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SHORT COMMUNICATION

Intentional methomyl-poisoning of peregrine falcons (*Falco peregrinus*) in Switzerland

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Abstract The present report describes two proven cases of illegal poisoning of peregrine falcons in the city of Zurich, Switzerland. Both animals died in their eyries after capturing and feeding on a methomyl-laced pigeon. Both eyries are surveillanced by cameras, and the death of one falcon was broadcasted live on the Internet. The city game warden had noticed the disappearance of a brooding female from an artificial eyrie in 2009 and had found five dead falcons at plucking posts or artificial eyries between 2009 and 2013. Owing to these reports in combination with reports on the disappearance of at least eight pairs of peregrine falcons from traditionally used nesting sites in north-western Switzerland since the 1980s, the authors presume that there may be a high number of unreported cases of illegal killing of peregrine falcons in Switzerland. They suggest an increased surveillance, and a coordinated collection of data on wildlife crime may aid the prosecution of perpetrators.

Keywords Pesticide · Carbamate · Intoxication · Bait · Falcon

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Introduction

The killing of birds of prey is prohibited in Europe since the 1970s, according to International (e.g. CITES from 1973), European (e.g. Bern Convention on the Conservation of European Wildlife and Natural Habitats from 1979) and National laws (e.g., Swiss hunting law from 1988). Nonetheless, birds of prey are still widely persecuted as perceived nuisance wildlife and competitors for human hunters, but also for illegal trade, taxidermy or recreation (BirdLife International 2011). The authors found the Royal Society for the Protection of Birds (RSPB) to maintain the most comprehensive and current European database on illegal persecution of birds including an annual publication of bird crime incidents. For 2012, for example, they listed shooting and poisoning as the main methods for illegal persecution of birds of prey and owls in the UK with 33 and 29 out of 102 confirmed cases (RSPB 2012). They identified farmers, gamekeepers, hunters and pigeon fanciers to be the most common offenders (RSPB 2012).

In the current report, the authors are addressing illegal poisoning of peregrine falcons (PF, *Falco peregrinus*) in Zurich, Switzerland.

The PF is a species with almost worldwide distribution and is widespread throughout continental Europe and the British Isles (BirdLife International 2014). Due to its sensitivity towards the pesticide DDT, the European populations experienced a severe decrease in the 1960s with the Swiss population becoming nearly extinct in the early seventies (Schmid et al. 2001). After the prohibition of DDT and the implementation of protective measures, the population of PFs has recovered over the past 40 years to an estimated 300–400 breeding pairs in Switzerland in 2010 (Swiss Ornithological Station 2014). In the city of Zurich, two artificial eyries (nest boxes) were mounted in 1997 as a reestablishment project for PFs. Both locations were well accepted, and the birds used them

continuously from 2003 until 2011 and from 2006 until 2014, respectively.

PFs prey mainly on medium-sized birds, with Columbiformes as the dominant prey group (White et al. 2013). They usually strike and capture their prey in mid-air. If not killed by the impact, the prey is dispatched by a bite through their neck. The prey is then brought to its eyrie or an established plucking area at which the preys' feathers are removed prior to consumption. This behaviour is used by perpetrators to selectively poison unwanted PFs: The poison (in many cases a pesticide) is blended with a sticky substance, usually honey, and applied to the neck feathers of a pigeon. The pigeon, sometimes after partial clipping of the wings to impair its flight, is then released in a PF territory. The PF is poisoned when its oral mucosa is exposed to the pesticide during plucking. Several reports in the "grey literature"—especially from Germany and Austria—refer to this procedure (e.g., Der Standard 2012; NABU 2014; Police Department Tuttlingen 2014). Usually, fanciers of racing or flyer pigeons, the latter are known for their abnormal flight patterns as compared to the flying behaviour of wild pigeon species, are suspected. In Switzerland, pigeon fanciers came into the focus of police surveillance activities in 2009: users of pigeon fancier websites propagated the extirpation of PFs, and several individuals reported that they had successfully used methomyl (*S*-methyl-*N*-[(methylcarbamyl) oxythioacetamide]) to kill PFs.

Material and methods

The animals included in this report were collected at the two artificial eyries from the Zurich reestablishment project. Both eyries are located on high chimneys of waste-to-energy incineration plants. Eyrie 1 (Josefstrasse) is located approximately 2 km north-west and eyrie 2 (Hagenholzstrasse) approximately 5 km north-east of the city centre. Eyries are each fitted with two video cameras pointing at the inside of the eyrie and the landing board, respectively. While eyrie 1 may be permanently viewed in real time by the public (webcam: www.stadt-zuerich.ch/falken), the cameras at eyrie 2 (DCS-942L and D-Link DCS-2121 from D-Link GmbH, D-65760 Eschborn, Germany) are motion-triggered, filming for 5–10 s after being set in motion, and are used for police surveillance only. Video sequences are stored on a FTP-Server.

Video sequences are analysed daily, and deaths of PFs were readily detected. All animals were collected and submitted for further analysis the day after their death. One was a female PF with its prey, collected at eyrie 1 on May 9, 2011 (=case 1), and the other a male PF with its prey, collected at eyrie 2 on March 5, 2014 (=case 2). The prey animal in case 1 appeared like a feral domestic pigeon (*Columba livia* forma *domestica*) as it is commonly found in cities; the prey from case 2 was a white pigeon with black tail feathers; neither of the pigeons was ringed. Both PFs and the first pigeon were submitted to the National Reference Centre for Poultry and Rabbit Diseases (NRGK), University of Zurich, Switzerland. The second pigeon was sent to the Forensic Institute Zurich (FOR) for forensic analysis involving the possible prosecution of a suspect prior to post-mortem examination at the NRGK.

At the NRGK, a post-mortem examination was performed in all four animals including gross examination, parasitological examination and a histological examination of selected organs in PF1. Gizzard contents of both PFs, crop content of pigeon 1 and liver tissue of PF2 were sent to Interlabor Belp AG (Interlabor Belp, CH-3123 Belp, Switzerland) for toxicological analysis. Samples of case 1 animals were screened for over 400 pesticides; the gizzard contents of the second PF was analysed for possible methomyl contents. Analysis was performed using gas chromatography-time-of-flight/mass spectrometry (GC-TOF/MS) and liquid-chromatography-mass spectrometry/mass spectrometry (LC-MS/MS) with a detection limit of 0.1 mg/kg. In the frame of the forensic analysis at the FOR, a whitish substance recovered from the wing feathers of the pigeon was analysed using a general screening by gas chromatography-mass spectrometry (GCMS).

Results

Video footage for eyrie 1 documented the return of PF1 with a prey pigeon at 7:29 a.m., May 9, 2011. Within minutes after starting to pluck its prey, the PF seemed to have balance problems and fell over at 7:43 a.m. without being able to right itself. The dead body was collected the following morning. The three young peregrines present in the eyrie were moved to a local wildlife rescue centre and released after fledging.

At eyrie 2, the first evidence of a preyed pigeon in the eyrie was recorded at 7:39 a.m. on March 4, 2013. Within the next hours, the female PF was observed to occasionally pluck the pigeon. Later, the male was seen to feed from it. The last feeding was recorded at 12:34 p.m., and at 17:19, the male was visible lying unmoving. The camera was not triggered in between. The dead body was collected on the following day. Nine days after the incident, the female laid a single egg, which she abandoned. It was removed by the city's gamekeeper.

At post-mortem examination, both PFs were found to be in good body condition with weights of 1060 and 557 g, respectively, and showed a well-tended outer appearance; PF2 had several feathers, presumably from its last meal, sticking to its head. The liver of PF1 was congested, the gizzard contained skin and feathers. PF2 showed dark, slightly enlarged and highly congested liver and spleen and plump kidneys. The gizzard contained a pellet of feathers, one pigeon foot and a small quantity of meat. Both pigeons were in good body condition. While in pigeon 1, the gastrointestinal tract, including the crop, was well filled with ingesta, the head, crop a foot and

the larger part of the feathers of pigeon 2 were missing. A microscopic examination of native smears of the different intestinal sections (duodenum, jejunum, ileum, caeca, colon) did not reveal the presence of any endoparasites. A small number of *Serratospiculum* sp. was found in the left cranial abdominal air sack (PF1) and the left caudal thoracic air sack (PF2). No ectoparasites were detected. Histological examination of PF1 confirmed the congestion of inner organs.

The combined sample of crop contents of prey pigeon 1 and gizzard contents of PF1 yielded 64 mg/kg methomyl. Toxicological analysis of the gizzard contents of the second PF revealed a methomyl content of 11 mg/kg. The GCMS analysis of the second prey pigeon by the FOR could not detect any pesticides/toxic substances. The liver tissue of the PF did not contain a detectable amount of methomyl, and no pesticides were detected in the whitish substance from the second pigeons' wings.

Discussion

The carbamate pesticide methomyl is highly toxic in birds with the acute oral LD_{50} ranging from 10 to 42 mg/kg depending on bird species (Smith and U.S. Department of the Interior, Fish and Wildlife Service 1987). Raptor species, and within these the smaller-bodied birds, appear to be more sensitive to carbamate pesticides than non-raptor species (Mineau et al. 1999). Like all carbamates, methomyl acts by inhibiting the enzyme cholinesterase (ChE) that is responsible for the degradation of the neurotransmitter acetylcholine (ACh) in the synaptic gap (Fairbrother 1996). The following accumulation of ACh leads to an uninterrupted stimulation of postsynaptic nerves. In cases of exposure to highly toxic doses, the onset of clinical signs is immediate and death—preceded by clonic-tonic convulsions and prostration (Fairbrother 1996)—may occur within minutes after exposure (Berny 2007).

In the reported cases, the good body condition, the filled stomach and the well-tended outer appearance of the PFs indicate that the birds were in good health prior to their sudden death. As Samour and Naldo (2001) suggest, the presence of *Serratospiculum* sp. was regarded as an incidental finding that did not present a clinical problem. Congested liver, spleen and kidneys are indicative of circulatory failure. This would also be consistent with a possible aetiology of acute poisoning. The detection of 64 mg/kg methomyl in the mixed sample of pigeon and raptor ingesta in combination with the webcam footage and the detection of 11 mg/kg methomyl in the ingesta of the second PF strongly suggest that acute intoxication by methomyl is responsible for the death of both PFs. The authors assume that the whitish substance recovered for toxicological analysis from pigeon 2 might as well have been urine. As the larger part of the pigeon carcass, including most feathers and its head, was missing, no further analyses were performed. The lack of methomyl in the liver sample of PF2 does not contradict poisoning as cause of death. It is known that while methomyl can be readily detected in the bait, it is difficult to trace in tissue due to its low volume of distribution (Zsatsakis et al. 1996). According to a report from the European Food Safety Authority (EFSA) from 2008, methomyl is highly toxic via the oral route and Villar et al. (2010) reported that pigeons that fed on methomyl-treated corn died within minutes. Additionally, Zsatsakis et al. (1996) found that methomyl, in contrast to other ChE inhibitors, is not only due to ChE inhibition, but may cause acute cardiovascular toxicity associated with only minimal inhibition of ChE activity. The survival of the methomyl-laced pigeons as live bait may be explained by the low dermal toxicity of methomyl (EFSA 2008).

Table 1 Incidents involving dead or disappearing PFs in the city of Zurich

Date	Eyrie	Breeding status	Animal	Incidence	Comment/methomyl
2009, Apr 30	Eyrie 2	Active brood	Ad, f	Disappeared; abortion of brood	–
2009, Jun 26	Plucking area 1	n/a	Ad	Found dead with preyed pigeon in claws/fang	–
2010, Jan 27	Eyrie 2	Courting	Ad, f	Found dead below eyrie with head trauma—was dead for some time	–
2010, Mar 30	Eyrie 2	Active brood	Juv	Found dead below eyrie—was dead for some time	–
2010, Jul 06	Plucking area 2	n/a	Ad	Found dead; photo taken and body destroyed	–
2011, May 09	Eyrie 1	Active brood	Ad, f (**PF 1**)	Died in front of webcam after feeding on prey pigeon; juveniles raised artificially	64 mg/kg in mixed sample of contents of pigeon crop and PF stomach
2013, Jun 12	Limmattalstr.	n/a	Juv, f	Found dead	No methomyl detected
2014, Mar 04	Eyrie 2	Courting, egg formation	Ad, m (**PF 2**)	Found dead next to prey pigeon; egg abandoned	11 mg/kg Methomyl in gizzard contents of PF; pigeon negative

Bold entries indicates the cases discussed in the report.

f female, *m* male, *juv* juvenile, *ad* adult, *n/a* not applicable

As PFs usually catch and kill birds in mid-air, it can be assumed that live pigeons were used as bait to selectively target and kill the two PFs. While the plumage of the second bait pigeon suggested that the animal might have been a fancy breed, the plumage of the first pigeon was suggestive of a feral pigeon. Either way, pigeon breeders are the most likely culprit: they may use one of their own less valued animals or ferals that have taken residence in their loft for this mission (M. Kéry, personal communication). This suspicion is also backed by data from the Birdcrime report from 2009, which lists pigeon fanciers along with game wardens and egg collectors as the most common offenders regarding peregrine falcons (RSPB 2009).

Confirmation of a poisoning event by detecting toxic compounds is in general difficult, as especially the less stable responsible agents might be disintegrated by the time of sample recovery (Wobeser et al. 2004). Additionally, it has to be taken into account that only a small percentage of wild animal carcasses is ever detected (Berny 2007). Illegal persecution as cause of death of raptors is therefore most likely underdiagnosed (RSPB Scotland 2009; Hirschfeld 2010). The awareness regarding wildlife crime suddenly increased in Zürich, Switzerland, after the death of PF1 was broadcasted on the Internet via the live webcam of its eyrie. This incident raised suspicion towards the cause of a previous disappearance (2009) and two deaths (2010) of PFs at eyrie 2 during active brood and the incidental discovery of three PFs (2009, 2010, 2013), two of them at plucking posts, in advanced states of decomposition in Zurich (Table 1).

Based on the two confirmed poisonings as listed in this report, combined with the unexplained disappearances and deaths of PFs, the authors presume that the reestablished population of PFs in Zurich has repeatedly fallen victim to illegal persecution. Further, the disappearance of all five breeding pairs that were commonly observed on their traditional breeding sites in the urban areas of the Basel metropolitan area (north-western Switzerland) since 2008 and of at least three previously highly regular breeding pairs in the rural areas south of Basel since the 1980s (M. Kéry, personal communication) suggests that there may be a high number of unreported cases of illegal persecution of PFs in Switzerland. The authors recommend increasing surveillance measures to identify the causes of disappearances of PFs in Switzerland and should carcasses be recovered, to generally send these for post-mortem examination. They further propose that the collection of all identified and suspect cases of wildlife crime in a national database may aid prosecution of perpetrators.

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Conflict of interest The authors declare that they have no conflict of interest.

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