REVIEW

Veterinary treatment and rehabilitation of indigenous wildlife

E. Mullineaux

Secret World Wildlife Rescue, Highbridge, Somerset TA9 3PZ

Veterinary surgeons in general practice are frequently presented with injured or orphaned animals by wildlife rescue centres, members of the public or police officers. Following treatment, many of these animals are released to the wild. Despite the large numbers of wildlife casualties rehabilitated in this way there are few published data detailing species, numbers treated, quality of care provided and outcome following release. There is also ongoing debate regarding the welfare and conservation benefits of such human intervention. This article reviews the available published evidence on wildlife rehabilitation and offers recommendations on future policy.

Journal of Small Animal Practice (2014) **55**, 293–300
DOI: 10.1111/jsap.12213

Accepted: 10 February 2014; Published online: 12 April 2014

INTRODUCTION – THE REHABILITATION OF WILDLIFE CASUALTIES

The International Wildlife Rehabilitation Council (IWRC) defines wildlife rehabilitation as; the treatment and temporary care of injured, diseased, and displaced indigenous animals, and the subsequent release of healthy animals to appropriate habitats in the wild (Miller 2012). The process of rehabilitation varies according to the species involved and injuries sustained. A deer entangled in a wire fence without other injury may be released to the wild immediately (Green 2003), whilst an orphaned otter requires specialist care for over a year before release (Simpson & King 2003). People involved in the rehabilitation process have a range of abilities and skills, varying from enthusiastic lay people with little training working with limited facilities, through to qualified professionals working in veterinary hospital standard premises (Kirkwood 2003).

RATIONALE FOR TREATMENT AND REHABILITATION OF WILDLIFE CASUALTIES

Most people become involved in wildlife rehabilitation to provide care for individual casualty animals until released or euthanased (Dubois 2003, Guy *et al.* 2013). The need to avoid causing unnecessary suffering to animals brought into captivity through an inappropriate attempt to extend their natural life must, however, be balanced against such well-meaning altruism (Best & Mullineaux 2003, Kirkwood 2003). Several authors have debated the ethics and welfare of treating wildlife species (Cooper 1989, Kirkwood & Sainsbury 1996, Kirkwood 2003, Cooper & Cooper 2006) with all concluding that the welfare of the individual casualty should be the overriding consideration. Unfortunately, the views of stakeholders (veterinary surgeons, rehabilitators and conservationists) can be at odds when subjects such as the preservation of life and prevention of unnecessary suffering (e.g. by performing euthanasia) are involved (Dubois 2003).

One justification for the treatment of wildlife casualties is an attempt to counter the negative actions of man on species demographics and individual animal welfare. This moral and ethical responsibility is most powerfully illustrated in large man-made catastrophes such as oil spills that impact upon large numbers of seabirds (Wernham *et al.* 1977, Mazet *et al.* 2005) and marine mammals (Baker *et al.* 1981). The same principles of "redressing the balance" can be applied to other man-made problems; 40% of European hedgehogs (*Erinaceous europaeus*) treated by wildlife rescue centres in the United Kingdom (UK) and the Netherlands arise from road traffic collisions (RTC), garden and pet injuries, poisoning, and disturbance of local environments (Reeve & Huijer 1999).

In countries with unique indigenous species, care of individual animals plays a part in conservation, for example in endangered bird species in New Zealand (NZ) (Mullineaux 2006). Rehabilitation of Australian species including wombat (*Vombatus ursinus*) (Saran *et al.* 2011), koala (*Phascolarctos cinereus*) and common brushtail possum (*Trichosurus vulpecular*) (Tribe *et al.* 2005) has successfully contributed to conservation of these species. Under such circumstances provision of expert care is important but it is nonetheless essential that the individual animal's welfare is not superseded by conservation aims (Kirkwood & Sainsbury 1996, Cooper & Cooper 2006). In the UK, it is unlikely that veterinary surgeons will be presented with individual animals that pose a conservation risk. Admissions data for wildlife centres and

JSAP JOURNAL OF SMALL ANIMAL PRACTICE

veterinary practices can, however, help highlight environmental problem areas, such as polluted water courses or busy roads, allowing mitigation policies to be put in place (Ramsden 2003).

The reporting of wildlife diseases can be an important part of national disease surveillance affecting conservation, livestock diseases and zoonoses (Randall *et al.* 2012). The need to investigate and monitor wildlife for new and emerging infectious diseases of man and other species has been discussed on a Europe wide basis (Artois *et al.* 2001) and the requirement for coordinated monitoring of wildlife diseases in the UK has been acknowledged (Sainsbury *et al.* 2001). Much of the wildlife disease monitoring in the UK is carried out by the Animal Health Veterinary Laboratories Agency (AHVLA) Wildlife Disease Monitoring Program, which aims to detect reservoirs of potential zoonotic diseases, diseases of livestock, and new pathogens and environmental pollutants (Duff 2003). Opportunities exist for lay rehabilitators and veterinarians to contribute to such monitoring. Reports of diseases across Europe and the rest of the world are disseminated through organisations such as the Wildlife Disease Association (WDA), European Wildlife Disease Association (EWDA) and the World Organisation for Animal Health (OIE). The investigation of the cause of clinical illness in wildlife casualties may lead to the identification of novel pathogens not previously described in that species, such as those associated with enteric disease in European badger (*Meles meles*) cubs (Barlow *et al.* 2011, 2012) and causing Tyzzer's disease in a rehabilitated European otter (*Lutra lutra*) (Simpson *et al.* 2008).

Internationally, there is strong public support for animal welfare, protection of wild populations, and protection of ecosystems, however, individuals may rank these differently (Dubois & Fraser 2013). Provision of professional veterinary services to members of the public finding sick or injured animals generates a "feel good factor" for those involved and a secondary public relations benefit to the veterinary practice (Kirkwood 2003, Cooper & Cooper 2006). There is also an educational benefit to those dealing with wildlife casualties, creating an environmental and conservation awareness (Wobeser 2007, Vogelnest 2008). Improving public awareness and education is cited a close second to provision of individual animal care by people involved in wildlife rehabilitation (Dubois 2003). Veterinary treatment of wildlife casualties may help to develop skills not normally used in general practice and improve these for future use when presented with endangered species (Sikarskie 1992, Wobeser 2007). At all times the welfare of the individual casualty must be the first priority and personal and professional development a secondary consideration (Cooper & Cooper 2006).

There is much ethical debate regarding the treatment of individual casualties with some authors regarding the only role of the veterinary surgeon as ending suffering through euthanasia (Loftin 1985), whilst others promote the benefits of treatment and rehabilitation (Kirkwood 2003). The potential negative ecological effects of rehabilitated animals on existing populations (Robinson 2002), especially where animals are translocated (Griffith *et al.* 1993, Wobeser 2007) are not often fully considered. There is also a credible argument that funds should not be diverted from habitat conservation (Sikarskie 1992, Wobeser 2007) and other "worthwhile goals" (Loftin 1985) to the care of casualties. There is, however, little evidence to suggest that those who fund wildlife rescue work would donate elsewhere if such work was to cease (Sikarskie 1992).

For the veterinary practitioner perhaps the greatest risks of dealing with wildlife casualties are related to health and safety of the practice work force. Many wildlife species will bite, kick or scratch, as well as being a potential source of zoonotic diseases (Best & Mullineaux 2003). The risk of disease transmission also extends to domestic species within the veterinary practice. Suitable standard operating procedures, training and risk assessments must be in place to mitigate these risks (Cooper 2003). Professional time, resources and materials diverted into wildlife care must be fully accounted (Sikarskie 1992).

REGULATORY FRAMEWORKS

There is an international appreciation of the need to treat wildlife casualties correctly and educate those involved in their care (Vogelnest 2008, Miller 2012), but the regulatory frameworks governing wildlife care vary greatly around the world. In Australia, NZ and North America, some statutory framework exists, but the extent to which standards and training are enforced varies between states within the same country. In South Africa, a need for centralization and enforced minimum standards has been recognized (Wimberger *et al.* 2010) but there is currently no formal regulation. Where licensing and standards exist there is often criticism from stakeholders that these are not stringent enough and relevant training is lacking (Sikarskie 1992, Dubois 2003). The best attempt to produce international standards and guidelines comes in the form of the IWRC, which offers training and publishes rehabilitation research in its journal.

In Ireland, a licence is required to keep an injured animal in captivity, but no such restrictions exist in the UK. Wildlife in the UK is protected under animal welfare legislation (Animal Welfare Act 2006) and some species-specific legislation (Protection of Badgers Act (1992), Deer Act (1991)). These Acts prohibit "taking" wild animals and ensure their general welfare in captivity. The Wildlife and Countryside Act (1981) restricts the keeping of certain species in captivity and the release of others back into the wild. Wildlife also comes under the Veterinary Surgeons Act (1966), limiting the treatment of all animals to registered veterinary surgeons. There is no central database of those people involved in wildlife rehabilitation and their qualifications, or the numbers of animal in wildlife centres and those eventually released. Informal self-regulation of wildlife rehabilitation has come from the various Wildlife Trusts such as the Badger Trust, Bat Conservation Trust, British Hedgehog Preservation Society and British Trust for Ornithology (BTO), although the main focus for these groups has remained conservation rather than the treatment of individual animals. Later, rehabilitators from these groups have formed the British Wildlife Rehabilitation Council (BWRC), which produces guidelines for rehabilitation and has collected data on treatment and release rates (Best 1999, Kirkwood 2003).

ADMISSIONS TO WILDLIFE RESCUE CENTRES

There are approximately 80 UK wildlife rescue centres (Mullineaux & Kidner 2011) dealing with an estimated 30 to 40,000 animals per annum (Molony *et al.* 2007), although true figures of admissions have been suggested to be double this (Grogan & Kelly 2013). Information relating to admissions to these centres is limited to surveys carried out by the BWRC in the late 1990s (Best 1999, Kirkwood 2003). From 16,000 admissions 67·1% were birds, 32·5% mammals, with small numbers of reptiles and amphibians (Kirkwood 2003). Four common species accounted for over 40% of admissions; hedgehogs, feral pigeons (Columbidae), blackbirds (*Turdus merula*) and collared doves (*Streptopelia decaocto*). Hedgehogs accounted for 16% of all admissions and 54% of mammals (Kirkwood 2003).

Juvenile animals feature heavily in admissions to wildlife centres. In the BWRC survey, 50% of bird and 54% of mammal admissions were of immature animals (Kirkwood 2003). Thirty-two percent of birds and 27% of mammals had no injuries and were considered to be "orphans" (Kirkwood 2003). In other UK surveys 65% of polecat (*Mustela putorius*) admissions (Kelly *et al.* 2010) and 68% of woodpigeon (*Columba palumbus*) admissions (Kelly *et al.* 2011) were juveniles. Similar patterns are seen elsewhere in the world; records from a South African rescue centre showed 43% of admissions to be juveniles (Wimberger & Downs 2010), as were 32·2% of raptor casualties (Molina-López *et al.* 2011) and 53·2% of little owl (*Athene noctua*) casualties (Molina-López & Darwich 2011) in Spain.

Traumatic injuries are a common reason for casualty admissions, representing approximately 39% of all admissions and 30% of mammal casualties in the UK (Kirkwood 2003). Trauma may occur alone or be secondary to debilitation as a result of disease. Traumatic injuries were responsible for the death of 39% of bats (Chiroptera) in a German study (Mühldorfer *et al.* 2011). In hedgehogs, 40% of admissions arose predominantly from trauma (Reeve & Huijer 1999). Trauma due to RTC is a primary reason for morbidity and mortality in mammals. High rates of hedgehog mortality were found on Polish roads, especially in urban areas (Orlowski & Nowak 2004). RTC also accounted for 37% of adult badger casualties admitted to wildlife hospitals in the UK (Mullineaux & Kidner 2011) and was the most common reason for presentation of koala in Australia (Griffith *et al.* 2013). Naturally occurring trauma such as conspecific ("territorial") wounding in badgers may also be a reason for admission whereby 58% of all badger casualties had this lesion (Mullineaux & Kidner 2011).

Trauma accounts for 43% of bird casualties in the UK (Kirkwood 2003); 50 and 42% of raptor casualties presented to rehabilitation centres in mainland Spain (Molina-López *et al.* 2011) and Tenerife (Rodrigues *et al.* 2010) had traumatic injuries. Falconiformes appear especially susceptible to trauma (Kelly & Bland 2006, Molina-López *et al.* 2011). Trauma is less common in Stringiformes (Molina-López *et al.* 2011), but still accounted for 31·4% of admissions in little owls (Molina-López & Darwich 2011). "Collision" is a common trauma in birds (Rodrigues *et al.* 2010; Cousins *et al.* 2012). Collisions with vehicles and windows caused a range of soft tissue and skeletal injuries in NZ pigeons (*Hemiphaga novaeseelandiae*) (Cousins *et al.* 2012). Vehicle injuries affected the extremities, whilst window collisions resulted in head, coracoid, clavicle and internal soft tissue injuries (Cousins *et al.* 2012).

Predation by domestic cats is a common cause of trauma. Estimates indicate that the nine million cats in the UK kill approximately 90 million "prey items" over the spring and summer months (Woods *et al.* 2003). The BWRC surveys found admissions due to cat trauma to occur in birds (13%), mammals (5%), reptiles and amphibians (24%) (Kirkwood 2003). These findings concur with the survey of cat owners in which 71 species of animals were caught; 69% mammals, 24% birds and 5% reptiles and amphibians (Woods *et al.* 2003). Some species of birds appear to be more commonly caught by cats; for example cats accounted for injuries in 21% of adult and 16% of juvenile woodpigeon (Kelly *et al.* 2011). Bats are also especially susceptible to cat trauma and this accounted for the primary reason for admission of 28·7% of bat casualties in a study in Italy (Ancillotto *et al.* 2013) and around half of the traumatic deaths of bats found in Germany (Mühldorfer *et al.* 2011).

Many authors have observed a distinct seasonality to casualty admissions, typically related to breeding season (Kelly & Bland 2006, Molina-López & Darwich 2011, Molina-López *et al.* 2011, Mullineaux & Kidner 2011, Ancillotto *et al.* 2013, Griffith *et al.* 2013). Seasonal trends may allow for planning of resources within wildlife centres and veterinary facilities. A skewed sex distribution of certain injuries in some species is also noted (Mullineaux & Kidner 2011, Ancillotto *et al.* 2013).

TRIAGE OF CASUALTIES

Key to ensuring the welfare of individual wildlife casualties is a proven process that enables the rapid euthanasia of animals that are considered unlikely to be able to be released back to the wild, this process is referred to as "triage" (Best & Mullineaux 2003, Molony *et al.* 2007, Vogelnest 2008). In medical terms, "triage" is usually used to differentiate between the most urgent and less medically concerning cases in an emergency room or at the site of an accident, in order to provide first aid and emergency care with priority where it is most needed. The limiting factors of medical triage are time and resources. There are wildlife situations where true "triage" is required, for example in a mass cetacean stranding (Baker *et al.* 2000, Barnett & Robinson 2003, Gales *et al.* 2008), bush fire (Vogelnest 2008) or an oil spill event (Mazet *et al.* 2005).

Where individual wildlife casualties are involved triage decisions are made based upon the condition of the individual animal and its suitability for eventual release. Authors agree that wildlife casualties should be released in a state of physical and psychological fitness that enables them to survive in the wild equally as well as other free-living members of their species (Best & Mullineaux 2003, Molony *et al.* 2007). Illness and injury are generally considered to be more important factors than body mass in making

a clinical decision to continue with treatment (Molony *et al.* 2007). All the factors that contribute to an eventual successful outcome for a casualty need to be considered in the triage decision and not all these factors are veterinary considerations. The success of treatment and rehabilitation of wildlife casualties depends upon the facilities, suitably trained personnel, veterinary services, adequate funding and availability of release sites (Best & Mullineaux 2003, Wobeser 2007).

Triage decisions should be made quickly, ideally within 48 hours of admission (Kelly *et al.* 2011) in order to prevent unnecessary suffering of casualties in captivity. Figures for casualty survival beyond 48 hours following admission, either as a result of death or euthanasia, are around 60% (Kirkwood 2003, Molony *et al.* 2007). Ideally a veterinary examination should be part of the triage process for all casualties (Best & Mullineaux 2003, Vogelnest 2008). In large wildlife hospitals, where casualties arrive at all times of day and night, and there is a good relationship with a local veterinary practice, initial triage may be through the use of written schemes of practice allowing trained non-veterinary staff to make triage decisions and carry out humane euthanasia of casualties (Best & Mullineaux 2003). Suitable training is required in appropriate euthanasia techniques (Dubois 2003) and consideration must be given to relevant firearms and medicines legislation (Best & Mullineaux 2003).

VETERINARY CARE

Review of the extensive published literature of wild animal diseases is beyond the scope of this article. However, the conditions presented to veterinary surgeons originate from areas of human–wildlife interactions around houses, gardens and roads and are consequently biased towards trauma rather than disease with only 9% of "casualties" presented for "natural causes" including disease (Kirkwood 2003). The prognosis for this category is poor and most are euthanased at first examination. Diseased adult animals are often older individuals at the end of their natural life and typically emaciated (Mullineaux 2003, Griffith *et al.* 2013). Disease conditions are more commonly treated in juvenile casualties, for example hedgehogs with parasitic skin and lung disease (Bexton & Robinson 2003).

Specific disease in some species may become a significant rehabilitation issue, both as clinical cases and because of a need to screen some animals before release. Examples include tuberculosis in badgers (Mullineaux & Kidner 2011) and chlamydiosis in koalas (Griffith *et al.* 2013).

Veterinary first aid provision during triage follows the same basic principles as domestic species. Where treatment is carried out it is essential that the long-term future of the casualty animal is continually considered where release remains the ultimate aim. Some specific knowledge of the ecology, biology and specific problems encountered by the various species is necessary; reference to the available literature together with a good working relationship with naturalists and rehabilitators (Miller 2012) is essential to this process.

After initial assessment and treatment animals are usually moved to a rehabilitation facility for further treatment and eventual release. Pre-release fitness assessment is an important and often overlooked part of the rehabilitation process and should include a veterinary examination (Vogelnest 2008), all too often veterinary intervention is limited to the early part of the rehabilitation process.

VETERINARY RESOURCES

Published information, in particular peer-reviewed literature, relating specifically to veterinary care and treatment of wildlife casualties is limited. The amount of available literature is dependent upon the value placed on wildlife, either as a commercial resource (e.g. in Southern Africa) or through being unique to a specific country (e.g. in Australia, New Zealand) or considered of international importance [e.g. Giant pandas (*Ailuropoda melanoleuca*) and tigers (*Panthera tigris* spp.)]. In the UK, several textbooks describing the care of British wildlife to a general audience have been available for many years (Cooper & Eley 1979, Stocker 2005). More recently literature aimed specifically at veterinary surgeons in practice, rather than rehabilitators, has been produced (Mullineaux *et al.* 2003). Online resources are available to veterinary surgeons and several articles have been published in veterinary journals aimed specifically at the first opinion practitioner dealing with wild birds (Cousquer 2005a), including raptors (Chitty 2006a,b, Couper & Bexton 2012) and swans (Routh 2000, Cracknell 2004), and mammals, including badgers (Lewis 1997a,b,c, Cousquer 2005b, Mullineaux 2012), bats (Mullineaux & Brash 2009, Bexton & Couper 2010), deer (Benato & Bexton 2011) and hedgehogs (Robinson & Routh 1999).

Veterinary nurses are often responsible for the care of wildlife both in veterinary practices and as employees of wildlife centres. Published information specifically aimed at veterinary nurses (Gosden 2004, Meredith *et al.* 2008, Varga *et al.* 2012) is a useful addition to available literature.

REHABILITATION CARE

The possibility for disease transfer to and from wildlife casualties to domestic animals and the environmental conditions in most veterinary facilities (bio-containment risks) make them unsuitable for anything other than short-term care. Casualties should be moved to a more suitable rehabilitation facility as soon as they are clinically stable. The availability of facilities, suitably trained personnel and funding are limiting factors in rehabilitation (Best & Mullineaux 2003, Dubois 2003, Wobester 2007). Standards of care and facilities vary enormously, especially when regulatory standards are lacking.

A good working relationship between lay rehabilitators and vets is an essential part of a successful rehabilitation programme (Miller 2012) and this can sometimes be difficult when emotive subjects such as euthanasia must be discussed. Most wildlife care

and rehabilitation is provided by lay people rather than veterinary surgeons and this may create emotional and philosophical, as well as veterinary, problems (Sikarskie 1992).

RELEASES FROM WILDLIFE RESCUE CENTRES

There are limited data relating to release rates from wildlife centres. BWRC figures suggested 42% of all admissions were eventually released (Kirkwood 2003). The RSPCA estimated an overall 40% release rate from its centres (Grogan & Kelly 2013). A detailed study of RSPCA admission records for eight common species suggested an overall release rate of 39% (Molony *et al.* 2007). Similar release rates were found in casualties from Australian wildlife centres (Vogelnest 2008).

BWRC figures for mammals suggested an overall release rate of 31% (Kirkwood 2003). Release rates for the mammalian species, across all ages, considered in the review of RSPCA data were; badgers 32%, foxes (*Vulpes vulpes*) 43%, hedgehogs 53% and *Pipistrellus* spp. bats 29% (Molony *et al.* 2007). Other studies found that 36% of adult badgers (Mullineaux & Kidner 2011) and 43% of adult polecats (Kelly *et al.* 2010) survived to release.

Release rates are overall higher for birds than mammals, across all ages. Forty-seven percent of birds in the BWRC surveys survived to release (Kirkwood 2003). Release rates were slightly lower for the avian species included in the RSPCA survey; blackbirds 37%, house sparrows (*Passer domesticus*) 33%, starlings (*Sturnus vulgaris*) 36%, tawny owls (*Strix aluco*) 45% (Molony *et al.* 2007). Other studies found only 14% of adult woodpigeons (Kelly *et al.* 2011) and 24% of sparrowhawks (*Accipiter nisus*) were released after treatment (Kelly & Bland 2006).

Release rates are generally higher in juveniles compared to adult casualties, reflecting the lack of injury in "orphan" animals. For example, 89% of juvenile polecats (Kelly *et al.* 2010), 31% of juvenile woodpigeons (Kelly *et al.* 2011), 65% of mallard (*Anas platyrhynchos*) ducklings (Drake & Fraser 2008) and 81·5% of juvenile wombats (Saran *et al.* 2011) survived to release.

EVALUATING A SUCCESSFUL OUTCOME

The first issue in evaluating the success of rehabilitation is to define "success", which may be viewed differently by the various people involved in the process (Dubois 2003). Success may be judged in terms of "preventing unnecessary suffering" whereby a high level of euthanasia could be considered successful (Loftin 1985). For most people a "successful" process is defined by the number of casualties rehabilitated, together with the educational benefits of this process (Dubois 2003). Poor records in many wildlife centres results in a lack of reliable information and bias. Where records are kept the quality of these is variable depending upon the expertise of those making the records (Moloney *et al.* 2007, Grogan & Kelly 2012), and the transparency and honesty of the figures released (Dubois 2003).

RELEASE

Release is broadly divided into two types, "soft" and "hard". Soft release involves initial provision of shelter and support feeding, usually in a temporary enclosure within the release site. Hard release, usually used only for adult short-term casualties, involves simply releasing the animal back into the wild as close as possible to its capture site (Llewellyn 2003). The time of year can influence the success of releases (Tribe *et al.* 2005) and juvenile animals should be released when food is plentiful and territorial behaviour reduced; special consideration must be given to the release of migratory species (Llewellyn 2003). Selection of release site areas is critical to the release process (Tribe *et al.* 2005).

Release is an underestimated component of the rehabilitation process with the potential for high losses (Vogelnest 2008). Animals need to re-integrate into the wild for the release to be considered truly successful (Grogan & Kelly 2003) and this includes normal behaviour and future breeding. Release also has potentially negative ecological, genetic and disease effects on existing populations (Cunningham 1996, Robinson 2002, Vogelnest 2008), especially when animals are translocated (Griffith *et al.* 1993, Wobeser 2007). An Australian survey of rehabilitation and release practices found most centres conducted limited or no pre-release veterinary screening, animals exhibiting stereotypic behaviours were often released, and only 40% of centres had criteria for evaluating the success of releases, with just 58% of centres carrying out short-term post-release monitoring (Guy *et al.* 2013). The author's knowledge of rehabilitation practices in the UK suggests the situation is no better.

METHODS OF POST-RELEASE MONITORING

Post-release monitoring is essential to assess the true success of the release process. Such monitoring may simply involve direct observation with recognition of individual animals achieved by marking with rings, tags, fur clips, coloured dyes or tattoos (Llewellyn 2003, Guy *et al.* 2013). Movement sensitive cameras assist this process and allow for monitoring at night. Permanent marking of animals generally requires a licence through an appropriate agency (e.g. Natural England). Radio frequency identification (RFID) transponders or passive integrated transponders (PIT tags) placed as subcutaneous chips or ear tags can be used to identify animals moving through readers fitted to feeding tubes or shelter openings (Rigby *et al.* 2012). Proximity loggers can be used to measure contacts between individual animals in a group (Ji *et al.* 2005). However, these methods are time consuming and animals are "lost" once they disperse from the release site.

The "return" of rings, bands tags or tattoo number data to a central organisation (e.g. BTO) affords long-term marking of animals and birds. Easily visible rings such as Darvic rings permit longer-term individual live monitoring of larger birds such as swans (Grogan & Kelly 2013).

Several types of remote tracking are used to monitor animals post rehabilitation, and in ecological projects. Traditional radio tracking (radio telemetry) involves the use of very high frequency

(VHF) radio signals, which are picked up using a handheld receiver (Llewellyn 2003). Data produced tend to be spatially crude and temporally sparse (Cross *et al.* 2009). This type of tracking, although labour intensive, is inexpensive (Cross *et al.* 2009) and is the method most commonly employed for post-release monitoring of British wildlife (Grogan & Kelly 2013). Modern tracking systems transmit signals to tracking satellites or receive signals from satellites allowing the use of global positioning systems (GPS). These systems are initially costly but produce very detailed temporo-spatial data with minimal manpower costs (Cross *et al.* 2009, Thomas *et al.* 2011).

All tracking systems have to be attached to the animal in some way. In non-mammalian species they may be glued on to the skin (e.g. crocodiles) or feathers (e.g. larger birds) or even placed in more novel areas such as drilled into the horns of rhinoceros (Lander *et al.* 2001). If glue is used then the transmitters/receivers may fall off or be shed in the next moult (Lander *et al.* 2001). A collar, harness or ear tag is commonly used in mammals (Karesh 1999). Transmitters may be placed internally (e.g. cloaca, peritoneal cavity, subcutaneously) which reduces wear and tear, but requires appropriate licensing (Lander *et al.* 2001). All systems rely on battery power and this limits the number and frequency of data produced, and the lifespan of the tracking method (Fedak *et al.* 2002). Battery size also limits which species the systems can be used in effectively – the weight of the battery should typically be no more than 4% of the animal's body weight (Walters 1998). Monitoring systems may have an effect upon the animal's behaviour and activity (Vandenabeele *et al.* 2011), and in the worst situations may cause trauma (Tribe *et al.* 2005, Michael *et al.* 2012). Radio or satellite receivers also need a power supply and this can be an issue in the field.

The cost of tracking systems is becoming cheaper allowing more ready access to rehabilitators. Battery size and lifespan are also improving, reducing weight and allowing monitoring for longer periods of time (Recio *et al.* 2011). Other developments include solar cells (Karesh 1999) and acoustic tags for marine animals (Lander *et al.* 2001).

The newest animal tracking technologies involve DNA sampling and analysis from hair plucks (e.g. from sleeping areas or on fences) and faecal samples to track free-ranging wild animals (Bryan *et al.* 2012). These systems have the advantage of being non-invasive, but are very time consuming and costly at present.

POST-RELEASE STUDIES OF REHABILITATED ANIMALS

Captive reared animals are known to have lower survival rates that wild-caught animals in reintroduction projects (Jule *et al.* 2008) and natural losses of juveniles in their first year of life are high. Post-release studies are additionally limited by sample size and the methods of tracking employed (Griffiths *et al.* 2010). These studies have, however, been used to justified the process of rehabilitation and confirm that it does not compromise animal welfare (Morris 1998; Leighton *et al.* 2008; Kelly *et al.* 2010).

European hedgehogs are the UK mammal species seen most frequently by rescue centres (Reeve & Huijer 1999, Kirkwood 2003) and several authors have reported survival rates in rehabilitated juvenile hedgehogs. These vary from good; 82% survival at 6 weeks following release (Morris 1998), 77% survival at 6 weeks (Morris 1997), 75% survival at 5 weeks (Morris *et al.* 1993), to less successful rates; 33% survival at 6 weeks (Sainsbury *et al.* 1996), 25% survival at 8 weeks (Morris & Warwick 1994). Studies of other UK mammals showed poor survival rates in foxes (Robertson & Harris 1995a) and in polecats a 50% survival at 1 month (Kelly *et al.* 2010). In many cases, RTC and predation were significant causes of death (Robertson & Harris 1995a, Sainsbury *et al.* 1996, Kelly *et al.* 2010).

The post-release survival of rehabilitated birds of prey, mostly juveniles, using leg band return data and radio-tracking was approximately 66% including tawny owls (Bennet & Routh 2000, Leighton *et al.* 2008, Griffiths *et al.* 2010), barn owls (*Tyto alba*) (Fajardo *et al.* 2000), western screech owls (*Otus kennecotti*) (Allbritten & Jackson 2002) and peregrine falcons (*Falco peregrinus*) (Sweeney *et al.* 1997). Limited longer-term survival rates (over 1 year) (Leighton *et al.* 2008) are comparable to wild populations (Francis & Saurola 2004). It has been suggested that 4 to 6 weeks is the critical point for survival of rehabilitated birds, after which mortality rates resemble those of wild birds (Martell *et al.* 1991, Fajado *et al.* 2000). Post-release survival of rehabilitated woodpigeons was comparable to wild birds (Kelly *et al.* 2011).

As well as release rates, post-release studies can help to establish factors in the rehabilitation process that influence release success. A period of time in captivity before release was shown to be beneficial in a group of hedgehogs translocated from Uist to the UK mainland (Molony *et al.* 2006). Excessive human contact may result in "imprinting" especially in juvenile animals (Llewellyn 2003) and in all animals human contact reduces the success of rehabilitation. Human habituation specifically reduces an animal's ability to deal with hazards and predators efficiently (Robertson & Harris 1995a, Ben-David *et al.* 2002, Tribe *et al.* 2005, Jule *et al.* 2008) and in some species results in abnormal denning and foraging behaviour (Tribe *et al.* 2005). Although animals need to be physically fit for release, unnecessary time in captivity is clearly disadvantageous (Tribe *et al.* 2005). With the correct management, the behaviour of released animals is not dissimilar to their wild counterparts (Lander *et al.* 2002).

Physical fitness for release includes correct bodyweight for its size because most animals lose weight after release (Robertson & Harris 1995a, Morris 1998, Kelly *et al.* 2010). Survival is generally higher for larger animals (Bunnell 2002, Tribe *et al.* 2005). Optimum weights have been suggested for the release of hedgehogs (Morris & Warwick 1994). Provision of naturally occurring foods in captivity before release has encouraged post-release feeding and improved survival (Guy *et al.* 2013).

Pre-release flight training is an essential part of the rehabilitation process in birds and bats (Fajado *et al.* 2000, Holz *et al.* 2006, Kelly *et al.* 2008, Serangeli *et al.* 2012). Flight training has been shown to be most successful where it attempts to mirror natural conditions. Post-release survival rates were improved in falconry-trained peregrine falcons and brown goshawks compared to those

subjected to cage exercise (Holz *et al.* 2006). Owls released following training programs with live prey also showed higher survival values (Fajado *et al.* 2000). Pre-release flight training using large flight cages (Kelly *et al.* 2008) and training to negotiate small openings to avoid entrapment upon release (Kelly *et al.* 2012) are important for successful bat release.

Post-release studies contribute to decisions regarding when and how to release casualties. Releases are more successful when food is plentiful and territorial stressors are reduced (Fajado *et al.* 2000, Llewellyn 2003, Tribe *et al.* 2005). In some species, such as foxes (Robertson & Harris 1995b), soft release pens have been shown to improve post-release survival in captive reared animals. Conversely, survival of tawny owls (Griffiths *et al.* 2010) is not significantly negatively affected by adopting hard release techniques.

Conclusions

Wildlife rehabilitation fulfils a welfare, conservation and educational role, which varies around the world. The welfare of casualty and orphan animals would benefit from increased veterinary intervention especially in areas such as pre-release assessment. The true success of rehabilitation cannot be assessed without improved post-release monitoring. How animals survive, integrate and behave in the wild will determine the effectiveness of clinical triage, veterinary treatment and care received during rehabilitation. Such information can be used to educate veterinarians and wildlife rehabilitators, and ultimately benefit the welfare of the animals in their care.

Conflict of interest

None of the authors of this article has a financial or personal relationship with other people or organisations that could inappropriately influence or bias the content of the paper.

References

Allbritten, M. & Jackson, D. (2002) A post release study of rehabilitated western screech owls (Otus kennecotti) in Douglas County, Oregon. *Journal of Wildlife Rehabilitation* **25**, 5-10

Ancillotto, L., Serangeli, M.T. & Russo, D. (2013) Curiosity killed the bat: Domestic cats as bat predators. *Mammalian Biology* **78**, 369-373

Artois, M., Delahay, R., Guberti, V., *et al.* 2001. Control of Infectious diseases of Wildlife in Europe. *Veterinary Journal* **162**, 141-152

Baker, J. R., Jones, T. P & Watson, H. C. (1981). Otter Lutra lutra mortality and marine oil pollution. *Biological Conservation* **20**, 311-321

Baker, J., Barnett, J., Cooke, M., *et al.* (2000) Assessment of stranded cetaceans. *Veterinary Record* **147**, 340

Barlow, A. M., Mullineaux, E., Wood, R., *et al.* 2011. Giardiosis is Eurasian badgers (Meles meles). *Veterinary Record* **167**, 1017

Barlow, A. M., Schock, A., Bradshaw, J. M., *et al.* 2012. Parvovirus enteritis in Eurasian badgers (Meles Meles), *Veterinary Record* **170**, 416

Barnett, J. & Robinson, I. (2003) Marine mammals. In: *BSAVA Manual of Wildlife Casualties*. Eds E. Mullineaux, D. Best, J. E. Cooper. BSAVA Publications, Gloucester, MA, USA. pp 182-202

Benato, L. & Bexton, S. (2011) The management of an injured roe deer (Capreolus capreolus) with a metacarpal fracture and cortical blindness resulting from a vehicle collision. *Journal of Wildlife Rehabilitation* **31**, 15-20

Ben-David, M., Blundell, G. M. & Blake, J. E. (2002) Post-release survival of river otters: effects of exposure to crude oil and captivity. *Journal of Wildlife Management* **66**, 1208-1223

Bennet, J. A. & Routh, A. D. (2000) Post-release survival of hand-reared tawny owls (Strix aluco). *Animal Welfare* **9**, 317-321

Best, D. (1999) BWRC wildlife casualty recording scheme – the first five years. *The Rehabilitator* **28**, 2-3

Best, D. & Mullineaux, E. (2003) Basic principles of treating wildlife casualties. In: *BSAVA Manual of Wildlife Casualties*. Eds E. Mullineaux, D. Best and J. E. Cooper. BSAVA Publications, Gloucester, MA, USA. pp 6-29

Bexton, S. & Couper, D. (2010) Handling and veterinary care of British bats. *In Practice* **32**, 254-262

Bexton, S. & Robinson, I (2003) Hedgehogs. In: *BSAVA Manual of Wildlife Casualties*. Eds E. Mullineaux, D. Best and J. E. Cooper. BSAVA Publications, Gloucester, MA, USA. pp 49-66

Bryan, H. M., Darimont, C. T., Paquet, P. C., *et al.* (2012) Grizzly Bears Show Hormonal Responses to changes in salmon consumption and abundance. In: Proceedings of the joint 61st WDA/10th biennial EWDA conference 'Convergence in wildlife heath', Lyon 23-27 July 2012, Lyon, France. p58

Bunnell, T. (2002) The assessment of British hedgehog (Erinaceus europaeus) casualties on arrival and determination of optimum release weights using a new index. *Journal of Wildlife Rehabilitation* **25**, 11-21

Chitty, J. (2006a) The injured bird of prey Part 1: Legal and logistical issues. *UK Vet (Companion animals)* **11**(3), 60

Chitty, J. (2006b) The injured bird of prey Part 1: Decision-making, feeding and biosecurity. *UK Vet (Companion animals)* **11**(4), 38

Cooper, J. E. (1989) Care, cure or conservation: developments and dilemmas in wildlife conservation. In: *Proceedings of the Inaugural Symposium of the British Wildlife Rehabilitation Council (BWRC)*. Eds S. Harris & T. Thomas. BWRC Horsham, UK. pp 14-23

Cooper, M. E. (2003) The law affecting British wildlife. In: *BSAVA Manual of Wildlife Casualties*. Eds E. Mullineaux, D. Best and J. E. Cooper. BSAVA Publications, Gloucester, MA, USA. pp 42-49

Cooper, J. E. & Cooper, M. E. (2006) Ethical and legal implications of treating wildlife casualties. *In Practice* **28**, 2-6

Cooper, J. E. & Eley, J. T. (1979) *First Aid and Care of Wild Birds*. David and Charles PLC, Newton Abbot, UK

Couper, D. & Bexton, S. (2012) Veterinary care of wild owl casualties. *In Practice* **34**, 270-281

Cousins, R. A., Battley, P. F., Gartrell, B. D., *et al.* (2012) Impact injuries and probability of survival in a large semiurban endemic pigeon in new zealand, hemiphaga novaeseelandiae. *Journal of Wildlife Diseases* **48**, 567-574

Cousquer, G. (2005a) First aid and emergency care for the avian casualty. *In Practice* **27**, 190-203

Cousquer, G. (2005b) Dealing with the roadside casualty badger. *In Practice* **27**, 264-269

Cracknell, J. (2004) Dealing with line and hook injuries in swans. *In Practice* **26**, 238-245

Cross, P. C., Drewe, J., Patrek, V., *et al.* (2009) Wildlife population structure and parasite transmission: implications for disease management. In: *Management of Diseases in Wild Mammals*. Eds R. J. Delahay, G. C. Smith and M. R. Hutchings. Springer-Verlag, Heidelberg, Germany

Cunningham, A. A. (1996) Disease risks of wildlife translocations. *Conservation Biology* **10**, 349-353

Drake, A. & Fraser, D. (2008) Admission trends and mortality correlates for mallard ducklings at wildlife rehabilitation facilities. *Journal of Wildlife Rehabilitation* **29**, 4-14

Dubois, S. (2003) *A survey of wildlife rehabilitation goals, impediments, issues, and success in British Columbia, Canada*. University of Victoria, Vancouver, Canada

Dubois, S. & Fraser, D. (2013) Rating harms to wildlife: a survey showing convergence between conservation and animal welfare views. *Animal Welfare* **22**, 49-55

Duff P. (2003) Wildlife disease surveillance by the Veterinary Laboratories Agency. *Microbiology Today* **30**, 157-159

Fajardo, I., Babiloni, G. & Miranda, Y., 2000. Rehabilitated wild barn owls (Tyto alba): dispersal, life expectancy and mortality in Spain. *Biological Conservation* **94**, 287-295

Fedak, M., Lovell, P., McConnell, B., *et al.* (2002) Overcoming the constraints of long range radio telemetry from animals: getting more useful data from smaller packages. *Integrative and Comparative Biology* **42**, 3-10

Francis, C. M. & Saurola, P. (2004) Estimating components of variance in demographic parameters of tawny owls, Strix aluco. *Animal Biodiversity and Conservation* **27**, 489-502

Gales, N., Woods, R. & Vogelnest, L. (2008) Marine mammal strandings and the role of the veterinarian. In: *Medicine of Australian Mammals*. Eds L. Vogelnest and R. Woods. CSIRO Publishing, Collingwood, Victoria, Australia. pp 39-55

Gosden, C. (2004) *Exotics and Wildlife: A Manual of Veterinary Nursing Care*. Butterworth-Heinemann, London, UK.

Green, P. (2003) Deer. In: *BSAVA Manual of Wildlife Casualties*. Eds E. Mullineaux, D. Best and J. E. Cooper. BSAVA Publications, Gloucester, MA, USA. pp 166-182

Griffith, B., Scott, J. M., Carpenter, J. W. & Reed, C. (1993) Animal translocations and potential disease transmission. *Journal of Zoo and Wildlife Medicine* **24**, 231-235

Griffiths, R., Murn, C. & Clubb, R. (2010) Survivorship of rehabilitated juvenile tawny owls (Strix aluco) released without support food, a radio tracking study. *Avian Biology Research* **3**, 1-6

Griffith, J. E. , Dhand, N. K., Krockenberger, M. B. & Higgins, D. P. (2013) A retrospective study of admission trends of koalas to a rehabilitation facility over 30 years. *Journal of Wildlife Diseases* **49**, 18-28

Grogan, A. & Kelly, A. (2013) A review of RSPCA research into wildlife rehabilitation. *Veterinary Record* **172**, 211-215

Guy, A. J., Curnoe, D. & Banks, P. B. (2013) A survey of current mammal rehabilitation and release practices. *Biodiversity and Conservation* **22**, 825-837

Holz, P. H., Naisbitt, R. & Mansell, P. (2006) Fitness level as a determining factor in the survival of rehabilitated Peregrine falcons (Falco peregrinus) and Brown goshawks (Accipiter fasciatus) released back into the wild. *Journal of Avian Medicine and Surgery* **20**, 15-20

Ji, W., White, P. C. L., Clout, M. N. (2005) Contact rates between possums revealed by proximity data loggers. *Journal of applied ecology* **42**, 595-604
Jule, K. R., Leaver, L. A. & Lea, S. E. G. (2008) The effects of captive experience on reintroduction survival in carnivores: a review and analysis. *Biological Conservation* **141**, 355-363
Karesh, W. B. (1999) Applications of biotelemetry in wildlife medicine. In: *Zoo and Wild Animal Medicine Current Therapy 4*. Eds M. E. Fowler & R. E. Miller. W.B. Saunders Co., Philadelphia, PA, USA
Kelly, A. & Bland, M. (2006) Admission, diagnoses, and outcomes for Eurasian Sparrowhawks (Accipiter nisus) brought to a wildlife rehabilitation center in England. *Journal of Raptor Research* **40**, 231-235
Kelly, A., Goodwin, S., Grogan, A., *et al.* (2008) Post-release survival of hand-reared pipistrelle bats (Pipistrellus spp). *Animal Welfare* **17**, 375-382
Kelly, A., Scivens, R. & Grogan, A. (2010) Post release survival of orphaned wild-born polecats Mustela putorius reared in captivity at a wildlife rehabilitation centre in England. *Endangered Species Research* **12**, 107-115
Kelly, A., Halstead, C., Hunter, D., *et al.* (2011) Factors affecting the likelihood of release of injured and orphaned woodpigeons (Columba palumbus). *Animal Welfare* **20**, 523-534
Kelly, A., Goodwin, S., Grogan, A., *et al.* (2012) Further evidence for the post-release survival of hand-reared, orphaned bats based on radio-tracking and ring-return data. *Animal Welfare* **21**, 27-31
Kirkwood, J. K. (2003) Introduction: wildlife casualties and the veterinary surgeon. In: *BSAVA Manual of Wildlife Casualties*. Eds E. Mullineaux, D. Best and J. E. Cooper. BSAVA Publications, Gloucester, MA, USA. pp 1-5
Kirkwood, J. K. & Sainsbury, A. W. (1996) Ethics of intervention for the welfare of free-living wild animals. *Animal Welfare* **5**, 235-243
Lander, M. E., Westgate, A. J., Bonde, R. K., *et al.* (2001) Tagging and tracking. In: *CRC Handbook of Marine Mammal Medicine*. 2nd edn. Eds L. A. Dierauf and F. M. D. Gulland. CRC Press, Boca Raton, FL, USA. pp 851-880
Lander, M. E., Harvey, J. T., Hanni, K. D., *et al.* (2002) Behaviour, movements and apparent survival of rehabilitated and free-ranging harbour seal pups. *Journal of Wildlife Management* **66**, 19-28
Leighton, K., Chilvers, D., Charles, A., *et al.* (2008) Post-release survival of hand-reared tawny owls (Strix aluco) based on radio-tracking and leg-band return data. *Animal Welfare* **17**, 207-214
Lewis, J. C. M. (1997a) Badgers for vets. 1. Biology. *UK Vet (Companion animals)* **2**(2), 60
Lewis, J. C. M. (1997b) Badgers for vets. 2. Common Problems. *UK Vet (Companion animals)* **2**(2), 68
Lewis, J. C. M. (1997c) Badgers for vets. 3. Approach to injured badgers. *UK Vet (Companion animals)* **2**(4), 56
Llewellyn, P. (2003) Rehabilitation and release. In: *BSAVA Manual of Wildlife Casualties*. Eds E. Mullineaux, D. Best and J. E. Cooper. BSAVA Publications, Gloucester, MA, USA. pp 29-37
Loftin, R. W. (1985) The medical treatment of wild animals. *Environmental Ethics* **7**, 231-239
Martell, M., Redig, P., Nibe, J., *et al.* (1991) Survival and movements of released rehabilitated bald eagles. *Journal of Raptor Rescue* **25**, 72-76
Mazet, J., Tseng, F., Holcomb, J., *et al.* (2005) Oiled wildlife care network development for integrated emergency response. International Oil Spill Conference, IOSC, 5795-5798.
Meredith, A., Redrobe, S. & Mullineaux, E. (2008) General care and management of other pets and wildlife. In: *BSAVA Manual of Practical Animal Care*. Eds P. Hotston Moore and A. Hughes. BSAVA Publications, Gloucester, MA, USA. pp 123-137
Michael, S., Gartrell, B., Hunter, S., *et al.* (2012) Wing injury caused by backpack harnesses for radio transmitters in takahe (*Porphyrio hochstetteir*). Proceedings of the joint 61st WDA/10th biennial EWDA conference 'Convergence in wildlife heath', Lyon 23-27 July 2012, Lyon, France. p 304
Miller, E. A. (2012) *Minimum Standards for Wildlife Rehabilitation*. 4th edn. National Wildlife Rehabilitators Association and International Wildlife Rehabilitation Council, St. Cloud, MN, USA
Molina-López, R. A. & Darwich, L. (2011) Causes of admission of little owl (Athene noctua) at a wildlife rehabilitation centre in Catalonia (Spain) from 1995 to 2010. *Animal Biodiversity and Conservation* **34**, 401-405
Molina-López, R. A., Casal, J. & Darwich, L. (2011) Causes of morbidity in wild raptor populations admitted at a wildlife rehabilitation centre in Spain from 1995-2007: a long term retrospective study. *PLoS ONE* **6**, 24603
Molony, S. E., Dowding, C. V., Baker, P. J., *et al.* (2006) The effect of translocation and temporary captivity on wildlife rehabilitation success: an experimental study using European hedgehogs (*Erinaceus europaeus*). *Biological Conservation* **130**, 530-537
Molony, S. E., Baker, P. J., Garland, L., *et al.* (2007) Factors that can be used to predict release rates for wildlife casualties. *Animal Welfare* **16**, 361-367
Morris, P. A. (1997) Released, rehabilitated hedgehogs: a follow-up study in Jersey. *Animal Welfare* **6**, 317-327
Morris, P. A. (1998) Hedgehog rehabilitation in perspective. *Veterinary Record* **143**, 633-636
Morris, P. A., Meakin, K. & Sharafi, S. (1993) The behaviour and survival of rehabilitated hedgehogs (Erinaceus europaeus). *Animal Welfare* **2**, 53-66
Morris, P. A. & Warwick, H. (1994) A study of rehabilitated juvenile hedgehogs after release into the wild. *Animal Welfare* **3**, 163-177
Mühldorfer, K., Speck, S. & Wibbelt, G. (2011) Diseases in free-ranging bats from Germany. *BMC Veterinary Research* **7**, 61
Mullineaux, E. (2006) Wildlife in New Zealand. *Journal of Small Animal Practice* **47**, 240-241
Mullineaux, E., 2012. Badger emergency care. *Companion*. BSAVA publications, Gloucester, MA, USA. pp 20-23
Mullineaux, E. & Brash, M. (2009) How to handle bats. *Companion*. BSAVA publications, Gloucester, MA, USA. pp 8-11
Mullineaux, E. & Kidner, P. (2011) Managing public demand for badger rehabilitation in an area of England with endemic tuberculosis. *Veterinary Microbiology* **151**, 205-208
Mullineaux, E., Best, D. & Cooper, J. E. (2003) *BSAVA Manual of Wildlife Casualties*. BSAVA Publications, Gloucester, MA, USA.
Orlowski, G. & Nowak, L. (2004) Road mortality of hedgehogs (Erinaceus spp.) in farmland in Lower Silesia (south-western Poland). *Polish Journal of Ecology* **52**, 377-382
Ramsden, D. J. (2003) *Barn owls and major roads: results and recommendations from a 15 year research project*. The Barn Owl Trust, Ashburton, New Zealand
Randall, N. J., Blitvich, B. J. & Blanchong, J. A. (2012) Efficacy of wildlife rehabilitation centers in surveillance and monitoring of pathogen activity: A case study with west Nile virus. *Journal of Wildlife Diseases* **48**, 646-653
Recio, M. R., Mathieu, R., Denys, P., *et al.* (2011) Lightweight GPS-tags, one giant leap for wildlife tracking? An assessment approach. *PLoS ONE* **6**, 28225
Reeve, N. J. & Huijser, M. P. (1999) Mortality factors affecting wild hedgehogs: a study of records from wildlife rescue centres. *Lutra* **42**, 7-24
Rigby, E. L., Aegerter, J., Brash, M., *et al.* (2012) Impact of PIT tagging on recapture rates, body condition and reproductive success of wild Daubenton's bats (Myotis daubentonii). *Veterinary Record* **170**, 101-106
Robertson, C. P. J. & Harris, S. (1995a) The condition and survival after release of captive-reared fox cubs. *Animal Welfare* **4**, 281-294
Robertson, C. P. J. & Harris, S. (1995b) The behaviour after release of captive-reared fox cubs. *Animal Welfare* **4**, 295-306
Robinson, I. (2002) Health monitoring of casualties and potential threats posed to wildlife populations by released casualties. In: The Proceedings of the Symposium of The British Wildlife Rehabilitation Council 2000. London, UK.
Robinson, I. & Routh, A. (1999) Veterinary care of the hedgehog. *In Practice* **21**, 128-137
Rodrigues, B., Rodriguez, A., Siverio, F. & Siverio, M. (2010) Causes of raptor admissions to a wildlife rehabilitation center in Tenerife (Canary Islands). *Journal of Raptor Research* **44**, 30-39
Routh, A. (2000) Veterinary care of the mute swan. *In Practice* **22**, 426-443
Sainsbury, A. W., Cunningham, A. A., Morris, P. A., *et al.* (1996) Health and welfare of rehabilitated juvenile hedgehogs (*Erinaceus europaeus*) before and after release into the wild. *Veterinary Record* **138**, 61-65
Sainsbury A. W., Kirkwood J. K., Bennett P. M., *et al.* (2001) Status of wildlife health monitoring in the United Kingdom. *Veterinary Record* **148**, 558-563
Saran, K. A., Parker, G., Parker, R., *et al.* (2011) Rehabilitation as a conservation tool: A case study using the common wombat. *Pacific Conservation Biology* **17**, 310-319
Serangeli, M. T., Cisterone, L., Ancillotto, L., *et al.* (2012) The post-release fate of hand-reared orphaned bats: survival and habitat selection. *Animal Welfare* **21**, 9-18
Sikarskie, J. G. (1992) The role of veterinary medicine in wildlife rehabilitation. *Journal of Zoo and Wildlife medicine* **23**, 397-400
Simpson, V. R. & King, M. A. (2003) Otters. In: *BSAVA Manual of Wildlife Casualties*. Eds E. Mullineaux, D. Best and J. E. Cooper. BSAVA Publications, Gloucester, MA, USA. pp 137-147
Simpson, V. R., Hargreaves, J., Birtles, R. J., *et al.* 2008. Tyzzer's disease in a Eurasian otter (Lutra lutra) in Scotland. *Veterinary Record* **163**, 539-543
Stocker, L. (2005) *Practical Wildlife Care*. Wiley Blackwell, London, UK.
Sweeney, S. J., Redig, P. T. & Tordoff, H. B (1997) Morbidity, survival and productivity of rehabilitated peregrine falcons in the upper midwestern US. *Journal of Raptor Research* **31**, 347-352
Thomas, B., Holland, J.D. & Minot, E. O. (2011) Wildlife tracking technology options and cost considerations. *Wildlife Research* **38**, 653-663
Tribe, A., Hanger, J., Nottidge, B., *et al.* (2005) Measuring the success of wildlife rehabilitation. Proceedings of the National Wildlife Rehabilitation Conference, NWRC, Australia, pp 1-14
Vandenabeele, S. P., Wilson, R. P. & Grogan, A. (2011) Tags on seabirds: how seriously are instrument-induced behaviours considered? *Animal Welfare* **20**, 559-571
Varga, M., Lumbis, R. & Gott, L. (2012) *BSAVA Manual of Exotic Pet and Wildlife Nursing*. BSAVA Publications, Gloucester, MA, USA
Vogelnest, L. (2008) Veterinary considerations for the rescue, treatment, rehabilitation and release of wildlife. In: *Medicine of Australian mammals*. Eds L. Vogelnest & R. Woods. CSIRO Publishing, Collingwood, Victoria, Australia. pp 1-12
Walters, E. L. (1998) *Wildlife Radio-telemetry. Standards for Components of British Columbia's Biodiversity No. 5*. BC Environment. Vancouver, Canada
Wernham, C. V., Peach, W. J. & Browne, S. J. (1997) Survival Rates of Rehabilitated Guillemots. BTO Report No 186. British Trust for Ornithology, Thetford
Wimberger, K. & Downs, C. T. (2010) Annual intake trends of a large urban animal rehabilitation centre in South Africa: a case study. *Animal Welfare* **19**, 501-513
Wimberger, K., Downs, C. T. & Boyes, R. S. (2010) A survey of wildlife rehabilitation in South Africa: is there a need for improved management? *Animal Welfare* **19**, 481-499
Wobeser, G. A. (2007) *Disease in Wild Animals*. 2nd edn. Springer-Verlag, Heidelberg, Germany
Woods, M., McDonald, R. A. & Harris, S. (2003) Predation of wildlife by domestic cats Felis catus in Great Britain. *Mammal Review* **33**, 174