Article

Mortality and morbidity associated with gunshot in raptorial birds from the province of Quebec: 1986 to 2007

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Abstract — Although raptors have been protected for decades in Quebec they are still regular victims of poaching. The objective of this study was to characterize cases of raptor shootings in Quebec over the last 2 decades. We reviewed clinical files, radiographs, and pathology reports on 4805 free-flying birds of prey admitted to the *Faculté de médecine vétérinaire* between 1986 and 2007. Evidence of gunshots was detected in 6.4% of the birds. Large species, such as ospreys, turkey vultures, snowy owls, and bald eagles represented the most frequently targeted species.The percentage of shot birds has decreased from 13.4% during 1991 to 1992 to 2.2% in 2006 to 2007. Potential reasons for this trend include a decrease in the presence of firearms in raptor habitats and changes in human attitude towards raptorial birds.

Résumé — Mortalité et morbidité associées aux blessures par projectiles d'armes à feu chez les oiseaux de proie au Québec : de 1986 à 2007. Même si les oiseaux de proie sont protégés depuis des décennies au Québec, ils sont toujours régulièrement victimes du braconnage. L'objectif de la présente étude était de caractériser les cas de blessures par projectiles d'armes à feu ayant eu lieu au Québec au cours des deux dernières décennies. Nous avons examiné les dossiers cliniques, les radiographies et les rapports de pathologie de 4805 rapaces en liberté admis à la *Faculté de médecine vétérinaire* entre 1986 et 2007. Des signes de blessures par projectiles d'armes à feu ont été décelés chez 6,4 % des oiseaux. Les espèces de grande taille, comme les balbuzards pêcheurs, les urubus à tête rouge, les harfangs et les pygargues à tête blanche, représentaient les espèces les plus fréquemment ciblées. Le pourcentage des oiseaux atteints est passé de 13,4 % en 1991–1992 à 2,2 % en 2006–2007. Les raisons potentielles de cette baisse incluent une réduction de la présence des armes à feu dans les habitats des rapaces et une modification des attitudes des humains envers les rapaces.

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Introduction

Humans have considerable impact on the environment and wildlife. Habitat destruction, pollution, and poaching are some of the dangers that threaten wild animals, including birds of prey. Being at the top of the food chain, raptors are prone to the bioaccumulation of various pesticides with potentially harmful effects (1). Some species are, in addition, sensitive to habitat loss (1). Anthropogenic, often fatal, injuries caused by events such as car collisions, structure impacts, and poaching by trap or gunshot, have been frequently described in raptorial birds (2–12). In the province of Quebec, Canada, several species of birds of prey are classified as vulnerable, or are quickly approaching such a status. Hunting or trapping of any bird of prey species is prohibited by law in the province (*Loi sur la conservation et la mise en valeur de la faune*, L.R.Q.,c. C-61.1).

The *Clinique des oiseaux de proie* (COP), *Faculté de médecine vétérinaire de l'Université de Montréal* has treated injured and ill raptors for over 20 y. These birds of prey, retrieved in all regions of the province, are transferred to the rehabilitation center through the network of the *Union québécoise de réhabilitation des oiseaux de proie* (UQROP). In addition to its mandate of overseeing raptor rehabilitation in the province, the UQROP also has provided comprehensive educational programs on the promotion of raptor conservation since 1990.

Although raptors have been protected for decades in Quebec, they are still regular victims of illegal shooting (*Ministère des Ressources naturelles et de la Faune du Québec*, unpublished observation). The amplitude and trends of this phenomenon have not been properly explored in the province of Quebec. Consequently, we aimed to better characterize cases of illegal shootings of raptors across the province of Quebec over the last 2 decades, in order to evaluate trends in regard to species, time, and geography.

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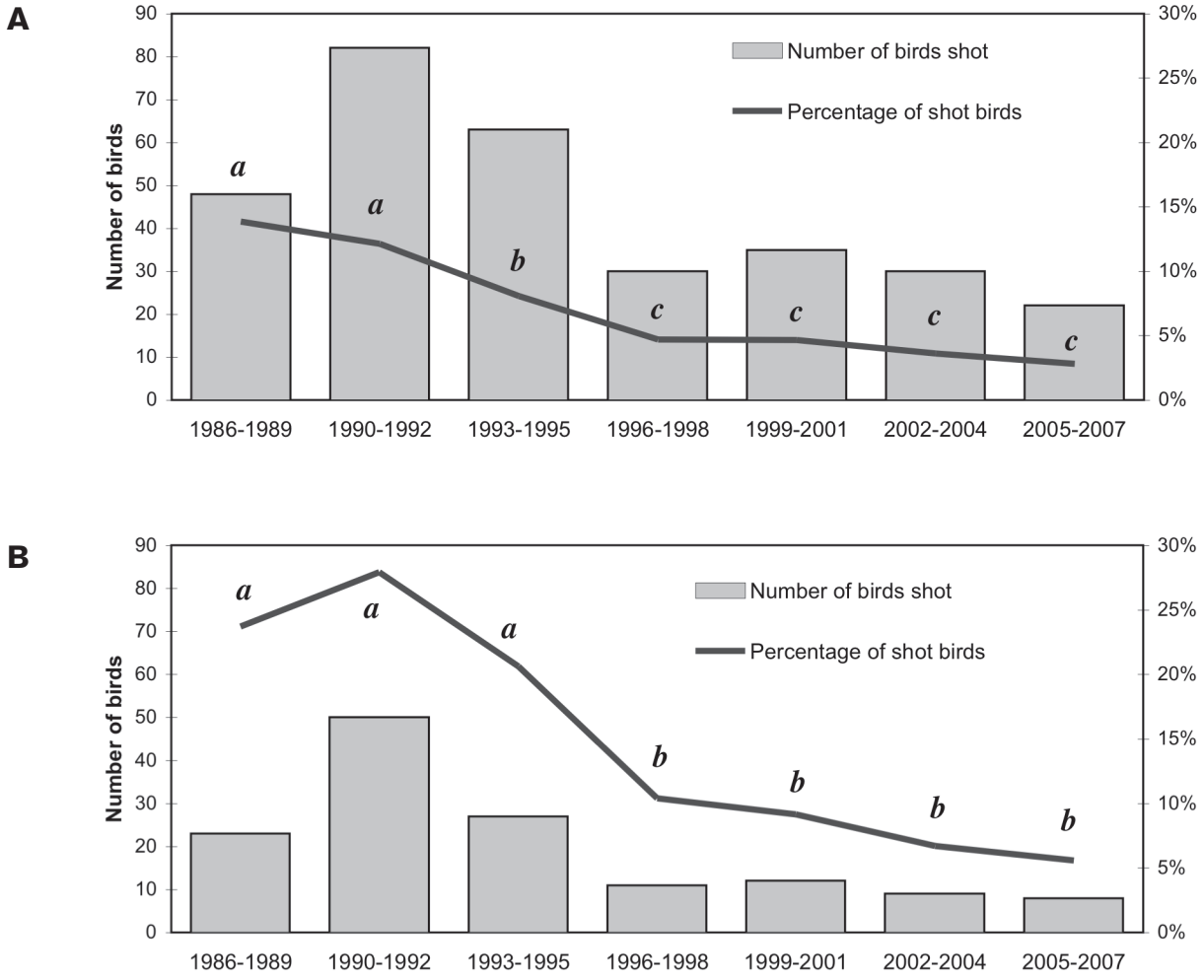

Figure 1. Variations over the years in the number of birds of prey that were poached through use of firearms and were admitted to the *Clinique des oiseaux de proie*, Quebec. A – All bird species admitted ($n = 4805$). B – Numbers using the 7 species most frequently shot (osprey, turkey vulture, snowy owl, northern hawk owl, rough-legged hawk, bald eagle, and red-tailed hawk) ($n = 921$). Years that have the identical subscripts are not significantly different for the percentage of birds shot ($P \geq 0.05$).

Materials and methods

The rehabilitation of raptors is overseen by a provincial network (UQROP) formed of various regional satellites: veterinary clinics, zoos, wildlife conservation officers, and registered rehabilitation centers. Almost all injured or sick birds of prey admitted through these regional nodes are transferred to the provincial raptors hospital (COP) for clinical evaluation and appropriate treatment.

For the retrospective study, all clinical files belonging to free-ranging birds of prey located in the province of Quebec, that were admitted to the COP between June 1, 1986 and December 31, 2007 were reviewed. Only birds from the order Strigiform (owls), the order Falconiform (hawks, falcons, eagles, and ospreys), and the family *Cathartidae* (turkey vulture) were included in this study, since these birds meet the definition criteria for birds of prey.

The species, gender (when feasible), cause and date of admission, and the latitude and longitude of the nearest town from the location of its discovery were recorded for each bird. We also noted whether or not a full body radiograph was taken and the outcome of the rehabilitation process (euthanasia, death, release, or under human care). For this study, birds were categorized into 3 age groups according to the North American Bird Banding Manual used by the Canadian Wildlife Service Bird Banding Office: L (local) — a young bird incapable of sustained flight; HY (hatching year) — a bird capable of sustained flight and known to have hatched during the calendar year; and AHY (after hatching year) — a bird known to have hatched earlier than the current calendar year. Evidence of poaching by means of firearms was established by visualization of projectiles compatible with gunshot on the radiographs during physical or postmortem examination. For statistical analysis, locations of raptor discoveries were recorded and compared through the use of administrative regions *(Commission de toponymie du Québec)*. The Laval, Montreal and Montérégie regions were grouped into the Grande région métropolitaine de Montréal. Abitibi-Témiscamingue and Nord-du-Québec were also united due to the small number of submissions from these 2 northern regions. The admission dates were gathered by season as follows: spring — March 21 to June 20; summer — June 21 to September 20; fall — September 21 to December 20; and winter — December 21 to March 20. Data were then organized

Table 1. The percentage of birds of prey admitted to the *Clinique des oiseaux de proie* in Quebec that had been poached with the use of firearms, categorized according to the species and in relation to the season received ($n = 4805$)

Species	Percentage of shot birds (birds shot/total birds)				
	Total	Spring	Summer	Fall	Winter
Osprey *(Pandion haliaetus)*	29.8 (37/124)	54.0 (27/50)	14.3 (6/42)	12.5 (4/32)	0 (0/0)
Turkey vulture *(Cathartes aura)*	29.2 (14/48)	33.3 (4/12)	26.7 (4/15)	30.0 (6/20)	0 (0/1)
Snowy owl *(Bubo scandiacus)*	18.8 (39/208)	20.0 (8/40)	14.3 (1/7)	15.2 (19/125)	30,6 (11/36)
Northern hawk owl *(Surnia ulula)*	15.9 (10/63)	4.8 (1/21)	0 (0/6)	31.6 (6/19)	17.6 (3/17)
Rough-legged hawk *(Buteo lagopus)*	15.4 (24/156)	11.5 (3/26)	0 (0/10)	17.6 (19/108)	16.7 (2/12)
Bald eagle *(Haliaeetus leucocephalus)*	13.6 (11/81)	9.1 (1/11)	11.8 (2/17)	17.1 (7/41)	8.3 (1/12)
Red-tailed hawk *(Buteo jamaicensis)*	11.5 (42/365)	14 (6/43)	4.0 (4/101)	15.4 (31/201)	5.0 (1/20)
Barred owl *(Strix varia)*	10.3 (21/204)	3.1 (1/32)	0 (0/27)	19.5 (15/77)	7.4 (5/68)
Golden eagle *(Aquila chrysaetos)*	8.3 (2/24)	0 (0/1)	33.3 (1/3)	5.6 (1/18)	0 (0/2)
Great horned owl *(Bubo virginianus)*	8.1 (44/545)	3.4 (4/116)	4.9 (8/162)	15.6 (23/147)	7.5 (9/120)
Peregrine falcon *(Falco peregrinus)*	9.1 (9/99)	7.1 (1/14)	0 (0/40)	18.4 (7/38)	14.3 (1/7)
Northern Harrier *(Circus cyaneus)*	7.3 (9/124)	15.4 (2/13)	1.1 (1/91)	30.0 (6/20)	0 (0/0)
Great gray owl *(Strix nebulosa)*	6.1 (3/49)	5.9 (1/17)	0 (0/1)	15.4 (2/13)	0 (0/18)
Cooper's hawk *(Accipiter cooperii)*	5.3 (7/131)	5.9 (1/17)	1.8 (1/55)	16.1 (5/31)	0 (0/28)
Northern Goshawk *(Accipiter gentilis)*	3.7 (7/189)	0 (0/29)	0 (0/69)	3.3 (2/60)	16.1 (5/31)
Boreal owl *(Aegolius funereus)*	3.2 (2/62)	0 (0/15)	0 (0/5)	14.3 (2/14)	0 (0/28)
Sharp-shinned hawk *(Accipiter striatus)*	2.3 (8/341)	6.1 (5/82)	0 (0/192)	6.8 (3/44)	0 (0/23)
Merlin *(Falco columbarius)*	2.2 (9/413)	3.4 (2/59)	2.1 (6/285)	1.9 (1/52)	0 (0/17)
Broad-winged hawk *(Buteo platypterus)*	2.1 (4/194)	10.7 (3/28)	0.7 (1/153)	0 (0/12)	0 (0/1)
Red-shouldered hawk *(Buteo lineatus)*	2.0 (1/51)	0 (0/12)	0 (0/33)	20.0 (1/5)	0 (0/1)
Long-eared owl *(Asio otus)*	1.5 (1/66)	0 (0/23)	0 (0/17)	4.8 (1/21)	0 (0/5)
American kestrel *(Falco sparverius)*	0.6 (4/666)	0 (0/135)	0.4 (2/450)	2.2 (1/45)	2.8 (1/36)
Northern saw-whet owl *(Aegolius acadicus)*	0.6 (2/326)	0 (0/50)	0 (0/75)	0.6 (1/172)	3.4 (1/29)
Other species[a]	0 (0/276)	0 (0/40)	0 (0/39)	0 (0/117)	0 (0/80)
Total birds admitted	6.4 (310/4805)	7.9 (70/886)	2.0 (37/1895)	11.4 (163/1432)	6.8 (40/592)
Total radiographed birds	10.6 (280/2636)	13.1 (64/490)	3.5 (33/946)	17.2 (151/880)	10.0 (32/320)

[a] Eastern screech owl *(Megascops asio)* n =166; short-eared owl *(Asio flammeus)* n = 107; gyrfalcon *(Falco rusticolus)* n = 2; barn owl *(Tyto alba)* n = 1.

in a computerized database (Microsoft Excel 2003; Microsoft Canada Corporation, Mississauga, Ontario). Statistical analysis was performed using the NCSS Trial statistical software (NCSS, Kaysville, Utah, USA); $P \leq 0.05$ was considered significant.

Results

Between June 1, 1986 and December 31, 2007, a total of 5300 free-ranging birds of prey found in the province of Quebec were admitted to the COP. Of these birds, 495 aged as "L," were removed from the data set, since they were not considered at risk of being gunshot victims. The results, therefore, are based on the evaluation of 4805 cases of raptors that had been admitted either alive for rehabilitation or dead thereby permitting necropsy. Standard radiographic examinations were performed on 2638 (54.9%) of these birds. Evidence of trauma induced by firearms was detected in 310 of the 4805 raptors (6.5%). In 280 birds (90.3% of the positive gunshot cases), evidence of gunshot was observed on the radiographs. In the remaining birds, firearm implication was based on the observation of bullet fragments associated with the wounds. Based on either the history of the case, or the evidence suggesting a connection between the presenting injuries and the projectiles identified, shooting was considered to be the cause of admission in 296 of the 310 birds showing signs of trauma from firearms. Another cause of admission was identified in the other cases where gunshot was visible on the radiographs; it was speculated that these birds might have been shot weeks or months before being admitted.

The number of birds admitted for each species per season and the number of birds that were shot are presented in Table 1. More than half of the cases associated with firearm poaching were seen in the fall. The number and percentage of poached birds admitted over the years are presented in Figure 1A. Since the beginning of the 1990s, the absolute and relative numbers of admitted birds poached using firearms have decreased from 65 birds (13.4% of the birds admitted) during the combined years of 1991 and 1992, to 12 birds (2.2% of the birds admitted) during the last 2 years of this study. The percentage of birds admitted that had been shot during 1987 to 1997 (9.4%) was significantly greater than the percentage recorded from 1998 to 2007 (3.8%) ($P < 0.001$). The same trend was observed when the analysis was limited to the 7 most commonly shot species, which was done in an attempt to reduce the variation in abundance of numerous species over the years (Figure 1B).

Comparison between age groups revealed that hatching year birds were less frequently admitted for trauma induced by firearms (6.9%) compared with adult birds (12.2%) (n = 2468 birds of known age; $P < 0.001$). There was no statistical difference between the males and the females in regard to the percentage of the birds that had been shot (n = 2036 birds of known sex; $P = 0.63$).

The distribution of cases among administrative regions is presented in Table 2. Birds found in *Saguenay-Lac-Saint-Jean* were the most frequently shot (11.9% of the birds admitted from this region); however, the total volume of birds from this region was low (n = 42). Birds from *Abitibi-Témiscamingue/Nord du Québec* were the least frequently shot (3.4%). Unfortunately, sample bias and a relatively low number of birds admitted from this region (n = 176) prevent any conclusive interpretation of this finding.

Table 2. The percentage of birds of prey with evidence of poaching, by use of firearms, that were admitted to the *Clinique des oiseaux de proie* in Quebec classified by administrative region ($n = 4802$)

Administrative regions	Percentage of birds shot (birds shot/total birds)
Saguenay–Lac-Saint-Jean	11.9 (5/42)
Chaudière-Appalaches	9.2 (28/305)
Lanaudière	8.4 (20/238)
Mauricie	8.0 (19/238)
Outaouais	8.0 (10/125)
Centre-du-Québec	7.7 (15/194)
Gaspésie–Îles-de-la-Madeleine	7.3 (9/124)
Côte-Nord	7.0 (19/271)
Capitale-Nationale	6.8 (36/527)
Estrie	6.8 (19/280)
Bas-Saint-Laurent	6.6 (15/228)
Grande région métropolitaine de Montréal[a]	5.5 (97/1777)
Laurentides	4.3 (12/277)
Abitibi-Témiscamingue/Nord-du-Québec	3.4 (6/176)

[a] Includes the regions of Montréal, Laval, and Montérégie.

Among the shot birds presented alive to the COP ($n = 279$), 39.8% were rehabilitated and released into the wild, 49.8% died or were euthanized, and 10.4% were considered non-releasable and placed under human care.

Discussion

Evidence of shooting was present in 6.4% of the birds of prey admitted to the COP over the last 2 decades; however, the results should be interpreted with caution, due to sampling biases associated with the admission of the birds within the rehabilitation program. Sampling of injured birds that relies on reports from members of the public is not randomized and tends to overestimate anthropogenic causes of morbidity and mortality, since birds with such injuries are more easily found by people (6,8,10). Therefore, we are unable to extrapolate our results to the wild raptor population. The percentage of birds with evidence that was compatible with poaching was higher when only the birds that had been radiographed were considered (10.6%) compared with the percentage recorded in all the admitted birds (6.4%). This suggests that cases of poaching in birds that were not radiographed were consequently missed. However, since radiographs are done routinely in birds with external wounds or fractures, the number of missed cases is presumed to be low.

The frequency of shot birds in the present study is lower than those reported in raptors from Iowa (17%) (6) and Greece (38.8%) (11), similar to reports from Florida, USA (7.5%) (8), but higher than results from rehabilitation center surveys in Colorado, USA (1.5%) (10), Virginia, USA (3.7%) (12), and Australia (3.8%) (9).

The 7 species found to have the highest proportion of individuals shot (osprey, turkey vulture, snowy owl, northern hawk owl, rough-legged hawk, bald eagle, and red-tailed hawk) are those that fly in open environments such as fields, marshes, lakes, and margins of logging trails (13). This natural behavior increases the odds of being seen and therefore being shot by poachers. The osprey is the species with the highest proportion of admitted gunshot-positive cases. The elevated incidence in the osprey is most likely due to the conflicting relationship between this fish-eating species and the aquaculture industry, in particular, the aquaculture workers (14). During spring migration to summer nesting grounds, ospreys will often take advantage of easily accessible prey in the shallow man-made ponds present in aquaculture facilities. This behavior increases their risk of being targeted by irritated owners. Although all species of birds of prey are protected under provincial regulation, one can legally destroy a raptor if it causes damage and this depredation cannot be prevented by non-lethal measures (article 67 in the *Loi sur la conservation et la mise en valeur de la faune*). In such situations, the kill must be reported to a wildlife officer (article 68). However, the destruction of ospreys for depredation is very rarely reported, and it is likely more frequent than our figures suggest. Boreal and subarctic species like the snowy owl, the northern hawk owl, and the rough-legged hawk are overrepresented in the poached birds category. Individuals from these northern species are, in general, less apprehensive of humans than their southern counterparts (1), which makes them easier to approach and therefore easy targets.

Some of the northern species, such as the snowy owl and the northern hawk owl, cyclically invade the more densely populated and agricultural southern regions (15–17), which increases their chances of being shot. Furthermore, large size and habitat use, relative lack of fear of humans, and diurnal activity are factors that probably contribute to making the snowy owl more prone to poaching.

Small and secretive species living beneath the tree cover, like the eastern screech owl, the northern saw-whet owl, and the sharp-shinned hawk (13) were rarely victims of trauma induced by firearms, most likely because they are difficult to locate. Results regarding age class are surprising, because it was expected that inexperienced and naïve HY birds would be more likely to be shot than older AHY individuals. This could be associated with the fact that a large proportion of the HY birds are admitted during their first summer prior to the hunting season and that HY birds are likely more prone to other health problems, such as emaciation.

Percentages of shot birds fluctuated among the 4 seasons (Table 1). In our study, peak percentages were observed in the fall, which has also been reported in studies in Iowa (6) and Virginia (12). A peak in the fall may correlate partially with hunting season. It is also possible that the increased movement of birds associated with fall dispersion and migration results in more frequent encounters with humans, but more importantly, poachers. During the spring, most of the birds shot (38.6%) were ospreys, whereas in the winter, 72.5% of the birds shot were owls.

Very few differences were noticed among the administrative regions as to the proportion of birds shot. *Saguenay-Lac-Saint-Jean* had the highest rate, but the number of birds admitted from this region was too low to draw any significant conclusions. In addition, the comparison between administrative regions should be done cautiously, since human population density, which has a direct impact on the probability of an injured bird being located and subsequently admitted, is highly variable in Quebec. Differences in the relative frequency of raptor mortality secondary to poaching are reported in different parts of the world. A recent

Greek study reported a high rate of gunshot-related admissions (38.8%) (11), while in East Africa, only 2.3% of the 43 raptor necropsies performed between 1970 and 1973 (3) associated the cause of death with poaching. Cooper explained this finding by suggesting that Africans naturally have little animosity directed towards birds of prey (3).

Sampling efforts and methods used have been similar over the years; therefore, the temporal trend observed in this data set is probably a good estimation of the actual annual variability of illegal shooting of raptors in Quebec. Over the last 2 decades we have observed a significant decrease in the percentage of admitted birds having suffered a gunshot, with the exception of a peak that occurred in 1991. This peak was most likely a consequence of a massive invasion of snowy owls, a commonly poached species, in the southern regions of the province that year (18). Analysis of past and recent studies of poaching in raptors and comparison to the study herein shows equivalent findings on the temporal tendency of gunshot cases. In the 1960's and 1970's, shooting was reported as a major cause of mortality: 59.2% of bald eagles in the USA between 1960 and 1965 (n = 76) (2); 31.6% of gyrfalcons in Iceland between 1966 and 1973 (n = 38) (4); 18.7% of 273 raptors from Canada and the USA between 1969 and 1981 (5) and 21.0% of 1051 birds admitted to the Raptor Rehabilitation Center of the University of Minnesota, USA between 1969 and 1979 (5). In the 1980s and 1990s, cases of poaching were relatively less common: 17.0% in Iowa, USA in 1986–1987 (n = 60) (6); 12.3% in Hawaii, USA (n = 81) (7); 7.5% of the 279 birds admitted to the University of Florida between 1988 and 1994 (8). The variation in the relative abundance of the different species that have been admitted over the years in our rehabilitation center could be responsible, at least in part, for the temporal changes in the percentages of admitted birds with evidence of a gunshot. The relative abundance of merlins and sharp-shinned hawks, 2 species that are relatively uncommonly shot, has shown an increase over the years. Snowy owls, however, are less frequently present than they were at the beginning of the 1990s (data not presented). This species shift should be seen as a potential explanation for the gradual decrease in the number of poaching cases over the past years. However, when the species variation is controlled by concentrating on only the most commonly shot species, this temporal decrease is still obvious and statistically significant (Figure 1B). This finding indicates that the variation in the percentage of birds shot is not only due to the variation in the abundance of the species. Two other factors can potentially explain the apparent decreasing trend of raptorial poaching in the province. Firstly, since 1986, the number of hunting licences sold in Quebec has steadily decreased (*Ministère des Ressources naturelles et de la Faune du Québec,* Canadian Wildlife Service). This decrease in recorded hunters, which parallels the decrease in the proportion of admitted birds shot, is likely to be associated with a diminishing use of firearms in the habitat of raptors, which therefore reduces illegal hunting opportunities. It is also possible that hunters in Quebec have greater awareness and are therefore less prone to shoot a protected bird instead of game birds. Secondly, we can speculate that the comprehensive outreach education program supported by the UQROP has contributed to increasing public awareness of the importance of raptorial birds in our ecosystems and by doing so has contributed to decreasing malicious behavior of humans who encounter raptors in the wild. Forty percent of birds admitted alive following a poaching incident were released into the wild. This result is similar to the rate reported in Virginia, USA, where the release rate was 35% (12).

This reduction in the percentage of shot birds over the years is promising; however, educational programs, law enforcement, and other mitigating measures in place to protect birds of prey should be maintained and reinforced to optimize the health of raptor populations.

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