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Mammal trapping: a review of animal welfare standards of killing and restraining traps

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Abstract

Millions of wild mammals are trapped annually for fur, pest control and wildlife management. Ensuring the welfare of trapped individuals can only be achieved by trapping methods that meet accepted standards of animal welfare. At the international level, the assessment of mechanical properties of killing and restraining traps is set out in two documents published by the International Organization for Standardization (ISO). Few traps currently in use have been tested according to the ISO standards and, in addition, new traps have been designed and old traps modified since the publication of the standards. In this paper we review trapping methods used in Europe and North America to see whether they meet the ISO standards and examine ways to improve the welfare performance of traps. In addition, international legislation is assessed to determine whether this ensures a sufficient level of welfare for trapped animals. Finally, trapping practices used in academic research are reviewed. We conclude that many of the practices commonly used to trap mammals cannot be considered humane. Current legislation fails to ensure an acceptable level of welfare for a large number of captured animals. New welfare standards for trapping wild mammals need to be established so that in future a minimum level of welfare is guaranteed for all trapped individuals.

Keywords: *animal welfare, international legislation, ISO standards, mammals, trapping standards, trap types*

Introduction

Historically, mammals were trapped mainly for fur and meat, but in recent times trapping has also been used as a management tool to resolve human-wildlife conflicts, for wildlife research and for conservation purposes. Worldwide, tens of millions of mammals each year are trapped legally. In the USA alone, up to two million muskrats (*Ondatra zibethicus*) are trapped every year (Fox 2004a). Additionally, an unknown number of animals are trapped illegally and, moreover, for every target animal captured, a varying number of non-target animals are injured or killed.

There are two basic types of traps: killing traps are used on land or underwater and render an animal unconscious within a certain time prior to death, whereas restraining traps hold the individual until contact is made by the trapper. The level of welfare of trapped animals (hereafter welfare performance) varies according to the type of trap. For instance, leg-hold traps are banned in 80 countries (Fox 2004a), including the European Union (The Council of European Communities 1991), because of their impacts on animal welfare.

Opposition of animal welfare groups in Europe and North America to trapping for fur culminated in the first effort by the International Organization for Standardization (ISO) to define humane international standards for killing and restraining traps (Harrop 2000; Princen 2004). However, no consensus could be reached on key thresholds for animal welfare standards, eg time to unconsciousness for animals trapped in killing traps, or levels of injuries for animals captured in restraining traps. Despite this, two documents were produced by the ISO to provide an agreed process for testing trap performance (safety and capture efficiency) and killing effectiveness for killing traps (ISO 10990-4 1999), and trap performance and trauma levels for physical injuries caused by restraining traps (ISO 10990-5 1999). Although the ISO standards do not offer any definition of acceptable standards of animal welfare, they are an initial step towards ensuring and improving welfare of wild mammals (Harrop 2000). The results collated from the tests as set by the ISO can, in fact, be interpreted in terms of the impact on animal welfare and the level of impact on animal welfare can, in turn, be used to make a decision on whether a trap falls below or above a threshold of acceptable standards of animal welfare. When the killing trap standards were published, the technical committee drafting the standards recommended a review of killing methods after five years so that all technical advancements could be incorporated. Similarly, for restraining traps it was recognised that physical injury represents only one component of welfare, and that the lack of data on other components such as behaviour, physiology, immunology and molecular biology prevented their use in welfare assessments. The technical committee advocated, therefore, that in future all these components of animal welfare should be integrated to provide a more comprehensive measure of welfare. Thus,

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the aim of this paper is two-fold. First, we review trapping methods of wild mammals in Europe and North America, assessing accepted standards of welfare and welfare performance of traps and taking into account the evaluation of trap devices as set by the ISO standards. Throughout this paper we review the extent to which the ISO standards provide a process for evaluating accepted standards of animal welfare *at present*, rather than when they were initially developed. We suggest ways to improve the welfare performance of traps that are currently used and examine the existing legislation on trapping and welfare of captured animals. Mason and Littin (2003) have already investigated the humaneness of control methods applied to rodents, so this review does not include rodent species. Whilst trappers and wildlife officers have discussed at length the implication of these regulations on the way trapping is carried out (eg Schmidt & Bruner 1981; Bluett 2001; British Association for Shooting & Conservation 2002), as yet there has been very little debate as to how standards for the welfare of trapped animals compare with other animal welfare standards. Thus we also compare welfare standards for trapped wild animals with other welfare standards such as those set for the slaughter of farm animals, shooting and bowhunting. Secondly, we analyse standards for trapping animals used in scientific research, as defined by guidelines published by leading scientific journals in the fields of zoology, behaviour and animal welfare.

Killing traps

Types of killing traps

There are five main categories of killing traps in use: deadfall traps, spring traps, snares, drowning traps and pitfall traps (Federation of Field Sports Associations of the European Union [FACE] 1998; Proulx 1999a; Powell & Proulx 2003). Deadfall traps use gravity to kill an animal by crushing its skull, vertebral column or other vital organs. There are two types of spring traps; one has spring-powered bars that kill an animal by crushing a vital region of the body, generally the neck; the other has rotating jaws which have two hinged metal frames that allow a torsion spring to rotate the frames in a scissor-like action (Garrett 1999; Powell & Proulx 2003). There are two kinds of killing snares: in self-locking snares an animal pulls against the snare, tightening it until asphyxiation occurs, as apposed to stopped and free-running snares which restrain the animal (see the section on restraining traps). Power snares similarly kill by asphyxiation, but use powerful springs to tighten the noose quickly. Drowning traps restrain an animal underwater, and kill by hypoxia-induced death. Finally, less commonly used traps include pitfall traps with water at the bottom, to drown small rodents (Proulx 1999a).

Assessing welfare performance of killing traps

Killing traps are widely used to catch a range of species, ranging in size from rodents to lynx. Here we analyse methods commonly utilised to kill furbearers and mammals other than rodents. The ability to kill an individual effectively depends on species, size, trap type and also, to great extent, trapper skill. In order to evaluate welfare performance of killing traps, we used four welfare measures: time to unconsciousness, the likelihood of escape of injured animals, the percentage of mis-strikes and selectivity. In the next section we focus on only the first three and analyse selectivity later. In laboratory conditions, killing methods approved as humane are those that minimise the time between the application of the killing procedure and the onset of unconsciousness (eg Beaver *et al* 2001). In field conditions however, the fast-acting killing methods used in laboratory settings (eg stunning, cervical dislocation, carbon dioxide) are not always feasible and the period of consciousness and thus, the potential for poor welfare, can last longer.

The welfare performance of killing traps in current use

Table 1 lists trap models which have been tested against accepted standards of animal welfare. Effectively, there is no research on trap welfare performance for most of the European species apart from the stoat (*Mustela erminea*) and muskrat. *M. erminea* is known as stoat in Eurasia and as short-tailed weasel in North America. Despite being the same species, the two populations differ in bodyweight and traps suitable for short-tailed weasels are unsuitable for stoats (Warburton *et al* 2002). As shown in Table 1, most of the tests were undertaken on North American species and the criteria for acceptability of a trap require 70% of animals tested to be unconscious within 60 seconds (stoat), 120 seconds (American pine marten [*Martes americana*], Canadian lynx [*Lynx canadensis*] and fisher [*Martes pennanti*]) and 180 seconds (all others) (Powell & Proulx 2003).

Two further parameters that are likely to have a significant impact on trap welfare performance, are the likelihood of escape of injured animals and the percentage of mis-strikes. However, data on these two parameters are scarce. Amongst the traps passing the welfare performance tests in Table 1, mis-strike varied between 0-10%. Data available for other species suggest that both parameters vary greatly according to trap type, species and, probably, trap setting. In neck snares set for coyote (*Canis latrans*) mis-strikes varied from 8 to 14%; of these the percentage of animals still alive in the traps varied from 17 to 86% and escapes varied from 3 to 13% (Phillips 1996). In spring traps set for red foxes (*Vulpes vulpes*) and stone martens (*Martes foina*) mis-strikes equalled 15 and 13% respectively (Pohlmeyer *et al* 1995). Few studies report the number of animals escaping from killing traps; about 50% of American martens escaped from snares set for snowshoe hares (Proulx *et al* 1994a), whilst in possums (*Trichosurus vulpecula*) escapes varied from 0 to 6% depending on the type of spring trap (Miller 1993; Warburton & Orchard 1996). The welfare of escaped (injured) animals is of concern; moreover, if an escaped animal is likely to become trap-shy, this is undesirable from a trapper's perspective.

To improve welfare performance of killing traps, the time lapse between the killing device being triggered and the onset of unconsciousness of the caught animal should be minimised. The vast majority of traps currently in use were

Table 1 Accepted standards of animal welfare for killing traps.

Species	Trap model	Mis-strike	Time limits to unconsciousness					Reference
			Current technology	n	Criterion	Pass	Fail	
Canis latrans	King necksnare[1]	-	> 180 s	-	180 s		×	Garrett 1999; Proulx 1999a
	Mosher necksnare[1]	-	> 180 s	-	180 s		×	
*Canis lupus**	-	-	-	-	180 s	-	-	
*Castor canadensis**	Conibear 330™	-	> 180 s	6	180 s		×	Novak 1981a
	Modified Conibear 330™	-	< 180 s	6	180 s	×		
Lontra canadensis	-	-	-	-	180 s	-	-	
Lynx rufus	-	-	-	-	180 s	-	-	
Lynx canadensis	Conibear 330™	1	> 180 s	9	180 s		×	Proulx *et al* 1995
	Modified Conibear 330™	1	67.2 ± 4.0 s	9	180 s	×		
Martes americana	Conibear 120™	3	> 180 s	6	120 s		×	Barrett *et al* 1989; Proulx *et al* 1989a,b
	Conibear 120 Magnum™	2	68 ± 8.2 s	14	120 s		×	
	Conibear 160™	3	> 180 s	16	120 s	×		
	Sauvageau 2001-5™	-	> 180 s	14	120 s		×	
Martes pennanti	Bionic[2]	0	< 55 s	9	180 s	×		Proulx & Barrett 1993a,b; Proulx 1999b
	Conibear 220™	-	> 180 s	4	180 s		×	
	Modified Conibear 220™	0	> 180 s	4	180 s		×	
*Ondatra zibethicus**	Leprich spring trap	0	31.5 ± 16.3 s	12	180 s	×		Inglis *et al* 2001
	Conibear 110™	3	184.0 ± 31.7 s[3]	12	180 s		×	
*Procyon lotor**	Conibear 160™	-	> 180 s	5	180 s		×	Novak 1981a; Proulx & Drescher 1994; Sabean & Mills 1994
	Conibear 280™	0	> 180 s	6	180 s		×	
	Conibear 330™	5	> 180 s	5	180 s		×	
	Sauvageau 2001-8™	0	> 180 s	3	180 s		×	
Taxidea taxus	-	-	-	-	180 s	-	-	
Castor fiber	-	-	-	-	180 s	-	-	
Lutra lutra	-	-	-	-	180 s	-	-	
Lynx lynx	-	-	-	-	180 s	-	-	
Martes martes	-	-	-	-	120 s	-	-	
Martes zibellina	-	-	-	-	120 s	-	-	
Meles meles	-	-	-	-	180 s	-	-	
Mustela erminea[4]*	Fenn Mk IV	-	> 180 s	-	60 s		×	Warburton *et al* 2002; Poutu & Warburton 2003; Warburton & O'Connor 2004
	Fenn Mk VI	-	> 180 s	-	60 s		×	
	Victor Snapback[5]	1	37.3 ± 5.0 s	7	60 s		×	
	Waddington backcracker	4	113 s	8	60 s		×	
Nyctereutes procyonoides	-	-	-	-	180 s	-	-	

Mis-strike refers to the number of animals struck in a non-target body part; time limits to unconsciousness refer to loss of corneal and palpebral reflexes; n is the number of animals tested.
Most of the tests were conducted in North America under the criteria that $\geq$ 70% of animals should be unconscious in $\leq$ 60, 120 or 180 seconds (eg Proulx 1999a; review in Powell & Proulx 2003). This is therefore used to assess passes and failures. The line divides North American from European species.
* Species found in both continents; [1] the trap failed because of high number of mis-strikes; [2] not tested in the field: in a different experiment 2/10 animals escaped and 1/10 mis-strike; [3] time to loss of heartbeat; [4] see main text for stoat; [5] the trap failed because of high number of escapes.

developed by trappers and so trap performance reflects the need to obtain undamaged pelts, with welfare of trapped animals being a secondary issue or one that was not even considered (Garrett 1999; Fox & Papouchis 2004a). However, recent research in New Zealand and Australia (eg see Littin *et al* 2004) has started incorporating animal welfare into trap development and, in our opinion, this should become common practice.

To assess the welfare performance of killing traps it has been suggested that trap performance should be evaluated following the ISO guidelines. Killing traps are tested in a laboratory environment on anaesthetised animals as well as in a compound designed to simulate field settings. However, time to loss of consciousness of anaesthetised animals is shorter than for unanaesthetised animals (Hiltz & Roy 2001). In artificial compounds animals are usually enticed to the trap through a channel to ensure strike precision (eg Inglis *et al* 2001). However, in the field, animals behave in unpredictable ways and all too often traps that deliver quick and effective kills in artificial compounds fail in the field

Table 2 Trauma scales developed by various authors; numbers represent scores given to each injury.

	van Ballenberghe (1984)	Tullar (1984)	Olsen *et al* (1988)	Onderka *et al* (1990)	Hubert *et al* (1996)	Phillips (1996)
Oedematous swelling and/or haemorrhage	Class 1	5	-	1-5	1-5	5-15
Avulsed nail	-	-	-	-	5	-
Cutaneous laceration ≤ 2 cm long	Class 2 (< 2.5 cm)	5	5	5	5	3
Cutaneous laceration > 2 cm long	Class 3 (> 2.5 cm)	10	10	10	10	10
Permanent tooth fracture exposing pulp cavity	-	-	-	-	10	-
Subcutaneous muscle laceration or maceration	Class 3	-	-	10-20	10-20	10-30
Tendon or ligament maceration with partial severance	Class 3	20	20	20-40	20-40	25
Damage to periosteum	-	-	-	-	30	10-30
Partial fracture of metacarpi or metatarsi	Class 4	-	-	30	30	-
Fracture of digits	Class 4	-	-	30-40	30-50	-
Joint subluxation	Class 4	30	30	-	100	-
Joint luxation	-	50	50	50	50	30-100
Luxation at elbow or hock	-	-	-	200-300	200	-
Compression fracture above or below carpus or tarsus	-	-	30	-	-	100
Simple fracture below carpus or tarsus	Class 3	50	100	100	100	100
Simple fracture above carpus or tarsus	Class 4	50	50	50	50	50
Damage or severance of tensons below carpus or tarsus	Class 4	-	-	50	20-50	-
Major laceration on footpads	-	-	-	-	-	30
Amputation of digit(s)	-	150	50-200	30-40	30-50	25-100
Compound fracture below carpus or tarsus	-	100	-	75	75	100
Compound fracture above carpus or tarsus	-	200	200	200	200	100
Amputation of limb	-	400	400	400	400	100

(eg Proulx *et al* 1989a, 1995; Proulx & Barrett 1990). These difficulties bring into question the usefulness of ISO standards for testing killing trap performance.

Drowning traps

Submersion or drowning traps are mainly used to kill semi-aquatic species, mostly muskrat and American mink (*Mustela vison*) in Europe and North American beaver (*Castor canadensis*) and river otter (*Lontra canadensis*), amongst others, in North America. Some of these species show physiological adaptations to aquatic life such as slower heart rates (bradycardia), and therefore can dive for prolonged periods. For instance, the Eurasian otter (*Lutra lutra*) dives for up to 22 minutes (Conroy & Jenkins 1986), the muskrat for 12-17 minutes (Inglis *et al* 2001) and the North American beaver for 15 minutes (Irving & Orr 1935). Death by drowning-induced hypoxia is a slow process for these species and even after struggling, which consumes oxygen more quickly, electroencephalogram loss occurs after an average of 4 minutes for the muskrat, and 9 minutes for the beaver (Gilbert & Gofton 1982). The animals show an indicator of distress because they struggle to get to the surface (Gilbert & Gofton 1982). Moreover, death by drowning-induced hypoxia is not considered an acceptable method of euthanasia by veterinary and laboratory researchers (Close *et al* 1996; Beaver *et al* 2001) and does not meet the presently accepted standards for killing traps (Ludders *et al* 1999).

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Table 3 Trauma scale developed by ISO Technical Committee 191.

Pathological observation	Score
Mild trauma	
1) Claw loss	2 points
2) Oedematous swelling or haemorrhage	5 points
3) Minor cutaneous laceration	5 points[1]
4) Minor subcutaneous soft tissue maceration or erosion	10 points
5) Major cutaneous laceration, except on footpads or tongue	10 points
6) Minor periosteal abrasion	10 points
Moderate trauma	
7) Severance of minor tendon or ligament	25 points
8) Amputation of 1 digit	25 points
9) Permanent tooth fracture exposing pulp cavity	30 points
10) Major subcutaneous soft tissue laceration or erosion	30 points
11) Major laceration on footpads or tongues	30 points
12) Severe joint haemorrhage	30 points
13) Joint luxation at or below the carpus or tarsus	30 points
14) Major periosteal abrasion	30 points
15) Simple rib fracture	30 points
16) Eye lacerations	30 points
17) Minor skeletal degeneration	30 points
Moderately severe trauma	
18) Simple fracture at or below the carpus or tarsus	50 points
19) Compression fracture	50 points
20) Comminuted rib fracture	50 points
21) Amputation of two digits	50 points
22) Major skeletal degeneration	50 points
23) Limb ischaemia	50 points
Severe trauma	
24) Amputation of three or more digits	100 points
25) Any fracture or joint luxation on limb above the carpus or tarsus	100 points
26) Any amputation above the digits	100 points
27) Spinal cord injury	100 points
28) Severe internal organ damage (internal bleeding)	100 points
29) Compound or comminuted fracture at or below the carpus or tarsus	100 points
30) Severance of a major tendon or ligament	100 points
31) Compound or rib fractures	100 points
32) Ocular injury resulting in blindness of an eye	100 points
33) Myocardial degeneration	100 points
34) Death	100 points

The terms and definitions are taken from ISO 10990-5: 1999 Animal (mammal traps) – Part 5: Methods for testing restraining traps, Annex C, C.1 Trauma scale (www.iso.org), and are reproduced with the permission of the International Organization for Standardization, ISO. Copyright ISO.

[1] maximum 15.

Restraining traps

Types of restraining traps

Five kinds of restraining traps are widely used: stopped neck snares, leg-hold snares, leg-hold traps, box or cage traps and pitfall traps (FACE 1998; Proulx 1999a; Powell & Proulx 2003). Neck snares are made of a wire loop set vertically, so the head of the animal enters the wire loop, which then tightens around the neck of the animal. In snares set for restraint, a stop prevents the noose closing below a certain diameter, thereby preventing asphyxiation. Within Europe, neck snares must be stopped or free-running to prevent strangulation (FACE 1998). Leg-hold snares are used extensively to capture animals in scientific studies. Leg-hold snares are also made of a wire loop, but placed horizontally and designed to close upon the animal's leg(s) to restrain it

Table 4 The percentage categories of injuries caused by neck snares, leg-hold snares and box traps.

Species	Sample size	Trap type	No injuries	Minor injuries	Major injuries	Mortality	Reference
Bassiriscus astutus	8	Box trap	75%	25%	-	0%	IAFWA 2003
Canis latrans	22	Box trap	83%	17%	-	0%	Way *et al* 2002
Didelphis virginiana	-	Box trap	61%	39%	-	-	IAFWA 2000
Gulo gulo	12	Box trap	100%	-	-	0%	Copeland *et al* 1995
Lynx canadensis	89	Box trap	100%	-	-	0%	Kolbe *et al* 2003
Lynx canadensis	19	Box trap	68%	32%	-	0%	Mowat *et al* 1994
Meles meles	5964	Box trap	88%	10%	2%	0%	Woodroffe *et al* 2005*
Panthera pardus	18	Box trap	-	39%	-	-	Frank *et al* 2003
Procyon lotor	-	Box trap	52%	43%	5%	-	IAFWA 2000
Urocyon cinereoargenteus	16	Box trap	13%	87%	-	0%	IAFWA 2003
Ursus americanus	25	Box trap	92%	8%	-	0%	Reagan *et al* 2002
Vulpes velox	125	Box trap	88%	12%	-	0%	Moehrenschlager *et al* 2003
Canis latrans	20	Leg-hold snare	5%	-	-	-	Onderka *et al* 1990
Canis latrans	-	Leg-hold snare	-	83%	9%	-	IAFWA 2003
Canis latrans	23	Leg-hold snare	-	60%	40%	0%	Shivik *et al* 2000*
Canis latrans	38	Leg-hold snare	6%	25%	69%	0%	Shivik *et al* 2000*
Canis familiaris, Vulpes vulpes	117	Leg-hold snare	55%	41%	4%	3%	Fleming *et al* 1998
Lynx canadensis	-	Leg-hold snare	-	80%	-	-	IAFWA 2003
Lynx canadensis	201	Leg-hold snare	48%	46%	6%	> 1%	Mowat *et al* 1994
Lynx rufus	-	Leg-hold snare	-	100%	-	-	IAFWA 2003
Panthera leo	27	Leg-hold snare	-	100%	-	0%	Frank *et al* 2003
Panthera tigris	19	Leg-hold snare	-	91%	9%	0%	Goodrich *et al* 2001
Procyon lotor	49	Leg-hold snare	82%	16%	2%	-	Novak 1981b
Puma concolor	209	Leg-hold snare	15%	83%	2%	1%	Logan *et al* 1999
Ursus americanus	340	Leg-hold snare	-	97%	3%	-	Powell 2005
Ursus americanus	37	Leg-hold snare	70%	30%	-	0%	Reagan *et al* 2002
Vulpes vulpes	-	Leg-hold snare	-	76%	5%	-	IAFWA 2003
Vulpes vulpes	117	Leg-hold snare	80%	14%	6%	0%	Englund 1982
Vulpes vulpes	81	Leg-hold snare	69%	31%	-	-	Novak 1981b
Canis latrans	51	Neck snare	-	-	2%	2%	Pruss *et al* 2002
Canis latrans	-	Neck snare	-	-	-	16%	Nellis 1968
Canis latrans	24	Neck snare	17%	53%	30%	4%	Shivik *et al* 2000*
Castor canadensis	132	Neck snare	-	-	-	5%	McKinstry & Anderson 1998

Major injuries include mortality; where given by the authors mortality is presented separately.
* Studies that used the trauma scale published by ISO (Table 4).

(Powell & Proulx 2003). In both cases, snares are usually anchored.

Leg-hold traps may be padded or unpadded. Leg-hold traps have two jaws that open to 180° when set, and clamp together to hold an animal's foot or leg when triggered. The trap is attached to the ground or an anchor by a chain or cable. The anchor restrains the animal by snagging on surrounding vegetation.

Box traps are constructed from a wide variety of materials including plastics, wire mesh and wood (Meyer 1991; Proulx 1999a) and all work on the same principle. An animal enters the trap through an opening attracted by bait, and triggers a device (eg treadle) that causes the door to close and lock. Box traps vary in size, and their design depends primarily on the target species (Powell & Proulx 2003).

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Table 5 The pattern of injuries caused by leg-hold traps.

Species	Sample size	Trap type	No injuries	Minor injuries	Major injuries	Mortality	Study
Procyon lotor	62	EGG trap	8%	56%	36%	-	Hubert *et al* 1996
Lontra canadensis	155	leg-hold	-	44%	56%	-	Tocidlowski *et al* 2000
Canis lupus	116	offset jaws leg-hold	-	65%	35%	-	Kuehn *et al* 1986
Canis lupus	129	offset jaws leg-hold	-	72%	28%	-	Kuehn *et al* 1986
Canis lupus	40	offset jaws leg-hold	-	100%	-	-	Kuehn *et al* 1986
Canis latrans	31	padded leg-hold	-	84%	16%	-	Olsen *et al* 1988
Canis lupus	48	padded leg-hold	-	-	48%	-	van Ballenberghe 1984
Canis familiaris	313	padded leg-hold	-	89%	11%	-	Fleming *et al* 1998
Canis familiaris	280	padded leg-hold	-	82%	18%	-	Fleming *et al* 1998
Lontra canadensis	87	padded leg-hold	16%	58%	26%	-	Serfass *et al* 1996
Lutra lutra	43	padded leg-hold	-	86%	14%	9%	Fernández-Morán *et al* 2002
Lynx canadensis	39	padded leg-hold	63%	8%	29%	-	Kolbe *et al* 2003
Lynx canadensis	23	padded leg-hold	34%	26%	40%	-	Mowat *et al* 1994
Lynx rufus	31	padded leg-hold	-	77%	23%	-	Olsen *et al* 1988
Procyon lotor	100	padded leg-hold	-	52%	48%	-	Olsen *et al* 1988
Urocyon cinereoargenteus	27	padded leg-hold	-	67%	33%	-	Olsen *et al* 1988
Vulpes vulpes	30	padded leg-hold	-	93%	7%	-	Olsen *et al* 1988
Vulpes vulpes	19	padded leg-hold	-	79%	21%	-	Meek *et al* 1995
Vulpes vulpes	28	padded leg-hold	36%	21%	43%	-	Englund 1982
Vulpes vulpes	91	padded leg-hold	53%	43%	4%	-	Travaini *et al* 1996
Alopex lagopus	155	unpadded leg-hold	41%	64%	23%	10%	Proulx *et al* 1994b
Canis latrans	36	unpadded leg-hold	-	47%	53%	-	Olsen *et al* 1988
Canis lupus	269	unpadded leg-hold	-	65%	35%	-	Kuehn *et al* 1986
Canis familiaris	73	unpadded leg-hold	-	69%	32%	5.5%	Fleming *et al* 1998
Canis familiaris	20	unpadded leg-hold	-	90%	10%	-	Fleming *et al* 1998
Lynx canadensis	12	unpadded leg-hold	23%	42%	25%	-	Kolbe *et al* 2003
Lynx rufus	47	unpadded leg-hold	-	79%	21%	-	Olsen *et al* 1988
Didelphis virginiana	15	unpadded leg-hold	67%	13%	20%	-	Berchielli & Tullar 1980
Mephitis mephitis	30	unpadded leg-hold	40%	10%	50%	-	Novak 1981b
Procyon lotor	17	unpadded leg-hold	41%	24%	6%	-	Berchielli & Tullar 1980
Procyon lotor	22	unpadded leg-hold	50%	27%	23%	-	Novak 1981b
Procyon lotor	40	unpadded leg-hold	2%	24%	74%	-	Hubert *et al* 1996
Procyon lotor	133	unpadded leg-hold	-	30%	70%	-	Olsen *et al* 1988
Urocyon cinereoargenteus	13	unpadded leg-hold	46%	54%	-	-	Berchielli & Tullar 1980
Urocyon cinereoargenteus	38	unpadded leg-hold	-	39%	61%	-	Olsen *et al* 1988
Vulpes vulpes	22	unpadded leg-hold	23%	45%	32%	-	Novak1981b
Vulpes vulpes	15	unpadded leg-hold	20%	67%	13%	-	Berchielli & Tullar 1980
Vulpes vulpes	48	unpadded leg-hold	-	63%	37%	-	Olsen *et al* 1988
Vulpes vulpes	115	unpadded leg-hold	61%	9%	30%	-	Englund 1982

Many studies do not combine whole body scores, but assess limb and oral injuries separately (eg Kuehn *et al* 1986); only limb scores are given in this table. When scoring, most researchers do not specify the number of animals with no injuries, which are usually pooled with animals with no or slight injuries.

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Table 6 Selectivity (number of non-target animals relative to total captures), mortality and injury caused to non-target species in various types of traps.

Trap type	Target species	Non-target species	Selectivity	Mortality	Injury	Reference
Killing traps						
Drowning trap	*Ondatra zibethicus*	*Anas platyrhynchos, Rattus* spp*, Mustela erminea*	1.44-7.40%[1]	-	-	Crasson 1996
Spring trap in tunnels	*Mustela erminea, M. nivalis, M. vison*	*Alectoris rufus, Erinaceus europaeus, Oryctolagus cuniculus, Mustela putorius*	5%	100%[2]	-	Short & Reynolds 2001
Tunnel traps/snare	-	*Mustela putorius*	-	61%	39%	Birks & Kitchener 1999
Spring trap	*Trichosurus* spp	*Erinaceus europaeus, Mustela putorius, Rattus* spp	23%	50%	50%	Warburton & Orchard 1996
Leg-hold snare/coil spring trap	*Oryctolagus cuniculus, Vulpes vulpes*	*Lynx pardinus*	-	64%	22.5%	García-Perea 2000
Neck snare	*Canis latrans*	*Odocoileus hemionus, O. virginianus, Bos taurus*	21%	33-63%	-	Phillips 1996
Neck snare	*Lepus americanus*	*Martes americana*	50%	0%	0%	Proulx *et al* 1994a
Rotating jaw-trap	*Martes americana*	*Perisoreus canadensis, Glaucomys sabrinus*	43%	100%	-	Naylor & Novak 1994
Rotating jaw trap	*Martes americana*	*Corvus brachyrhynchos, Rattus* spp*, Felis catus*	30%	-	-	Proulx & Barrett 1993a
Restraining traps						
Box trap	*Felis silvestris, Lynx lynx*	*Meles meles, Ursus arctos*	64%	0%	0%	Potočnik *et al* 2002
Box trap	*Canis familiaris*	*Corvus brachyrhynchos, Felis catus, Procyon lotor, Mephitis mephitis*	93%	-	-	Way *et al* 2002
Box trap	*Martes pennanti*	*Martes americana, Gulo gulo, Vulpes vulpes*	94%	1%	-	Weir 1997
Leg-hold snare	*Panthera leo*	*Hyaena hyaena, Crocuta crocuta, Acinonyx jubatus*	32%	0%	17%	Frank *et al* 2003
Leg-hold snare	*Puma concolor*	*Odocoileus hemionus, Canis latrans, Bos taurus*	45%	17%	-	Logan *et al* 1999
Neck snare	*Vulpes vulpes*	*Canis familiaris, Felis catus, F. sylvestris, Meles meles, Martes martes, Lutra lutra, Lepus europaeus*	46%	-	-	Chadwick *et al* 1997

[1] The relative % of injured and dead animals is not known. [2] Mortality and injury combined.

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Table 7 Trapping statistics (annual captures) from Canada (Statistics Canada 2004), Europe (FACE 1998), Russia (Dronova & Shestakov 2005) and USA (Fox 2004b) for the 19 mammal species included in the Agreement (Anonymous 1998a).

Species	Canada	Europe	Russia	United States
Canis latrans	55,500	-	-	110,000
Canis lupus	2,700	-	300*	1,200
Castor canadensis	260,000	300	-	300,000
Castor fiber	-	1,500	-	-
Lontra canadensis	19,000	-	-	25,000
Lutra lutra	-	-	2,000	-
Lynx canadensis	11,300	-	-	2,700
Lynx lynx	-	-	180*	-
Lynx rufus	2,100	-	-	27,000
Martes americana	120,000	-	-	14,000
Martes martes	-	45,000	-	-
Martes pennanti	23,500	-	-	8,300
Martes zibellina	-	-	250,000	-
Meles meles	-	43,000	-	-
Mustela erminea	30,000	27,200	105,000	14,000[1]
Nyctereutes procyonoides	-	90,000	4,100*	-
Ondatra zibethicus	290,000	700,000	1,100,000	2,000,000
Procyon lotor	72,000	7,000	-	2,100,000
Taxidea taxus	490	-	-	17,000
Total	886,590	914,000	1,461,580	4,619,200

Estimates from Europe include animals caught in both killing and restraining traps. Data from Canada and Russia do not include methods of capture. Russian statistics are official harvests and do not represent animals taken illegally which may be > 150% of the official harvest (Dronova & Shestakov 2005). * Data from Russian Far-east only; [1] data include *Mustela frenata* and *M. erminea.*

Pitfall traps are predominantly used to capture small terrestrial mammals such as shrews. The pitfall trap is a smooth-sided container, usually > 40 cm deep and between 20-40 cm in diameter. These can be unbaited or animals can be attracted to the trap by bait or by using barriers to force animals into the pit.

Assessing welfare performance of restraining traps

The purpose of a restraining trap is to hold the animal unharmed and with minimum stress until the trap is checked. The animal can then be despatched or released. There are two principle considerations when assessing welfare performance of restraining traps: mortality of trapped animals (target and non-target species) and injuries suffered by restrained individuals. To compare traps directly, a quantitative approach is needed, and several studies over the last couple of decades have used injury scales to assess welfare performance (Table 2). Most injury-scoring systems correspond to a detailed evaluation of pathological changes. However, some studies examine only specific body areas rather than the whole body, and this may affect the assessment of welfare performance (eg van Ballenberghe 1984; Onderka *et al* 1990).

Since the first injury scales were developed, the number of injury classes has increased from 12 to more than 15. Each study has added injury classes or altered scoring and this makes both the direct comparison of the standards of traps and the repeatability of studies difficult (Engeman *et al* 1997). In 1999, the ISO developed a standardised method for assessing welfare performance of restraining traps (ISO 10990-5 1999; Table 3). This improves on earlier injury scales in three ways: it has a larger number of categories, incorporating examination of all body areas including areas previously not covered (eg ocular injuries); it advocates examination of injuries by veterinary pathologists; and as an overall international standard for assessing restraining traps, it allows better comparative assessment of welfare performance. The ISO trauma scale constitutes a significant step towards improving assessment of trap welfare performance, though few studies have utilised it (Table 4).

Currently there are few objective criteria for interpreting the impact of injuries to animals, and so human-based scales are used to assess the importance of injuries (Kirkwood *et al* 1994). Regardless of the scoring system, injuries that have the potential to reduce survival of released animals always receive a high score, typically in excess of 50 points (Tables 2 and 3). In this respect, they have much in common with trauma scales used to assess life-threatening human injuries (Greenspan *et al* 1985). However, while these scales assess injury, they do not incorporate variables such as pain. Human trauma scales only examine the life-threatening nature of the injury (Greenspan *et al* 1985); separate scales exist to assess pain (Turk & Melzack 1992). Thus, while broken teeth receive relatively low trauma scores

(Tables 2 and 3), orofacial pain is some of the most intense and excruciating, rating highly on pain scales in humans (Tandon *et al* 2003).

Assessing injuries is a method that allows a quantitative assessment of trap performance to be made. Assessments can be made for those animals that are caught and killed or caught and released. However, there are reservations about how injuries can be directly related to welfare. Currently, injury-based trauma scales are the best available method (Proulx 1999a), but in our opinion different approaches are needed to assess accepted welfare standards. These should incorporate a) the individual animal and context (species, size, age, sex, season), b) location(s) of the wound(s), c) the nature and pain associated with the injuries, and most importantly if being released, d) the long-term survival and fecundity of the individual and the impacts of removal of animals from the population (such as those on dependants). As has already been shown in Rüppel's fox (*Vulpes rueppellii*), the majority of individuals received low injury scores when caught in padded leg-hold traps, yet subsequent survivorship was significantly reduced, possibly due to predation caused by temporary limping (Seddon *et al* 1999). Damage caused by the pressure of neck snares on tissue may take days to appear, often after individuals are released; such tissue necrosis can lead to death of the individual (Stocker 2005). For carnivores broken teeth have been linked to the inability to catch wild prey and increased livestock predation (Patterson *et al* 2003). Even such factors as claw loss may impact on subsequent ability to catch prey. Future assessment of trap performance must include an assessment of the longer-term impact on the individuals after release. Any negative impacts on survival or fecundity would have serious implications for the validity of many scientific studies and/or the post-release survival of non-target species.

Physical injury and pain comprise only one facet of the distress associated with trapping. Anxiety caused by confinement and physical exertion related to struggling will also affect the welfare of the animal (Marks *et al* 2004). When prolonged, this distress can have a deleterious effect on an animal's health and subsequent survival (Moberg 1999). As a consequence, an important, but often overlooked component of trap welfare performance involves assessing the physiological changes caused by trapping. There are three physiological responses to the psychological stress of being trapped, the pain of any injuries and exertion from struggling against or within the trap (Warburton *et al* 1999). Stress and pain of capture cause significant changes in hormones, enzymes and electrolytes, as well as muscle pH. Trapped animals have increased levels of serum cortisol (Hamilton & Weeks 1985; Kreeger *et al* 1990; White *et al* 1991; Cross *et al* 1999; Warburton *et al* 1999; Inglis *et al* 2001), indicating a stress response to being trapped. During the initial moments of capture, animals have increased activity as they struggle and move around (White *et al* 1991; Inglis *et al* 2001). This causes increased heart rate and body temperature (Kreeger *et al* 1990; White *et al* 1991; Inglis *et al* 2001). For scientists, this affects handling techniques. Individuals with higher body temperatures require larger dosages of anaesthetic (Cattet *et al* 2003; McLaren *et al* 2005). Increased activity causes a physiological response and may even cause long-term muscle damage (Duncan *et al* 1994); typically, enzymes and metabolites such as creatine kinase and circulating phosphate increase in the blood of trapped animals as a result of physical activity (Kreeger *et al* 1990; Hubert *et al* 1996; Huber *et al* 1997; Warburton *et al* 1999; Cattet *et al* 2003). Whilst it can be seen that many studies have examined the physiological changes caused by particular types and/or makes of traps, there is a need for more comparative studies between the principal trapping methods.

The welfare performance of restraining traps in current use

Trap-based injuries are rarely reported in scientific papers and, as such, this makes it hard both to improve and to compare trapping techniques. To assess welfare performance of restraining traps two factors must be considered: the nature and severity of injuries suffered by target and non-target species and the long-term impact on survival and fecundity for an individual (Kirkwood *et al* 1994; Littin *et al* 2004).

Neck snares are widely used both for pest control and fur trapping, but are less commonly used for scientific studies. Few studies have evaluated the humaneness of neck snares in the same way as has been done for leg-hold snares, leg-hold traps and box traps (eg Sala *et al* 1993; Lovari *et al* 1994; Lucherini & Lovari 1996). Those that do apparently pool categories of wounds or fail to provide information on numbers of individuals with no or minor injuries (van Ballenberghe 1984; McKinstry & Anderson 1998; Pruss *et al* 2002). When set correctly, serious injuries are purported to be relatively uncommon, though mortality of trapped individuals is higher than with both leg-hold snares and box traps (Table 4). One further difficulty in assessing welfare standards of neck and leg-hold snares stems from certain insidious injuries manifesting themselves days after the release of an individual. Pressure from the wire ligature can damage cellular structures, which can in turn lead to necrosis of tissues (pressure necrosis) and ultimately death in the days following release (Stocker 2005). Great concern also arises from the incorrect setting of neck snares (National Federation of Badger Groups 2002). While training and codes of practice are freely available (British Association for Shooting & Conservation 2002), deliberate setting of non-stopped snares where they are illegal, snares set where they may catch protected species or where animals may kill themselves, and snares not checked daily, are common (MacNally 1992; National Federation of Badger Groups 2002). In the UK, neck snares are the commonest form of restraining trap because they are cheap and require minimum effort to set and maintain. Reports of misuse are frequent; despite this, there are no quantified data on the level of use/misuse of snares (Department for Environment Food and Rural Affairs [Defra] 2005; League

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Against Cruel Sports 2005). Even when neck snares are set and utilised correctly, they commonly catch non-target species and these can have high mortality (see later section) (Phillips 1996; Chadwick *et al* 1997; Defra 2005). Modification of neck snares may increase target specificity and reduce capture of non-target species (Pruss *et al* 2002; Luengos Vidal *et al* 2003), but overall the lack of data on the use of snares makes it difficult to assess their welfare impact.

In comparison to neck snares, the effectiveness and welfare performance of leg-hold snares is more commonly reported in the scientific literature (Table 4). In general, leg-hold snares appear to have an acceptable effect on welfare, with little target species mortality (Table 4). However, the same cannot be said for non-target species, which may experience high mortality (see later section). One further problem arises from foot swelling; several studies highlight that most individuals have a swollen foot caused by the noose, yet do not classify these as serious (Logan *et al* 1999; Frank *et al* 2003). Since snares may cause subsequent pressure necrosis, and even temporary limping may have a negative impact on an individual, further work is needed to examine the long-term welfare impact of leg-hold snares.

Leg-hold traps are considered inhumane and banned within the EU and 80 countries worldwide (Fox 2004a); nonetheless, they are a common capture device in North America and Canada. Across the literature, the majority of studies show a significant percentage of trapped individuals suffering major injuries (Table 5). If the criterion used is that 80% of individuals have nothing more than minor injuries (Anonymous 1998a), it is clear that both padded and unpadded leg-hold traps fail in this respect. Comparative studies have shown that padded leg-hold traps cause fewer injuries than unpadded leg-hold traps, but at the same time different studies on the same species have found contrasting welfare performance results (Table 5). For example, welfare performance of leg-hold traps for red foxes has been assessed extensively in different locations around the world, yet red foxes have very different body-weights in different locations. Since smaller body size may increase the levels of injuries sustained using the same leg-hold traps (Seddon *et al* 1999), location differences of trap tests may confound results (International Association of Fish and Wildlife Agencies [IAFWA] 2003). In addition, the many different kinds of leg-hold traps (padded, unpadded, off-set jaws, double jaws, various sizes, different numbers of springs) and contrasting methods of assessing injuries make true comparisons difficult (Engeman *et al* 1997). What is clear is that 28/38 studies on leg-hold traps (Table 5) fall outside currently accepted standards of welfare (eg Proulx 1999a; Powell & Proulx 2003). Physiological studies demonstrate that they are more stressful than other capture techniques (Kreeger *et al* 1990; White *et al* 1991; Cross *et al* 1999; Warburton *et al* 1999), can have poor capture specificity (Table 6), and can reduce long-term survivorship of released individuals (Seddon *et al* 1999). Leg-hold traps are clearly not the most humane capture technique, yet where legal, for example in many states in the USA, they are widely used for a range of species (Fox & Papouchis 2004b).

Box and cage traps are one of the most widely used trapping techniques. Animals captured in these traps appear to undergo fewer traumas than those captured in snares and leg-hold traps (Table 4) (Powell & Proulx 2003). Significantly, if checked regularly and used correctly, mortality rates approach zero (Table 4). Wounds appear to be less severe, with most injuries confined to skin abrasions and broken teeth, often reduced by improved trap design and reduced mesh size (Short *et al* 2002; Powell & Proulx 2003). Box traps can capture a range of species, but unlike other trap methods, non-target species are typically released unharmed, the only distress experienced generally being that of restraint (Table 4). On the other hand, for large species, box traps can be bulky to transport and not practical to use in remote areas.

To date, there have been few comparative studies examining the physiological response to snares and box traps, other than a study comparing darting and leg-hold snares when capturing free-ranging brown bears (*Ursus arctos*) (Cattet *et al* 2003). Most studies compare physiological responses between leg-hold traps and box traps. The majority show that box traps are less stressful than leg-hold traps. Box traps caused an increase in cortisol compared to untrapped individuals (White *et al* 1991), but this was lower than individuals caught in leg-hold traps (Kreeger *et al* 1990; White *et al* 1991; Cross *et al* 1999; Warburton *et al* 1999). Significantly this was not related to injuries and therefore pain (Warburton *et al* 1999). Both box traps and leg-hold traps caused an increase in body temperature, heart rate and some blood metabolites, associated with increased activity, but box traps showed lower values than leg-hold traps, indicating lower physical activity when trapped (White *et al* 1991; Warburton *et al* 1999). Thus, box traps seem the most favourable option because the number of injuries is lowest and physiologically box traps appear to be the least stressful.

Trap selectivity

An important side-effect of both killing and restraining traps is selectivity, usually measured as the number of individuals of the target species caught relative to the number of non-target animals. It is evident from Table 6 that selectivity varies widely with trap type. However, whilst with killing traps all or the majority of non-target individuals captured are killed, restraining traps vary in mortality rates from 0% in box traps to 17% in leg-hold snares (Logan *et al* 1999; Potočnik *et al* 2002). It has long been recognised that non-target captures can be very high in comparison to target captures (eg it has been noted previously that the number of non-target to target animals can vary from 0-18.1) depending on trapping device used, season, bait and the way in which the trap is set in the field (Novak 1987; Proulx *et al* 1993). The capture of non-target individuals can also pose a serious threat to species of conservation concern. For instance, studies on museum specimens and necropsies of golden eagle (*Aquila chrysaeotos*), bald eagle (*Haliaeetus* *leucocephalus*) and Iberian lynx (*Lynx pardinus*) showed 42, 14 and 64% respectively died as a result of trapping or because of injuries caused by trapping (Bortolotti 1984; García-Perea 2000). However, not all mortality is immediately apparent at the time of the capture. For example, post-traumatic stress of capture can cause subsequent cardiac myopathy in ungulates (Putman 1995); moreover, post-release pressure necrosis may affect non-target species captured in snares (Stocker 2005). Guidelines to avoid capture of non-target species are available from organisations such as the British Association for Shooting and Conservation (2002), Defra (2005) and IAFWA (2006).

Making killing and restraining traps more humane

The development of higher welfare performance of traps should be a priority. Recently, much research has been devoted to testing the animal welfare impacts (reviews in Powell & Proulx 2003; Warburton & O'Connor 2004) and efficiency of killing traps (Pawlina & Proulx 1999), and integrating ethics and animal welfare in trapping research (IAFWA 1997; Broom 1999; Powell & Proulx 2003; Fox & Papouchis 2004a). In contrast, much less effort has been devoted to excluding non-target species from killing traps (Short & Reynolds 2001; Reynolds *et al* 2004).

Most of the killing traps currently in use fall below accepted standards of welfare (see next section on the Agreement), or may be effective when tested in compounds and ineffective in the field (Powell & Proulx 2003; Fox & Papouchis 2004b; Warburton & O'Connor 2004). Technical improvements may improve efficiency of some killing traps (Proulx & Barrett 1993a; Proulx *et al* 1995; Warburton & Hall 1995; Warburton *et al* 2000). For instance, improving strike precision of spring traps to target the neck and avoid back strikes can reduce the impact force needed to kill quickly (Nutman *et al* 1998; Warburton *et al* 2002). Increasing strike power is of concern for user safety but both strike precision and mechanical advances can avoid the use of increased power. Rotating-jaw traps can be further enhanced by offsetting the trap jaws (Zelin *et al* 1983) without the need to increase power. Some traps are quicker and more efficient killing devices than others. A trap designed to kill by shutting off the blood supply to the brain (a neck-hold trap) rather than one that aims to suffocate the animal by clamping its back (such as body-catch traps), will kill more quickly and more effectively (Proulx & Barrett 1991; Phillips 1996), although this may depend on the species (Copeland *et al* 1995). However, the trapping community seems to be resistant to the adoption of new devices and old and illegal methods are still widely used across the globe (Powell & Proulx 2003; Dronova & Shestakov 2005). An understanding of the biology of the target species, and extensive trapper training, are therefore essential to increase trap efficiency and improve animal welfare (Powell & Proulx 2003).

Many studies report slight species-specific modifications that can enhance the welfare of restraining traps. To reduce teeth breakage, box traps can be constructed from natural materials (Copeland *et al* 1995), mesh size or air hole size can be reduced (Arthur 1988; Powell & Proulx 2003), or box bars (a bar placed at the entrance of the trap to prevent biting of the door) can be added (Woodroffe *et al* 2005). For skin abrasions, smooth material can be used to construct traps or smooth coatings added to abrasive materials (Woodroffe *et al* 2005). Longer periods of time spent in the trap are often associated with greater exertion and more serious injuries (Powell & Proulx 2003). Most European countries and some North American states require traps (both killing and restraining) to be checked daily (although this may mean circa 36 hours, if traps are checked at dawn and then at dusk the following day [FACE 1998; Fox & Papouchis 2004a]). This is a minimum standard; reducing the time in traps by either checking more frequently (Proulx *et al* 1993) or monitoring traps with electronic devices can reduce the number of serious injuries (Kaczensky *et al* 2002; Potočnik *et al* 2002; Larkin *et al* 2003). The closure or tying open of traps during adverse weather conditions can reduce freezing damage or hypothermia in colder climes (de Vos & Gunther 1952). Welfare performance may also be improved in both neck and leg-hold snares. Increasing the diameter of the cable can reduce laceration injuries (Garrett 1999). The addition of swivels gives a struggling animal more flexibility and makes it more difficult to entangle or twist the snare (eg Nellis 1968; Logan *et al* 1999). Adding a breakaway snare lock, snare stops and pan tension devices can both minimise capture of non-target species, and ensure that stronger non-target species can escape from the snare (Garrett 1999). Altering the breaking tension of the cable itself can also minimise capture of some non-target species (Fisher & Twitchell 2003). A plastic coating around the wire noose can reduce injuries (Englund 1982). Careful site selection can prevent individuals becoming entangled in surrounding vegetation, and thus injured (Logan *et al* 1999). Some studies have shown that tranquillisers attached to snares can also reduce injuries (Garrett 1999; Pruss *et al* 2002; Marks *et al* 2004). Perhaps the greatest advancement to snare welfare would be better training for users and prosecution of those deliberately setting snares illegally. In future, new remote-controlled teleinjection methods (ie a blowgun remotely monitored and triggered up to 400 m away, shooting anaesthetised darts), which are being developed to catch large mammals with minimum stress and high selectivity, could be extremely useful for research and conservation purposes (Ryser *et al* 2005).

International legislation on mammal trapping

The ISO standards for killing and restraining traps were drafted by representatives of countries with an interest in trapping standards, members of the trapping community and animal welfare organisations (Harrop 1998, 2000). Since no agreement could be reached on either time to the onset of unconsciousness for killing traps or the use of non-physiological indicators of distress, which were perceived as two measures to assess humaneness (Harrop 1998, 2000), the European Union signed two international documents: the Agreement on International Humane Trapping

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Standards (Anonymous 1998a), signed between the EU, Canada and the Russian Federation (hereafter the Agreement) to facilitate the trade in fur and traps as well as to ensure the good welfare of trapped mammals (Harrop 1998), and the Agreed Minute between the EU and the USA on humane trapping standards (Anonymous 1998b), a document that differed only in small technical details from the Agreement (see Harrop 1998, 2000).

It is beyond the scope of this review to cover all national legislation on mammal trapping. Nonetheless it is important to mention a few pieces of legislation dealing with specific trap types. For instance, mammal trapping in Europe is also regulated by the Leg-hold Trap Regulation (The Council of European Communities 1991), which bans the use of leg-hold traps within the EU and prevents the import of fur from countries that employ leg-hold traps. Leg-hold traps are also completely or partially banned in eight US states (Arizona, California, Colorado, Florida, Massachusetts, New Jersey, Rhode Island and Washington) (Fox 2004b). At a national level, only five European countries (Belgium, France, Ireland, Spain, and the UK) still allow the use of neck snares (FACE 1998; Fox 2004b). Snares (all kinds) are banned in Arizona, Connecticut, Massachusetts, New York, Rhode Island and Vermont, whilst colony traps, a type of drowning trap or restraining trap underwater, are not allowed in Illinois, Delaware, Massachusetts, Missouri, New York, Pennsylvania and Wisconsin (Fox 2004b). This highlights the fragmented nature of trapping legislation at national and international level and is in part inconsistent with other animal welfare legislation. For instance, different pieces of legislation concerning the welfare of farm animals cover all stages of the process from housing, to transport and slaughter. In the controlled conditions of slaughterhouses the period of pain and distress before the loss of consciousness is often less than 60 seconds, and yet ongoing research aims to further shorten this time (Mellor & Littin 2004). Countries such as Australia have established humane standards for even the control of introduced pest species (Sharp & Saunders 2005). Codes of conduct developed by shooting or bowhunting organisations require hunters to target vital areas of an animal's body so that killing is fast acting; moreover hunters should aim to produce an immediate kill (Gregory 2005; British Association for Shooting & Conservation 2006; North Dakota Bowhunters Association 2006). In contrast, 300 seconds is considered as an acceptable time of suffering for wild mammals caught in killing traps and in some cases the period permitted between two visits to check restraining traps is 72 hours (Fox 2004b).

Limitations of the international legislation

The current legislation on trapping standards does not promote good animal welfare performance. For instance, some procedures in the ISO standards to test killing and restraining traps are less than ideal. Testing traps in an artificial compound is assumed to recreate actual field settings for both killing and restraining traps, whereas all conditions as well as individual animal behaviour cannot be easily recreated. This could lead to traps failing in the field and poor welfare of trapped animals (Powell & Proulx 2003; Fox & Papouchis 2004a; Warburton & O'Connor 2004). Moreover, the killing traps standards fail to recognise drowning traps as inhumane and ban their use. Despite the fact that the ISO standards advocate the need for target specificity, no actual guidelines are given to avoid capture of non-target species (but see British Association for Shooting and Conservation 2002; Defra 2005; IAFWA 2006). The ISO standards currently provide the best available information upon which a decision can be made regarding acceptability/humaneness of restraining traps. However, the long-term impact of some injuries, pain and physiological stress are not incorporated into this assessment.

The main aim of the Agreement is to facilitate the trade of fur amongst the participant countries. Consequently, several mammal species (eg red fox, coypu [*Myocastor coypus*]) and many rodents (Mason & Littin 2003) are commonly trapped in Europe to reduce numbers but are not included in the Agreement. Equally, several mammals trapped for fur in Canada and Russia (eg wolverine [*Gulo gulo*], red squirrel [*Sciurus vulgaris*]) are not included in the Agreement. While the Agreement sets welfare standards for 19 species (Table 7), there are no specific guidelines for the majority of species not included in the Agreement. In addition, when the Agreement was signed in 1997, different time limits to unconsciousness were set; smaller species must be rendered unconscious in shorter time limits (60 or 180 seconds) than larger ones (300 seconds). However, the time limits to unconsciousness adopted in the Agreement now fail to account for higher welfare standards currently accepted in trap research. Indeed, the traps currently available for American beaver, American pine marten, Canadian lynx, fisher and muskrat may kill within time limits shorter than those adopted by the Agreement (Powell & Proulx 2003; Table 1). By allowing the use of traps that fall below the accepted standards of animal welfare, the time limits set by the Agreement cannot be considered acceptable. Lastly, the Agreement considers killing and restraining traps to be humane if time to unconsciousness (for killing traps) and no indicators of poor welfare (for restraining traps) are achieved in a minimum of 80% of cases; for the remaining 20% or less of trapped animals, any level of welfare is acceptable. A minimum estimated 7,880,000 animals (excluding unrecorded and illegally trapped animals) of the mammal species included in the Agreement are trapped in killing and restraining traps in Canada, Europe, Russia and the USA annually (Table 7) and this implies that, at the very least, poor welfare for hundreds of thousands of animals each year is acceptable. A key goal should be to reduce this number substantially.

One missing aspect from the legislation concerns the methods of euthanasia of animals trapped in restraining traps. Trappers' magazines often advocate suffocation, drowning, gassing and hitting with clubs to minimise pelt damage (Minnesota Trapper Association 2000; Fox & Papouchis 2004c; Orr 2005). No formal guidelines are provided for pest control officers, and while some may use guns or other humane killing devices to despatch trapped animals (The Fund for Animals 2001), some will undoubtedly use less humane methods. Scientists, in contrast, follow precise guidelines on euthanasia, and only humane methods are allowed (Close *et al* 1996; Beaver *et al* 2001). Similarly, farmed animals must be stunned before slaughter in the vast majority of commercial slaughterhouses in Australia, Europe and the USA so that the period of distress before killing is minimised (Gregory 1989/1990); some forms of ritual slaughter also allow stunning prior to slaughter in certain contexts (Mellor & Littin 2004). There are no guidelines on how to kill a trapped animals humanely in either of the ISO documents or the Agreement. To improve welfare, this aspect of trapping needs to be addressed.

Mammal trapping for research

The welfare of animals used in research has become increasingly important in the last half century and is the subject of great public concern and debate among scientists (Broom 1988; Putman 1995; Dawkins 1998; Clutton-Brock 2003). In general, for a scientific journal to accept original research conducted using wild animals, authors must have complied with the laws and regulations of the country where the research was undertaken. If research techniques affect the animals under study, the value of the data collected is reduced, possibly significantly. When animals were kept confined temporarily in a laboratory, researchers must have followed guidelines such as *Guide to the Care and Use of Experimental Animals* (Canadian Council on Animal Care 1993), *Guide to the Care and Use of Laboratory Animals* (Institute for Laboratory Animal Research 1996), *Guidelines for the use of animals in behavioural research and teaching* (Anonymous 2003) by The Association for the Study of Animal Behaviour, and *Guidelines for the capture, handling and care of mammals* (American Society of Mammalogists Animal Care and Use Committee 1998). These guidelines are published to help researchers design studies that have minimum impact on the individuals, populations or communities under examination. This includes minimising sample sizes for statistical analyses, choosing live-capture methods which are humane or killing traps that kill as quickly and painlessly as possible, assuming responsibility for dependent offspring, and minimising the length of confinement to avoid disruption to social interactions (American Society of Mammalogists Animal Care and Use Committee 1998; Anonymous 2003). Researchers are responsible for all animals involved in their study: should restraining traps be laid out, only the number of traps that can be checked daily should be employed; where the target species is nocturnal, traps should be checked at dawn and closed during the day to avoid capture of diurnal non-target species; great care must be taken when small mammals are to be captured, as they are very sensitive to extreme temperature, dehydrate very quickly due to high metabolism, and may starve in short time spans; when research involves endangered species, researchers must work in co-operation with official agencies such as CITES (Convention on International Trade in Endangered Species of Wild Flora and Fauna) or IUCN (The World Conservation Union); sampling must be restricted to the smallest number of individuals and, whenever possible, conducted as far apart as possible so that recolonisation may take place from neighbouring populations (American Society of Mammalogists Animal Care and Use Committee 1998); in some instances during a study, animals might need to be killed; in such circumstances the accepted methods of euthanasia are those published by organisations such as American Veterinary Medical Association (Beaver *et al* 2001) or the Federation of European Laboratory Animal Associations (Close *et al* 1996).

In conclusion, there is no distinct definition of humane trapping; whoever undertakes the research is responsible for the welfare of the animals involved and must minimise disruption to the species at all levels ie individuals, groups, populations and communities, and at all stages of the study. These principles should be the basis for establishing welfare standards for trapping undertaken for other than research purposes.

Animal welfare implications

A large number of killing and restraining traps currently in use for mammals do not meet accepted standards of animal welfare. The methods currently in place to test trap devices are inconsistent. Testing restraining and/or killing traps in controlled systems is less than ideal; physiological responses of anaesthetised animals have been shown to differ from the responses of unanaesthetised animals (Hiltz & Roy 2001), and the full range of behaviours of animals in the wild cannot be recreated in captive conditions. With regard to restraining traps, there is no clear understanding of the injury scoring system or how this relates to animal welfare. Very few (if any) studies present good behavioural or physiological measures of animals in different trap types. Many facets of the welfare of trapped animals such as behaviour, physiology, immunology and molecular biology still need to be incorporated into trap evaluation to achieve a more complete assessment of welfare. The welfare of wild animals caught for fur or population control lags a long way behind other welfare standards, such as those set for slaughtering farm animals (Mellor & Littin 2004), trapping standards for scientific research or those for shooting and bowhunting. There is no logic for contrasting welfare standards for wild animals and captive animals or for different welfare standards for the same species when trapped either for scientific research or for pest control. The ISO standards should be seen as a baseline to set higher welfare standards. This can be achieved by reviewing the time to unconsciousness following improvements to killing traps, banning inhumane killing methods such as drowning traps, identifying acceptable methods for euthanasia of trapped animals and collecting new data on stress responses to different trap types. In conclusion, we believe that animal welfare standards for trapping should be the highest achievable whatever the need (for fur, population control or scientific research), should not fall below current accepted standards for other animal uses and, finally, that further improvements should always be sought.

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