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SHORT COMMUNICATION

Is electric fencing an efficient and animal-friendly tool to prevent stone martens from entering buildings?

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Abstract Wildlife such as stone martens *Martes foina* have adapted to live in urban areas, which are spreading worldwide. Conflicts with humans can arise when martens enter buildings and cause serious damage to roof insulation. Therefore, there is an increasing demand for measures that will reduce such human–wildlife conflicts. Data we collected from a big insurance company regarding the costs of repairs of damages caused by martens revealed an estimate of 655 annual cases per Mio inhabitants and pay-outs of approximately €200,000 per year from 2002 to 2006. The data collected from pest control organisations showed an increase of damage claims from around 20 up to 150 cases per year in the last 20 years. In an experimental case study, the analysis of video recordings (26 nights) and long-term bait controls (103 nights) showed that installed electric wires and woven wire mesh prevented martens from entering a building they previously used intensively. Our results suggest that electric fencing could be a simple, short-termed measure to exclude martens from buildings before definitively sealing the openings. Electric fencing needs further quantitative and qualitative evaluation at different study sites to develop an animal-friendly, practical and cost-effective tool that prevents martens from causing damage to roof insulations.

Keywords *Martes foina* · Electric fencing · Human–wildlife interaction · Damage · Management · Urban wildlife

Introduction

Nowadays, the spread of urban areas at the cost of pristine habitats is a worldwide phenomenon. Nevertheless, many vertebrate species thrive even in large cities and reach higher densities than in adjacent rural areas. Examples include the red fox *Vulpes vulpes* (Gloor et al. 2001), the stone marten *Martes foina* (Kugelschafter et al. 1984/1985; Broekhuizen and Müskens 2001) and various bird species (Marzluff 2001). As a consequence of the increasing population densities of wild animal species in urban areas, encounters between humans and wildlife occur more frequently, and the potential for conflicts rises (Bontadina et al. 2001; Adams et al. 2006; Hegglin et al. 2007). Therefore, there is an increasing demand for strategies that will reduce conflicts and lead to a coexistence of humans and wildlife living in urban habitats (e.g. Gehrt et al. 2009).

The stone marten is a medium-sized, omnivorous mustelid widespread in Eurasia. In Switzerland and Germany, problems arose in the 1970s when martens started to cause damage to cars (Kugelschafter et al. 1984/1985; Tschudin 2001; Herr et al. 2009). Two decades later, the number of complaints from homeowners or tenants regarding damage to roof insulation began to increase, indicating that the nocturnal, mainly solitary stone martens had discovered inhabited and even newly built houses as hiding places (Herr et al. 2010). Insulation material is used as nesting material, and noise is caused by adult animals running through the attic, by their offspring playing and by males chasing females during the reproduction season. Damage to insulation can cause substantial energy loss and result in high costs for repairs. Up to now, in order to solve these problems, people have tried to expel stone martens from buildings using ultrasonic protection tools, olfactory deterrents or by trapping

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and/or shooting. The shortcomings of these solutions are manifold. Deterrents have proved inefficient or at least not sustainable (Edgar et al. 2007). Hunting is often very time consuming, and it has a low acceptance among non-rural inhabitants (Adams et al. 2006). Moreover, hunting sometimes has serious animal welfare implications when live animals are locked in traps that are insufficiently checked (Iossa et al. 2007). More importantly, all these tools are not sustainable because, at high population densities, other animals quickly refill empty territories.

A number of studies have investigated the effectiveness of electric fencing. In Britain, two types of fencing (electric netting and electric strained-wire) had been successfully used to exclude foxes (Poole and McKillop 2002). Wire fences were about 30 % less effective than netting fences in rabbit control (McKillop et al. 1992). Electric fencing in combination with physical barriers successfully prevented badgers from entering farm buildings (Judge et al. 2011), electric strained-wires proved to be effective in excluding badgers from bait points (Poole et al. 2004) and electric fences prevented coyotes from preying on sheep (Dorrance and Bourne 1980). Experiments on car damage caused by martens have indicated that electric current might be effective in preventing stone martens from entering car engines (Kugelschafter et al. 1997). Based on the findings on the repellent effect of electric current, we suggest that electric current might also be effective in preventing stone martens from damaging building insulation. It might be used as a simple first measure to exclude stone martens from a building where potential openings cannot be easily sealed permanently.

To get an overview of the extent of the problems resulting from damage caused by stone martens, we first collected data regarding the costs of necessary repairs and the development of damage claims in Switzerland. Secondly, we experimentally tested whether electric fences could prevent stone martens from using a building. To observe the effect of electric wires on martens, we installed an automatic video recording system and monitored the long-term success by bait controls at two buildings where the owners reported a stone marten presence.

Material and methods

In some cantons of Switzerland, building insurance policies are legally mandatory and administrated by the government. We contacted a big insurance company of the canton of Bern, which has offered a supplementary insurance coverage for damage caused by martens since 2002, and we asked for the number of damage claims and for resultant costs for damage that were paid. Payments per claim and year are limited to 1 % of the insured value of the building and do not exceed a maximum of about €3,000. The canton of Bern well represents Swiss conditions regarding human population, settlements and presence of stone martens. We checked for a temporal increase on the number of cases reported based on information from four pest control technicians and from the official pest control office of the City of Zurich. One of the pest control technicians had specialised in excluding stone martens from buildings since 2005. Field experiments were done according to the national guidelines (Federal Veterinary Office 1995).

The study site was an industrial building built in the 1950s (Online Resource 1), situated in Menzingen, a mid-sized village in the canton of Zug, Switzerland. The martens had used the attic of this building for many years as a resting site and had caused serious damage to roof insulation. Video recordings (see below) were made from 12 June to 27 July 2006, for a total of 26 nights. Thereafter, the presence of martens was monitored by checking for faeces and for bait take (dried apricots and dog biscuits) from 27 July to 06 November 2006 (103 days).

We first identified openings that were probably used by the martens to enter the building and checked for traces to verify marten presence. If faeces were found, they were removed. We then monitored the selected openings using the automatic video system (pre-phase). Where possible, martens were also observed indoors. Where martens were observed entering the opening(s), the electric fencing equipment was installed (treatment). Finally, we checked for sustainable success of the deterrent technique, first by observing the building with the automatic video system and afterwards by checking for eaten bait (ten pieces of bait distributed) and the occurrence of fresh faeces.

A second study site was the top flat of a modern multifamily apartment house from the 1980s, situated in the city of Zurich, Switzerland. Here, a marten had been observed using a crevice on the balcony as access to the attic. Video recordings were made from 02 August to 12 September 2006 (40 nights). The marten's reluctance to further use the opening, possibly caused by the video surveillance, thwarted further tests with the treatments.

We used two types of electric fence designs: a woven wire mesh net (5.9 cm in mesh width) for bigger openings and electric wire strands (0.16 cm in diameter) for small openings. The wire mesh and wire strands were energised by a battery-powered energiser. The energiser worked with a safe high voltage that is commonly used in agriculture (pulsed energy output of 1.4 J at a resistance of 600 Ω). To block the opening in the damaged roof, the wire mesh was installed (Online Resource 2). To block a small crevice of 5 cm between the wall and the roof, two electric wire strands were fixed to the building with isolators (Online Resource 2). This arrangement is referred to as treatment 1. As the marten still passed through the crevice with this arrangement, we installed an additional electric wire strand. This arrangement is referred to as treatment 2. The electric wires were installed at the outside of the building such that the marten would still be allowed to leave the building through the crevice in order to make sure that it would not be trapped inside the attic. However, when leaving the building, it would touch the energised wire strands and thus learn to avoid the opening. We did not test non-electric fences or other physical barriers.

The presence and activity of the martens were recorded with a movement-triggered video system, which consisted of three infrared cameras, two transmitter–receiver devices for wireless transmission of images to a digital video recorder. The experimental treatment was considered successful if martens did not pass the protected openings, either confirmed by video or if no traces or removed bait were found at the access to the attic.

Results and discussion

The results of our enquiry about the supplementary insurance for martens in the canton Bern (0.97 million inhabitants) are given in Table 1. From 2002 to mid-2006, the insurance company dealt with 635 cases and paid out €972,593 (mean=€1,532 per case). For the specified duration, this results in a loss of €207,400 per year. Extrapolating these costs to the whole country resulted in a total loss of €1.6 million for Switzerland, equivalent to €0.21 million per million inhabitants (Table 1).

Three of the four interviewed pest control technicians stated that an increase in cases dealing with martens in the last decade, while the fourth could not provide any information. Only one of the pest control technicians and the official pest control office of the City of Zurich had recorded detailed statistics on cases with martens in buildings. In total, the number of cases of marten problem showed an increase during this period (1991 to 2011) with a linear regression better fitting the data than an exponential trend (Fig. 1). The amount of claims and the clear increase of cases reported show that damage caused by martens can be substantial. Although part of the increase in cases might be explained by an increase in demand for help or to the only recent possibility of supplementary insurance coverage, our data clearly demonstrate that practical solutions are urgently needed to reduce these human–wildlife conflicts.

Table 1 Annual costs of damage caused by martens in the canton of Bern and extrapolated values for Switzerland and per million inhabitants (for years 2002–2006; estimated values in *italics*)

	Human population (%)	Cases	Paid amount (€)	Per year (€)
Bern	969,683 (13)	635	972,593	*195,000*
Switzerland	7,459,000 (100)	*4,885*	–	*1,500,000*
per Mio	1,000,000	*655*	–	*200,000*

In the industrial building, damage to the roof and to insulation material was visible. Video analysis of the pre-phase (nine nights) showed that martens used two openings to enter the building. On average, there were about two marten passes per night (Fig. 2). By means of the video recordings, we identified at least two martens that were using this building. During treatment 1, the number of passages of martens per night decreased, and no marten was detected in the attic. During treatment 2, no marten was detected at all. During the two treatments and the following control phase (119 nights in total), no fresh faeces were detected in the attic (Fig. 2), and none of the baits was touched.

Our study revealed a strong increase in cases reported by homeowners or tenants living in urbanised areas of Switzerland that were affected by damage or disturbances caused by martens. The sum of nearly €1 million paid for more than 600 claims by the building insurance company clearly shows that damage to roof insulation caused by martens is significant. Furthermore, additional costs can result because the total cost for repairs normally exceeds the amount paid by insurance companies, and poor insulation can result in higher heating costs. The electric fencing system we tested is a rather low-priced measure (only a few €100) to avoid considerable damage caused by martens.

A possible explanation for the increase of damage cases could be that urban areas are spreading and there is an ongoing trend to high-density housing. Additionally, in these areas, older buildings such as barns or storehouses are often either renovated or demolished. Stone martens prefer warm and dry resting sites undisturbed by human activities (Herrmann 2004; Herr et al. 2010). Since such sites in urban areas are probably a limited resource, martens switch to places in closer vicinity to humans.

Using electric fencing in our experiment, martens were successfully kept out of an attic that previously had been intensively used by martens for years. The treatment was effective for several months. We consider electric fencing to be a more animal-friendly marten-control measure than trapping or shooting that are time consuming and often cause problems regarding animal welfare and acceptance among non-rural inhabitants (Adams et al. 2006; Iossa et al. 2007). Electric fencing can block access and still allow hidden animals to escape the building before the openings are eventually sealed. Combining the wire mesh with electric wires allowed us to adopt various configurations

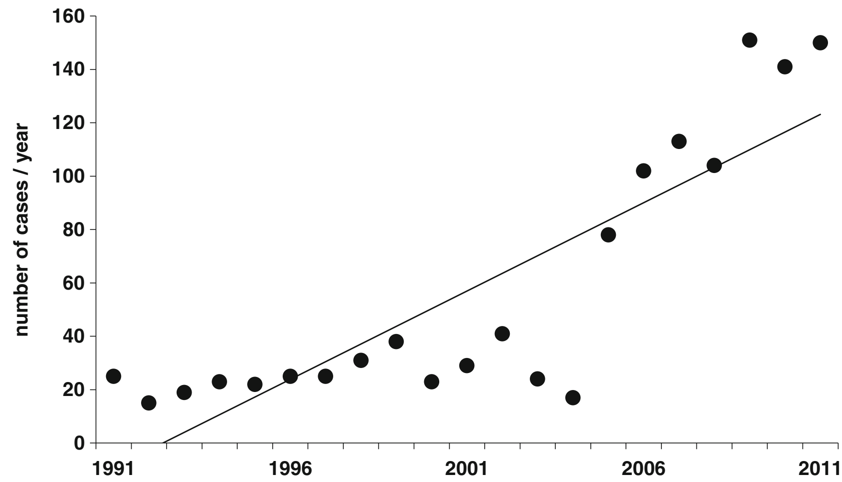

Fig. 1 Annual number of cases with problems in homes and buildings caused by martens, reported to two pest control centres in Switzerland (y=1,975.12+6.62x, N=21 years, R^2=0.72, $F_{1,19}$=48.6, p<0.001)

at different openings, thus protecting the whole building. We did not directly observe the reaction of the martens to the electric fencing. However, animals learn to avoid the electric fences after the first negative experience with the energised wire strands (McKillop and Wilson 1999; Poole et al. 2002). Moreover, the installation of excluding measures itself seems to have a deterrent effect on animals (Tolhurst et al. 2008; Judge et al. 2011). Still, it has been shown that animals can detect when fences are damaged or when there is power failure (Connolly et al. 2009). Therefore, proper functioning of electric fencing has to be ensured. The wide use of electric fencing in raising domestic animals such as chickens or in excluding pest animals such as badgers, rabbits or foxes from crops or endangered species (McKillop et al. 1992; Poole and McKillop 2002; Poole et al. 2002) has proven to be safe. Even negative experiences seem to have a sustained effect. For example, with European wild rabbits, electric fencing erected to protect crops was still effective after 6 weeks, even when power was disconnected, because the animals had altered their ranging behaviour (McKillop et al. 1993). As rearing places are probably limited, the most effective point of time for the installation would be in autumn when the young have left the female. Overall, electric fencing might be a simple, animal-friendly and short-termed first measure to exclude stone martens from buildings where potential openings could later be sealed permanently, e.g. by a professional roofer. The suggested method deserves further quantitative and qualitative confirmation in different housing situations.

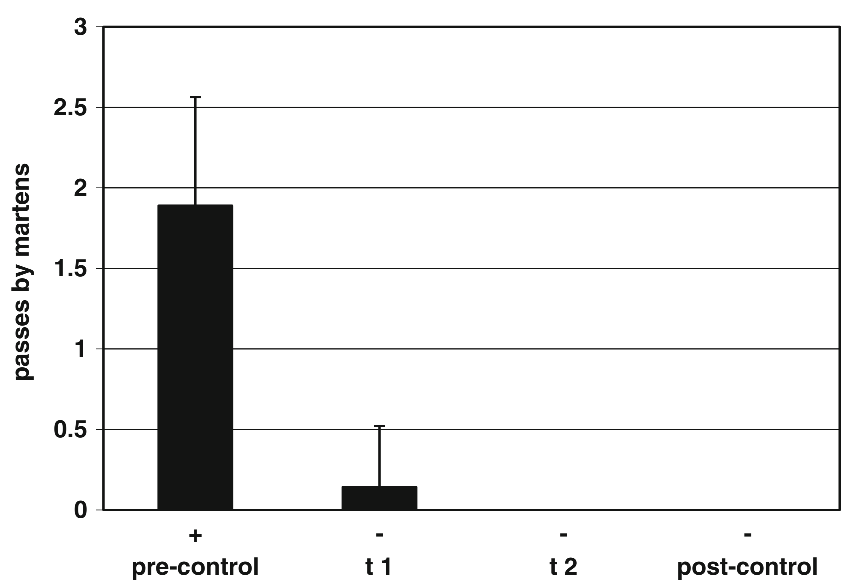

Fig. 2 Influence of electric fencing on marten observations in an industrial building. Average (+1 SE) number of martens passing per night, recorded by an automatic video system, in the pre-control phase (N=9 nights), at treatment 1 with two electric wire (t1, N=7 nights), treatment 2 with three electric wires (t2, N=10 nights) and at the post-control phase (post-control, N=103 nights). Fresh faeces found are marked (+=yes, -=no)

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Online Resource 1. The Industrial building (above), and the marten at the opening that later was protected by the wire mesh (below) (DOCX 715 kb)

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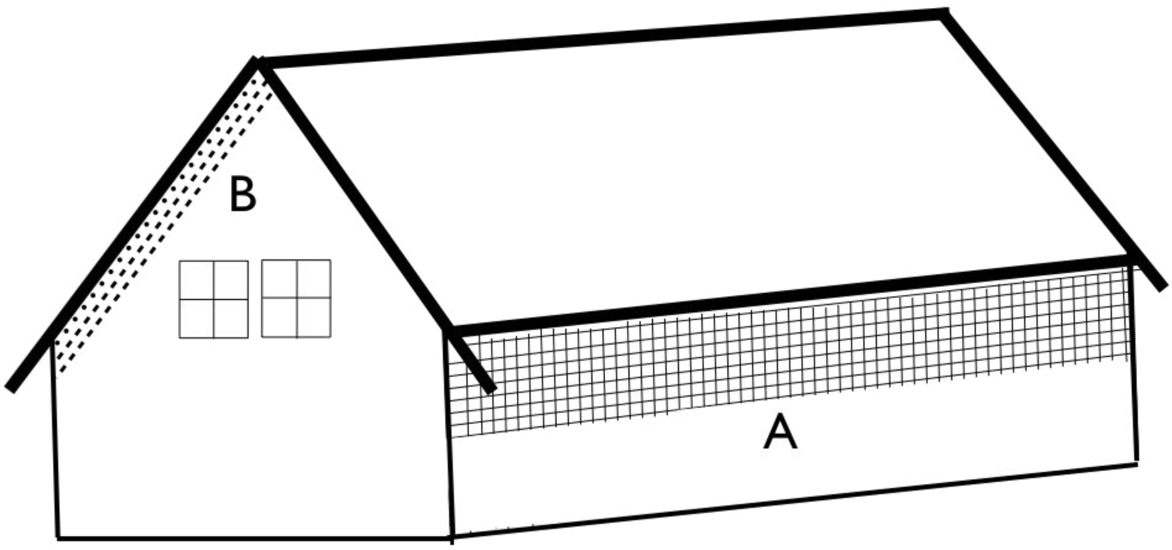

Online Resource 2. In the industrial study site, both types of electric fencing were used simultaneously. A woven wire mesh net (5.9 cm mesh width) was used to block the several openings in the damaged roof along the lateral house wall of the industrial building (A). Electric wire strands (0.16 cm diameter) plus an electric polytape (10 mm breadth, 4 x 0.16 stainless steel) were used to block a small opening between the roof and the house wall on the left side in the front (B). Dashed lines: treatment 1; dashed lines plus dotted line: treatment 2 (DOCX 114 kb)