anticipated, so that pairs get used to the noises associated with nest monitoring. Many of the falconiformes do not incubate from the first egg laid, so unless the nest site is checked daily, the date of first egg lay is unknown.

**Maximising Egg Production:** rather than just leaving a pair of birds to produce one clutch (of fixed size) in a season, eggs or clutches may be 'pulled'. If as soon as a hen lays the first egg, it is removed, instead of her just producing her predetermined clutch size of 4-5, she may lay additional eggs (in her attempt to complete a clutch of 4-5 eggs in her nest). This process may be detrimental to the hen, which was designed to lay just 4-5 eggs in a season. The hen may suffer hypocalcaemia, and each successive eggs tends to be marginally smaller, with lower yolk size, chick hatch weight, immunoglobulin and mineral content. Alternatively, a hen may be permitted to lay her full natural clutch. She is permitted to incubate the clutch for 10 days, at which point the whole clutch is removed. The hen will then normally 'recycle' and produce a second clutch. If the clutch is 'pulled' earlier, hatchability will be lower, if it is 'pulled later'; there is far less chance that she will produce a second clutch. All raptor species bred in captivity can recycle although some individual birds will not. Usually when the first clutch is removed, they will be transferred to an incubator (or a foster hen). If incubator hatched, when the chicks are 8-9 days old, they will be returned to the hen, which in turn will have completed laying a replacement clutch some 10 days earlier. At this point the hen is permitted to rear her first clutch, as they fledge, the second clutch are hatched and returned to her for rearing. If the natural mother is young, inexperienced, a poor rearer or of great value, an older more
experienced foster rearer of same species or the same or similar sized species may be given the task of bringing up the young.

**Manipulating Chick Quality:** apart from natural breeding, artificial production is now also widely used. Human imprinted birds (i.e. those who believe they are human - both male and female) are used in artificial breeding. The benefits of artificial breeding in raptors are similar to those in the cattle industry. Hybrids (many of whom are fertile) can be produced, and the semen from birds of particularly desirable colours, sizes, flight ability or temperament may be spread around between a number of females, so maximising the production of birds with these desirable traits. The aims of hybridisation, is to produce a bird which flies better, faster, more aggressively than either pure bred species would. The production and free flying of hybrid falcons is a contentious matter, and is banned in some countries.

Imprint birds are reared by hand, a close bond forming between rearer and youngster. As the bird reaches sexual maturity, the keeper will start to mimic courtship behaviour - encouraging the bird to make sexual advances to himself. Imprint birds are maintained in smaller aviaries (2.5m x 2.5m with 3m height for a falcon up to 1.5 kg. In this way when the keeper enters the bird's aviary, he is automatically entering the birds own private territorial space. By doing this continually, the bird is not frightened or phased by the proximity of the keeper.

**Semen Collection:** the best quality semen is donated voluntarily, either during natural copulation, or by copulation with another object (which the bird has been previously trained to use [generally a hat, knee, cushion or glove]). Natural copulation only takes 10-20 seconds but may be repeated up to twice every hour during the breeding season. Birds tend to copulate more in the early morning and during warm or mild weather. Early season semen is often of poor quality. Male larger falcons (e.g. peregrine, saker and gyr) start to produce semen in their second season but reach peak production by their fourth season. The 'conditioning' of a male semen donor is very time consuming, as a genuine breeding relationship must be forged and maintained through out the season, between bird and the same keeper. If you can persuade a male to donate for you, then you personally need to be present for collection at least three times a day through the breeding season (usually at least 6 weeks). With out you, the bird will stop producing semen. A good voluntary donor is invaluable, but a breeder should never rely on one donor alone. If a male will not donate semen voluntarily, he may be 'stripped', although this does require considerable experience as well as a good working knowledge of male avian anatomy and tends to produce inferior quality semen. Considerable practice and experience is required to achieve this in an effective and atraumatic manner. The bird is wrapped in a light towel, placed on its back, one finger is placed dorsal to the tail, whilst another is placed ventral to the pygostyle and the tail is elevated, to evert the cloaca. Very gentle pressure is applied from a cranial to caudal and ventral to dorsal direction, in a firm stroking action, just lateral to the cloaca, until a bead of semen wells up in the everted cloaca. This is collected with a sterile pipette. No one should attempt this technique on a falcon until they have observed it
being performed and practised on a cockerel or other obliging larger bird. The
bird should not have been fed for 12 hours prior to stripping, otherwise faecal
contamination of the sample may arise.

Electro ejaculation has also been used in birds (including raptors). Two
electrodes re used, each is lubricated with KY gel. One electrode is placed in
the coprodeum, the other is placed against the skin dorsal to the kidney. The
aim is to create a small electrical stimulation from the testes to the ductus
deferens. The ducts will briefly contract extruding any semen, which is
present. The voltage used varies from 3-5 volts AC, 3-10mA (for a 200g bird),
up to 15-20 volts and 10-20mA for a bird up to 1.5kg. However, by the use of
imprinted voluntary donors this technique is very rarely used in raptors.7

Semen handling and quality: all utensils used for semen handling should be
warm and sterile. Once semen is collected (typically10-50uL), it is mixed with
semen extender in a 1:1 ratio. Many breeders use their own extender recipes;
one commercial extender used is Beltsville chicken extender. Semen may be
checked for quality. The gross appearance of raptor semen is similar to a
small drop of watered down urates. Samples should be checked for
contamination with faeces, uric acid, and yeast. If examined under 400
magnification, following dilution with extender, vigorous movement should be
evident with approximately 100 spermatozoa per field. Live versus dead
counts may be achieved with eosin nigrosin or propidium iodine stained slides.
Sperm morphology may also be checked. Semen is best used fresh
(especially stripped semen), although a good quality sample (typically
voluntarily donated) may still be viable following for up to 60-72 hours if
refrigerated (at 4°C). Chilled semen should be gently warmed prior to use.
Regular sperm collection is necessary (even if the sperm is not required) in
order to ensure the male keeps producing good quality semen. Cryopreservation has been successfully achieved with a small number of
raptor species.8,9,10,11 The benefits of cryopreservation are that it can be used
to maintain heterozygosity in small populations (especially where they are
geographically dispersed), it can be used to over come sexual incompatibility.
More over in globally threatened species, gene material can be collected from
a wild male in order to enable captive propagation, without necessarily having
to remove it from the wild. The technique is still in its infancy, but has
significant benefits, in particular when dealing with endangered species, or
where male and female originate from different time zones, such that their
breeding seasons do not coincide. Research has been under taken to assess
the inherent tolerance to freezing of semen of a number of raptorial species.12

Insemination: fertilisation of the ova occurs prior to addition of the albumen
and shell membranes. Although good quality semen may survive up to 12
days in a raptors oviduct, it is difficult to evert the oviduct for forced inseminate
prior to the start of egg laying. Thus, it is difficult to forcefully inseminate a
female prior to arrival of the first (and hence infertile) egg. Most raptor hens
lay an egg every 48 hours until the clutch is completed. If she can be
inseminated within 2-4 hours of egg laying, the following egg may be fertilised.
It is only safe to forcefully evert an oviduct in the first 12 hours following egg
laying (as later the next egg will be far down the oviduct for it to be safely
everted). If inseminated within the 4-12 hour window following egg laying, the next egg will be missed, but those following may well be fertilised.

Rather than forced oviduct eversion, it is preferable to use an imprinted female who will stand for voluntary copulation. Here the semen is placed onto the hens partially everted cloaca. As the semen is not placed direct into her oviduct, more may be wasted. Frequent small inseminations are preferable (3-4 daily) in order to ensure high fertility. To achieve this a voluntary donor must be active, but the benefits are that no stress of handling is required of male or female bird. Moreover, it can be carried out at any part of the ovulatory cycle. Fertility achieved by artificial insemination is generally far lower than natural breeding; it is also far more labour intensive (before as well as during the season), however in experienced hands it can produce good results.7,13

Breeding season: the breeding season is triggered by a number of factors, e.g. temperature, food availability, nest site or mate availability, however it is the changing day length which has the major effect.14 Light is detected through the eyes but also via the pineal gland via the frontal bone. Where a species of bird has a naturally extended geographical range, different individuals may come into breeding condition at different times, even when housed together in the same aviary. Potential solutions are either to manipulate the day length for one bird (although this is difficult to achieve reliably), to have fresh or frozen semen available for artificial incubation, or to find an alternative mate.

Natural incubation, egg manipulation: established, experienced pairs of birds are perfectly capable of incubating, hatching and rearing without assistance. However young or inexperienced pairs may need some assistance in the first few seasons. With endangered or valuable species it is not advisable to leave the whole process to inexperienced parents as many things can go wrong. Some birds are naturally clumsy with eggs, if signs of this occur, undamaged remaining eggs should be removed and if a second clutch is not required, dummy eggs can be substituted for the parent birds to continue incubating (so that chicks can be returned later). Falconiformes are unlikely to accept young if they have not been sitting on eggs. Turned, wooden eggs make excellent replacement dummy eggs. If allowing birds to achieve the whole breeding cycle on their own, eggs should at the very least be checked for fertility after the first ten days of incubation.

Egg retrieval, candling, egg returning: two people should be present when eggs are removed from a nest. One person, with a net should gently fend off, or remove from the nest the incubating female. The female will tend to be the more aggressive bird during incubation. Care should be taken to make sure that in defending the nest, the female does not damage her own eggs. Both keepers should wear gloves, jackets and on occasions helmets to prevent damage from either parent. The second person, (protected by the first, should pick up each egg (wearing sterile gloves and gently turn the glove inside out over the egg and place each egg - into a clean, lined secure container, ensuring that the eggs are secure and placed pointed blunt end down (i.e. air cell up). If the candling of the eggs is going to take more than a few minutes, then dummy eggs can be left in the nest. Returning eggs (once candled)
should be done in the same manner, with two people, one to concentrate on the birds, one to manage the eggs. Once eggs have been returned the enclosure should be left well alone to give the birds time to settle. Most commercial egg candlers will give out enough light to candle all but the densest of raptor eggs. Gentle handling of eggs is vital as knocks or jolts can damage internal membranes and effect egg viability. Hands must be clean and disinfected. Eggs should not be exposed to the light from the candler for more than 5-10 seconds (less critical if a cold light is used). The date of incubation at which fertility can be determined is governed by the degree of pigmentation of the egg, the strength of the light and the experience of the candler. Fertility in most falcon eggs can be determined at 5 days. If eggs are fertile and the pair is to be allowed to hatch them naturally then the clutch should be returned to the pair as soon as possible. If the eggs are infertile then by failing to return the eggs (at an early stage on incubation i.e.10 days), the female is likely to recycle, so that the breeding season is not wasted. Most small to medium sized species of falconiformes will start to recycle at two to three weeks after the eggs have been removed. The larger species, such as the eagles, don’t recycle for a month or more. Recycling is an individual thing and some birds may not recycle, but if the first clutch of eggs was clear, nothing is lost. If recycling might be required, the eggs should not be left with the parents for longer than 12 days before removing or candling as beyond this stage the desire to replace a lost clutch is reduced.

If clutches are fertile, but the pair are young or inexperienced and have never reared, it is advisable (if experienced) to artificially incubate the eggs, or let broody hens (if less experienced) do part of it. Do not let broody hens hatch eggs, as they are liable to kill young raptors. Once hatched, young can then be hand reared for a few days before returning to the parents. A slightly older, stronger and more experienced chick is easier for the inexperienced parent bird to manage. Alternatively, if young from a suitable, less vital species are available; they can be used as foster young to see how the new parents cope. If coping well, their own youngster can be substituted or even added to the clutch, depending on the species. Many of the eagle species suffer from cainism in the nest with the first hatched young killing the second hatched. Careful management can avoid these unnecessary deaths. By removing the second (and third if there is one) egg after two weeks of natural incubation and hatching artificially, deaths are avoided. The young can then be switched at five day intervals so that all young benefit from some natural rearing as well as episodes of hand rearing, until the danger point is past (usually at about two and a half weeks old) after which stage all the young can be returned to their natural parents.

During natural incubation nests should be monitored daily to check incubating birds are well and eggs are not broken. A moment of listening may tell the keeper when young have hatched as they can sometimes be heard calling. It may be necessary to have two people approach the nest site and leave one silently there while the other walks on. This may give the chance to see the eggs, but some birds are very loath to leave the nest, if they believe anyone is watching or listening. Checking at feeding times can be useful.
As all pairs of birds are different, common sense should be used to access each pair and decide on the best course of breeding management. Without doubt almost all species of eggs have a higher percentage hatch if the eggs have some natural incubation in the first week to ten days. This does not necessarily have to be by the parent bird. Well-managed broody hens can successfully incubate eggs from all but the smallest of species. The hens must be kept in very clean dry conditions and be used to being handled during incubation.

**Egg storage:** raptor egg storage is not recommended unless absolutely necessary. Egg hatchability will decline after a few days. If stored at all this should be done in a dry stable room, at 60°F with a relative humidity of 75 - 80%. The Peregrine Fund have had good success storing eggs for short periods with the air cell (large end) uppermost with at least twice daily egg turning through 90 degrees.  

**Incubation**  
Scientific study on raptor incubation is still scant. Raptor incubation varies greatly from poultry and game birds. Incubation generally doesn't commence (species variation exists) until the third egg is laid, although parents may sit eggs lightly in extreme weather to prevent them freezing etc. Once incubation commences, the first third is the most critical period. Regular gentle turning as well as correct temperature and humidity is essential. Raptors do not naturally leave there eggs uncovered for extended periods (whilst parents forage etc. as poultry do), instead the average swap over (as both parents may incubate eggs) period is no greater than 3 minutes. Thus, it may be inferred that raptor eggs have never had to adapt to periods of cooling and so are more likely to be adversely affected by cooling (especially in the first third of incubation). Whether eggs are to be naturally or artificially incubated, there should be no break in incubation. It is important that provision is made for incubator or power failure and that disturbance of natural incubation is avoided.

**Foster incubation**  
Bantams and other fancy fowl may be brought into lay and hence incubation early in the season by artificially lengthening their day length (to 14 hours a day as from January 1\textsuperscript{st}. Such hens should then be available to incubate eggs from March 1\textsuperscript{st}. Bantams used for foster incubation should be young (less than 3 years old), as the risk of *M avium* is less as well as being sourced from an *M avium* free flock.

**Incubators**  
There are many different commercial incubators on the market. Familiarity and consistency with the make of incubator is vital. The instruments used to measure the temperature and humidity must be accurate. For the serious breeder, at least four incubators should be running during the breeding season. Each incubator may be ran at a different humidity, thus allowing eggs to be moved from one stable environment to another to achieve the desired daily weight loss. One should be used solely for hatching. If dealing with a large variety of species, different incubators may be required to cope with
widely differing egg sizes (as rates of weight loss during incubation will vary in relation to egg size). If artificially incubating eggs, candling should be conducted at least weekly so that dead or infertile eggs can be removed before they endanger vital eggs. An ‘all in’, ‘all out’ regime with incubators, with re-sanitation prior to re-use should be maintained. Incubators should be maintained within a room, which does itself have a relatively constant temperature and humidity and is not a thoroughfare. Incubators and the room containing them should be totally sterilised and cleaned prior to the breeding season. Incubators should be turned on at least a week before they are required to hold eggs. Incubators take at least 48 hours to stabilise at the correct temperature and humidity. Thermometers and hygrometers should be calibrated and cleaned. Incubator rooms should be kept as clean as possible at all times. Water containers and any other equipment used in incubators should also be sterilised. This cleaning process should be repeated at very regular intervals during the breeding season. General cleaning of the room - surfaces wiped etc. should be performed daily. However, if fumigation is to be the method used for disinfecting, viable eggs should be removed from the incubation room while any fumes are present. Keepers and any other living creature must also be well away from fumigation sites. If the incubator room has windows care should be taken to ensure that sunlight does not fall on the incubators at any time. A blind at the window will protect incubators from overheating due to direct sunlight. Maintaining an incubator solely for suspect eggs is useful.

**Egg Handling**

Regular egg turning is vital especially in the first trimester. Most commercial incubators turn the eggs up to 24 times per day. If hand turning eggs or candling eggs, they should only be turned slowly and gently. Quick, sharp movements when turning can damage eggs. Eggs should only be turned 180 degrees. Mark eggs on two opposite sides with arrows facing one another and only turn the egg the way the arrow showing points, until the other arrow is uppermost. Eggs are turned from side to side, not end over end.  

**Position, temperature and humidity**

Raptor eggs have been hatched in incubators at varying temperatures, but the most used and seemingly successful is 99.5°F. (37.5°C) with a relative humidity of 30 to 35%, however this will need to be changed if an egg is either loosing too much weight, or insufficient weight. The most accepted weight loss is 18% of the fresh egg weight by the time they hatch. Fifteen percent of this weight loss should have occurred by the time the egg has pipped.

The most difficult part is to measure the fresh egg weight (FEW). Unless each egg is weighed as it is laid, it is impossible to know the FEW of a clutch of eggs that is removed from parents after any period of natural incubation. A formula from the Peregrine Fund has been determined Burnham refining that of Hoyt. By measuring the egg (Several times in differing areas as no egg is perfectly symmetrical) both the length and breadth with callipers, the following formula can give and estimated FEW.
\[ W = Kw \cdot (LB^2) \]

Where:
- \( W \) = fresh weight
- \( Kw \) = observed coefficient for peregrine eggs \((0.0005474)\)
- \( L \) = Length of egg (mm)
- \( B \) = breadth of egg (mm)

A sample calculation for an egg 50mm long, 40mm in breadth would look as follows:

\[
W = Kw \cdot (50 \times 40^2) \\
= 0.0005474 \cdot 80,000 \\
= 43.79 \text{ grams}
\]

This calculated FEW can be in error by as much as 2%, however, this is not normally sufficient to affect the hatchability of healthy eggs. Although this formula relates to Peregrines, it may be effectively applied to other raptor species.

Eggs begin to lose weight as soon as they are laid. Until now, egg weight loss was measured by weighing and calculating weight loss on graphs or charts. This method relied on accurate weighings at the same time of day followed by careful calculations by the operator. Now computer software programs perform these functions. By entering the weight data into the program it will check the weight loss required, calculate the loss since the last weighing and inform the operator the current weight loss, the suggested correct weight loss and the correct humidity to achieve that weight loss. If egg weight is excessive, the humidity of the incubator is increased (e.g. by placing petri dishes of sterile water in the incubator), if weight loss is inadequate, desiccant powders are placed in the incubator. The ideal weight loss will vary between species. It is advisable for keepers or technicians responsible for incubation to gain experience on Chicken eggs through every stage of egg handling and incubation before going on to more important species.

**Incubation Periods**

The majority of raptor eggs hatch in 28 to 35 days, the larger species can go as long as 56 days (see Table 2). It is strongly recommended that all eggs thought to be viable be allowed to continue incubation for at least one week over the known incubation period.

**Records**

It is vital that good records are maintained of all breeding pairs, recording the dates when all eggs are laid, which are fertile, hatchability, rearing and post mortem results. All eggs which are handled should be identified with a soft non-toxic pencil.

**Hatching**

Some chicks will become very vocal once the internal pip has occurred, i.e. before the egg-shell is broken. Sometimes movement can be seen as the embryo starts to become active, others make no sound or movement until the external pipping process has begun. By checking the incubators on a very regular basis pipping eggs should be observed soon after the shell has first cracked. With more highly coloured eggs such as the falcons, the first crack
may be difficult to spot, however it can usually be felt by running a clean finger gently round the egg's surface. Once an egg has pipped it should be moved to another incubator for hatching, particularly if other eggs are present, but not hatching. Turning ceases and the egg should be placed so that the pip is uppermost. The hatching incubator is run at the same temperature 99.5°F - 37.5°C, but the relative humidity is increased to 55 to 60%. After the egg has pipped there may be an interval of rest for the chick, some will enlarge the pip area to a hole and can be seen moving, others may have no movement until they actually starting to turn. This period can be very worrying for the technician; patience is required, particularly for the less experienced. Interference too early is often detrimental or even fatal. Once the embryo starts to turn in the egg the hatching process should only take from ten minutes to an hour. If the hole has become too enlarged before turning commences the membrane may start to dry out and cause the embryo to become stuck and unable to move, spraying with a fine mist of warm sterile water, or painting with a soft, wet, sterile paintbrush can help the membrane to become loose. The hole only can be partially covered with cling film to stop drying out occurring.

Once the chick has hatched the navel should be swabbed with an iodine based disinfectant. The hatched chick can be left in the hatcher until dry or moved to a brooder straight away. A newly hatched chick has an oddly shaped head, a bulbous neck and very protruding eyes, all this will settle down within 24 - 48 hours. Some chicks may look very distended due to insufficient water loss, but this will dissipate as long as the chick survives.

**Hatching Difficulties:** Some eggs will prove more difficult than others. Only the experience of the technician will be able to judge really well when to assist hatching embryos and when to leave well alone. Assisted chicks are usually weaker in the first few days of rearing and may need extra care and support. In most cases, the pipping egg should be left for sixty hours before attempting to help the embryo to hatch. As experience is gained, assistance can be given earlier if foetal positional abnormality is present. If the chick is experiencing problems, it should be candled and the air sac marked on the shell with a felt tip pen, small parts of the shell can be removed with forceps, being careful not to disturb the membranes. Once the membrane is exposed, if it is touched with a wet, sterile paint bush or cotton bud, the membrane blood vessels will become visible. On should test if the blood supply is still flowing or has closed down. Gentle pressure is applied to the most obvious vein with the tip of the paint brush, then removing the brush, it can be seen if blood is still flowing through the vessel or not. If the vessels are completely closed, the membrane may be cut and the embryo removed safely. If the blood is still flowing, cover the hole with the exposed membrane with cling film and place in a still air incubator. Keep checking until the blood flow has ceased. If the hatch is assisted, remove the top of the shell and associated membranes, but leave the chick to crawl out of the base of the egg itself (which may take up to a further 12 hours). This is particularly important if the yolk sac is not yet retracted. The chick will be prone to chilling at this stage, maintain the
temperature of the still air incubator at 99.5°F until the chick is out safely, dry and warm.

**Dead in Shell and Infertility:** it is important that the veterinarian impress on the breeder the importance of maintaining good records and undertaking full investigations of all dead in shell embryo, as well as any cases of infertility. In cases of infertility, a full study of the breeding records is essential. This should not only provide age, sex, egg production, rates for fertility, hatching and rearing but also full details of observations relating to courtship, attempted matings, actual matings etc. These details are required not only for this pair, but also any previous breeding records relating to previous breeding with any other partners. Even if historical evidence suggests that one or other bird has previously successfully bred, it should not be assumed that difficulties have not arisen since. Full physical examinations and blood profiles should be undertaken on each bird, prior to endoscopic examination. If necessary endoscopic fine needle aspiration biopsy can be collected from the testis. The clinician should first discuss with the pathologist, at which stages of the breeding cycle he should usefully collect biopsies.

**Development and Care of Young.**

**Brooding:** raptor chicks are altricial. Newly hatched chicks should be placed in a still air incubator or brooder running at no lower than 95°F. This temperature can be reduced by 1 degree a day until the secondary down comes through and young birds are able to thermo-regulate, or are returned to parents or foster parents. Hand reared newly hatched birds should be put in containers that are designed to hold the legs neatly tucked under the birds. Splayed legs can occur within hours if the chick is maintained on an inappropriate surface. A plastic 2-litre ice cream or margarine container, with at least five centimetre of sand formed into a hollow covered with clean paper towel is ideal. This should be placed in the brooder at least 24 hours before needed such that a warm and stable nest cup for young birds is ready when required. The kitchen towel can be replaced after each feed and the depression in the sand can be reformed. Young that are too cold will huddle together and cry. Young that are too hot will pant, spread out away from one another and vocalise. The skin may become wrinkled, dull rather than pink, and shiny. Over heating is more likely to lead to weak and ill young.

**Feeding:** after hatching, chicks live of their yolk sac for up to 48 hours. Except for tiny young tiny young (e.g. those weighing less than 10g at hatch), the first feed should not be given until at least twelve hours. Feeding a chick at this stage can be detrimental, as food passage from the crop is slow, during which time the food can rapidly putrefy. Newly hatched chicks that look distended with fluid should be left without food until the stomach is flaccid and soft to the touch. Once chicks start to beg, they may be offered food from a pair of forceps. Using forceps tiny pieces of minced food can be offered to the chick, which should raise its head to accept feeding. Falcons need food to be placed in the beak, often with the upper palate being touched by the food before they will close their beaks and swallow. The rest of the raptors, with the
exception of the New World vultures will respond to the food being brought in slowly towards the beak at about their eye level and will then attempt to snatch the food from the forceps. Young chicks are pretty inept to start with, missing the food, or falling over, however they soon get strong enough to take food more easily. The New World vultures naturally feed by putting their beaks inside the parents’ beak and receiving regurgitated food. By gently encircling the beak with finger and thumb the adults beak can be represented and then the young birds will take food from forceps touching the side of the beak.

The New World vultures naturally feed by putting their beaks inside the parents’ beak and receiving regurgitated food. By gently encircling the beak with finger and thumb the adults beak can be represented and then the young birds will take food from forceps touching the side of the beak. Feeding responses may be improved by vocalising to the chick as you offer it food. Raptor chicks can be easily killed by over feeding. Frequent feeding whilst avoiding over filling of the crop is important. As soon as chicks start to feed, they should be given mincéd up whole carcass food. Young birds should not be offered casting (indigestible fibrous food e.g. fur and feather) until they are over 10 days of age. Merlins (*Falco columbarius*) in particular should not receive casting until they are 20 days old. Feeding of casting at younger ages can lead to proventricular impactions. Young raptors require the same food as adult birds, although the correct provision of vitamins and minerals (especially calcium) is more critical. It is important to consider the diet consumed by a chick rather than the food offered. Feeding larger carcasses to parents rearing young, can lead to selective feeding (of meat rather than bone), or failure to consume bones because of bone size in relation to chick size. A mixed diet of finely minced or chopped whole carcass (i.e. including bones) meat is suitable for most species. A probiotic supplement may be usefully added to the diet in the first 14 days of life. Some Vultures may do better if a digestive enzyme (or vulture vomit) is added to the food as well as a paediatric probiotic. Damping the food for all young raptors with saline assists feeding, swallowing and helps to prevent dehydration. Apart from the smallest of young (the under 10g hatch weight) four feeds daily is sufficient. Chicks should be weighed regularly, preferably before and after each feed, so food weight consumed can also be recorded. Raptor chicks fed at excessive rates will develop angel wing. If this condition is diagnosed early, the wing tip should be bandaged back against the body, and the food intake reduced. The bandaging should be changed after 48 hours (in view of fast growth rates). Bandaging for 2-4 days is typically sufficient if the condition is detected soon after onset.

**Rings:** most chicks can be closed rung once they are ten to fourteen days old. As most female raptors are 30% larger than males, it is normal to place 2 rings (one male one female), placing the smaller ring on last (to stop the larger one falling off). Once the sex is know, the incorrect sized ring should be removed.

**Supplements:** in view of the storage period of some commercial foods, the addition of supplements to raptor diets (particularly at times of increased requirement, e.g. breeding, growing, moulting, training) is recommended.
Once young birds have reached ten to twelve days, are looking healthy, eating well and have been rung, they should wherever possible be returned to parents or foster parents. As discussed above, imprinting may be purposefully carried out in order to create imprint-breeding birds. Imprint raptors are also easier to train for falconry, as they have no fear of humans and actively want to be with you, rather than wanting to fly away from you. Raptors trained using traditional techniques are kept hungry during the flying season such that they will hunt or return to you for food. When flying imprint birds this is not necessary, so birds are stressed less, they fly at a heavier weight, are fitter and less prone to disease. However, imprinting relies on a close bond and trust between falconer and bird. In the event that the imprinted bird is ‘deserted by’, or ‘man handled’ by the person he is imprinted on, this can be very detrimental and even more stressful. The effective and beneficial production of an imprint raptor is not easy. The aim is that the bird should be a ‘social imprint’, ie he likes being with you, but does not feel entirely dependent on you. If imprinting is successful the bird enjoys being with you and it is a joy to have it near you. If it goes wrong the bird may be either aggressive towards you (a particular problem in eagles and other larger species), or may call incessantly for you at high pitch and volume. Such a bird is termed a screamer and is a nightmare to own.

If experienced and correct imprinting is not possible, then chicks should where ever possible to return to their parents or placed with suitable foster parents. If this is not possible then all through the rearing the young should have as little as possible in the way of contact and handling from the humans caring for them. Puppets shaped to the colour and build of the adult can be used to assist in avoiding any severe imprinting on keepers. Most raptor species will learn to pick up food for themselves at about 10 days old. Encourage any young that are having to be totally hand reared to learn to feed themselves as quickly as possible, but spend as little time as possible exposing them to human interference.

Chicks should be returned to their parents no later than 14 days of age. If older there will be more chance of the young retaining some human imprinting, furthermore they will be mobile enough to try to get out of the nest in fear when they first come face to face with their parents, which will reduce the chances of a successful reunion. First time parents are an unknown quantity and keepers should always make sure that they have plenty of time set aside on the day chosen to return young. A moment standing still by the nest ledge to watch the first reaction of the parent birds is advisable. If you are lucky, the female will immediately come up to the nest, (watch for her ‘balling’ her feet) and may even cover the young straight away. The enclosure should still be observed, as the reaction of the male has to be assessed before keepers can relax. If the female takes to the young it is rare for the male to cause problems, however it can happen and should a young bird be picked up or grabbed by either of the adults the chick should be removed immediately. More often, the two adults sit well away from the nest watching the new young. Eventually most birds will show some sign of reaction (in particular if the chick becomes cold or hungry). It is rare for birds to completely ignore the young and refuse to either sit on or try to feed the young.
**Foster Parents:** most buteos will rear any other species of buzzard, hawk, eagle or similar species. Most falcons will rear any falcon, although species size should be taken into consideration. It is unwise to ask very large species to rear the young of very small, although related species. Some species do require their own kind as parents or fosters. Common Caracaras (Polyborus plancus) have a bare face and a very bare crop (once full), this is too visually different for even closely related foster parents to cope with.

**Monitoring:** once young are successfully accepted by parents or fosters they should be monitored to check there are no problems. On rare occasions chicks in stick nests can get a twig caught under the closed ring and the tarso-metatarsus- this does not normally cause problems if detected early but can damage a bird permanently if left unnoticed. In clutches of two or more, one young may not be doing as well. Removing either the smaller chick, or the largest and hand feeding it for a few days will normally solve the problem, the chick can then be returned to the nest.

### Table 3. Preventive Medicine - Bird Health

<table>
<thead>
<tr>
<th>Health</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Closed collection</td>
<td></td>
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<tr>
<td>Carefully sourced birds</td>
<td></td>
</tr>
<tr>
<td>Quarantine, screening, annual health screen</td>
<td></td>
</tr>
<tr>
<td>Routine parasite screening of resident stock</td>
<td></td>
</tr>
<tr>
<td>Avoidance of any decaying vegetable material (ref. risk of Aspergillosis)</td>
<td></td>
</tr>
<tr>
<td>Control of endo, ecto and environmental parasitism</td>
<td></td>
</tr>
<tr>
<td>Good breeding records</td>
<td></td>
</tr>
<tr>
<td>Good individual bird health records</td>
<td></td>
</tr>
<tr>
<td>Post mortem examinations</td>
<td></td>
</tr>
</tbody>
</table>

| Nutrition                          |                                   |
|-------------------------------------|                                   |
| Good quality varied, whole carcass, well sourced diet. |                           |
| No excessive or improper storage   |                                   |
| No excessive feeding               |                                   |
| Risks associated with specific food items to be noted (e.g. Trichomoniasis, Falcon Herpes Virus, Adenovirus, Newcastle Disease, Salmonellosis, *M avium*, *E coli*, lead poisoning) | |

| Vaccination                        |                                   |
|-------------------------------------|                                   |
| Few commercial vaccines available consider - Newcastle Disease, Falcon herpes virus, Pox virus, Salmonella | |

| Vermint                            |                                   |
|-------------------------------------|                                   |
| Suitable control, no excessive feeding to stock |                           |

### Table 4. Preventive Medicine - Parasitic infestations

<table>
<thead>
<tr>
<th>Blood parasites</th>
<th>Gyr (<em>Falco rusticolus</em>) and Snowy owl (<em>Nyctea scandiaca</em>) particularly susceptible. Screen parents prior to breeding season (many false negatives). Control ecto parasites (Fipronil 7.5 - 15mg/kg treatment of parents). Full post mortems including heart blood smears for diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tick Infestations</td>
<td>Acute deaths to be fully investigated. Treat environment as required with permethrin and pyriproxyfen.</td>
</tr>
<tr>
<td>Ecto parasites</td>
<td>Presence is often an indication of general ill health. Treat with fipronil 7.5-15mg/kg</td>
</tr>
<tr>
<td>Nematodes</td>
<td>Adult birds should be screened prior to entering breeding aviaries. Aviary design should exclude arthropod and invertebrate intermediate hosts.</td>
</tr>
<tr>
<td>Caryospora</td>
<td>This is the greatest endemic disease risk associated with captive breeding of falcons (there is no evidence yet that hawks or eagles are affected). Repeated breeding within an enclosed environment leads to a severe build up of environmental contamination causing endemic infestation. The greatest risk period is from fledging to initial training. There are 6 species of Caryospora reported to effect falcons and there is no evidence of cross antibody protection. If possible young falcons should be exposed to the parasite in a controlled manner and then treated with toltauril (25mg/kg po once weekly 3 weeks), during prepatency.</td>
</tr>
</tbody>
</table>
Table 5. Emergency Medicine

<table>
<thead>
<tr>
<th>Condition</th>
<th>Treatment</th>
</tr>
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</table>
| Egg binding     | Correct hypovolaemia and hypocalcaemia if present. Oxytocin has been administered historically (0.01-0.1ml once), but may in fact be deleterious. The application of 0.2mg/kg PGE2 gel, applied to the utero-vaginal sphincter is recommended. Failing this, drainage of the egg, implosion and passing naturally by the hen, or alternatively salpingohysterectomy and intact egg removal is recommended.
| Egg peritonitis | Fluid therapy, antibiosis, coelomic lavage with hyaluronidase, salpingohysterectomy may be indicated. |
| Prolapse Oviduct| These birds are severely shocked and will not tolerate immediate extensive surgery. Supportive and shock therapy is indicated together with action to decrease the oedema of the prolapsed organ. Replacement via the cloaca alone is typically ineffective due to the size and length of the organ. A length of tissue often remains intussuscepted within the oviduct, stimulating more contractions and likely re-prolapse. Surgical options are left lateral coeliotomy and salpingohysterectomy or replacement of the oviduct (if viable) with plication to retain in position.
| Trauma          | In view of the frequent intra-pair aggression in many species, potentially fatal puncture wounds and lacerations are not uncommon and should be treated symptomatically. Any bird who may have suffered a puncture wound from another raptor, should have antibiosis administered for a minimum of 5 days. |

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