EXPERIENCES WITH TRAPPING, CHEMICAL IMMOBILIZATION, AND RADIOTAGGING OF BROWN BEARS IN SLOVENIA

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Abstract: Wildlife research on brown bears (*Ursus arctos*) and other shy, nocturnal, or forest dwelling animals with large ranges has improved enormously with the help of radiotelemetry. However, in the small and threatened bear populations of central and southern Europe, accidents that may injure or kill a bear during trapping, immobilization, and radiotagging are a major concern to bear conservationists and animal protection groups. Much information and experience is available from bear work in North America, but some of the techniques do not seem to be appropriate or acceptable for bear populations in Europe. We describe our experiences with trapping, chemical restraint, and radiotagging of 25 different bears during 31 capture events in a research project in Slovenia, 1993–98. Focus is on safety considerations for trapping, chemical immobilization, and radiotagging of bears, and also on minimizing risk for the capture team and local people frequenting the vicinity of the trap sites. The use of Aldrich foot snares proved to be a reasonably efficient (0.72 bears/100 trap nights), selective (only 3 non-target species captured), and safe (only 2 minor capture related injuries) method to capture bears on forested range. We conclude that it is most important to use a trap transmitter system in combination with a carefully designed trap arrangement to guarantee that handling of bears starts within 1–2 hours of initial capture. In addition, the capture team needs to be well trained in the theoretical and practical aspects of trapping, immobilization, and radiomarking of brown bears.

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Key words: animal welfare, brown bear, chemical immobilization, public safety, radiomarking, Slovenia, trapping, *Ursus arctos*

Wildlife research on brown bears and other shy, nocturnal or forest dwelling animals with large ranges has improved enormously with the help of radiotelemetry. A major drawback to most research is the need to trap, immobilize, and radiotag bears, which holds a certain risk for the bears and people involved (Jonkel 1993). Especially in the small and threatened bear populations of central and southern Europe, research-related accidents that may injure or kill a bear are a major concern to bear conservationists and animal rights groups. The European Flora Fauna Habitat (FFH) guidelines (Council of the European Union 1992) and the Bern Convention (Council of Europe 1979), as well as national legislation in several countries (e.g., Austria, Germany), have great reservations about the use of snares because they are considered non-selective traps (Hinterleitner and Völk 1996).

Contrary to North American experience, live trapping of bears was limited in Europe before the 1990s (3 bears 1972–77 in Trentino, Italy [Roth 1983]; 26 bears 1981–91 in Croatia [Huber and Roth 1993, Huber et al. 1996]; 1 bear 1985–87 in Cantabria, Spain [Clevenger et al. 1990]; 40 bears 1984–89 in Scandinavia [P. Wabakken, A. Bjärvall, and F. Sandegren, 1990, Radio-tracking Scandinavian brown bears: progress report, Hedmark College, Koppang, Norway]). However, these techniques have become more important for research and management in the past years. By the year 2000, the Scandinavian brown bear project had handled bears more than 755 times (A. Soderberg, Swedish Association for Hunting and Wildlife Management, Uppsala, Sweden, personal communication, 2000). New research projects using telemetry have started in several other European countries, e.g., central Italy (Gentile et al. 1996), Greece (Y. Mertzanis, 1999, Home ranges and movements of brown bears in the Pindos range, Greece, LIFE-Nature Project ARCTOS, ARCTURUS, Thessaloniki, Greece), Spain (A. Fernandez, J. Naves, C. Villalba, and M. Delibes, 1999, Forest fragmentation and brown bear forest selection in Somiedo Natural Park (Asturias, Spain), University of Oviedo, Oviedo, Spain), Romania (A. Mertens, Carpathian Large Carnivore Project, Brasov, Romania, personal communication, 2000), and Finland (I. Kojola, Finnish Game and Fisheries Research Institute, Oulu, Finland, personal communication, 1999). Radiotelemetry has also become an important tool for monitoring reintroduced or problem bears in Austria (Zedrosser et al. 1999), the French Pyrenees (Camarra et al. 1998), and northern Italy (Mustoni and Genovesi 2001).

There have been a few cases in Europe where brown bears died due to trapping or chemical restraint (2 bears captured in Slovenia for the reintroduction in Austria [Rauer and Kraus 1993], 2 bears in Croatia [D. Huber, Veterinary Faculty at the University of Zagreb, Zagreb, Croatia, personal communication, 2000], and 10 bears in

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Scandinavia [A. Söderberg, Swedish Association for Hunting and Wildlife Management, Uppsala, Sweden, personal communication, 2000]). There have also been cases where bears suffered neck injuries from ingrown collars (1 bear in Scandinavia [P. Wabakken, Hedmark College, Koppang, Norway, personal communication, 1994]; 1 bear in Croatia [D. Huber, Veterinary Faculty at the University of Zagreb, Zagreb, Croatia, personal communication, 2000]). The most recent accident, an adult male bear from the small population in the Cantabrian mountains that apparently died of capture-related myopathy in 1998 (J. Naves, University of Oviedo, Oviedo, Spain, personal communication, 1999), created a significant amount of anti-telemetry emotions in Spain. But it also triggered scientific discussions concerning acceptable risks and basic safety standards for trapping bears. As a consequence, the International Bear Association (IBA) initiated a world-wide survey on injuries and mortalities associated with bear research and management (D. Sheldon, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, USA, personal communication, 2001).

All European bear research teams follow capture protocols based on their own and rather restricted experience of trapping bears in Europe or based on experience gained in North America (Jonkel 1993). Unfortunately, some of the techniques from North America do not seem to be appropriate or acceptable for the small bear populations in southern and central Europe. This is because: (1) the death of a single bear in a small population can severely affect the population, especially if the bear is female, (2) public acceptance for bear deaths is very low, and (3) public safety is a major concern because most areas with bears are also heavily frequented by people who may accidentally or deliberately disturb trap sites and get injured by traps or trapped bears.

Exchange of experience among European bear researchers is therefore important and provides an opportunity to learn from the mistakes of others and improve safety standards. Here, we describe our experience with trapping, chemical restraint, and radiotagging of 25 bears during 31 capture events during a research project in Slovenia, 1993–98.

METHODS

Capture

With 2 exceptions, we caught all bears using Aldrich foot snares (Jonkel 1993) at established bait sites (Fig. 1). These sites are used for hunting and have been in place for many years. Usually bait was provided by local hunters and consisted of meat (carcasses or slaughtering remains of domestic animals), corn, and fruits. During the spring 1993 and 1994 capture seasons, we prepared small sand beds on bear trails and in front of traps to monitor bear activity, check for possible trap avoidance, and detect non-target animals that sprung snares without getting caught.

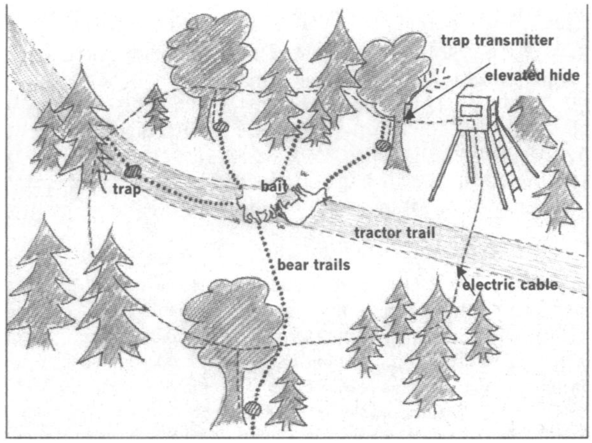

Fig. 1. Schematic of trap site and alarm system used to capture bears in Slovenia, 1993–98. Two to 6 traps were arranged at each bait site, connected with each other and a trap transmitter. The trap transmitter was mounted in a tree to allow for a reception range up to 30 km. Electric wires connecting the traps and transmitter were mounted 2–3 m above ground to avoid problems with rodents.

Our capture seasons were restricted to the spring and fall and had to be coordinated with local hunters. No trap site was used for hunting and live-trapping simultaneously, and in areas where hunters wished to shoot a bear, we normally waited until their bear was shot. Our spring trapping season began after most of the snow had melted and continued until the beginning to middle of May. Our fall trapping season lasted from October until the first heavy snowfalls.

To minimize the time bears were snared, we used an alarm system by surveying snares with trap transmitters (Wagener, Cologne, Germany; Fig. 1). The electrical cable was connected via small plugs to a short piece of electric cable fixed at the snare loop just behind the swivel. Thus, merely springing the snare did not trigger the alarm. Rather, the animal had to move the snare to disconnect the plugs and trigger the alarm. These transmitters were monitored hourly during daylight and every 30 min at night. All traps were visually inspected every morning to check for sprung traps and to back up the alarm system. We visited trap sites immediately after the alarm signal was triggered, regardless of weather or light conditions. For safety reasons, we only selected trap sites accessible by car and that could be reached within an hour from the field station. These requirements considerably restricted possible trap sites. In total, we used 18 trap sites in 10 hunting areas. We never had more than 7 trap sites activated simultaneously. Each trap site was equipped with 2–6 snares to enhance the probability of capturing the accompanying female in cases where a cub or yearling of a family group was caught. To avoid catching non-target animals and small cubs, we taped the snare loop so that it could not close completely. To avoid catching red deer (Cervus elaphus), we fixed horizontal poles above the traps at bait sites with corn and fruits or near known deer trails (see Jonkel 1993).

Chemical Immobilization

We immobilized the majority of bears using a combination of tiletamine HCl and zolazepam HCl (Zoletil 100®; Virbac SA, Louvain la Neuve, Belgium); 6 bears received additional or different drugs (Table 1). Drugs were administered by a carbon dioxide (CO_2) dart gun (Telinject, Stubenberg, Austria) and air-pressure activated 3.5-ml darts (Telinject, Stubenberg, Austria) with barbed 45-mm needles in spring and 60-mm needles in fall. Shooting distance normally did not exceed 10 m, but 2 bears were free-range immobilized without snaring. We took standard body measurements, collected hair and blood samples for genetic and serological analysis, pulled a premolar (PM1) for aging (Matson's Lab, Milltown, Montana, USA), and fitted bears with colored eartags (Prima-Flex, Caisley International, Bocholt, Germany) for permanent identification in both ears. During handling we monitored body temperature, pulse, and respiration rate at irregular intervals.

Radiomarking

Bears were categorized as adults (≥4 years), subadults (2–3 years), yearlings (1 year) and cubs of the year (cubs) according to tooth wear, presence of cubs, size of testes or nipples, and body measurements. Due to the rapidity of bear growth, only adult or subadult bears >70 kg were fitted with radiocollars weighing 500 and 200 g, respectively (MOD-600 and MOD-400; Telonics, Mesa, Arizona, USA). In addition we used breakaway devices on all collars (Fig. 2), either 18 loops of 1-mm iron wire, a system developed by H. Roth (Abruzzo National Park, Pescasseroli, Italy, personal communication, 1993) and D. Huber (Veterinary Faculty at the University of Zagreb, Zagreb, Croatia, personal communication, 1993) in Croatia or cotton spacers (cotton webbing links with grommets spaced to fit hardware; Hellgren et al. 1988). For subadult bears, we further notched cotton spacers on one or both edges to allow for a more rapid break off. We fit collars around the neck with enough space so that they would slide over the bear's head when pulled hard. Starting in 1996, yearlings and cubs were fitted with eartag transmitters weighing 42 g (EL-2[42]) and 29 g (EL-2[29]) (Holohil, Carp, Province, Canada; Fig. 2) or hair-mount transmitters weighing 90 g (MOD-225; Telonics, Mesa, Arizona, USA). Before 1995, 2 yearlings were fitted with radiocollars (Telonics' MOD-600; Televilt, Lindesberg, Sweden) and 3 were released without radiotags (Table 2).

RESULTS

Capture

A total of 4,041 trap nights resulted in 29 captures of 25 different bears; additionally, 2 free-ranging bears were tranquilized (Table 2). Six bears were captured twice, and none was captured more than twice. All bears were captured from early dusk to late dawn (Fig. 3). Bears/100 trap-nights averaged 0.72, but this varied from season to season and decreased ($r^2 = 0.815$, $P < 0.001$) from 1993 to 1998 (Table 3).

Traps were triggered by non-target animals and bears that evaded capture in 161 cases (4%; Table 3). Non-target animals included, in decreasing order of frequency, wild boars (*Sus scrofa*), red deer, roe deer (*Capreolus capreolus*), red fox (*Vulpes vulpes*), dogs, humans, and unknown species. Non-target animals were caught 3 times: 1 young wild boar weighing about 30 kg, another wild boar weighing 60 kg, and 1 adult female red deer. The wild boars were successfully released, the younger one uninjured and the older one with bruises on the leg. The red deer had fallen and, although it had no fractures and only slight bruises, was unable to move both front legs. We euthanized it by gunshot.

We did not precisely document our efforts to immobilize free-ranging bears, but we spent numerous nights in elevated blinds at bait sites. We observed bears on 4 occasions: twice a bear was spooked before we got a chance to shoot, once it was too dark to shoot, and once we managed to chemically immobilize a free-ranging yearling female. The bear was darted with a CO_2 gun (Daninject, Gelsenkirchen, Germany) and a black powder charge triggered dart (Pneudart, Williamsport, State, USA) at a distance of 65 m from an elevated blind. Visibility was good because of a full moon and snow cover on the ground. Even though we greatly overestimated the bear's body mass and therefore overdosed her (about 3-times the required dosage; Table 1), she was able to run for more than 500 m after darting. We also immobilized from close range a free-ranging bear that had gotten its head stuck in a plastic oil container.

We captured 17 males and 8 females as 7 adults, 10 subadults, and 11 yearlings. Of the 11 yearlings captured, only 1 was with the mother; all other yearlings were either alone or the mother was not detected during handling. In the 1 case where the mother remained with the yearling, she did not leave when we approached the first time

Table 1. Bears trapped and immobilized in Slovenia, 1993–98.

Bear	Date	Time darted	Sex	Age (years)	Mass (kg)	Trapping situation	Estimated dose (mg/kg body weight): Zoletil ®	Estimated dose: Other drug	Estimated dose: Antidote	Time (min) for: Head up	Time (min) for: Leave[a]	Comments
Yogi	26 Apr 1993	000	M	1	36		7.2			75	210	
Krabat	28 Apr 1993	550	M	1	42		6.1			55	115	
Jana	4 May 1993	2200	F	1	40		5.0			70	120	
Metka	24 Mar 1994	800	F	13–14	85	trapped >2 hr	7.1			70	165	
Clio	25 Mar 1994	2115	M	1	35		6.9			50	140	
Janko	28 Mar 1994	2230	M	2–3	118		7.1			70	160	
Luka	31 Mar 1994	2230	M	1	~35	trapped >2 hr	8.6			60	100	
Metka	1 Apr 1994	700	F	13–14	~85	trapped >2 hr yearling in trap	17.4			70	100	
Mishko	7 Apr 1994	2330	M	2–3	155		13.3			65	335	slept at trap site
Clio	7 Apr 1994	815	M	1	~35		6.3			30	75	
Ancka94	22 Apr 1994	2240	F	4	73		10.5			65	80	
Jana	7 Nov 1994	1830	F	2	120	severe neck injury	11.3			unk[b]	unk	
Jure	16 Nov 1994	1900	M	2	154	problems with drugging: bear extremely fat	37.3			90	<510	slept at trap site
Urosh	5 Apr 1995	400	M	1–2	~80	bear rather thin	6.3			30	120	
Milan	15 Apr 1995	2200	M	3	110		18.2			115	235	
Mishko	19 Apr 1995	415	M	3–4	162		15.4			105	375	actively chased away
Maja	23 Apr 1995	400	F	7	101		10.0			130	280	
Vera	5 Oct 1996	400	F	Cub	25	trapped >2 hr mother with siblings around	20			70	250	slept at trap site
Lucia	18 Oct 1996	1930	F	1	80		11.0			100	unk	
Vinko	31 Oct 1996	530	M	0	35	trapped >2 hr	8.6			40	90	
Srecko	28 Mar 1997	55	M	3	120		12.5			60	unk	fell asleep
Vanja	21 Apr 1997	2045	F	1	40	free-range anesthetized	16.3	0.075 medetomidine	0.375 atipamezole 0.0125 flumazenil	180	280	slept at trap site
Dusan	3 May 1997	2200	M	1	38		13.2		0.0132 flumazenil	265	395	slept at trap site
Vera	9 May 1997	630	F	1	28		17.9			45	145	
Joze	18 Mar 1998	430	M	1	47		31.9			240	245	
Nejc	23 Mar 1998	1930	M	1	55		9.0			80	130	
Polona	6 Apr 1998	615	F	5	110		9.1			125	370	slept at trap site
Klemen	7 Apr 1998	1100	M	3	118	trapped >2 hr	12.7	0.0169 medetomidine	0.0085 flumazenil	70	280	slept at trap site
Ancka98[c]	10 Apr 1998	2335	F	unk	92		8.2	0.0217 medetomidine	0.163 atipamezole	180	510	slept at trap site
Ivan	14 Apr 1998	115	M	2	140		5.4	0.0214 medetomidine	0.107 atipamezole	88	unk	slept at trap site
Dinko	31 Apr 1998	1445	M	2	73	free-range anesthetized handicapped by oil canister		8.6 ketamine HCl 8.6 xylazine HCl		120	180	

[a] Bear left the trap site and disappeared
[b] unk = unknown
[c] Identity unclear due to loss of eartags

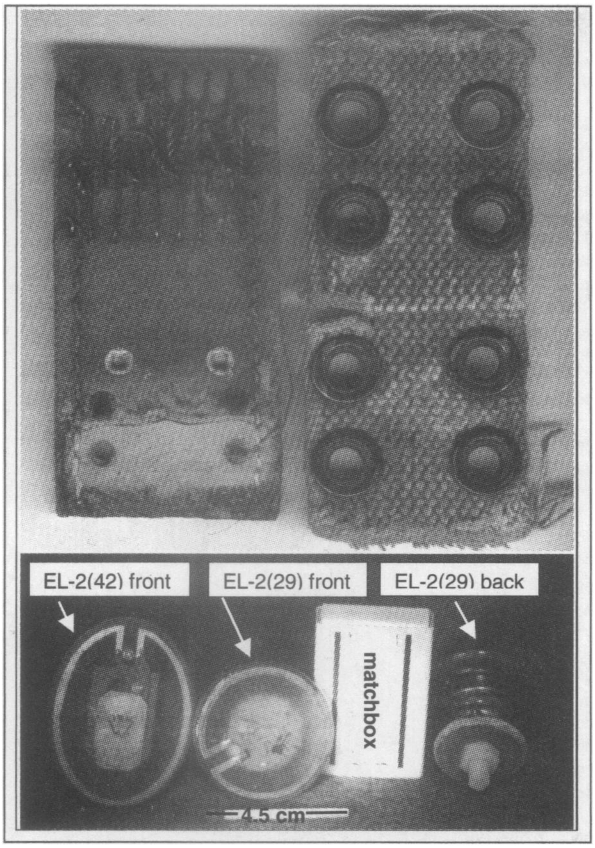

Fig. 2. Breakaway devices used on radiotransmitter collars in Slovenia, 1993–98. Top: Collar featured either 18 loops of 1-mm iron wire (left) or cotton spacers (cotton webbing links with grommets, right). For subadult bears, collars were notched on one or both edges to allow for a more rapid break off. Bottom: Eartag transmitters (used after 1996) weighed 42 g (EL-2[42]) and 29 g (EL-2[29])g.

and appeared ready to attack the car. We therefore waited until daylight, by which time the female had been trapped in another snare.

Even though we never trapped a female with cubs, in 2 cases we caught cubs alone. In the first case the mother, a radiomarked female with 3 cubs, stayed with her 2 snared cubs and we were unable to chase her away with the car at night. The next morning, when we attempted to immobilize the cubs from the car, 1 cub managed to free itself and the female ran off with the 2 free cubs, leaving the third behind. In the second case, we did not see a female nearby, but for safety reasons waited until daylight before we immobilized the cub. A few weeks later, tracks in the snow showed that the cub was with a larger bear, most likely its mother.

Two additional bears were snared for an extended period (possibly >2 hours) due to a failure of the alarm system (Table 1). Despite these complications, both were uninjured. Of all captured bears, only 2 suffered minor capture-related injuries: a subadult male pulled a premolar (PM2) tooth and a cub broke one front claw. Almost all bears were in good or very good body condition.

Chemical Immobilization

Most bears were drugged exclusively with Zoletil®, using an average dose of 12.6 mg/kg body mass (SE = 7.8 mg, range: 5.0–37.3, $n = 26$; Table 1). With a high enough initial dosage, all bears were in lateral recumbency within 5 min. With Zoletil® and no antagonist, the head-up time (time the bear could hold its head up) varied from 30 min to 4.4 hours and the leaving time (time from dosing until the bear left the area) from 75 min to >8 hours. Neither time until head up nor time until leaving were highly correlated with dosage, but rather varied greatly among individuals (Table 1, Fig. 4). With 1 exception, body temperature of drugged bears were ≤39°C to ≥37°C and did not seem to affect recovery time, but for obvious reasons body temperature could not be measured during recovery.

There was no reduction in the head up time when using Zoletil® and medetomidine and the antagonists atipamezole, flumazenil, or both (mean without antagonist: 80 min, SD = 44, $n = 24$; mean with antagonist: 157 min, SD = 79, $n = 5$), but the sample size was very small and bears were dosed too high with tiletamine HCl and zolazepam HCl (Table 1). However, an increase in respiratory rate and depth were noted 10 min after application of the intramuscular antagonist (Kaczensky, unpublished data).

Radiomarking

On 18 occasions, we used radiocollars with breakaway devices (Table 2). Radiocollars with unnotched cotton spacers remained on bears 7–26 months ($n = 5$), collars with notched cotton spacers from 2 weeks to 7 months ($n = 4$), with 0.5 mm wire loops for 2 months ($n = 1$) and for 1 mm wire loops from 2 to 18 months ($n = 4$; Table 2).

No radiocollar failed before the expected lifespans of 24 and 36 months. One bear dispersed and could not be tracked after dispersal, 1 bear was presumably poached, and 1 slipped the collar. The batteries in the collars of 2 adult females expired, as expected, before the collar broke off.

On 1 occasion a collar did not come off as expected resulting in serious neck injuries. We accidentally attached the collar to a female yearling which we judged to be a 2-year-old female. During the 18 months until her recapture, she tripled her body mass from 40 kg to 120 kg. The collar had a 1 mm wire loop breakaway but became imbedded in the fat of the fast-growing bear. The fat had stopped any further corrosion of the wires. We decided to euthanize the bear because of the risk that the injured bear might attack a person. As a consequence, we did not use

Table 2. Radiotags and breakaway devices used on bears captured in Slovenia, 1993–98.

Date	Bear	Sex	Age	Radio tag	Type	Breakaway	Months radiotag lasted
1993							
4 May	Jana	F	1	collar	MOD-600	18 loops of 1 mm iron wire	≥18 (embedded in bear's neck)
1994							
24 Mar	Metka	F	13–14	collar	MOD-600	18 loops of 1mm iron wire	6 (broken)
25 Mar	Clio	M	1	collar	Televilt	9 loops of 0.5 mm iron wire	2 (broken)
28 Mar	Janko	M	2–3	collar	MOD-600	18 loops of 1mm iron wire	≥3 (bear disappeared)
7 Apr	Mishko	M	2–3	collar	MOD-600	18 loops of 1mm iron wire	7½ (broken)
22 Apr	Ancka94	F	4	collar	MOD-600	18 loops of 1mm iron wire	14 (broken)
16 Nov	Jure	M	2	collar	MOD-600	cotton spacer with 1 cut	≥4 (bear poached)
1995							
5 Apr	Urosh	M	1–2	collar	MOD-400	cotton spacer with 2 cuts	2 (broken)
15 Apr	Milan	M	3	collar	MOD-400	cotton spacer with 2 cuts	½ (broken)
19 Apr	Mishko[a]	recapture		collar	MOD-600	cotton spacer	7 (broken)
23 Apr	Maja	F	7	collar	MOD-600	cotton spacer	26 (broken)
1996							
5 Oct	Vera	F	cub	eartag	EL-2(42)	none	7 (hole in ear)
18 Oct	Lucia	F	1	collar	MOD-400	cotton spacer	≥12 (bear killed)
31 Oct	Vinko	M	cub	eartag	EL-2(42)	none	7 (lost)
1997							
28 Mar	Srecko	M	3	collar	MOD-400	cotton spacer with 2 cuts	7 (broken)
				eartag	EL-2(42)	none	? eartag broken
21Apr	Vanja	F	1	eartag	EL-2(42)	none	4 (lost)
3 May	Dusan	M	1	eartag	EL-2(42)	none	2½ (lost)
9 May	Vera[a]	recapture		hair mount	MOD-225	none	1 (shed with fur)
1998							
18 Mar	Joze	M	1	eartag	EL-2(29)	none	1½ (unscrewed)
23 Mar	Nejc	M	1	eartag	EL-2(29)	none	≥12 (battery expired)
6 Apr	Polona	F	5	collar	MOD-400	cotton spacer	≥18 (battery expired)
7 Apr	Klemen	M	3	collar	MOD-400	cotton spacer with 1 cut	6 (broken)
				eartag	EL-2(29)	none	? (eartag broken or lost)
10 Apr	Ancka98[b]	recapture		collar	MOD-400	cotton spacer	≥18 (battery expired)
14 Apr	Ivan	M	2	collar	MOD-600	cotton spacer	≥½ (slipped over head)
31 Aug	Dinko	M	2	collar	MOD-600	5 loops of 2mm iron wire	≥3½ (bear lost)

[a] Collar lost between captures.
[b] Identity unclear due to loss of eartags

collars any more on bears <70 kg.

We used eartag and hair-mount transmitters as an alternative or supplement for radiocollars on 9 bears. The heavier EL-2(42) eartag transmitters lasted from 2.5 to 7 months. In 1 case, a bear lost the tag during recapture because the ear had a slit that was just large enough for the tag to slip through. The mass of the tag most likely caused this slit. During 3 occasions when bears with EL-2(42) transmitters were seen by the field crew, the tagged ear was noted to be hanging down. The 2 tags that lasted for 7 months were worn by bears over the winter denning period.

The 3 lighter EL-2(29) tags lasted the full battery period of 12 months; 1 became unscrewed after 6 weeks due to insuficiently secured screws and 1 broke or was lost after a few weeks. One hair mount was applied to a yearling in spring before most of the winter fur was shed and came off after 6 weeks.

In general, the range of the eartag- and hair-mount transmitters was greatly reduced when compared to the radiocollars in the rugged terrain of our study area. During periods of activity, it was a matter of pure luck to find unmarked bears.

DISCUSSION

Trapping with Aldrich Snares in Combination with an Alarm System

Our experience showed that snaring is a safe, selective, and efficient method to capture bears in forested habitats. Still, the effort was considerable (Table 3) and it was not possible to selectively capture certain individuals or avoid catching young of a family group. In addition, it proved very difficult to recapture an individual because bears learned to avoid or even deactivate traps. We also observed this phenomenon with bears in Austria. The risk of a bear injuring itself in the snare can be reduced by careful snare placement (Jonkel 1993) and by minimizing the time the animal is snared (Woodbury 1996). We strongly advocate a trap transmitter system and a trap site arrangement that allows a response time of no longer than 1–2 hours. This makes handling bears at night necessary and exposes the capture team to a higher risk due to reduced visibility. The chance of trapping a cub and having an angry, free-ranging female nearby should never be underestimated. In addition, our experience demonstrated that bears behave less shyly, perhaps feeling more secure at night. We therefore strongly recommend trapping only

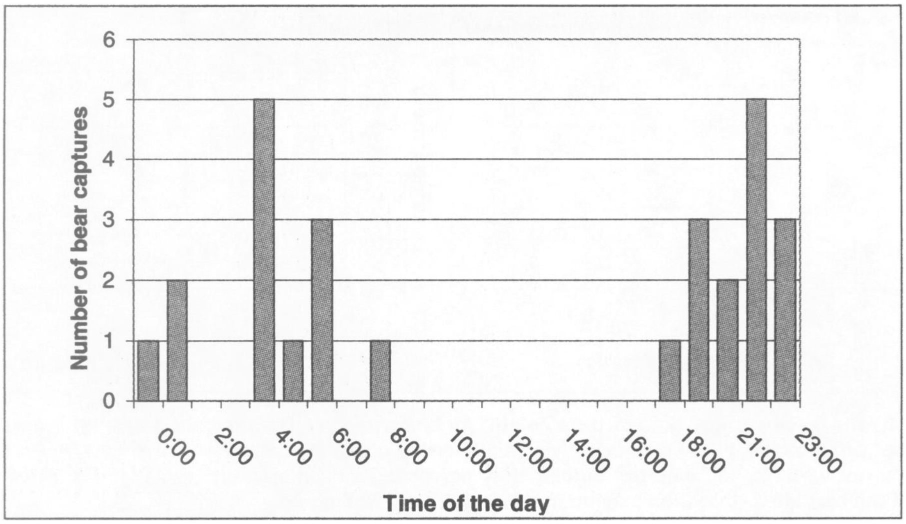

Fig. 3. Time of day bears were captured in Slovenia, 1993–98.

Table 3. Trapping effort and success during 7 seasons trapping brown bears in Slovenia, 1993–98.

Season	Bears/100 trap nights	Bears trapped	Sprung traps	Non-target species
Spring 1993	1.45	3	4	0
Spring 1994	2.44	8	14	0
Fall 1994	1.32	2	7	0
Spring 1995	1.16	4	15	0
Fall 1996	0.44	3	26	1 red deer, 1 boar[a]
Spring 1997	0.38	4	40	1 boar
Spring 1998	0.40	5	73	0
Total	0.72	29	161	3

[a] *Sus scrofa*

in places accessible by vehicle.

Minimizing the time a bear is trapped also has human safety implications. Most areas with bears in Europe are not wilderness areas, and the forests are heavily frequented by people. This use is often facilitated by a dense network of forest roads. Warning signs may act as attractants or be ignored. The risk always exists for a forest worker or hiker to accidentally stumble on a trap site and get attacked by a snared bear or a female protecting her snared cub. This risk is greatly increased during the daytime hours. We stopped trapping altogether at the beginning of May because humans started to use the forest quite intensively. Furthermore, visibility at the trapsites was greatly reduced due to the growing vegetation.

Free-range Darting: an Alternative to Snaring?

Free-range darting of bears is often considered an alternative to snaring bears. Our experience was that the efficiency of darting is rather low, the opportunities to dart a bear are very restricted, and the risks for the capture team are considerable. Bears in Slovenia are generally shy and only visit bait sites at night. The use of artificial light is possible with some individuals, but most bears seem very sensitive to such disturbance. All of our attempts were restricted to nights with full moon or the early evening. Even at the established bait sites, the distance between a bear and the observer was almost always >50 m, the limit of most CO_2activated tranquilizing guns. The use of black powder powered guns allows for a wider range, but the distance has to be estimated precisely (e.g., by laser distance measure) because of the risk of injury to the bear if the projectile's impact is too hard or it hits the wrong spot.

Poor light conditions make it difficult to estimate the mass of a bear. Overdosing is not a serious problem with Zoletil® because it has a wide safety margin. Still, even overdosed bears may run for quite a distance. The yearling female we immobilized while free-ranging ran for >500 m, and only the snow cover made it possible to rapidly find her. Without snow or a trained dog, it is difficult and dangerous to search for bears in the dark, possibly in dense cover and not knowing if the animal is fully immobilized. For free-range darting, the use of transmitter darts is advisable, but darts should be tested before use; all 4 darts we intended to use broke during the test shooting. Dart transmitters produced by Pneudart and incorporated within the aluminum dart proved reliable and were used successfully on 1 occasion to dart a bear in Austria

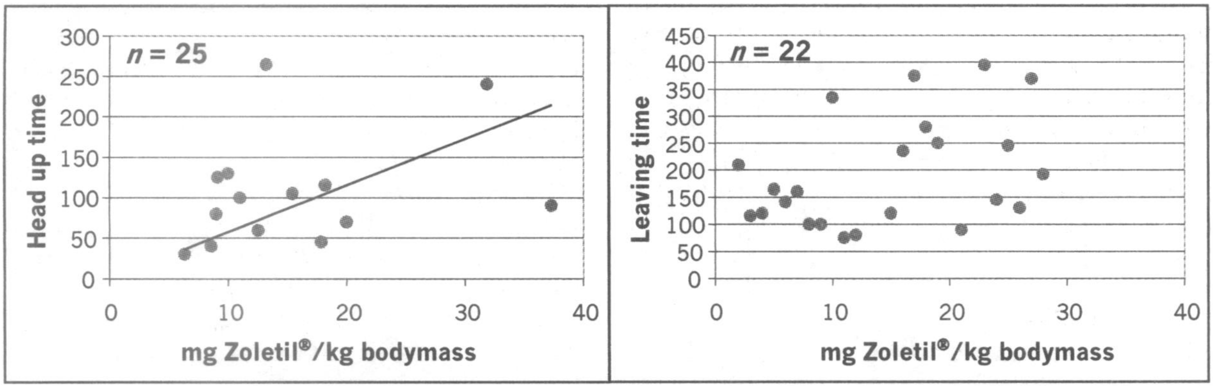

Fig. 4. Head-up (left) and leaving (right) time on pure Zoletil® for bears captured in Slovenia, 1993–98. Time until head up was positively correlated with dosage, but explained only a small portion of the overall variation (r^2 = 0.178, P = 0.036). Time until leaving was even more variable and was not significantly correlated with dosage (r^2 = 0.124, P = 0.108). Several bears apparently slept at the trap site rather than leaving immediately after waking up.

(Kaczensky, unpublished data). Development of better equipment and additional experience is still needed. Advanced Telemetry Systems transmitter darts were apparently effective for immobilizing urban white-tailed deer (*Odocoileus virginianus*, Kilpatrick and Spohr 1999).

Efficiency of free-range darting from the ground is also low when compared to snares, which can be set in several places and do not require all-night tending. We feel that free-range darting is a good alternative to snaring in special situations, e.g., for handicapped bears (the bear with the plastic container) or problem bears that have lost their fear of people (e.g., 1 yearling female in Austria; Kaczensky, unpublished data), or for females next to trapped young (1 bear in Romania, A. Mertens, personal communication, 2000). Free range darting from the helicopter on the other hand is very efficient and highly selective (Swenson et al. 1998), but largely restricted to open areas.

Chemical Immobilization

Following other researchers (Jonkel 1993, Ramsay et al. 1995, Kilpatrick and Spohr 1999), we consider Zoletil 100® a very safe and reliable drug. There were no complications even with greatly overdosed bears, and no bear suddenly awoke during handling, which is known with ketamine–xylazine (Jonkel 1993) and ketamine–medetomidine combinations. In our experience the recommended 5 mg Zoletil 100®/kg body mass was not sufficient in several cases, and multiple injections of Zoletil® resulted in a far higher total drug dose. In addition, the stress level for the animal and the capture team greatly increased. We therefore aimed to use a dosage of 10 mg/kg body mass, and in case of doubt always used the highest mass estimate.

Although the safety margin for Zoletil® is high and bears do not seem to be particularly sensitive to a high dosage, it is important to regularly monitor pulse, respiration, and body temperature from drugged bears. Every capture team should have the basic equipment and at least 1 person, preferably a veterinarian, who knows what to do in case of complications (Kaczensky et al. 1997).

The wake-up pattern always followed the same scheme; it began with tongue movements followed by head movements, movements of front feet and finally of hind feet, and allowed a reliable judgment of how safe it is to handle the bear. This was crucial because local hunters or foresters often wanted to be present during capture events. Although we tried to restrict the number of people, it was not always possible. Allowing only a restricted number of people to be present was safer, but viewing a bear capture greatly increases support for the bears and the bear research project.

The only disadvantage of Zoletil 100® is that no complete antagonist exists and that head-up time and leaving time were highly variable (Fig. 4). In a few cases we had to stay with recovering bears for up to 8 hours (Table 1). Flumazenil reverses the effects of zolazepam HCl, but not of tiletamine HCl. In the Scandinavia bear project, Zoletil 100® has been used with medetomidine. This halves the Zoletil 100® dosage, and medetomidine is fully reversed with atipamezole (Antisedan®). Unfortunately, our experience with this combination was restricted to only 4 bears, and all 4 were dosed with too much Zoletil 100®. Experience gained in captive bears in the past 2 years shows some promise for the medetomidine–tiletamine HCl–zolazepam HCl combination. In contrast to the dosages used in Scandinavia, this combination uses high dosages of the reversible medetomidine (80 μg/kg) and a very low dosage of tiletamine HCl/zolazepam HCl (Walzer 1997).

We waited for all bears to wake up and leave the trap site after handling, and consider this an important safety aspect: drugged bears might be attacked by another bear or wild boar, or even more critical, humans may stumble upon the half-drugged bear. Several of our bears were caught in the early morning, so the wake-up period was during daylight, where chances for human–bear encounters greatly increase. Three bears reacted very aggressively shortly after they recovered from the anesthesia. A male cub attacked our nearby car, evidently in response to barking from dogs inside. A subadult male attacked a battery pack, and an adult female was highly agitated, circling the trap-site for about half hour before leaving for dense cover.

Radiomarking

Our experiences with breakaway devices were within the range described by Garshelis and McLaughlin (1998). Attachment duration was variable, ranging from a few weeks to >2 years. The growth of bears, especially in food-supplemented populations like Slovenia, can be rapid, and in such a setting we do not recommend fitting a collar to yearling bears in spring. The 3-fold increase in the mass of the yearling female we observed within 18 month is probably no exception. Another yearling, a male also caught in spring but not radiotagged, was shot 18 month later and had increased his mass from 42 to 99 kg, a 2.4 increase in body mass.

The mass increase in subadult male bears can also be very high. A 2-year old male weighing around 80 kg at capture was killed in spring 2 years later weighing more than 200 kg, a 2.5 increase in body mass. We therefore recommend using short-term breakaway devices for subadult males (e.g., notched cotton spacers in our case). The rapid increase in body mass, especially of males, made it difficult for us to differentiate between subadult and adult males. We misclassified 3 presumably adult males and 1 presumably 2-year old female, based on cementum annuli counts. Females on the other hand seem to reach a constant mass much earlier, and on average weighed approximately 100 kg in spring. The heaviest spring mass of an adult female shot in Slovenia during 1991–98 was 160 kg; the heaviest adult male was 285 kg (B. Krze, Slovenian Hunters Association, Ljubljana, Slovenia, personal communication, 2000). Any collar on bears should be able to slip over the bear's head with a hard pull.

Eartag transmitters have proven to be a reasonable alternative for fast growing yearlings, but signal reception range is low and lifespan short (12–18 months). The bigger eartag transmitters designed and tested for American black bears (*Ursus americanus*; H. Jolicoer, Direction de la Faune et des Habitats, Ministry of Environment, Quebec, Canada, personal communication, 1996) did not last the expected 18 months on our brown bears. The lighter eartags developed for red deer calves, on the other hand, seemed to fit well and in 1 case lasted the complete 12-month period. Other alternatives are tags produced by Advanced Telemetry Systems (Isanti, Minnesota, USA) equipped with a programmable microcontroller chip with specific on–off cycle (M.L. Gibeau, 1997, Innovations in eartag transmitters for bears, University of Calgary, Alberta, Canada) that may last 2 years. Eartag transmitters also seem a good back up in case of radiocollar loss or failure (Camarra et al. 1998, Mustoni and Genovesi 2001). Hair-mount transmitters are shed with the fur and therefore are not long lasting, although they might be a good alternative to eartag transmitters or radiocollars in the case of a young bear with injured ears. In Spain, on the other hand, 1 hair-mount transmitter attached on the bear in November lasted for 9 months until the following June (Fernandez et al. unpublished report).

MANAGEMENT IMPLICATIONS

We advocate caution when bear researchers and managers attempt to trap, chemically immobilize, and radiotag bears. In all these procedures there are risks to the bear, the capture team, and people around the trap sites. Especially in small and threatened bear populations, the decision to trap and handle bears is definitely a trade off: will the information gained be worth the risk of possibly losing a bear from the population? Not all questions can or have to be answered with telemetry. On the other hand, telemetry can be a powerful tool in research and management and risks can be minimized for brown bears by:

- a trap transmitter system in combination with a care fully designed trap site arrangement to guarantee that handling of bears starts within 1–2 hours of the initial capture event
- careful training of the capture staff in theoretical and practical aspects of trapping, chemical restrain, and radiomarking of bears and presence of an experi enced wildlife veterinarian
- regular monitoring of pulse, respiration, and tempera ture of the bear during immobilization and survey ing the bear until it has completely recovered and left the vicinity of the trap site
- not collaring of yearling bears or bears <70 kg, man datory use of breakaway devices at least for male bears of all age classes and for subadult females and females of unclear age status

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