Raptor Rehabilitation

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Introduction

Every year numerous sick or traumatised raptors are found and presented to veterinarians, who are faced with the responsibility of treating them and ensuring their greatest possible chance of survival when subsequently returned to the wild. This essay provides information of use to veterinarians and covers a broad range of topics with which they should be thoroughly familiar before embarking on this type of rehabilitation project. These topics include the diseases and injuries suffered by raptors, the treatment of these injuries and diseases, as well as restraint, physical examination, history taking, medication techniques, transportation, housing, nutrition, care of young, physical therapy, exercise and release into the wild.

Raptors (birds of prey) are diurnal or nocturnal carnivorous birds with fleshy ceres, large eyes, hooked beaks, well developed talons and the ability to regurgitate indigestible dietary components as pellets (Jakob-Hoff 1988). There are two orders of raptors which share these characteristics but differ markedly in their internal anatomy, physiology and responses to drugs and infectious agents (Cooper 1978). Appendix 1 lists the Australian members of the orders *Falconiformes* (diurnal birds of prey) and *Strigiformes* (owls).

Raptor rehabilitation is the series of steps taken to restore an incapacitated raptor to its natural habitat in a state in which it is likely to survive. After the bird is presented, it is necessary to make an assessment of its condition (after which euthanasia may be the best option) and then treatments can be initiated. Whilst the bird recovers, care should be taken to ensure it is fed and housed in a suitable manner. Even with veterinary attention, the time taken to recover from disease and injury may last from days to months and in this time the bird may become unfit and lose body condition. Therefore physical therapy and exercise techniques will be necessary to return the raptor to its previous level of fitness and strength before it can be released into a suitable environment (Jakob-Hoff 1988). Injured raptors are able to be successfully released in 38-56% of cases (Olsen 1990). This figure is not higher as only severely debilitated or traumatised raptors will allow themselves to be caught by humans (Wilson 1988). Thus raptors are frequently seen by veterinarians when an injury or disease impairs their hunting ability to such an extent that they are presented in an emaciated state.

Diseases and injuries with which raptors are presented

Wild birds of prey that are presented to veterinarians suffer from a wide range of problems including malnutrition, exposure, traumatic injury, infectious disease, poisoning and metabolic disorders (Cooper 1978). Malnutrition has been implicated in 25% of raptorial deaths (Halliwell 1979). This nutritional depletion can occur as a primary event, if there is a shortage of prey or in juvenile birds that have not learned to hunt effectively, or as a secondary event if old age, injury or disease prevents raptors from hunting (Redig 1992). Large raptors such as eagles can last without food for a couple of weeks whereas small raptors are in danger after 48 to 72 hours (Halliwell 1979).

Traumatic incidents are very common and involve such things as flying into powerlines, windows and motor vehicles as well as being shot or caught in a trap (Redig 1992). Injuries sustained include fractures, dislocations, sprains, lacerations, haemorrhage, penetrating wounds, contusions and

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concussion.

Appendicular bones are most frequently fractured (Olsen 1990) and such fractures are easily diagnosed but axial fractures are only detectable radiographically (Redig 1992). Haemorrhage mainly occurs externally and internal haemorrhages are rare (Redig 1992). It must be remembered diaphragmatic herniation does not occur in birds as they lack a diaphragm (Redig 1992).

Birds of prey are often poisoned by a large range of agricultural pesticides, lead shot and other chemicals. As they are near the top of the food chain they are especially vulnerable (Cooper 1978). Organophosphate and lead poisoning are considered medical emergencies (Redig 1992). Organophosphate poisoning leads to prostration, tremors, convulsions, hypersalivation and lung congestion (Redig 1992). Organophosphate poisoning can be treated with atropine (0.5 mg/kg), given every three to four hours (Wallach and Boever 1983). Lead poisoning may occur if raptors hunt or scavenge prey that has been killed or wounded with lead shot (Wallach and Boever 1983) and results in chronic weight loss, depression, anaemia, convulsions and possible blindness (Redig 1992). Lead poisoning is treated with the chelating agent, calcium EDTA at 35 mg/kg (Wallach and Boever 1983).

Infectious disease can be of bacterial, fungal, viral or parasitic origin (Halliwell 1979). Bumblefoot (pododermatitis) is a very common, mainly bacterial, disease of the plantar aspects of the feet of raptors (Olsen 1990). Bumblefoot develops after pathogens invade the subcutaneous tissues and tendon sheaths secondary to pressure necrosis or penetration of the skin (Wallach and Boever 1983, Forbes 1992). The most commonly involved pathogen is *Staphylococcus aureus* (Wallach and Boever 1983) but other bacterial and fungal pathogens including *Escherichia coli*, *Proteus* sp, *Pseudomonas* sp, *Aspergillus fumigatus* and *Candida albicans* have occasionally been implicated in the disease process (Wallach and Boever 1983, Olsen 1990). Raptors with chronic bumblefoot may develop septicaemia or osteomyelitis of the foot bones (Wallach and Boever 1983). Of the infection does not clear with a correction of perch design (discussed later) or antibiotic therapy (cloxacillin 250 mg/kg daily for 7 days has been recommended by Olsen (1990)), surgery is recommended to curette the infected areas, remove any scar tissue or amputate any digits with unresolvable osteomyelitis (Wallach and Boever 1983).

Other diseases recorded in raptors and attributable to bacteria include listeriosis, erysipelas, salmonellosis (from catching rodents for food), tuberculosis and chlamydiosis (Wallach and Boever 1983). Fungal diseases are more important in the northern hemisphere than in Australia. *Aspergillus fumigatus* is the single largest cause of death of raptors in the United Kingdom (Forbes 1992) whereas aspergillosis is considered extremely rare in Australia (Olsen 1990). *A. fumigatus* colonises the air sacs and lungs and infection is more common if the raptor has a chronic thiamine deficiency (Wallach and Boever 1983). Aspergillosis may run an acute, rapidly fatal course or be a chronic disease which leads to weight loss and respiratory signs (Forbes 1992).

A large variety of parasites has been recorded as living in and on raptors but not all are responsible for disease. External parasites include mites, ticks, and lice and do not cause ill effects in normal birds, but in sick raptors they may proliferate and become a burden and cause plumage damage (Olsen 1990). To treat these parasites pyrethrin-containing dusting powders (Olsen 1990), carbaryl, ivermectin or moxadectin (Cross 1994) can be used.

Trichomoniasis (frounce) is a protozoal parasitic disease which effects the mouth, oropharynx, oesophagus and crop and is caused by *Trichomonas gallinae*. In cases of trichomoniasis the raptor exhibits hypersalivation, halitosis, marked swallowing motions and "flicking" of its food as well as yellow/white caseous lesions in its mouth and throat (Wallach and Boever 1983, Olsen 1990). Trichomoniasis should be diagnosed by examining scrapings of the lesions as the lesions grossly resemble those of oral capillariasis and candidiasis (Olsen 1990). Trichomoniasis can be treated by

giving oral metronidazole at 50 mg/kg (Forbes 1992). Another protozoal disease, found especially in young raptors, is coccidiosis which leads to enteritis, diarrhoea, depression, weight loss and even death (Wallach and Boever 1983, Olsen 1990). It can be treated with sulphonamides at 500 mg/kg (Olsen 1990).

Both nematode and cestode species have been identified as causing disease in raptors. Infection is best diagnosed by performing a faecal flotation test. Nematode genera include *Syngamus*, *Capillaria*, *Serratospiculum* and *Ascaridia* (Olsen 1990). *Syngamus trachea* (gapeworms) can be found around the gape of the bird, resulting in open-mouthed breathing and can be treated with fenbendazole or ivermectin (Halliwell 1979, Forbes 1992). *Capillaria* are found in the lining of the mouth, oesophagus and crop and can be treated with fenbendazole, ivermectin, moxadectin or piperazine citrate (Olsen 1990, Forbes 1992, Cross 1994). Serratospiculum are found in the air sacs and lungs of raptors and can be treated with thiabendazole (Olsen 1990). Ascaridia are intestinal roundworms which are removed with piperazine citrate or thiabendazole (Halliwell 1979).

History Taking

It is important to take a thorough history from the person presenting the raptor. The locality and the date on which it was found are ascertained. Finding it under powerlines or by the roadside may point to traumatic injury; finding it in an agricultural field may indicate poisoning (Redig 1992). Determining the location is also important as rehabilitated raptors should be released back into their own territories, if feasible (Perry 1988). The presenter should be asked if the bird has been given any treatment or medication (Perry 1988).

A thorough physical examination which involves evaluation of all the systems of the body should be given to all raptors that are presented to veterinarians (Halliwell 1979). Initially, a distant visual examination is performed which should involve identification of the species, sex and approximate age as well as assessment of demeanour, behaviour, condition, posture, temperament and respiration character and rate (Halliwell 1979, Jakob-Hoff 1988). Male and female raptors cannot be differentiated by plumage differences (except in Australian Kestrels) but can normally be sexed based on size. Female raptors are significantly larger than male raptors in all species except owls of the genus *Ninox* (Schodde and Tidemann 1990). It is also important to weigh the bird so its progress can be monitored (Cooper 1978). Body condition can be determined by palpating the muscular cover of the keel (Cooper 1978). The physical examination should be given in a dimly lit room with the aid of a torch (Halliwell 1979).

Any mutes (faeces) in the bottom of the box in which the raptor was presented should be assessed for quantity and quality (Redig 1992). These consist of a well-formed brown to black faecal component and white urinary portion (Jakob-Hoff 1988). Biliverdin from the liver may turn the faecal part green if the raptor has fasted for more than 24 hours (Jakob-Hoff 1988) or has gastrointestinal dysfunction (Redig 1992). The urinary portion is more watery if the bird has polyuria, changes to yellow or green if it has hyperbiliverdinaemia (Jakob-Hoff 1988) or is sparser if the raptor is dehydrated (Redig 1992).

It is necessary for two people to be present during the rest of the physical examination so one can examine the bird and the other can restrain it. It is important to remember when handling raptors that their talons are their most dangerous parts (Schultz 1978) Some Cross 1994). It is therefore necessary to control the wings and talons first and then secure the head when catching (casting) raptors (Jakob-Hoff 1988). This is done by approaching the bird from behind and using a large, opaque towel the wings are held against the bird's body with both hands (Jakob-Hoff 1988). After this is done your hands are slowly repositioned to grasp both legs at the level of the hock joints between your index and middle fingers and the wing tips are encircled by your thumbs (Jakob-Hoff 1988). In most cases it is possible to maintain this grip with one hand and then gently grasp the neck just below the head

(Jakob-Hoff 1988). Covering the bird's head with a towel or hood will pacify it (Jakob-Hoff 1988). As a safety precaution, it is good to give the raptor something to grasp in each foot, such as a roll of bandage or rubber ball, before wrapping the feet in tape (Perry 1988). Alternatively, a small dose of ketamine hydrochloride (15 to 30 mg/kg) intramuscularly is useful for short term restraint (Halliwell 1979).

Once the bird is restrained the rest of the physical examination can be performed in a systematic manner. A cloacal or axillary temperature is taken (Cooper 1978) to ensure it is in the normal range of 40-41°C (Cross 1994). The heart should be auscultated in the interclavicular space although the rate is generally very fast (160-300 per minute) (Cooper 1978, Halliwell 1979). The airways, lung fields and air sacs should be percussed and auscultated (Halliwell 1979) and the presence of any abnormal respiratory signs such as sneezing, open-mouthed breathing, alteration of voice, tail-bobbing or coughing is noted (Jakob-Hoff 1988). The abdominal cavity is palpated for liver enlargement, a full stomach, space-occupying lesions or eggs (Cooper 1978). The cloaca is examined for faecal staining which indicates diarrhoea (Wilson 1988) and is palpated externally and internally (with a gloved finger) (Cooper 1978).

The raptor's integument and plumage should be carefully assessed. The primary and secondary flight feathers and tail feathers should be examined to check for the correct number, any damage and the presence of hunger traces (areas of weakness of the rachis corresponding to periods of undernutrition) as the integrity of these feathers is vital to successful rehabilitation (Cooper 1978). A smaller number of feathers than normal may be due to moulting which in Australia generally occurs between October and April (Olsen 1990). An unkempt or dull plumage may indicate illness (Olsen 1990). It is also necessary to check the talons and distal upper mandible for cracks or overgrowth, the colour of the unfeathered skin around the eyes, cere and legs, the uropygial gland and for the presence of ectoparasites (Jakob-Hoff 1988).

Careful attention should be given to the ocular examination as approximately 25% of the raptors admitted to veterinarians have eye lesions (Redlich 1985). The eyes should be examined both with an ophthalmoscope and the naked eye (Cooper 1978). The gross examination should include checking pupil size and pupillary light reflex, cataracts, ocular discharge and any signs of trauma or disease of the nictitating membrane, cornea and sclera (Halliwell 1979, Jakob-Hoff 1988). Birds with a visual deficit may show abnormal head posture, poor condition, an inability to hunt and a reluctance to fly (Redlich 1985, Jakob-Hoff 1988). The shape and position of the eyes is also important as they will be sunken in severe dehydration (Redig 1992) and almond-shaped instead of round if the raptor is sick or emaciated (Cooper 1978, Olsen 1990).

The head should also be examined for symmetry, injury, nasal discharge and patency, and infraorbital sinus distension (Halliwell 1978, Jakob-Hoff 1988). The infraorbital sinuses are located between the commissures of the beak and the eyes and can be distended with exudate from an upper respiratory tract infection (Jakob-Hoff 1988). The beak should be observed externally and then opened (artery forceps can be used) to examine the oral cavity, oropharynx and glottis and to check for lesions, halitosis and mucous membrane colour (Cooper 1978). Pale plaques in the mouth may indicate trichomoniasis, hypovitaminosis A, candidiasis or capillariasis (Jakob-Hoff 1988).

The crop is palpated in the necks of diurnal birds of prey (it is absent in owls) to detect the presence of food, thickening of its wall or gas accumulation (Jakob-Hoff 1988). The trachea should also be palpated and auscultated (Cooper 1978).

Since traumatic injury to raptors' extremities is very common, a careful examination of the pectoral and pelvic limbs should be performed. They should each be checked visually for signs of trauma (feather loss, open fractures, bleeding) and all bones and joints should be palpated and compared with

the contralateral side for swelling, deformity and muscle tone and mass (Cooper 1978). Each joint should be flexed and extended to help diagnose traumatic injury or articular gout (Jacob-Hoff 1978). Subcutaneous emphysema may be detected around a fractured humerus as it is a pneumatic bone. The feet and talons should be examined for bumblefoot.

Further diagnostic tests which may be performed depending on the case include radiography (useful in detecting fractures, or lead shot in cases of lead poisoning), microbiology, haematology, biochemistry and a packed cell volume (PCV) (Redig 1992)). A PCV higher than 55 indicates severe dehydration whilst a PCV below 15 shows the need for a blood transfusion (Forbes 1992, Redig 1992).

Medical Treatment

When presented with a critically ill patient it is first necessary to stabilise it before treating other non life-threatening problems (like fractures) (Redig 1992). To stabilise the patient it is necessary to control haemorrhage, normalise body temperature, correct dehydration, acid/base balance, hypoglycaemia, starvation, shock and severe anaemia (Redig 1992).

Dehydration is a major cause of death in sick, injured and young raptors (Olsen 1990). Raptors frequently become dehydrated when they fail to catch sufficient prey as the majority of their requirements for water are met by their food. Other causes of dehydration are blood loss, vomiting and diarrhoea (Cooper 1978). Assessment of dehydration can be performed by examining eye position (the eyes become sunken with dehydration) and by sliding the skin over the pectoral muscles. The attachment of the skin to the muscles becomes firmer with a greater degree of dehydration (Perry 1988).

Fluid therapy can be performed intravenously, intraosseously, intramuscularly, subcutaneously and orally. Fluids should be warmed to near body temperature (35 to 40°C) before administration (Redig 1992). Oral fluid therapy is good in mildly debilitated birds. Fluids given orally are often mixtures of solutions containing various substances such as glucose (a ready source of energy and treatment of hypoglycaemia), electrolytes (for example saline or lactated Ringer's solution) and vitamins (Wilson 1988). These fluids are debilitated it may aspirate these fluids and absorption from the gastrointestinal tract is minimal (Cross 1994). In these birds it is necessary to give intravenous or intramuscular fluids. Lactated Ringer's solution and/or dextrose are given intravenously as a bolus over 20 to 30 seconds (Perry 1988, Wilson 1988, Redig 1992). Lactated Ringer's solution can be given at a rate of up to 2 to 3% of bodyweight (Redig 1992).

Corticosteroids (eg dexamethasone 2-4 mg/kg) can be given to raptors to treat shock and stress (Redig 1992). Biotin should be given to starving raptors to protect their livers from fatty degeneration (Cross GM pers comm). B-complex vitamins may be given to debilitated raptors (to total 10 mg/kg thiamine) and iron dextran (10 mg/kg) is useful in cases of anaemia (Redig 1992). If evidence of bacterial infection exists, antibiotics should be given (eg broad spectrum oral oxytetracycline (250 mg/kg)) but in no circumstances should aminoglycosides or procaine penicillin be used (Redig 1992, Cross 1994).

If a raptor presents in a severely emaciated state it is first necessary to treat its dehydration, but after 12 to 24 hours baby food or an easily digested slurry of blended meat, electrolytes and vitamins (eg nutrical) should be introduced into the crop in small quantities (Redig 1992). Gradually the amount of solid food should be increased in the diet. If a less debilitated raptor refuses to eat, it may start eating with a change of diet or may require force-feeding (Cooper 1978). This may be done by opening the beak and pushing a small bolus of food over the base of the tongue and down the oesophagus.

Anaesthesia

Several anaesthetic protocols have been recommended in birds of prey and each has its own advantages and disadvantages. Injectable anaesthetic agents which can be used include ketamine, alphaxalone/alphadolone and metomidate. Ketamine hydrochloride is an agent which can be given intramuscularly or intravenously (Forbes 1992) and results in a rapid induction and recovery (Perry 1988). The dose given depends on the size of the raptor and generally owls receive smaller doses than diurnal species (Wallach and Boever 1983). The dose rates for various sizes of raptor, as recommended by Forbes (1992), are 30 mg/kg of ketamine if the bird weighs 100-150 grams, 20 mg/kg if 200-400 grams, 10 mg/kg if 750-1000 grams and 5 mg/kg if it weighs more than two kilograms. Ketamine is frequently given in combination with xylazine (0.25-0.5 mg/kg IV or IM) or diazepam (1.0-15 mg/kg IV or IM) resulting in 15 minutes of surgical anaesthesia (Forbes 1992). To make it easier to perform a physical examination or diagnostic procedure a smaller dose of ketamine can be given (Wallach and Boever 1983) and the duration of anaesthesia can be lengthened by maintaining with a gaseous agent or giving an additional ketamine dose (Forbes 1992).

Alphaxalone/alphadolone (Saffan) is another agent which can be given to a large range of raptors, intravenously (10 mg/kg) or intramuscularly (36 mg/kg), to give ten minutes of surgical anaesthesia but the occasional bird may adversely react (Forbes 1992).
Halothane and isoflurane are two gaseous agents which can be used to induce and maintain anaesthesia in raptors. A mask or chamber is used to deliver the agent to induce the bird, before it is intubated with a cuffed endotracheal tube and connected to a T-piece anaesthetic delivery system (Perry 1988). Gaseous anaesthesia is considered superior in many ways to injectable anaesthesia (Perry 1988). Isoflurane is the better gaseous anaesthetic agent as recovery is faster, it is less hepatotoxic and results in safer anaesthesia even in moderately debilitated raptors (Forbes 1992, Redig 1992). It is however, expensive and requires the use of a special vaporiser, so is available for use in general veterinary practice less frequently (Forbes 1992). In assessing the level of anaesthesia in raptors, heart and respiratory rates are more consistently useful than corneal, palpebral and pedal reflexes (Forbes 1992).

Surgery

Similar surgical techniques are used on birds of prey as are used on other birds (Cooper 1978). In comparison to the case in mammals, post-operative infection is rare but strict asepsis should still be observed (Cooper 1978). Before surgery, the feathers in a 1 to 2 centimetre radius of the proposed incision site should be plucked, the skin disinfected with a warm, dilute povidone iodine solution (Halliwell 1979) and a small amount of petroleum jelly applied around the site to prevent down from contaminating it (Wallach and Boever 1983). Raptors are prone to excessive cooling during surgery due to their small body size so excessive wetting should be avoided (Wallach and Boever 1983) and surgery should take the shortest possible time (Halliwell 1979). A lesser amount of energy is expended to maintain body temperature if warmth is provided from a heat pad, infra-red lamp or warmed intravenous fluids (Cooper 1978). In order to prevent dangerous hypotension, caused by diminished venous return, birds of prey should not be left in dorsal recumbency for long periods of time (Cooper 1978). Blood loss is a problem, especially in small raptors, so haemostasis is important (Cooper 1978).

In repairing fractures in raptors' bones, internal and external fixation can be utilised. Internal fixation is difficult due to the fact that raptors have thin cortices and large medullary cavities, so plating is trying and intramedullary pins necessarily large (Wallach and Boever 1983). Splinting and taping of the fractured limbs is useful (Wallach and Boever 1983). If not delayed by infection, fractures heal rapidly and splints and pins can be removed after 4-5 weeks (Halliwell 1979, Wallach and Boever 1983).

Medication techniques

A raptor can be medicated in numerous different ways including by injection, mouth, or inhalation as well as topically. Injections can be made by the intravenous, intramuscular, subcutaneous, intraosseous, intraperitoneal or intrasinus routes. Intravenous injection gives the fastest and most reliable distribution of a drug but is also the most stressful to the raptor (Jakob-Hoff 1988). The right jugular vein (which is more highly developed than the left) is the best venipuncture site as haematomata are less likely and indwelling catheters can easily be secured in place (Jakob-Hoff 1988). The brachial vein, which is found on the medial aspect of the ulna, is more likely to develop haematomata after use (Jakob-Hoff 1988). If the peripheral veins are too small or collapsed, fluids and drugs may be given into the peripheral circulation via the intraosseous route (Abou-Madi and Kollias 1992). The site of choice for needle placement is the distal ulna as it is not a pneumatic bone and its medulla is relatively large (Abou-Madi and Kollias 1992). Swabbing of the skin with disinfectant is routinely performed before intravenous or intraosseous injection (Jakob-Hoff 1988).

Intramuscular injections, given into the pectoral and quadriceps muscles, are the most convenient and often-used form of parenteral administration (Jakob-Hoff 1988). In pectoral injections the needle is inserted lateral to the keel and the plunger of the syringe should be withdrawn to ensure a blood vessel hasn't been penetrated (Jakob-Hoff 1988). If large volumes are to be administered, divided doses should be given in both pectoral muscles (Jakob-Hoff 1988). The advantage of giving injections into the thigh muscles is that irritant drugs will have no effect on flight (Cooper 1978).

Subcutaneous injections can be given into the nape, ventral thorax, medial thigh and patagial membrane (Jakob-Hoff 1988). This technique is often used in administering fluids but care should be taken as the skin is thin and firmly attached (Jakob-Hoff 1988). Intraperitoneal injections should not be used for any purpose except euthanasia due to the danger of entering the air sacs (Cooper 1978). Intrasinus injections can be used in treating sinusitis (Jakob-Hoff 1988). In any of these injections the smallest feasible syringes and needles should be used (Jacob-Hoff 1988).

Numerous methods have been tried to medicate raptors orally. Giving the drug in the bird's drinking water is unreliable as raptors only drink intermittently (Jakob-Hoff 1988). Giving the medication concealed in a prey item is only successful if the raptor eats its food whole or else it will be detected and avoided (Jakob-Hoff 1988). Success may, however, be more likely if the bird is starved for 24 to 48 hours before this technique is tried (Cooper 1978). Tablets may be manually placed into the oropharynx and massaged down the neck into the crop (Jakob-Hoff 1978). Alternatively, liquids may be placed directly into the crop (gavage) either by crop needle or crop tube (Jakob-Hoff 1988). A suitable crop tube can be made of a 10 cm piece of plastic tubing attached to a 5 to 10 mL syringe (Forbes 1992). This tube is passed into the oesophagus caudal to the tongue and the liquid carefully expelled into the crop (or proventriculus in the crop-free owl) being careful that it does not overflow into the trachea (Jakob-Hoff 1988, Forbes 1992). Oral medications should ideally be given on an empty crop or stomach (Cooper 1978).

Nebulisation is a useful method of administering drugs to treat respiratory tract infections (Jakob-Hoff 1988). Sprays and powders are topical means of treating external parasites.

Transportation

Raptors are best transported in a darkened box as diurnal birds of prey are rendered almost completely motionless when they cannot see (Jakob-Hoff 1988). The box should be approximately three times the volume of the bird (to allow it to turn without damaging its wings or tail), strong, well ventilated, cool and lined with a towel or hessian for grip (Jakob-Hoff 1988, Olsen 1990). It is unnecessary to provide food or water to adult raptors which are travelling for less than 24 hours (Olsen 1990) and this may

also prevent motion sickness which can occur in raptors which have been fed in the four hours before travelling (Jakob-Hoff 1988).

Housing

It is necessary to have access to three types of housing during the rehabilitation process, including a small hospital enclosure, a medium-sized enclosure and a large flight aviary (New South Wales National Parks and Wildlife Service (NSW NPWS)). The hospital enclosure is used to hold raptors who need intensive care and can be a cardboard box or a normal stainless steel hospital cage with a towel covering the front wire grid (Jakob-Hoff 1988). It should be sufficiently large to comfortably house the raptor and kept warm (using an infra-red lamp, light bulb, heat mat or other heat source), quiet, well-ventilated and dark (NSW NPWS). The air in the cage should be humidified by placing a dish of water near the heat source, the temperature should be monitored with a thermometer and the floor should be lined with newspaper (Jakob-Hoff 1988, Wilson 1988).

After the raptor has passed the critical stage it should be moved to a larger enclosure which allows close monitoring and easy capture of the bird. This aviary should be constructed with opaque (if not solid) walls, measure approximately three metres in each dimension, be quiet and have a constant temperature (NSW NPWS). Minimising any disturbance is important in reducing the raptor's stress level. After the bird has recovered sufficiently it should be moved to a large flight aviary where it can exercise more. The aviary should measure at least six metres long and three metres in height and breadth for small to medium raptors or double this size for eagles and should also have opaque walls (Olsen 1990). If the aviary is of hessian-lined wire mesh the walls and roof at one end should be enclosed in corrugated iron to provide some shelter from rain and wind and offer some privacy (Olsen 1990, NSW NPWS). If it has solid walls a window of vertical slats is useful on the protected side of the aviary for ventilation (Olsen 1990). Provision of a small food door and peep-holes in the aviary allows feeding and observation without disturbing the raptor (Olsen 1990).

The floor of the aviary can be covered in grass, clean sand or gravel and all raptors should have access to small pebbles which are thought to aid digestion (Olsen 1990, NSW NPWS). No nails, sharp projection or loose string should be in the aviary which may injure or entangle raptors (Olsen 1990). A shallow bath which is as long as the raptor should be provided (Olsen 1990).

Except in the case of breeding pairs and juveniles it is best to house raptors individually (Jakob-Hoff 1988). Excess food should be removed daily and the aviary should be cleaned twice annually (Olsen 1990). Care should be taken when entering the aviary at night as raptors are easily startled but owls are best fed at night and diurnal raptors are easily caught in the aviary at night (Perry 1988, Olsen 1990).

It is necessary to give careful consideration to the type of perches provided for raptors. Falcons (which have long, thin toes) require flat perches and hawks (which have larger feet) need round perches of varying diameter (Jakob-Hoff 1988). To reduce the likelihood of raptors developing bumblefoot whilst in captivity the perches should be covered in synthetic grass, paperbark, rope or coconut fibre (NSW NPWS, Galvin 1980) or be of a swinging design (Olsen 1990). The perches should be located far enough away from the walls to prevent feather damage and at a variety of heights (Perry 1988).

Prevention of damage to the wing and tail feathers is of prime importance in captive raptors as a bird with damaged flight feathers may be less able to hunt in the wild. To reduce the occurrence of feather damage at least three sides of the enclosure should be smooth and opaque so wire aviaries are to be avoided unless lined with hessian or shadecloth (NSW NPWS, Jakob-Hoff 1988). Their feathers are especially at risk when the bird is in close confinement and so the tail can be stapled (avoiding the feather shaft), taped or fastened with elastic bands into a sheath made from a manilla envelope (see

Perry 1988). If a feather is bent it can be straightened by soaking it in hot water for 30 to 60 seconds (Jakob-Hoff 1988). Broken feathers can be repaired by the process of "imping" in which the corresponding piece from another bird's feather is joined to the broken stump by inserting and gluing a splinter of wood or pin into the shaft cavity (Wallach and Boever 1983, Jakob-Hoff 1988). If the stump is too small it should be removed to stimulate the growth of a new feather (Jakob-Hoff 1988).

Special care of the raptor should be given during the moult. The birds should be kept in a large enclosure to prevent any feather damage and fed *ad libitum* to prevent the development of stress lines, which are lines of weakness in the feathers corresponding to days of undernutrition (Jakob-Hoff 1988).

Nutrition

The three main types of diet which have been used to feed captive raptors are lean muscle meats, natural foods and commercially prepared rations (Cooper 1978). An all-muscle meat diet is considered inadequate at meeting the raptor's nutrient requirements in a number of areas. Lean meat contains insufficient calcium and B group vitamins and an excess of phosphorus (Olsen 1990) and is also deficient in vitamins A and E (Kirkwood). Because of these imbalances muscle meat alone cannot be recommended as a standard diet, but may be used as part of the ration when supplemented with calcium and vitamins (Cooper 1978). Very fatty meats such as lamb should never be fed to raptors as the fat reduces the available calcium even further by binding it to form calcium soaps (Halliwell 1979).

The calcium to phosphorus ratio of muscle tissue is between 1:15 and 1:40 whereas the optimal dietary ratio is 1.5:1 (Cooper 1978). If raptors are fed an unsupplemented muscle meat diet for prolonged periods their skeletal calcium reserves are progressively mobilised resulting in a nutritional osteodystrophy with bony destruction and spontaneous pathologic fractures (Cooper 1978). After the skeletal reserves are nearly depleted the plasma calcium concentration can no longer be maintained (hypocalcaemia) and the bird may have local muscle spasms ("cramps") or may even progress to total body tetany ("fits"), especially if it is suddenly startled (Wallach and Boever 1983). A 10% solution of calcium borogluconate can be given subcutaneously or intravenously to treat hypocalcaemia (Olsen 1990).

Various supplements can be added to lean meat to make it more suitable for use a raptor food. Calcium carbonate can be added at a rate of 1 gram per 100 grams of meat to correct the meat's calcium to phosphorus ratio (Jakob-Hoff 1988). Bone meal or dicalcium phosphate can also be used for the same purpose (Olsen 1990).

An all-meat diet does not contain any of the roughage, such as skin, fur, feathers and bone, which is used to form pellets which are generally regurgitated after every meal in owls and after one or more meals in hawks (Halliwell 1979). However, the requirement for roughage is questionable as many birds of prey have survived for long periods of time in captivity on a roughage-free diet (Halliwell 1979, Jakob-Hoff 1988). Feeding excessive roughage in the diet or suddenly introducing roughage to a previously roughage-free diet may result in impaction of the raptor's crop, which may then be treated by irrigating the crop, digital manipulation of the impaction or in extreme cases, surgery (Cooper 1978, Halliwell 1979).

Natural diets are considered the best type of diet because they include items most closely resembling those eaten by wild raptors in the way of freshly killed, whole animals (Cooper 1978, Muller 1978). A variety of animals have been fed to captive birds of prey including insects, rodents, rabbits, birds and fish (Muller 1978, Olsen 1990). The type of animal used as prey depends on the natural preferences and size of the raptor.

Rats and mice are available from laboratories and make a very good diet for many types of raptors (Olsen 1990). Mice are, in fact, the staple diet of several Australian birds of prey such as the Black-shouldered Kite (Olsen 1990) and Barn Owl (Hollands 1991). Mature rats and mice with fully ossified skeletons should be used as they have the correct calcium to phosphorus ratio (Jakob-Hoff 1988). Raptors fed rodents will often refuse to eat the intestines which can accumulate and contaminate the housing. Raptors are, however, more likely to eat the viscera if the rodents have been fasted for six hours before death which partially empties the rodents' gastrointestinal tracts (Cooper 1978).

Day-old chicks are readily available from hatcheries and are a rich source of vitamins A and D3 but they have insufficient calcium and phosphorus and so should not be fed as a sole food source if unsupplemented (Kirkwood). The feeding of these chicks results in an intensification of the yellow pigmentation that many raptors have in their ceres, irises and legs (Olsen 1990). These areas lose their yellow pigmentation if raptors are fed rodents only (Olsen 1990). Raptors fed day old chicks are in danger of *Escherichia coli* infection as these chicks frequently have infected yolk sacs (Cross GM pers comm).

Coturnix quail (*Coturnix coturnix*) make an excellent diet for birds of prey in captivity (Olsen 1990). The feeding of pigeons, however, carries a potential risk as they may act as a source of infection for several raptor infectious diseases including frounce (caused by *Trichomonas gallinae*) (Cooper 1978, Olsen 1990). However, freezing of the pigeons for 24-48 hours prior to feeding kills most trichomonads (Halliwell 1979). Pest bird species such as Common Starlings (*Sturnus vulgaris*) and House Sparrows (*Passer domesticus*) make very good food (Olsen 1990). Road-killed birds and animals can be fed to raptors if they are fresh but it is wise to be cautious of pesticide residues in these items (Olsen 1990).

Fish should be fed to those birds such as the Osprey (*Pandion haliaetus*) whose staple diet in the wild consists of fish. It should be remembered that some fish species contain thiaminase which inactivates thiamine (vitamin Bl) (Cooper 1978, Wallach and Boever 1983).

Although the use of commercially prepared artificial diets has been questioned by some observers due to a poor understanding of the nutrient requirements of raptors (Cooper 1978), several have been used successfully. One such diet formulated at the San Diego Zoo contains a mixture of trout pellets, horsemeat and calcium carbonate (Muller 1978).

It is best to feed a variety of foods to raptors so as to reduce the chances of developing a nutritional deficiency or poisoning from eating one type of food only (Cooper 1978).

It is important to feed a raptor undergoing rehabilitation a sufficient quantity of the chosen diet to meet its requirements for growth or maintenance. Small raptors (100-200 grams bodyweight) require relatively more food (18-25% of their own bodyweight per day) than larger raptors (800-1200 g) which need 7-11% of bodyweight per day for maintenance (Halliwell 1979). A 4.0 kilogram Golden Eagle (*Aquila chrysaetos*) requires just 6.25% of its bodyweight in food per day (Cooper 1978). It is best to supply more food than the raptor will eat and remove any surplus daily (Olsen 1990).

To determine whether a raptor is consuming an adequate amount of food to meet its requirements it should be weighed regularly (Cooper 1978). A reduction in weight when the bird is eating all that is offered indicates the need to increase its ration (Cross 1994). The bird should be weighed after it has cast a pellet and before it has eaten on that day so that the weight of the gut contents is minimal. Raptors need a higher plane of nutrition at certain times such as during cold weather (Cooper 1978, Halliwell 1979) or in young growing (Cooper 1978), active (Cooper 1978), stressed (Cross 1994), healing (Cooper 1978) or moulting birds (Kirkwood).

Fresh food is preferable to thawed frozen food as freezing causes food deterioration and vitamin depletion (especially B group vitamins (Cross 1994)).

Vitamin A deficiency is a common problem in raptors whose diet contains inadequate quantities of the preformed vitamin (Wallach and Boever 1983) as vitamin A cannot be synthesised from carotenoid precursors in these birds (Halliwell 1979). Hypovitaminosis A leads to pallor of the cere, talons and legs, as well as hyperkeratosis of the birds' squamous epithelium, especially around the eyes, oropharynx and syrinx (which can lead to voice changes) (Halliwell 1979).

Vitamin D deficiency occurs in raptors which don't receive adequate exposure to sunlight and results in rickets in young, growing birds or osteomalacia in mature birds (Cooper 1978). Other vitamin deficiencies which have been reported in birds of prey include thiamine (B_1), riboflavin (B_2) and vitamin E (Halliwell 1979), and these may be treated with an appropriate vitamin supplement.

The water requirements of raptors are generally met by the water content of their diet in addition to that supplied by metabolism but it is safest to provide a supplemental source of fresh water in case of high environmental temperatures or other causes of increased requirement such as stress (Halliwell 1979).

Care of young raptors

If it is at all possible, juvenile raptors should be returned to the locality where they were found and either replaced in their parents' nest or placed high in a tree so they are fed (Cooper 1975). Alternatively, raptor nestlings can be fostered into the nests of raptors of the same species with young of the same age (Olsen 1990). If these are not feasible, juvenile and nestling raptors need special attention during their rehabilitation. Raptors are altricial (poorly developed at birth) so their thermostatic mechanisms are imperfect and it is necessary to carefully supply them with warmth from a brooder or heat pad (Olsen 1990). They should also be given access to sunlight for 10 minutes daily to help synthesise their required vitamin D_3 (Olsen 1990).

Raptors that have recently hatched should be fed very small pieces of highly digestible food such as rodent, quail or other meat every four hours (Olsen 1990). This can be done by placing the food into the open beak with forceps whilst being careful not to overfeed (Olsen 1990). Blended skinned animals (including bones) are fed from day three and feathers or fur can introduced after the first fortnight (Olsen 1990).

Imprinting of nestlings on humans is deleterious as it leads to unnatural tameness and will prevent them from later breeding in the wild (Cross 1994). Certain things can be done to prevent this from happening including keeping nestlings together so they imprint on each other (Cross 1994) and avoiding an association between food and humans (Olsen 1990). This can be done by feeding them with tweezers held by a puppet resembling the head of an adult, whilst being out of sight (Perry 1988, Olsen 1990). In hawks the sensitive imprinting period ends by day 18 and in owls by week six (Cross 1994). If association with humans occurs early in this sensitive period they may accept a human as a surrogate sexual partner and later contact in this period leads to tameness only (Cross 1994). If a nestling is trained using falconry techniques avoiding imprinting is impossible (NSW NPWS).

Exercising birds of prey

Raptors must attain a high level of fitness, muscular strength and stamina before they can be released into the wild. Exercising raptors using a large flight aviary or exercising equipment is recommended over free-flying the bird using falconry methods as the process is quicker and the raptor becomes less tame (NSW NPWS). The only situation in which falconry techniques should be used is in hand-raised

Australian Hobbies and Peregrine, Black and Grey falcons which are too old to hack (NSW NPWS). In other raptors sufficient exercise is gained by making the bird fly around a large aviary, from perch to perch, several times a day (Cross 1994). This method has the advantage of requiring less handling (therefore it is less stressful). Another very successful technique is to attach the bird to an angled wire, via a sliding connection, so it is forced to fly up an incline to feed (Cross GM pers comm). Alternatively, it may be placed in an empty silo and fed frequently each day which encourages vertical flight to develop muscular strength (Cross 1994). As the rehabilitation process progresses the intensity and duration of exercise should increase (Horowitz, Schulz and Fowler 1983).

Physical therapy

If a raptor is not likely to use a limb for several weeks after a traumatic incident it may be necessary to perform physical therapy on that limb to increase the joint mobility, muscular strength and reduce the level of oedema and deposition of restrictive fibrous tissue (Horowitz *et al* 1983). Horowitz *et al* (1983) lists the three types of physical therapy as passive, active and functional. Passive therapy is where the raptor does not expend any energy. It includes moving the limb through its range of motion manually and massaging the area. Massage (either light or deep stroking or friction massage) increases the circulation to the area, relaxes muscle spasm and increases flexibility. Active therapy

Release into the wild

Care needs to be taken to ensure that juvenile raptors do not starve once they are liberated. They may be housed with or within sight of mature birds of the same species so they can observe hunting and feeding behaviour (especially good in owls) (Perry 1988). If still at the nestling stage they can be "hacked" which allows them to practice their hunting skills in the wild whilst still being fed. This method works best in diurnal raptors. The nestlings are placed in an artificial nesting box which is isolated, offers shelter from the weather and is safe from predators (Olsen 1990). The young (at least two) are placed in the box well before their first flight so they may observe and imprint on the surroundings (Olsen 1990). Food should be provided to the nest, without them observing humans, from when the nestlings are placed in the nest until they can catch enough prey on their own, at between weeks two and eight (Olsen 1990).

It is best to rehabilitate and liberate raptors as soon as possible to minimise the potential for habituation to humans and traumatic injury in captivity (Horowitz *et al* 1983). Only raptors in good health with excellent plumage, eyesight, condition and powers of flight should be released (Perry 1988, Olsen 1990). If a raptor is not in full health with a high level of fitness, its chances of survival in the wild are reduced. The raptor should not be imprinted on humans, and should be shy of dogs and cats (Galvin 1980). If it is imprinted it may act aggressively or solicit food from humans (Cross 1994).

The area in which the bird is released should be far from human disturbance, in a place that offers shelter and abundant food (Muller 1978, Galvin 1980). Ideally, the bird should be returned to its own territory, if this is feasible (Olsen 1990). It should not be released in areas in which birds of the same species or harassing bird species (for example the Australian Magpie and Pied Currawong) are present (Olsen 1990).

After being fed, diurnal raptors should be released in the early morning and owls should be released soon after dusk to ensure that they have the maximum opportunity to settle into their new environment (Perry 1988). Telemetry, banding and tagging are useful tools in determining if the level of rehabilitation has been adequate for survival (Perry 1988).

Alternatives to release

A decision has to be made as to whether a raptor will ever recover and develop adequate fitness and strength to have a good chance of survival after release. If a bird is permanently incapacitated, it may be used for educational, research or captive breeding purposes, especially if it is of a rare or endangered species (Perry 1988).

Discussion

Much of the information on raptor diseases and nutrition in the literature has been determined in Europe and North America in relation to captive raptors which are used in the ancient sport of falconry. In this sport raptors are kept and trained to hunt game, but this is illegal in Australia. The NSW NPWS limits the keeping of raptors, to help prevent illegal falconry, by making it mandatory to obtain a permit if raptors are kept. Other research has been performed in other countries on the supplementation of wild populations and local reintroduction in endangered raptors (like the Peregrine Falcon subspecies of the eastern United States) (Olsen 1990). It will be necessary to apply much of the information presented in these overseas studies to the rehabilitation of raptors in Australia, until more work is performed in this country to ascertain any differences here.

Conclusion

Increasingly people are becoming aware of the plight of our native animals and birds. With their position near the top of the food chain, raptors have been persecuted and are especially prone to environmental changes caused by man including habitat destruction and widespread pesticide utilisation. Helping to rehabilitate sick and injured raptors, by offering an assessment upon presentation and then treating, housing, feeding and exercising them correctly before they are released back into the wild, is one way a veterinarian can fulfil a desire to help guard the welfare of these majestic species.

APPENDIX 1: CLASSIFICATION OF AUSTRALIAN BIRDS OF PREY

Family Accipitridae (hawks, eagles and osprey)

Pandion haliaetus	Osprey
Elanus notatus (caerulus)	Australian Black-shouldered Kite
Elanus scriptus	Letter-winged Kite
Milvus migrans	Black Kite
Aviceda subcristata	Pacific Baza
Lophoictinia isura	Square-tailed Kite
Haliastur indus	Brahminy Kite
Haliastur sphenurus	Whistling Kite
Accipiter cirrhocephalus	Collared Sparrowhawk
Accipiter novaehollandiae	Grey Goshawk
Accipiter fasciatus	Brown Goshawk
Erythrotriorchis radiatus	Red Goshawk
Heiraaetus morphnoides	Little Eagle
Haliaeetus leucogaster	White-breasted (bellied) Sea-Eagle
Aquila gurneyi	Gurney's Eagle
Aquila audax	Wedge-tailed Eagle
Circus assimilis	Spotted Harrier
Circus approximans	Swamp Harrier

Family *Falconidae* (falcons)

Falco longipennis	Little Falcon
Falco peregrinus	Peregrine Falcon
Falco subniger	Black Falcon
Falco hypoleucos	Grey Falcon
Falco berigora	Brown Falcon
Falco cenchroides	Nankeen Kestrel

Order Strigiformes (owls) (Hollands 1991)

Family Strigidae (typical owls and hawk owls)

Ninox rufa	Rufous Owl
Ninox strenua	Powerful Owl
Ninox novaeseelandiae	Boobook Owl
Ninox connivens	Barking Owl

Family Tytonidae (Barn owls)

Tyto alba	Common Barn-Owl
Tyto longimembris	Eastern Grass-Owl
Tyto novaehollandiae	Masked Owl
Tyto tenebricosa	Sooty Owl
Tyto multipunctata	Lesser sooty owl

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