# Mortality factors and nestling diet of the Eagle owl *Bubo bubo* in Switzerland

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Ich widme diese Arbeit meinen beiden Nichten Mai und Airi als Repräsentantinnen der nächsten Generation
Ich hoffe, sie werden von der heutigen Forschung und den heute unternommenen Verbesserungen im Naturschutz profitieren und auch in Zukunft noch das Glück haben,
einen Uhu in freier Wildbahn beobachten zu dürfen

I dedicate this work to my two nieces Mai and Airi as representatives of the next generation
I hope they will profit from the conservation biology research and management plans undertaken nowadays to preserve biodiversity and also in future will still have the chance to see an Eagle owl in its natural habitat

# 1 Abstract


1. In order to protect the Swiss Eagle owl (*Bubo bubo*) population, it is important to know its resource utilization patterns as well as the contribution of breeding success and mortality to the overall population dynamics. This study, performed in 2004, presents a synthesis of data obtained on mortality factors and nestling diet. It is part of the Eagle owl long-term research programme of the division of Conservation Biology of the University of Bern launched in 2002.

2. *Mortality*: I studied a sample of 340 dead Swiss Eagle owls collected since 1829. The number of yearly found individuals increased until 1994 but decreased again afterwards. 75.9% of all the recorded Eagle owls with known age did not reach their $4^{th}$ calendar year. The two most important mortality factors were electrocution (31%) and traffic (car and train) accident (27%). There were significantly more females recorded than males. Early death due to anthropogenic factors appears to be the main cause of the slow demographic recovery or local extinction of the Swiss Eagle owl population.

3. *Nestling diet*: Eagle owl parents provisioned, on average, 1.0 ± 0.1 (mean ± se) prey item per nestling and night. In terms of frequency and biomass, hedgehogs and rabbits were the most important prey species. Diet composition differed from a study that was conducted at the same site one year before.

4. *Conclusions and applications*: Our analysis of the dead Swiss Eagle owls shows, that car and train accidents are as important mortality factors as electrocution. However, dangerous pylons can be mitigated easily, in contrary to traffic hazards which may even increase further. Concerning nestling diet, our results suggest that there was no food shortage at site A during 2004. By means of radio tracking it would be possible to assess actual sources of mortality in Swiss Eagle owls, as that method has no biases, contrary to the analysis of dead found birds.

# Zusammenfassung


1. Um die schweizerische Uhupopulation (*Bubo bubo*) schützen zu können, ist es wichtig, die Nutzung der Ressourcen sowie den Beitrag des Bruterfolgs und der Mortalität an der gesamten Populationsdynamik zu kennen. Diese Studie, durchgeführt im Jahr 2004, beinhaltet eine Synthese der Daten, welche zur Mortalität und Nestlingsnahrung der Uhus in der Schweiz erfasst wurden. Sie ist Teil der Uhu-Langzeitstudie der Abteilung Conservation Biology der Universität Bern, welche 2002 gestartet wurde.

2. *Todesursachen*: Ich habe eine Stichprobe von 340 toten schweizer Uhus, gesammelt seit 1829, analysiert. Die Anzahl der jährlich gefundenen Individuen nahm bis 1994 zu, nahm danach aber wieder ab. 75.9% der Uhus starben vor dem 4. Kalenderjahr. Die beiden wichtigsten Mortalitätsfaktoren waren Stromschlag (31%) und Verkehrsunfälle (27%). Es wurden signifikant mehr Weibchen als Männchen gefunden. Die frühe Mortalität der Uhus, meist bedingt durch anthropogene Faktoren, scheint der Hauptgrund für die nur sehr langsame Zunahme oder lokale Auslöschungen der Uhupopulation zu sein.

3. *Nestlingsnahrung*: Die Uhueltern haben durchschnittlich 1.0 ± 0.1 (mw ± sf) Beutetier pro Nestling und Nacht ans Nest gebracht. Igel und Kaninchen waren die beiden Hauptbeutetiere bezüglich Anzahl und Biomasse. Die Nahrungszusammensetzung unterscheidet sich von einer Studie, welche an der gleichen Stelle ein Jahr zuvor durchgeführt worden ist.

4. *Schlüsse und Anwendungsmöglichkeiten:* Unsere Analyse der in der Schweiz tot gefundenen Uhus ergab, dass Strassen- und Bahnverkehr als Todesursachen ebenso wichtig waren wie Stromschlag. Allerdings kann man gefährliche Strommasten unschädlich machen, wohingegen Verkehrsunfälle wohl auch in Zukunft weiter zunehmen werden. In Bezug auf die Nestlingsnahrungsanalyse zeigen unsere Resultate, dass es keine Nahrungsknappheit am Ort A in 2004 gab. Durch Radiotelemetrie wäre es möglich, die tatsächlichen Quellen der Mortalität der schweizer Uhus aufzuzeigen, da diese Methode, im Gegensatz zur Analyse von Todfunden, keinen Bias beinhaltet.

# 2 Introduction

## 2.1 Status of the Eagle owl in Europe & Switzerland

The Eagle owl *Bubo bubo* is one of Europe's top predator species. It was once widely distributed over almost all kinds of habitats, from the Siberian taiga to the macchia of southern Europe and from lowland up to alpine environments (Desfayes & Géroudet 1949, Glutz von Blotzheim & Bauer 1980, Mikkola 1983, Mebs & Scherzinger 2000). Thorough persecution by man until the middle of the 20$^{th}$ century led to a steep decline in the population. Adult Eagle owls were shot (for example in Grisons, 294 individuals during 1887-1901, Corti 1947) and young owls were taken out of the nest to be used for the so-called "Hüttenjagd" (Desfayes & Géroudet 1949, Glutz von Blotzheim & Bauer 1980). This led to a withdrawal of the last Eagle owls into remote regions like the Alps (Frey 1981). In wide parts of Europe they went extinct (von Frankenberg und Ludwigsdorf et al. 1984, Frei 1984, Grüll & Frey 1992). Moreover, the remaining population was progressively subjected to new risks linked to rapidly developing human activities (Desfayes & Géroudet 1949; Trüb 1979; Glutz von Blotzheim & Bauer 1980; Frey 1981; Piechocki 1984; Grüll & Frey 1992; EGE 1999; Leditznig 1999; Langgemach et al. 2000; Asmussen 2001; Dalbeck & Breuer 2001; Rubolini et al. 2001; Sergio et al. 2004).

In Switzerland, the Eagle owl was officially protected by legislation in 1925. In 1998, the Swiss Eagle owl population was estimated to consist of 120 reproductive pairs (Schmid et al. 1998; Mosimann-Kampe et al. 1998). In the canton of Valais a trend towards recolonisation of formerly abandoned sites has been observed since 1985 (Arlettaz 1988; Mosimann-Kampe et al. 1998).

## 2.2 Aims of the study

In order to draw appropriate recommendations for preserving an endangered species, it is important to recognize first its resource utilization patterns as well as the contribution of breeding success and mortality to the overall population dynamics. Therefore, the division of Conservation Biology of the University of Bern has launched a long-term research programme in 2002 to understand the reasons for the only slow population increase of the Eagle owl in Valais. This diploma study is part of the programme. Its goal is to uncover the relative importance of different mortality factors affecting the whole Swiss population and to further investigate the diet of nestlings at several broods, continuing the research by Nyffeler (2004).

The Eagle owl has difficulties to survive in the modern landscape, which is full of risks for a large nocturnal raptor: aerial cables, pylons with electric hazard, traffic, etc. We may expect the Eagle owl to function as an umbrella species (Lambeck 1997; Miller et al. 1998/1999) for any large-sized birds inhabiting highly anthropized habitats.

### 2.2.1 Nestling diet

A reduction of food resources has been claimed as a major cause for the diminution of Eagle owl populations in certain regions (Desfayes & Géroudet 1949; Görner 1998, Choussy 1971, Knobloch 1981), although this species is a food opportunist throughout Europe (Burnier & Hainard 1948; Blondel & Badan 1976; Glutz von Blotzheim & Bauer 1980; Mikkola 1983; Bayle et al. 1987; Bayle 1992; Cekoni-Hutter 1998; Dalbeck 2003). Actually, prey availability and biomass provisioned to Eagle owl nestlings have a direct influence on reproductive success, as shown by previous studies of pellets and/or prey remains at the nest (Richard 1923; Desfayes & Géroudet 1949; Desfayes 1951; Bezzel & Lechner 1968; Wagner & Springer 1970; Orsini 1985; Bayle 1987; Bayle et al. 1987; Arlettaz 1988; Bayle 1992; Martinez et al. 1992; Wadewitz & Nicolai 1993; Dalbeck 1996; Rathgeber & Bayle 1997; Cekoni-Hutter 1998; Leditznig 1999; Dalbeck 2000; Serrano 2000; Leditznig et al. 2001; Martinez & Zuberogoitia 2001; Marchesi et al. 2002a; Marchesi et al. 2002b; Penteriani et al. 2002; Dalbeck 2003). Yet, these approaches have inherent biases. In particular, diet analyses based on pellets systematically overestimate the proportion of small mammals, whereas the analysis of prey remains is biased towards large prey items and birds (Förstel 1995; Leditznig 1999). To correct for this bias, we rely on video to study the actual diet of Eagle owl nestlings. More specifically, we addressed the following questions:

1. What kinds of prey are brought to the nest and which are most prevalent?
2. Which prey accounts for most of the biomass provisioned to the chicks?
3. Which quantity of biomass is delivered per chick and night?

### 2.2.2 Mortality factors

All estimations of risks and mortality factors affecting the dynamics of Eagle owl populations are based on records of individuals found injured or dead. Electrocution has frequently been reported as the main cause of death, followed by traffic accidents (car, train) and collisions with cables (Wickl 1979; Marti 1998; Sergio et al. 2004). There are different suggestions in literature regarding the time of the year when mortality incidents are highest (Piechocki, 1984, Rubolini et al., 2001). No synthesis exists as regards the Swiss Eagle owl population, however.

In this study we investigated risks and mortality factors of the Swiss population, relying on extant data available since 1829 from museums and rescue centers. We addressed the following questions: 1. Has there been a change in the most important mortality factors over time? 2. What are the proportion of young, subadults and adults among the recovered owls? 3. Is there an increased mortality during juvenile dispersal (September until December)? 4. Are the causes of death age-dependent, except as regards electrocution, since it has been postulated that owls can learn to avoid traffic and collision hazards, but not electric pitfalls (Arlettaz 1988, Radler 1992)? 5. Is the there a sex-specific mortality?

# 3 Material and methods

## 3.1 Nestling diet

We video-monitored food provisioning to nestlings at two sites in the Swiss Rhône valley in 2004. This 1-6 km wide plain is flanked with scarps and rock faces. Both nesting sites were near the valley floor. Site A was situated near the city of Sion, Site B about 20 km to the west. The main habitat around both sites constituted of intensively used agricultural land on the plain, interspersed with small woods, the Rhône river and several gravel-pit lakes. The plain was fragmented by roads, railways and canalized rivers. Settlements and recreational facilities were numerous. On the north-exposed mountain slope there were mainly apricot orchards, forests, meadows and human settlements. On the south-exposed slopes there were mainly vineyards, forests and meadows.

Two infrared video sets were used, a Monacor CCD 140 IR (site A) and a Monacor TVG-300 camera (site B), each with an infrared light source (WF-I/LED80-230, Videor Technical E. Hartig GmbH, Rödermark, Germany). Video tape recorders had a long play function (Sanyo, SRT 7168P, Osaka, Japan). Equipment was automatically switched on and off using a digital clock timer. Picture quality was controlled daily with a small portable TV monitor (Sony, GV-D800E, Tokyo, Japan). We recorded 8.5 to 9.5 h of activity on 300 min cassettes (Sony, E-300VG), starting 30 min before sunset and stopping after sunrise. At site A, recording took place from 12 June 2004 to 24 July 2004, covering 45 nights with more than 7 h of filming. 8 nights could not be recorded completely due to technical problems and will be considered only in the analysis of diet composition. At site B, recordings were undertaken from 25 May to 10 June, but only 5 nights yielded data, because the nestling left the filming area.

To standardize the procedure of prey biomass estimations, we used the same figures as Nyffeler (2004). Because parents, mainly the female, were sometimes eating parts of a provisioned prey or removed it from the nest, we estimated the percentage of prey actually eaten by nestlings.

## 3.2 Mortality factors

A questionnaire was sent to all Swiss cantonal hunting and fishery services, bird rescue centers and museums of natural history. We inquired about number of birds collected and/or recorded, date and location of finding, sex and age, cause of mortality, and whether the owl originated from a wild or captive population. The information was often incomplete, especially as regards individuals that stemmed from the 19$^{th}$ and early 20$^{th}$ century. In most cases the age of the animal at death was unknown. We had to age birds (n = 108) on the basis of molt pattern (Martinez et al. 2002). Four age classes could be identified: 1$^{st}$, 2$^{nd}$, 3$^{rd}$ and ≥4$^{th}$ calendar year. 76

owls that were aged by other persons using three age categories ($1^{st}$, $2^{nd}$ and $\geq 3^{rd}$ calendar year) were not checked again by our selves. Additionally, cases of death published in the literature have also been considered (Corti 1933, 1947; Desfayes & Géroudet 1949; Stricker 1950; Witzig 1950; Corti 1952, 1962; Trüb 1979; Schifferli et al. 1980; Strahm 1982; Arlettaz et al. 1990; Meier 1992; Marti 1993; Sermet & Ravussin 1996; Mosimann-Kampe et al. 1998; Nef 2002). For the study of mortality factors we included only birds stemming from free-ranging, wild populations, since Bezzel & Schöpf (1986) showed that the median of the age at death of wild Eagle owls (1.9 years) differed from that of Eagle owls that stemmed from breeding programs (0.43 year). Also, there was a difference in the mortality factors between these two groups. Birds originated from all Swiss cantons but Baselstadt, which is totally urban. We also looked at geographic differences in mortality factors between the Alps and the Jura / Plateau (for canton classifications see Table 1).

## 3.3 Statistical analysis

Univariate comparisons comprised Kruskal-Wallis-tests. Frequency distributions were tested using contingency table $\chi^2$-tests. The sex ratio was tested by a binomial z-test. Statistical analyses were run with the program JMP5 (SAS Institute Inc. 2003, Cary, NC, USA).

# 4 Results

## 4.1 Nestling diet

At site A, there were 79 prey items brought to the nest. We identified 14 prey categories (Table 2). Mammals made up 76% of prey item frequency and 78.4% of overall biomass, birds 23% (21.4% biomass) and amphibians 1% (0.2% biomass). In terms of frequency and biomass, hedgehogs were the most important prey species, with 29.1% of frequency and 45.8% biomass, respectively, followed by rabbits (21.5% and 20.7%) and fat dormice (17.1% and 5.0%).

The food provisioned per nestling and night amounted to a mean biomass of 351 g. The parents provided, on average, 1.0 ± 0.1 (mean ± se) prey per chick and night. There were 6 nights with no food provisioning recorded. No feeding was recorded during a maximum of two consecutive nights (17 and 18 July). Prey items were provisioned evenly throughout the night (Kruskal Wallis test: $H = 10.15$, $df = 8$, $p = 0.25$; Fig. 1).

At site B, videos could be recorded for 5 nights only. The following 5 prey items were noted: 1 juvenile hare, 1 small rodent (*Microtus arvalis*?), 2 black medium-sized birds (Black birds?) and parts of a larger bird (Common kestrel?).

## 4.2 Mortality factors

### 4.2.1 Spatio-temporal patterns of mortality

In total, we could collect data from 340 wild-born Eagle owls. From 313 birds the canton of discovery was known (Table 1). Moreover, in 226 cases, the mortality factor had been identified properly.

There was a marked increase in the number of dead Eagle owls recorded since 1965, with a peak in the early 90s and a slight drop afterwards until 2004 (Fig. 2 and 3). The collected animals were not evenly distributed across the Swiss cantons. Almost half (46%) of the data came from the Grisons, followed by Bern (9%), Ticino (7%) and Valais (7%) (Fig. 4). Each of the other 20 cantons had less than 4% of records (Table 3).

The seasonal distribution of mortality did not differ significantly between younger owls (i.e. from August of birth year until July of second year) and older owls ($\chi^2$-Test, $\chi^2=3.18$, $df = 5$, $p = 0.67$; Fig. 5).

### 4.2.2 Causes of mortality

The two most important mortality factors were electrocution (31%) and traffic accident (27%; Fig. 6), followed by collisions with a cable or fence (13%), direct human persecution (13%), illness/weakness (8%) and other factors (8%). Although there was a trend towards more traffic accidents (37%) in fledged 1st year Eagle owls compared to older owls (31%; Fig. 7 a-b), the absolute frequency of the three mortality classes electrocution, traffic accident and other did not differ significantly in young Eagle owls (fledged 1st year owls) and owls that were older ($\chi^2$-Test, $\chi^2 = 0.43$, df = 2, $p = 0.80$). Also, the importance of the different mortality factors electrocution, traffic accident and other did not differ significantly over the time period 1975-2004 ($\chi^2$-Test, $\chi^2 = 9.08$, df = 10, $p = 0.52$, Fig. 8).

The distribution of the three mortality factors electrocution, traffic accident and others differed significantly between the two regions Alps and Plateau/Jura ($\chi^2$-Test, $\chi^2 = 6.93$, df = 2, $p = 0.03$; Fig. 9). Electrocution was more important in the Alps than elsewhere.

### 4.2.3 Gender and age of dead owls

In our sample, the gender of 50% of all the recorded owls was known. Sex ratio of dead owls (99 females, 70 males) was unbalanced (binomial test, n = 169, Z = 2.34, $p < 0.01$).

Among 184 individuals with known age at death, 42 (22.8 %) died during the first calendar year between August and December, and 14 (7.6 %) during their second calendar year until July, and the remaining at an older age (69.6 %; Fig. 10). There was no significant difference in the distribution of the mortality factors electrocution, traffic accident and other between males and females ($\chi^2$-Test, $\chi^2 = 0.344$, df = 2, $p = 0.84$). 75.9% of the recorded Eagle owls were younger than 4 years (n = 141; Fig. 11).

# 5 Discussion

## 5.1 Nestling diet

Diet composition of nestlings at the same breeding site (site A) differed markedly between 2003 and 2004. While in 2003 the juvenile owls were mainly fed with smaller prey like fat dormouse (Nyffeler 2004), in 2004 they got mainly bigger prey like rabbits, European hedgehogs and crows. In 2003, the owl parents brought no hedgehogs and only one rabbit. We know that at least the female had changed in between (the female in 2003 was radio-tagged and was found electrocuted in early spring 2004). The replacement of at least one adult could thus be the reason why prey preference differed. Unfortunately, we know nothing about the population size of fat dormice in 2004 vs 2003. Was the difference observed due to adult predatory specialization or to varying prey availability? In a study by Dalbeck (2003), nestling diet composition at the same breeding place in two consecutive years was more similar than at two different breeding places in the same year.

In Provence (France), low Eagle owl population density and productivity correlated with a diet based on fat dormice and rats (Bayle et al. 1987). Fat dormice seem thus to be energetically less profitable than, for instance, rabbits and hedgehogs, two very profitable prey which are frequently taken, be it in Valais (Desfayes & Géroudet 1949) or in other regions of Europe (Glutz von Blotzheim & Bauer 1980; Knobloch 1981; Dalbeck 1994).

Our estimation of provisioned food biomass showed a higher mean daily food intake of nestlings (351 g) than what has been reported for adult captive birds (200-500 g a day; Heinroth & Heinroth 1926; Ceska 1978; Mikkola 1983; Zoos of Bern & Basel, Vogelwarte Sempach, and J.Häseli, pers. comm.), or chicks during their first month of life (210-250 g; Heinroth & Heinroth 1926). This would mean that our nestlings at site A got enough food. Moreover, our estimates are minimum figures as chicks can also be fed during the day.

One prey item was brought to the nest per night and juvenile, on average. This corresponds to the former findings by Nyffeler (2004). As Nyffeler, we could also not find any difference in night feeding phenology. No feeding could be recorded on 6 nights, but this does not mean that the nestlings did not feed on these days. Food could have been eaten during the day, outside video-monitoring sessions.

## 5.2 Mortality factors

### 5.2.1 Spatio-temporal patterns of mortality

It is difficult to interpret the overall temporal increase of dead Eagle owls reported in Switzerland. Does this reflect an actual long-term population increase, an increase in casualties, or the fact that people are now more prone to report such findings? An increase in the number of sites occupied in Switzerland has been observed in the last decades (Mosimann-Kampe et al. 1998). Interestingly, our data suggests that a recent decrease might have taken place since the early 1990s. This may reflect the fact that releases of captive birds ceased about at that time, with a subsequent demographic drop in overall productivity.

There are several reasons why the recorded Eagle owls were not evenly distributed over the cantons of Switzerland. First, the strongholds in Switzerland were mostly in the Grisons (Mosimann-Kampe et al. 1998; Schmid et al. 1998). The existence of a very good reporting and collecting history in this canton does possibly also play a role. The other cantons with many reported Eagle owls (Bern, Ticino and Valais) are, like the Grisons, primarily Alpine cantons. Note here that the data on artificially raised and released birds were excluded from our analysis. Although, there might have been some animals found that were the unringed progeny of released owls, we expect that the fate of those young stemming from captive parents would not differ strikingly from normal young born from wild parents.

### 5.2.2 Causes of mortality

In this study, at least 84% of all the recorded mortality cases were connected directly or indirectly to anthropogenic factors. This corresponds well with the findings by Haller (1978), who showed that in his sample all except one of the known mortality cases were due to humans and their facilities. In the former eastern Germany and in Baden Würtemberg (Germany), 66.8% and 88.0% of all recorded dead Eagle owls died due to anthropogenic factors (Rockenbauch 1978; Piechocki 1984). In our sample, 37% of 24 fledged 1$^{st}$ year Eagle owls (August-December) and 31% of the older individuals died after traffic accidents. Unfortunately, this source of mortality can hardly be mitigated. The situation is different as regards electrocution, with 31% of all recorded deaths of Swiss Eagle owls. Electrocution is a widespread problem for Eagle owls. Between 1993 and 2000, for example, 16 out of 22 dead Eagle owls with known mortality cause in the central-eastern Italian Alps died by electrocution (Marchesi et al. 2002b). However, in our study, electrocution played a less important role than in other studies (Piechocki 1980; Rubolini et al. 2001; Dalbeck 2003). There are many safe and easy to apply options to protect dangerous electric power pylons (Mades 1995; Harness & Wilson 2001; Lehman 2001, Marti 1998; Sergio et al. 2004). Although traffic has tremendously increased over the past decades, we could not detect a significant effect on mortality.

We could not show any differences in mortality factors between young and old birds. This corresponds to the findings by Piechocki (1984) in former eastern Germany.

In the Alps, the relative importance of electrocution was higher than in the Plateau / Jura region. Many power lines lead from hydroelectric power plants in high regions of the Alps through valleys down to the supply stations. This might explain why electrocution is higher in the Alps.

### 5.2.3 Gender and age distribution

The distribution of males vs females was significantly unbalanced towards females in our sample, pointing to sex-specific mortality, although there was no difference in the distribution of the different mortality factors between males and females. Females might face greater risks than males. For instance, they may be more prone to electrocution or collision due to their larger wingspan (Glutz von Blotzheim & Bauer 1980). Yet, on the other hand, females stay at the breeding site during a large part of the reproductive time, which may counterbalance size effects. Unfortunately, our sample size was too small to allow testing sex ratio with respect to mortality factors separately.

Given the longevity of Eagle owls (68 years in captivity, 27 years in nature [Mebs & Scherzinger 2000], it is striking that 75.9% of all the recorded Eagle owls in this study did not reach their 4$^{th}$ calendar year. Apparently, younger owls are over-represented in our sample. If the mortality distribution across age classes in our sample actually matches conditions prevailing in nature, then it is to expect that anthropogenic factors seriously affect the dynamics of the Swiss Eagle owl population.

## 5.3 Implications for conservation

Our results of the nestling diet at site A suggest that chicks received enough food during 2004. The change in the delivered prey species from one year to the next illustrates the capability of opportunistic use of prey in the Eagle owls.

Regarding mortality factors, traffic accidents were as important as electrocutions. While it is easily possible to mitigate dangerous electric power pylons, we are not able to reduce traffic accidents.

Unfortunately, studies of dead Eagle owls that were found and collected by humans by chance are presumably biased. Due to the fact that route networks and power lines are located close to settlements there is a higher probability to find injured or dead birds there than in remote areas, where natural mortality might be more frequent (Wickl 1979; Langgemach et al. 2000; Kenward 2002). New, modern techniques are to be used to draw unbiased information about vital parameters, risks and mortality factors, for instance radio tracking. This would enable a calibration of the validity of the data drawn from casualties only.

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# 8 Tables, Figures and Appendix

**Table 1:** Number and percentage of collected dead Eagle owls in the different cantons, with geographic regions (see Fig. 4).

| Canton | N | % | Alps | Plateau | Jura |
|---|---|---|---|---|---|
| AG | 4 | 1.3 | | x | |
| AI | 1 | 0.3 | | x | |
| AR | 1 | 0.3 | | x | |
| BE | 27 | **8.6** | x | x | x |
| BL | 5 | 1.6 | | x | x |
| FR | 12 | 3.8 | x | x | |
| GE | 4 | 1.3 | | x | |
| GL | 6 | 1.9 | x | | |
| GR | 145 | **46.3** | x | | |
| JU | 8 | 2.6 | | | x |
| LU | 2 | 0.6 | x | x | |
| NE | 2 | 0.6 | | | x |
| OW | 5 | 1.6 | x | | |
| SG | 11 | 3.5 | x | x | |
| SH | 3 | 1.0 | | x | |
| SO | 8 | 2.6 | | x | x |
| SZ | 3 | 1.0 | x | x | |
| TG | 3 | 1.0 | | x | |
| TI | 23 | **7.3** | x | | |
| UR | 3 | 1.0 | x | | |
| VD | 11 | 3.5 | x | x | x |
| VS | 22 | **7.0** | x | | |
| ZG | 1 | 0.3 | x | | |
| ZH | 3 | 1.0 | | x | |
| **Total** | **313** | 100 | | | |

**Table 2:** Taxon, prey item frequency and biomass provisioned at site A. Biomass of prey items that could not be identified down to species level was estimated from data on closely related species. N* represents the amount of the taxon that was eaten by the young ((Frequency)*(% eaten)).

| Taxa | | Frequency (N) | % eaten | Amount eaten by young (N*) | Estimated mass per taxon (g) | Biomass eaten (g) |
|---|---|---|---|---|---|---|
| **Mammals** | | **58** | **78** | **45.5** | | **21'746** |
| European Hedgehog, small | *Erinaceus europaeus* | 22 | 72 | 15.75 | 800 | 12'600 |
| European Hedgehog, juv | *Erinaceus europaeus* | 1 | 100 | 1 | 100 | 100 |
| Rabbit, adult small | *Oryctolagus cuniculus* | 4 | 75 | 3 | 1000 | 3'000 |
| Rabbit, juvenile large | *Oryctolagus cuniculus* | 5 | 80 | 4 | 500 | 2'000 |
| Rabbit, juvenile small / parts | *Oryctolagus cuniculus* | 8 | 63 | 5 | 250 | 1'250 |
| Fat dormouse | *Glis glis* | 12 | 94 | 11.25 | 125 | 1'406 |
| Garden dormouse | *Eliomys quercinus* | 3 | 100 | 3 | 85 | 255 |
| Hare | *Lepus europaeus* | 1 | 50 | 0.5 | 1500 | 750 |
| Squirrel | *Sciurus vulgaris* | 1 | 100 | 1 | 355 | 355 |
| Muridae sp. | *Microtus arvalis* | 1 | 100 | 1 | 30 | 30 |
| **Birds** | | **20** | **86** | **17.25** | | **5'938** |
| Corvidae | *Corvus corone* | 10 | 83 | 8.25 | 500 | 4'125 |
| Similar Corvidae | *Corvus corone* | 1 | 100 | 1 | 500 | 500 |
| Black bird | *Turdus merula* | 1 | 100 | 1 | 95 | 95 |
| Chaffinch | *Fringilla coelebs* | 1 | 100 | 1 | 20 | 20 |
| Jay | *Garrulus glandarius* | 1 | 100 | 1 | 175 | 175 |
| As big as Jay | *Garrulus glandarius* | 2 | 100 | 2 | 175 | 350 |
| Pigeon | *Columba livia* | 3 | 67 | 2 | 315 | 630 |
| Swift | *Apus apus* | 1 | 100 | 1 | 43 | 43 |
| **Amphibians** | | **1** | **100** | **1** | | **60** |
| Frog | *Rana ridibunda* | 1 | 100 | 1 | 60 | 60 |
| **TOTAL** | | **79** | | | | **27'744** |

## Figure captions

**Fig. 1:** Mean (± se) number of feedings per night at site A in 2004 (n = 66).

**Fig. 2:** Number of dead Eagle owls recorded in time steps of 20 years from 1825 to 2004 in Switzerland (n = 306).

**Fig. 3:** Number of dead Eagle owls recorded in time steps of 5 years since 1950 in Switzerland (n = 246).

**Fig. 4:** Locations of dead-found Eagle owls in Switzerland, according to mortality factor (n = 275). The red lines delimit the regions Jura, Plateau and the Alps (from north to south).

**Fig. 5:** Seasonal mortality in young Eagle owls (from August of birth year to July in the following year [n = 36]) and older owls (n = 92).

**Fig. 6:** Relative frequency of mortality factors of all fledged Swiss Eagle owls found since 1829 (n = 225).

**Fig. 7a & b:** Relative frequency of mortality factors having affected a) fledged 1$^{st}$ year Eagle owls (August-December) (n = 24) and b) older owls (n = 106).

**Fig. 8:** Relative contribution (%) and number of different mortality factors to total mortality from 1900 to 2004. Traffic accidents consist of both car and train accidents (n = 215).

**Fig. 9:** Geographic distribution of mortality factors (Jura n = 11, Plateau n = 20, Alps n = 172).

**Fig. 10**: Age distribution of recorded dead Eagle owls in 3 age categories: 1$^{st}$ calendar year from August onwards, 2$^{nd}$ calendar year until end of July and older (n = 184).

**Fig. 11:** Age distribution of recorded dead Eagle owls in 4 age categories: 1$^{st}$, 2$^{nd}$, 3$^{rd}$ and ≥4$^{th}$ calendar year (n = 108).

## Figures

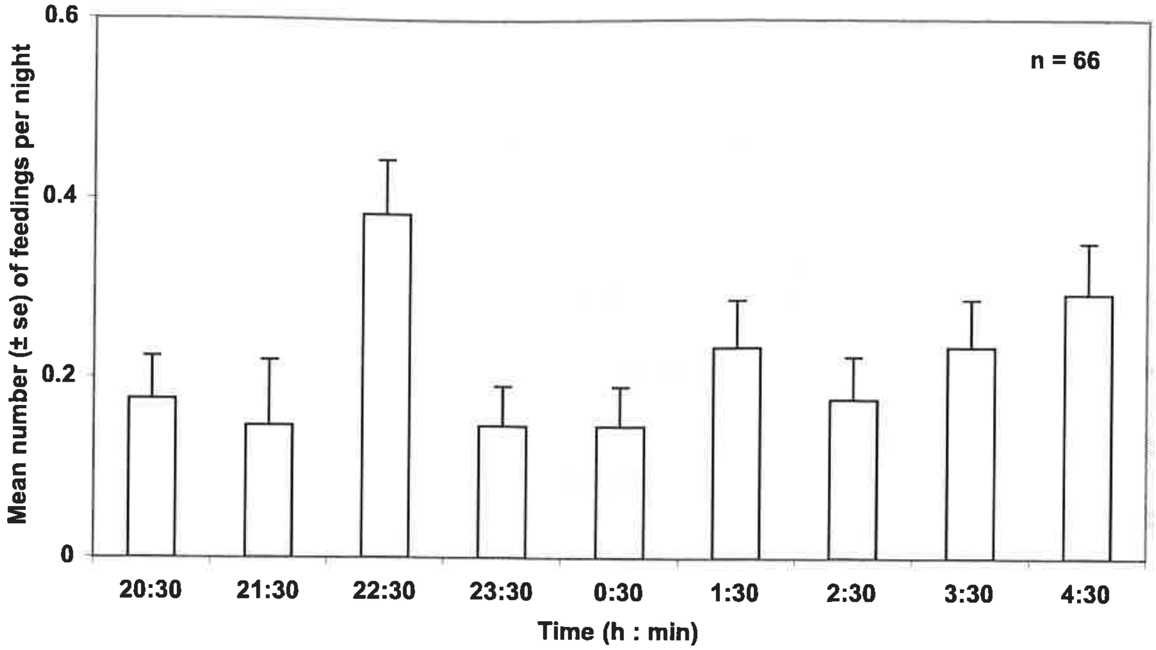



**Fig. 1**

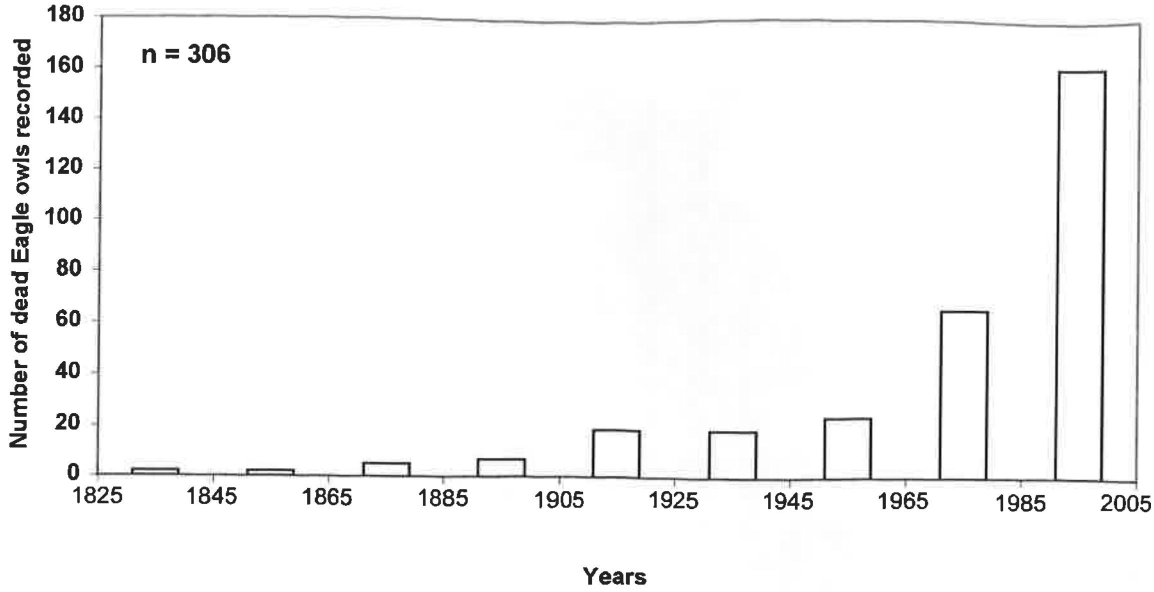

n = 306
Number of dead Eagle owls recorded
180
160
140
120
100
80
60
40
20
0
1825
1845
1865
1885
1905
1925
1945
1965
1985
2005
Years

**Fig. 2**

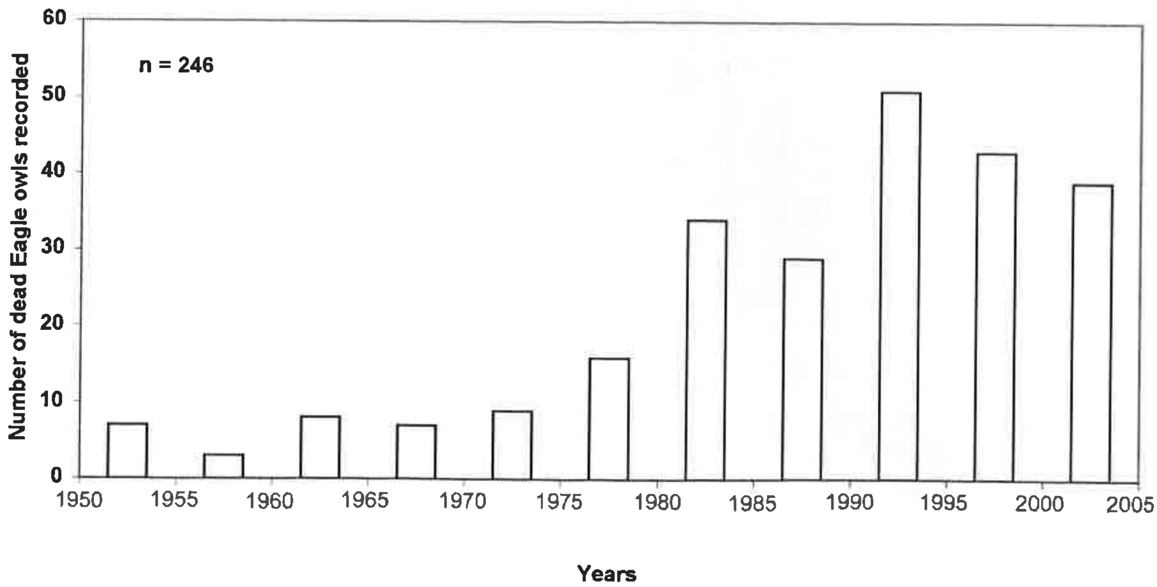

n = 246
Number of dead Eagle owls recorded
60
50
40
30
20
10
0
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
Years

**Fig. 3**

# Recordings of dead Eagle owls

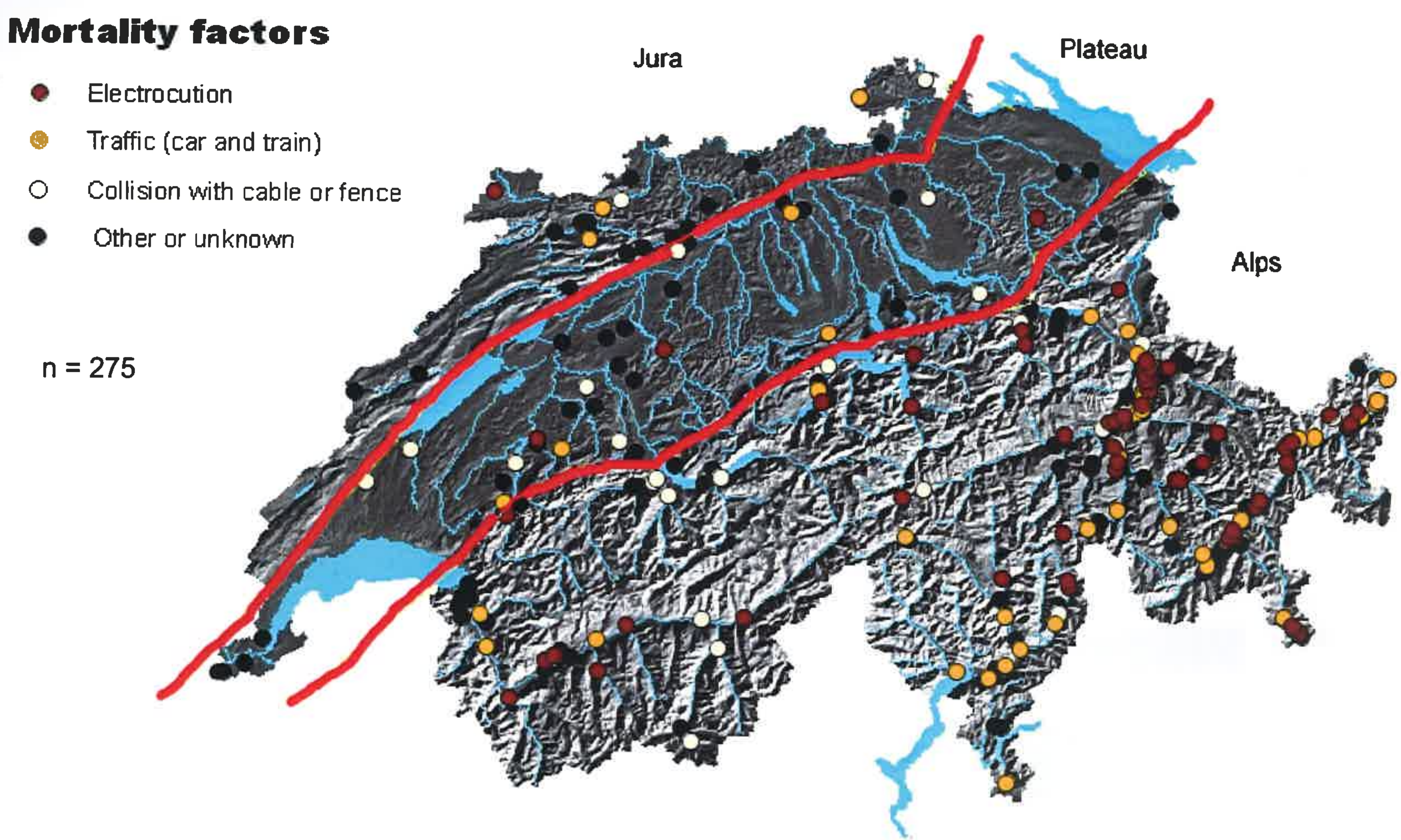



Fig. 4

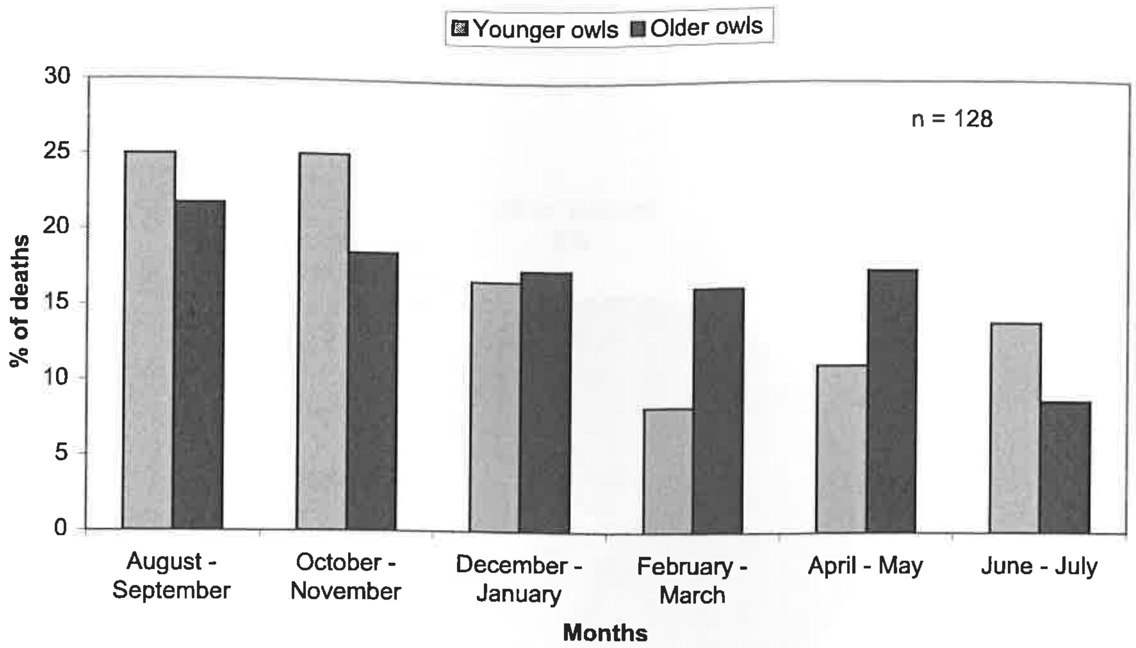

Younger owls
Older owls
n = 128
% of deaths
30
25
20
15
10
5
0
August - September
October - November
December - January
February - March
April - May
June - July
Months

**Fig. 5**

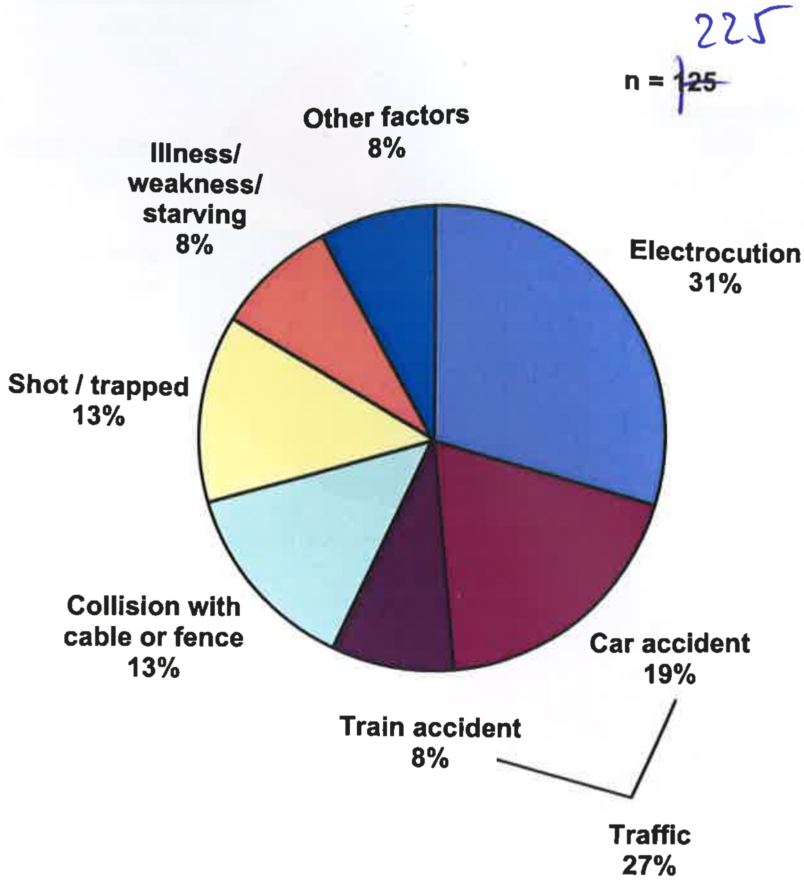

225
n = 125
Other factors
8%
Illness/
weakness/
starving
8%
Electrocution
31%
Shot / trapped
13%
Collision with
cable or fence
13%
Car accident
19%
Train accident
8%
Traffic
27%

Fig. 6

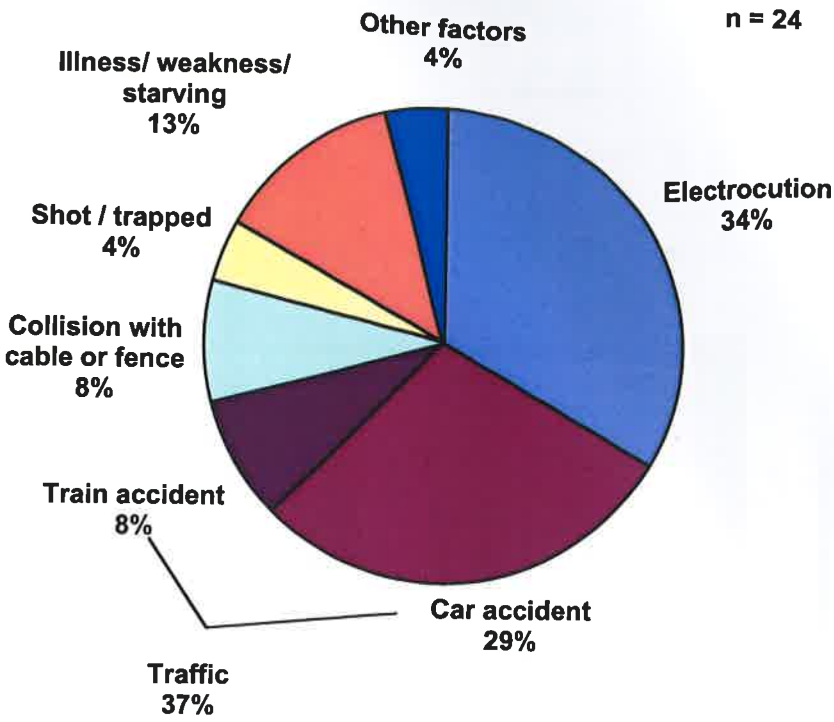

n = 24
Other factors
4%
Illness/ weakness/
starving
13%
Electrocution
34%
Shot / trapped
4%
Collision with
cable or fence
8%
Train accident
8%
Car accident
29%
Traffic
37%

Fig. 7a

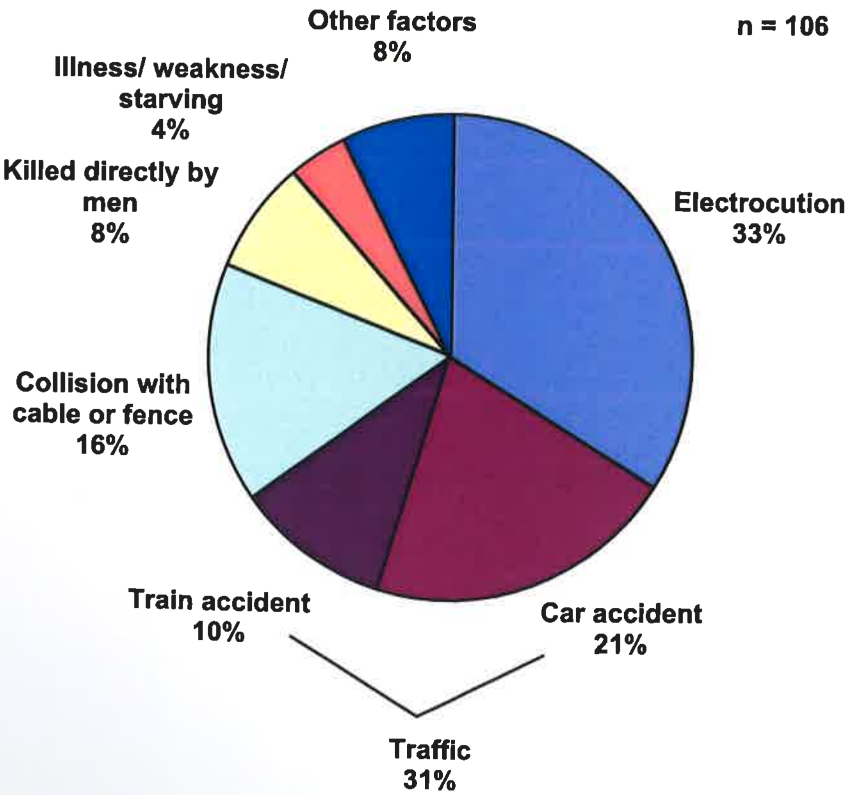

Other factors
8%
n = 106
Illness/ weakness/
starving
4%
Killed directly by
men
8%
Electrocution
33%
Collision with
cable or fence
16%
Train accident
10%
Car accident
21%
Traffic
31%

Fig. 7b

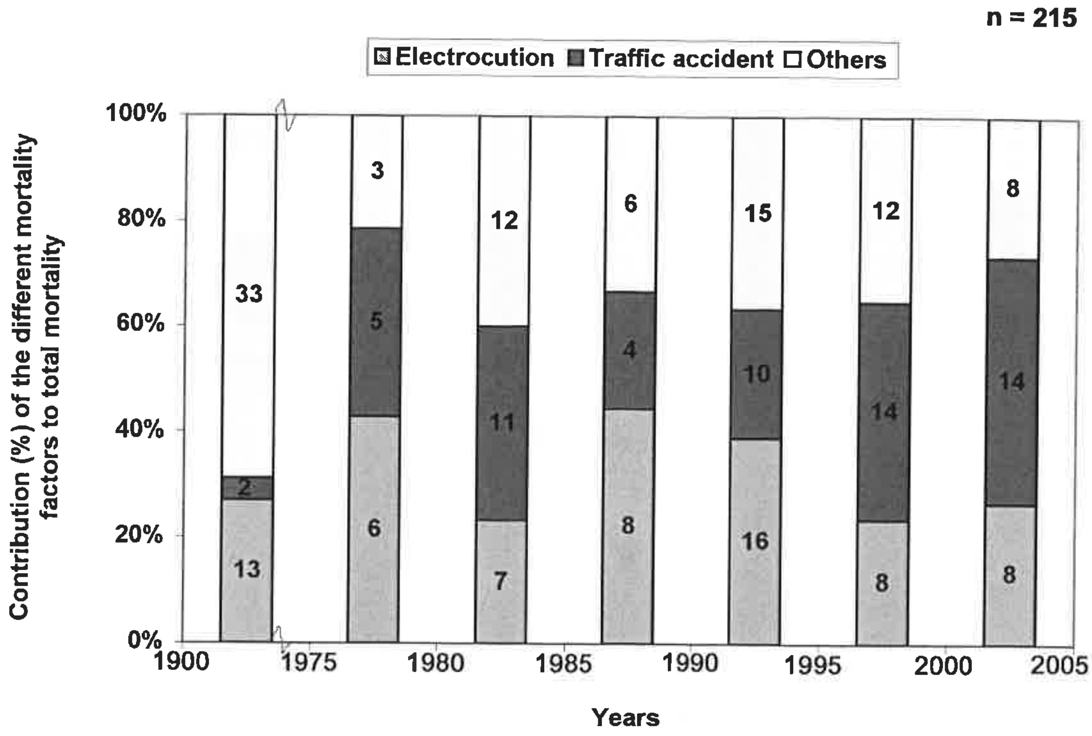
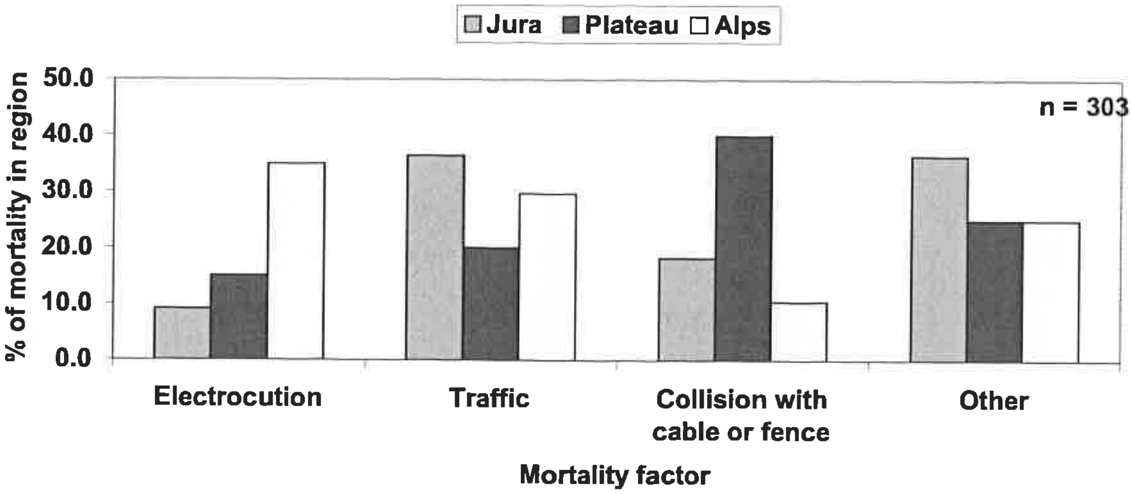
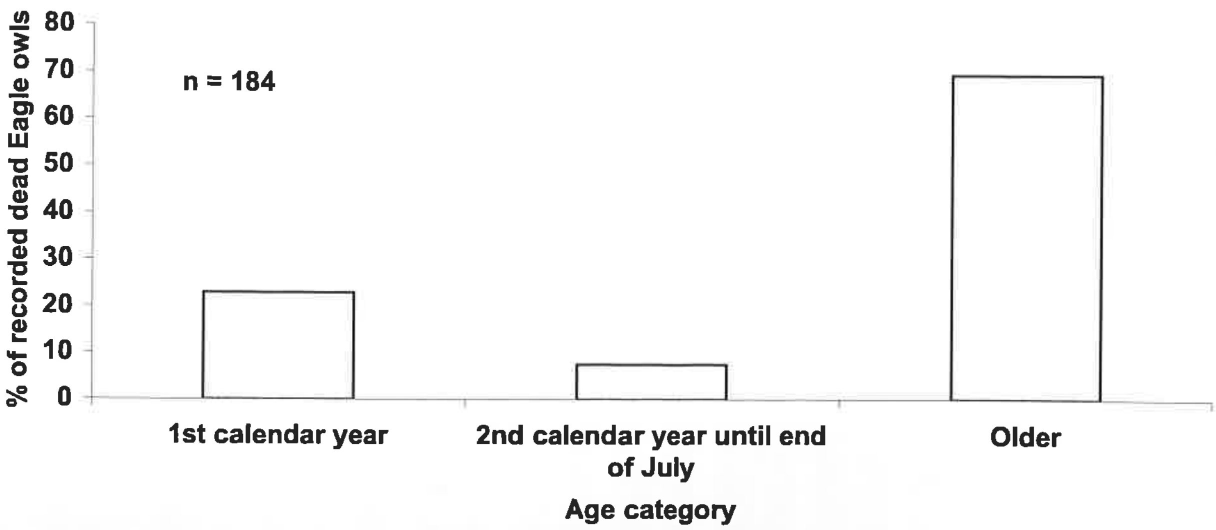

n = 215
Electrocution
Traffic accident
Others
100%
80%
60%
40%
20%
0%
Contribution (%) of the different mortality factors to total mortality
33
2
13
3
5
6
12
11
7
6
4
8
15
10
16
12
14
8
8
14
8
1900
1975
1980
1985
1990
1995
2000
2005
Years

**Fig. 8**



Jura
Plateau
Alps
% of mortality in region
50.0
40.0
30.0
20.0
10.0
0.0
n = 303
Electrocution
Traffic
Collision with cable or fence
Other
Mortality factor


**Fig. 9**



% of recorded dead Eagle owls
80
70
60
50
40
30
20
10
0
n = 184
1st calendar year
2nd calendar year until end of July
Older
Age category


**Fig . 10**

35
30
25
20
15
10
5
0
% of dead Eagle owls
n = 108
1
2
3
4+
Age classes (calendar years)


Fig. 11

**Appendix 1:** Institutions and responsible persons who provided data on dead Eagle owls

| Place / Institution | Name |
|---|---|
| Jagdverwaltung AG | D. Klauser |
| Verein für Natur und Vogelschutz AG | D. Kummer |
| Naturama Aarau AG | R. Foelix |
| Auenstein AG | A. Aellig |
| Ziefen BL | F. Martin |
| Naturhistorisches Museum BS | R. Winkler |
| Grindelwald BE | B. Inäbnit |
| Amt für Landwirtschaft und Natur BE | P. Juesy |
| Naturhistorisches Museum BE | M. Güntert |
| Naturhistorisches Museum FR | M. Beaud |
| Museum d'histoire naturelle GE | L. Vallotton |
| Jagd- und Fischereiverwaltung GL | R. Hauser |
| Schwändi GL | M. Hauser |
| Mollis GL | K. Wettli |
| Oberurnen GL | S. Nooser |
| Naturmuseum Engi GL | R. Müller |
| Benken GL | Chr. Obrist |
| Amt für Jagd und Fischerei GR | H. Jenny |
| Bündner Naturmuseum | J. P. Müller |
| Musée jurassien des sciences naturelles JU | J. Chalverat |
| Office des eaux et de la protection de la nature JU | J.-C. Schaller |
| Natur Museum Luzern LU | R. Heim |
| Museum d'histoire naturelle NE | B. Mulhauser |
| Verwaltungspolizei NW | K. Antener |
| Abteilung Natur und Jagd OW | R. Krummenacher-Ettlin |
| Melchtal OW | Fam. Rohrer |
| Thayngen SH | J. Richter |
| Stemmler Museum SH | M. Huber |
| Departement der Innern SH | L. Homberger |
| Beringen SH | V. Homberger |
| Siebnen SZ | St. Diethelm |
| Fischerei- und Jagdverwaltung SZ | M. Husi |
| Naturmuseum Solothurn SO | A. Schäfer |
| Naturmuseum Olten SO | F. Flückiger |
| Amt für Jagd und Fischerei SG | M. Brülisauer |
| Naturmuseum St. Gallen SG | J. Barandun |
| Vogelpflegestelle "Adlerhorst" Höfen SG | J. Vetsch |
| Wittenbach SG | P. Braunwalder |
| Naturmuseum TG | R. Frei |
| Office de la chasse et pêche TI | M. Salvioni |
| Museo cantonale di storia naturale TI | A. Fossati |
| Pflegestation Kanton TI | R. Hürzeler |
| Amt für Forst und Jagd UR | A. Infanger |
| Service chasse et pêche VS | Y. Crettenand |
| Musée d'histoire naturelle Sion VS | J.C. Praz |
| Musée cantonal de zoologie VD | O. Glaizot |
| Centre de Conservation de la faune et de la nature VD | O. Reymond |
| Tierspital Zürich ZH | H. Steinmetz |
| Berg am Irchel ZH | V. Stockar |