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RESEARCH ARTICLE

Cage trapping and field anaesthesia of brown bears as part of nuisance bear management

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ABSTRACT

The population and distribution of the European brown bear (*Ursus arctos*) in Slovakia are expanding as bears were observed beyond the southern border of the country in Hungary. This study presents the authors' experience with field anaesthesia of wild brown bears trapped in a custom-made container trap and of free-ranging individuals. A total of 25 bears were captured and translocated using a specially designed metal cage trap. The study compared the effectiveness of three anaesthetic protocols in managing both free-ranging and trapped bears. For juveniles, or small adults up to 70 kg body weight (BW), ketamine-xylazine mixture was used at doses of 3.0–4.0 mg kg^{-1} ketamine and 1.0–1.5 mg kg^{-1} xylazine BW. The immobilisation of free-ranging bears, which are usually attracted by municipal solid garbage, was performed remotely using PneuDart darts with 2–3 ml of anaesthetics. For this purpose, tiletamine-zolazepam-detomidine (T-Z-D) was preferred at a dose of 1.7–2.5 (T) mg kg^{-1}, 1.7–2.5 (Z) mg kg^{-1}, and 0.1–0.2 (D) mg kg^{-1} BW. Induction time was from 7 to 18 min post darting with the average of 12.04 min. The same combination was applied to bears trapped in a container trap, with anaesthesia lasting from 40 to 150 min. If T-Z-D was used, no further anaesthetic was needed. In all cases, anaesthesia was antagonised by atipamezole at a dose of 0.15–0.225 mg kg^{-1} BW. Atipamezole was injected at a half dose intramuscularly and a half dose subcutaneously at the time when the palpebral reflex reappeared and the bear was able to move his tongue. It was shown that the T-Z-D mixture is a safe, low-volume anaesthetic darting protocol that is reversible, has minimal adverse effects on physiological parameters, and has a sufficient duration. The results can be used to manage large carnivore populations in the Carpathian region.

KEYWORDS

European brown bear, cage trap, immobilisation, Zoletil, xylazine, detomidine

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INTRODUCTION

The European brown bear (*Ursus arctos*) inhabits 22 European countries with an estimated total number of approximately 17,000 individuals (Aghazadeh et al., 2015). The majority of these populations are strictly protected and are currently increasing (Kaczensky et al., 2013).

It is very likely that some of these bears also have trans-border home ranges (Rigg, 2005). Worldwide, brown bear population management (North American, Dinaric, Scandinavian, and Alpine brown bear populations) was heavily influenced by the results of telemetry studies over the past four decades. Brown bears are opportunistic omnivores and their movements and presence are heavily influenced by food resource availability (Štofik et al., 2013; Kavcic et al., 2015). Other factors, such as the reproductive stage, the availability of dens, and urbanisation, may also play a key role in the size of the bear population. Furthermore, environmental factors such as deforestation, urban development in protected areas, and expansion of ski resorts may result in the temporary concentration of bear populations, which may trigger the nuisance-causing behaviour of these individuals. Global warming plays an important role, as increased maize production in high-altitude regions of northern Slovakia attracts large groups of 40–50 bears in autumn, some of which do not hibernate and remain synanthropic. Large forest habitats in the Carpathians and banned hunting management over the past 50 years (hunting allowed only for individuals weighing up to 100 kg) along with increased reproduction rates (females with up to 4 cubs were reported) increase the need for comprehensive bear population management, in which veterinary interventions such as immobilisation, sampling, transportation or euthanasia play a fundamental role. Each country has specific landscape conditions, human interactions in the countryside may vary from region to region, and the attitude of regulatory authorities towards planned interventions also differs. Extensive research on bear populations has been carried out in various countries, from which experience and knowledge can be extrapolated, but it still has serious limitations. For instance, the helicopter darting method used in North America and Scandinavia has serious limitations in small Central European countries. According to the European Directive on Conservation of Natural Habitats of Wild Fauna and Flora within the framework of nature protection policy in the countries of the European Union, there are strong reservations about Aldrich foot snares, as they are considered non-selective traps, which can be triggered by species not targeted for trapping (Reagan et al., 2002). Leg-hold snares are widely used to catch bears alive but should be considered less acceptable than other techniques due to the significant risk of serious injury to captured bears (Cattet et al., 2008). Taking all these concerns into account, a custom-made container trap was designed and used by the Slovak Bear Intervention Team (SBIT). The bear container trap must be portable in size but large enough not to frighten animals for easy entry, must be safe in close proximity to public places, avoid accidental release, also be fitted with a safety lock when closed and provide a peaceful environment without the risk of injury. Regarding anaesthetic protocols, many combinations of drugs have been reported for the chemical immobilisation of bears, such as tiletamine-zolazepam, medetomidine, xylazine, ketamine, or detomidine. Some drug combinations were proven to be unreliable in immobilising bears due to the risk of sudden recovery (Caulkett and Cattet, 2002). Zoletil 100, a combination of tiletamine and zolazepam, has become the drug of choice for captive and free-range bears.

As the SBIT team used custom-made container traps to catch wild bears but also remote immobilisation, the aim of our study was to evaluate the use of a selected anaesthetic protocol for both conditions. The duration of target-controlled sedation of the bear was a minimum of 30–60 min, necessary for performing a detailed clinical examination, including the oral cavity, deployment of transmitter collars, weight measurement, recording of body dimensions, sampling for further examination such as blood, tissue biopsy for DNA analyses (Paule et al., 2016), and faecal analyses for parasite research (Molnár et al., 2020). The study also describes the benefits of custom-made container traps and field anaesthesia of brown bears, captured within the project of Large Carnivore Management in Slovakia.

MATERIALS AND METHODS

Study area

The study was conducted in the home range of the European brown bear population in the Slovakian mountain regions during the years 2013–2019. The bear population is expanding every year towards the borders with the Czech Republic and Hungary. The estimated population density is between 5 and 11 bears per 100 square kilometres. Bear populations are expanding rapidly southwards, individuals were reported near Slovak towns such as Nitra, Lučenec, Rimavská Sobota, and Košice, while individuals were also reported in close proximity to the Hungarian border. The Slovak Bear Intervention Team, which carried out field capture, assisted various research groups by deploying GPS telemetry collars and assisted local municipalities in managing nuisance bears, especially in the northern part of Slovakia. The age of the captured brown bears was estimated according body weight, morphometric dimensions and tooth wear (Sládek, 1992); no premolar extraction was performed for exact age determination.

Trap construction

The trap used for the capture was a custom-made metal container measuring $2.0 \times 1.7 \times 2.5$ m with a sliding front door (Fig. 1). The door was equipped with a safety mechanism for accidental triggering and unwanted capture after release. In the three sidewalls of the trap, five ventilation windows were manufactured according to the SBIT proposal and made by a local steel company (L.S.O. s.r.o., Bardejov, Slovakia. The total weight of over 500 kg ensured that neither a large male nor a female with its cubs could turn the trap over. Manipulation with the trap as well as the transport to the destination were provided by a forestry tractor equipped with a hydraulic crane. The capture site was set 2–3 weeks prior to the capture using odour-baited traps consisting of maize mixed with honey or chocolate chip biscuits. In the case of nuisance bears, a trap was placed next to the

Fig. 1. The custom-made metal container used for the capture

rubbish bins and the rubbish was dumped inside the trap. As a result of our experience, the trap was put into a safe mode and the bears began to enter regularly. After a few days, a maximum of 14 days, bears got used to entering the traps. This was the time to trigger and set the trap for capture.

To track the movement around the trap, a Bushnell Trophy Cam Wireless HD GSM/GPRS trail camera was installed nearby, which transmitted short videos and pictures by MMS. If several bears visited the trap site at the same time, a remote trigger would be used to close the trapdoor. The biggest challenge was the female with its cubs. If it was aimed only at the young cubs, a metal frame with gaps of 35 cm was placed in front of the sliding door. After trapping the individuals, the capture team was present on the spot within 6–12 h. The trail camera can monitor even random or unwanted visitors. Armed hunters from the local hunting community secured the capture team during all capture procedures. They were present in case of an accidental attack by an immobilised animal till its release.

Anaesthesia protocol

Drug dose calculation was provided based on the individual's body weight (BW) when estimating the probable individual size, gender, and seasonality. After immobilisation, the bears were weighed on a digital scale (Caston-1, CAS, Seoul, Korea). Subsequently, each bear was monitored in terms of heart rate (HR), respiratory rate (RR), and rectal temperature (RT).

Measurement of HR, RT and oxygen saturation (SpO2) became the standard care for monitoring a patient (Vet/Ox G2 Digital monitor, Heska, Fort Collins, Colorado, USA) within which RR was also measured by observing chest movements. Anaesthesia induction time T1 was recorded as the time from initial injection to complete immobilisation without pedal or corneal reflex until a complete relaxation time T2 – required for complete recovery (time from antagonist injection to animal-sitting posture or animal standing on all four legs).

The bears were anesthetised with intramuscular injections delivered by 3 port darts with a volume of 2–3 ml (Pneu-Dart USA, for an adult individual) and a blow pipe using a 3-ml syringe for juveniles animal with 3 anaesthetic protocols:

1. Ketamine-Xylariem (K-X), Ketamine 100 (100 mg mL^{-1} ketamine, Dechra, USA) – Xylariem (xylazine 100 mg mL^{-1} Bioveta a.s., Czech Republic lic. Ecuphar, Belgium). The mixture was used for young and subadult animals up to 70 kg. Dose rate: 3–4 mg ketamine/kg and 1–1.5 mg xylazine/kg BW.
2. Zoletil-Xylariem (T-Z-X), Zoletil 100 (250 mg tiletamin – 250 mg zolazepam, Virbac, France) and Xylariem (100 mg mL^{-1} xylazine, Bioveta a.s., Czech Republic lic. Ecuphar, Belgium).
3. Zoletil-Domosedan (T-Z-D), Zoletil 100 (250 mg tiletamine – 250 mg zolazepam, Virbac, France) and Domosedan 10 mg mL^{-1} detomidine, Pfizer, USA) at a dose of 1.7–2.5 (T) mg kg^{-1}, 1.7–2.5 (Z) mg kg^{-1} and 0.1–0.2 (D) mg kg^{-1} BW.

To terminate or shorten anaesthesia, atipamezole (Antisedant, Pfizer, USA) was administered intramuscularly and subcutaneously (50:50) according to the condition of the bear, and the duration of anaesthesia was maintained at a dosage of 0.15–0.225 mg kg^{-1} BW. The animals were monitored for a minimum of 60 min.

Oxygenation and monitoring of anaesthesia

Recent studies have shown hypoxaemia in immobilised bears that can be corrected by intranasal oxygen administration (Fahlman et al., 2010). Under field conditions, measurements such as pulse oximetry were used to record peripheral oxygen saturation and heart rate (HR) with a pulse oximeter clip attached to the tongue. Due to peripheral vasoconstriction, especially when combined with prolonged anaesthesia for more than 60 min, the values obtained using pulse oximetry are unreliable and do not correlate with true tissue oxygen saturation. All immobilised bears were

Table 1. Physiological parameters of the captured bears (n = 25) during anaesthesia by different drug combinations

Bear No.	Weight/sex kg/(M/F)	Age year	HR beats/min min-max	RR breaths/min min-max	RT °C	T1 Induction time (min)	T2 Recovery time (min)	Drug combination
1	12O/F	8–10	45–54	5–34	39.8	9	86	T-Z-D
2	220/M	25+	40–58	11–24	38.4	14	142	T-Z-D
3	240/M	15+	45–52	12–25	39.1	18	115	T-Z-X
4	37/F	1.5	58–72	14–29	37.5	7	55	K-X
5	33/F	1.5	48–68	18–30	37.3	8	48	K-X
6	44/M	2	47–59	15–28	38.2	8	94	K-X
7	145/M	10–12	49–63	8–24	38.7	15	125	T-Z-X
8	157/M	8–10	48–71	8–27	38.8	11	150	T-Z-X
9	162/M	20	47–78	10–26	38.4	12	105	T-Z-X
10	95/M	4–5	49–70	11–31	37.0	10	165	T-Z-X
12	85/F	4–5	51–72	13–27	37.2	12	85	T-Z-X
13	130/F	25–28	55–84	9–20	38.2	14	133	T-Z-D
14	65/F	2	52–71	15–29	37.5	10	75	K-X
15	50/M	2	50–65	12–30	37.8	8	80	K-X
16	170/M	20–22	60–85	9–25	38.8	14	143	T-Z-X
17	70/M	2–3	62–88	13–29	37.4	7	68	K-X
18	125/F	5–6	55–79	11–33	38.0	13	124	T-Z-D
19	162/F	8–10	48–76	10–18	38.2	12	147	T-Z-X
20	280/M	25+	46–58	11–26	39.5	17	173	T-Z-D
21	110/F	4–5	52–71	15–29	37.5	10	75	K-X
22	87/M	4–5	52–65	12–30	37.8	8	86	K-X
23	170/M	10–12	60–85	10–25	38.8	14	143	T-Z-X
24	96/M	2–3	63–88	13–29	37.4	7	118	K-X
25	127/F	5–6	55–80	11–33	38.0	13	124	T-Z-D

M: male; F: female; HR: heart rate; RR: respiratory rate; RT: rectal temperature, T1: Induction time time from initial injection to complete immobilisation without pedal or corneal reflex and full muscle relaxation; T2: Recovery time to complete recovery (time from antagonist injection to sitting posture or standing on four legs); K: ketamine (Ketamine 100); X: xylazine (Xylariem); Z: tiletamine – zolazepam (Zoletil 100); D: detomidine (Domosedan)

intubated with an intranasal tube and given oxygen from a 5-l cylinder at a flow rate of 2–5 L min^{-1}.

RESULTS

The weight, sex, age, and selected physiological parameters of the captured bears during anaesthesia are described in detail in Table 1. Ten bears were darted in free-ranging conditions from a distance while another 15 individuals were darted after being trapped in a cage trap. Eight out of the twenty-five individuals were considered young or adolescents with an age of maximum of 2 years. The minimum estimated age was 1.5 years (cubs from the previous year), while the maximum estimated age was 30 years in an old male individual. The average age was 9 years. The weight of the immobilised animals ranged from 33 to 280 kg, with an average weight of 120 kg. This correlates with the representative sample of wild bears, which are often observed in Slovakia. In our research, the sex distribution was 10 females and 15 males. The anaesthesia is usually performed on free-ranging bears in the evening or at night with the aid of a spotlight. The darted animals were found using a night vision (Apex LRF Pulsar, USA) Thermal Scope or with the assistance of a hunting dog. An average of 3–4 attempts per site visit were required to shoot the bear with a tranquiliser dart in the wild. In two out of 10 cases, simulated attacks towards the vehicle were reported after firing the dart.

Mild salivation was observed in most of the bears, and often the surface of the cage trap was covered with watery faeces, indicating stress-induced intestinal hypermotility, observed mainly in juvenile individuals. The adult bears remained calm, with no aggressive behaviour when approaching the trap for darting. Darting in the cage trap also presented challenges due to exact weight estimation according to possible seasonal weight differences. Mistakes in weight estimates may also be caused by piloerection or a sitting posture. Excessive fat storage on the back and in the hind limbs in animals in autumn must be taken into an account for exact dart placement. We preferred a high shoulder location or the top of the neck.

In all cases, the recumbency time (T1) ranged from 7 min in subadults to 18 min in old males (mean: 12.04 min; SE: 2.86; median: 11; n = 25). The recovery time (T2) ranged from 72 to 150 min (mean: 125.2; SE: 50.73; median: 135; n = 15). There were no significant differences in the T1 and T2 between sexes, ages, and weights. The HR ranged from 66 to 84 beats per min (mean: 73.4; SE: 5.59; median: 72; n = 15). The range of RR intervals was 12–28 per min (mean: 16.8; SE: 4.53; median: 16; n = 15) and the RT range was 36.2 °C–39.9 °C (mean: 38.2 °C; SE: 0.92; median: 38.2 °

C; $n = 15$). We documented mild hyperthermia, bradycardia, and mild bradypnoea, with no significant differences observed in HR, RR, and RT between the two sexes. Gradually, the movement followed by recovery began with the head towards the back parts of the hind legs. A total of 76% of the animals anaesthetised with the mixture including Zoletil 100 were able to sit but unable to use their hind legs. This phenomenon was observed in older animals receiving higher doses of sedatives. No such recovery was observed in cases of K-X anaesthesia. One case of a sudden rise of an excited 70-kg male was recorded. Additional administration of ketamine at a dose of 2 mg kg^{-1} introduced intramuscularly in the hind leg resulted in the further onset of anaesthesia and recumbency within 5 min. No animals died or were injured during the capture.

DISCUSSION

This study documented the practical aspects of capturing European brown bear in the Carpathian Mountains, especially in the mountain area with the highest bear density during the EU-funded project Large Carnivores Management, implemented by the State Nature Conservancy Authorities of the Slovak Republic (SNCA SR). The captured bears were equipped with a GPS radio collar for terrestrial monitoring; these devices were attached to the bears by SNCA field guards. The project also included bears with synanthropic behaviour, which regularly visited urban areas. Three different drug combinations of a wide therapeutic index and safety margin were proven to be an effective and easily accessible immobilisation protocol. Immobilising anaesthetics were selected with regard to repeatability and availability in the Slovak pharmaceutical market. Some of the drugs used by other authors are not registered in Slovakia (Swenson et al., 2000). Only for this project, five pieces of cage traps were specifically designed by the Slovak Bear Intervention Team and manufactured by a local steel company (L.S.O., s.r.o. Bardejov, Slovakia). The construction of the metal cage trap is much different from that of the traps previously used by the SNCA. Its larger size and cubic shape make it more advantageous for the successful capture of an individual. With regard to the behaviour of the bears, the bears can get into these traps easier because they are not barrel-shaped, although their total weight (500 kg) is a disadvantage. This requires forestry tractors (4 × 4), which allow manipulation with a trap hydraulic crane. As part of our research, special efforts were made for selective triggering, monitoring the capture site by GSM trail cameras, or placing traps in urban areas close to surveillance cameras.

The combination of T-Z-X has many of the same characteristics as those found in the medetomidine-zolazepam-tiletamin (M-Z-T) mixture (Laricchiuta et al., 2008; Jeong et al., 2017). T-Z-X mixtures cause hypertension and hypoxaemia. In general, hypoxaemia is not severe and responds well to supplemental oxygen supply. T-Z-X mixtures produce effective and safe immobilisation within 20 min after their administration. It is also important to note that the quality of the anaesthesia differs from that induced by Zoletil itself, as the individuals may be able to lift their head or limbs. The combination of T-Z-D proved to be an excellent combination for low-volume anaesthesia used in Asiatic black bears (*Ursus thibetanus*) (Laricchiuta et al., 2008); however, it has not yet been used in wild European brown bears. Based on the authors' experience, cage trapping and application of a T-Z-D immobilisation protocol for brown bears in traps, also for trapped and for wild, free-ranging bears is a practical, reliable and safe method. It can be used as part of ecological, genetic, and epizootiological research projects (Paule, 2016; Molnár et al., 2020). The above-mentioned combination of drugs proved to be very effective in the distance shooting of large animals. The immobilised bears were usually found located in a recumbent position at a maximum of 300 m from the darting site. This was a great advantage in densely forested mountain areas. Using either combination, we did not find any sex-related differences in vital signs or in anaesthesia induction and recovery time. Young animals tend to have a higher metabolic rate due to stress and increased cerebral oxygen demand than older animals. Furthermore, age and seasonality may affect the hepatic metabolic and renal excretory rates of drugs, resulting in altered vital signs, anaesthesia-related induction, and recovery times (Clarke et al., 2014). Blood gas studies in other bear species showed hypoxaemia during anaesthesia with T-Z-X (Caulkett et al., 1999). Hypoxaemia is often clinically silent, while the result of pulse oximetry may not correlate with haemoglobin oxygen concentration, although a low oxygen saturation is observed. Oximetry may be unreliable in detecting hypoxaemia in bears and other wildlife species, but it can be a useful tool for heart rate monitoring (Cattet et al., 1999; Fahlman et al., 2010).

CONCLUSION

In conclusion, the preferred capture method used a specially designed metal cage trap, which has great safety benefits for use in urban areas because the trap is large in size and is more suitable for capturing large individuals or females with more cubs. Out of three different drug combinations, we recommend a mixture of tiletamine-zolazepam-detomidine (T-Z-D) at a dose of 1.7–2.5 mg kg^{-1} (T), 1.7–2.5 mg kg^{-1} (Z) and 0.1–0.2 mg kg^{-1} (D). This combination mixture of sedatives can be used for bears trapped in cage traps as well as for the remote immobilisation of free-ranging bears. High doses do not have a negative effect on selected physiological parameters and the combination is therefore suitable for inducing rapid-onset anaesthesia on a difficult terrain. The results in this paper can be used for population management of large carnivores in the Carpathian region.

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