Risk of capture-related mortality in large free-ranging mammals: experiences from Scandinavia

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Risk of capture-related mortality in large free-ranging mammals: experiences from Scandinavia

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Chemical capture and anaesthesia of free-ranging mammals will always involve some risk of mortality even in healthy animals. Deaths may be directly or indirectly attributable to the anaesthetic event itself (e.g. drug overdose, drowning during induction and dart trauma) or may be caused by secondary effects from the capture (e.g. stress, myopathy, trauma or instrumentation with radio-transmitters). In long-term research projects on five major wildlife species in Scandinavia, the capture-related mortality rates (number of captures) were: moose *Alces alces* 0.7% (N = 2,816), brown bears *Ursus arctos* 0.9% (N = 1,079), wolverines *Gulo gulo* 2.8% (N = 461), Eurasian lynx *Lynx lynx* 3.9% (N = 380), and gray wolves *Canis lupus* 3.4% (N = 89). We suggest that wildlife professionals should strive for a zero mortality rate but adopt the standard that a mortality rate of > 2% probably should not be accepted in any large mammalian species. This can be achieved by: 1) using an experienced professional capture team, 2) developing and following a capture protocol specific to each species, and 3) requiring that a mortality assessment be undertaken after any capture-related death. This assessment should re-evaluate the capture protocol, including how changes in anaesthetics and methodological approaches could have prevented the mortality.

Key words: anaesthesia, capture protocols, free-ranging, immobilisation, mammal, mortality rates, standards

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Anaesthetic drugs are never completely devoid of toxicity and induction of anaesthesia invariably carries a risk to the life of even healthy patients (Clarke & Hall 1990, Hall et al. 2001). Surveys show that the rate of mortality directly or partly attributable to anaesthesia is approximately 0.01-0.05% in humans, 0.1% in dogs and cats, and 1% in horses (Jones 2001). Main causes of anaesthetic mortality in domestic animals include compromised health, poor body condition, failure to obtain accurate body weight of the patient, failure to use adequate and effective pre-medication, lack of equipment for emergency situations, incompetent or inexperienced personnel and human error (Hall et al. 2001, Jones 2001). Because wildlife capture does not take place under controlled conditions, problems can more easily lead to injury and death. Even so, based on our experience in Scandinavia, we suggest that almost all mortalities can be avoided by applying proper protocols, given the recent advances in techniques, tools and anaesthetics.

General aspects

Chemical immobilisation or anaesthesia of free-ranging mammals is a form of veterinary anaesthesia conducted under the most difficult circumstances (Nielsen 1999, Kreeger et al. 2002), and the risk of severe side effects, injuries and death can never be completely eliminated. In addition, the health of a free-ranging animal can seldom be assessed prior to capture, and the presence of any pre-existing pathologic condition will significantly increase the risk of mortality. However, there is no doubt that the anaesthetic risk in wild animals is highly influenced by the capture protocol that is being applied. Therefore, in Scandinavia biomedical and capture protocols for several major wildlife species have been developed during the past years (Norwegian Directorate for Nature Management 2005). In all major research projects in Norway and Sweden, professional capture teams do most of the immobilisations. Consequently, these professionals have decades of experience, including several thousand immobilisations, and have been successful in developing protocols that substantially reduce mortality rates. We believe that the use of this model has been of paramount importance for successful outcomes with few mortalities.

Typically, most mortalities are seen in the early phase of a project, before species-specific capture methods have been refined, before drug doses have been adjusted and before the immobilisation team has gained adequate experience and training. Moreover, an increased risk of mortality may also occur when captures are carried out for specific purposes, e.g. health evaluation of animals under environmental or pathogenic stress. Mortalities caused by capture and anaesthesia of free-ranging mammals can be grouped into three different categories: 1) direct effects of the immobilising drug itself, e.g. respiratory depression, shock, hyperthermia and asphyxia due to tympany or vomiting, 2) indirect effects, e.g. drowning during induction, pneumothorax due to misplacement of darts, and trauma from dart impact, and 3) secondary effects caused by the capture process, e.g. trauma from traps, long-term effects from chasing or stress (exertional myopathy), separation of dam-offspring, and various problems with radio-collars or implantable transmitters. The secondary effects have nothing to do with the anaesthetic risk *per se* and should be treated as a separate entity. However, research ethics and animal welfare concerns dictate that the overall mortality rate, as well as injury rates, should be addressed.

Table 1. Capture-related mortality rates of large mammals in long-term research projects in Scandinavia. N = the number of captures; direct = drug related deaths; indirect = mortalities caused by drowning during induction or dart trauma; secondary = deaths due to radio-collars, implants, exertional myopathy, trauma or unknown causes within 30 days post-capture. The figures in parentheses give the mortality in %.

		Number of deaths (%)			
Species	N	Direct	Indirect	Secondary	Overall
Moose	2816	6 (0.2)	3 (0.2)	11 (0.4)	20 (0.7)
Brown bear	1079	6 (0.6)	3 (0.3)	1 (0.1)	10 (0.9)
Wolverine	461	5 (1.1)	1 (0.2)	7 (1.5)	13 (2.8)
Eurasian lynx	380	6 (1.6)	3 (0.8)	7 (1.8)	16 (4.2)
Gray wolf	89	2 (2.2)	0	1 (1.1)	3 (3.4)

Capture-related mortality rates of large mammals in Scandinavia

Here we describe the causes and rates of capture-related mortality in long-term studies of five species of large mammals in Scandinavia during the last two decades. The data are summarised in Table 1.

In moose *Alces alces*, an overall mortality rate of 0.7% (20 deaths) was seen during 2,816 immobilisations. Moose were darted from a helicopter using etorphine or etorphine-acepromazine-xylazine during 1984-2004 in winter on snow-covered ground (November-April). Only nine of the 20 deaths (0.3%) could be directly (respiratory depression due to a relative overdose in one cow and five calves) or indirectly (drowning in one cow and one bull, and dart trauma in one calf) linked to the use of the anaesthetic drugs. Secondary deaths included exertional myopathy in one cow and one calf, and bear predation in one cow. In addition, eight animals found dead of unknown causes within 30 days post-capture were included as capture-related.

For brown bears *Ursus arctos*, an overall mortality rate of 0.9% (10 deaths) was found for 1,079 captures carried out from a helicopter primarily during spring (April-May) in 1984-2004 (see Table 1). Of the 10 deaths, nine were directly or indirectly related to the effects of the drugs or drug administration; stress, hyperthermia and/or respiratory depression in three bears immobilised with etorphine (one of these animals had only one functional lung), shock/circulatory failure in three animals anaesthetised with medetomidine-tiletamine-zolazepam, drowning in two animals immobilised with etorphine, and pneumothorax from dart misplacement in one animal immobilised with etorphine. In addition, one bear anaesthetised with medetomidine-ketamine was shot for human protection due to a sudden and unexpected recovery. Since 1992, when standard doses of medetomidine-tiletamine-zolazepam have been used for all captures (N = 896), the mortality rate dropped to 0.3% (three animals) from 3.8% prior to 1992 (seven deaths in 183 captures).

During a total of 461 captures of wolverines *Gulo gulo* with either xylazine-ketamine or medetomidine-ketamine from 1990 to 2004, six anaesthetic mortalities (1.3%) occurred (see Table 1). Various capture methods were used; darting from a helicopter, darting in dens, and manual restraint of cubs with subsequent injection by hand syringe. Most animals were captured in spring (May-June). Causes of death included possible re-sedation with subsequent hypothermia in three adult females immobilised with medetomidine-ketamine (no antagonist given due to spontaneous recovery), and asphyxia during recovery in one adult female immobilised with xylazine-ketamine (no antagonist given). In addition, one cub, anaesthetised with medetomidine-ketamine that was reversed by atipamezole, was found dead shortly following capture after a transmitter was surgically implanted intraperitoneally. The carcass was scavenged and the implant had several bite marks. Possible causes of death include infanticide, dam-offspring separation and/or hypothermia. To be conservative, this case was included as an anaesthetic mortality. One adult female died from pneumothorax due to misplacement of the dart. Seven wolverines died from secondary causes. One adult female died due to post-operative complications after implantation of an intraperitoneal transmitter, whereas the death of one adult male was the result of wearing a radio-collar. Two of the females that died from possible re-sedation had a total of five cubs. These cubs (implanted with intraperitoneal transmitters) were euthanised and their deaths were recorded as capture related. Overall capture-related mortality rate (including secondary causes) was 2.8%.

In Eurasian lynx *Lynx lynx*, nine deaths (2.4%) occurred during 380 anaesthetic episodes from 1995 to 2004 (see Table 1). Different capture methods were applied: darting from a helicopter, darting of animals trapped in snares or cages, darting of animals chased into a tree by hunting dogs, and hand injection of manually restrained kittens. Lynx were captured year-round. Causes of death included pneumothorax in two animals

due to misplacement of the dart, stress with hyperthermia and/or circulatory failure in two animals captured with the use of dogs (one adult male and one adult female, both immobilised with xylazine-ketamine), and possible hyperthermia in one adult male during recovery (immobilised with medetomidine-ketamine, reversed by atipamezole). One adult female that fell from a tree during induction (immobilised with xylazine-ketamine) was euthanised due to a leg fracture. In addition, one adult female died immediately after being darted with xylazine-ketamine and two adult females (immobilised with medetomidine-ketamine, reversed by atipamezole) were found dead close to the capture site within a few days after immobilisation. Causes of death are unknown, but all cases were included as anaesthetic mortalities. Seven more lynx died from secondary causes. Two animals (one juvenile female and one adult male) were euthanised due to leg fractures after being captured in snares. These animals were not anaesthetised. Three animals (one juvenile female and two juvenile males) died because the mandible became caught under the radio-collar. Two animals (one juvenile male and one juvenile female) succumbed after the implanted transmitter was trapped in the pelvis with subsequent intestinal obstruction. Overall capture-related mortality rate (including secondary causes) was 4.2%.

In gray wolves *Canis lupus*, two deaths (one adult male and one adult female) occurred during 89 captures (2.2%) with tiletamine-zolazepam (N = 56), medetomidine-tiletamine-zoletil (N = 4) and medetomidine-ketamine (N = 29) from 1998 to 2004 (see Table 1). All animals were darted from a helicopter in winter (December-March). Necropsy showed that both animals died due to hyperthermia and shock development during anaesthesia with medetomidine-ketamine. Therefore, for captures using medetomidine-ketamine only, the mortality rate was 6.9%. There were no direct mortalities using the other two drug combinations. In addition, one adult male was hit by a car six hours after immobilisation with tiletamine-zolazepam and was euthanised. The animal had moved approximately 10-12 km from the capture site and was considered fully recovered by field personnel who observed the incident. However, we consider this death to be secondary to the capture event. Including this death, the overall capture-related mortality rate for wolves was 3.4%.

Discussion

In free-ranging mammals, chemical capture is an invaluable tool both for management and research. Since the pioneer days of the 1950s and 1960s, a large number of wild mammals has been chemically immobilised or anaesthetised for various purposes. During the initial phase of chemical capture, mortality rates were often very high, ranging within 26-35% in several studies (Rausch & Ritcey 1961, Bergerud et al. 1964, Thomas & Marburger 1964, Fuller & Keith 1981, Peterson et al. 2003). Causes of mortality included respiratory depression, cardiovascular collapse, hyperthermia, trauma (dart injuries), stress and exertional myopathy.

During the last two decades, effective drugs and antagonists have become available for reversible immobilisation of a wide range of mammalian species. In addition, remote drug delivery systems and lightweight darts were developed for non-traumatic administration of anaesthetic drugs. Access to portable and easy-to-use monitoring devices, such as pulse oximeters, has also improved animal safety during field anaesthesia. In spite of this progress, mortality rates routinely ranged within 2-10% (Jessup 1993), and high capture mortality rates are still being reported in several mammalian species.

By using drugs and doses with proven safety, proper remote drug delivery systems and established capture methods and techniques, a skilled and experienced capture team will reduce the risk of capture-related mortality to a minimum. This was especially evident in our 20-years of experience in capturing brown bears. By improving capture protocols and adopting improvements in drugs and doses, we were able to reduce the mortality rate to less than one-twelfth of the pre-1992 level. Also, due to the relatively high mortality rate in the lynx projects, the capture protocol for this species was refined. Captures with the aid of helicopters or dogs were carried out with a minimum of chasing and stress, captures during periods with extremely high or low ambient temperatures were avoided, and handling time and duration of anaesthesia were reduced to an absolute minimum. As a result, there was a substantial reduction in mortalities during lynx captures in recent years. An important part of this process included establishment of a refined capture protocol for this species that allows incorporation of additional improvements to the process as they become necessary or apparent. We strongly recommend that similar protocols be instituted for all important wildlife species being captured for research or management purposes.

In a review of stress and capture myopathy in artiodactylids, Spraker (1993) stated that a mortality rate of > 2% during trapping is not acceptable. We believe that this rule also should be applied to chemical immobilisation situations; a capture-related mortality rate of > 2% is not acceptable in any large mammalian species

and requires that the capture protocol be re-evaluated. At least this should be the rule of thumb when a large number (i.e. > 100) of free-ranging animals are being immobilised. We have demonstrated that by adopting protocols and improving them as needs become apparent, a capture mortality rate of 0.3% was achieved for at least one species using present technology. As responsible biologists our goal should be to eliminate capture-related deaths of wildlife.

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