

Introduction

In the course of centuries red squirrels (*Sciurus vulgaris*) many times experienced very sudden population losses in the UK. The main reason of such variation in red squirrel population in the UK was the destruction of their habitat and mass hunting that resulted in their almost total extinction in the UK already in 18th century and the necessity for their re-introduction from the continent (Ritchie 1920, Gurnell 1987, Harris et al. 2006). In the last 150 years for this reason red squirrels had to be introduced in various areas in the UK from the continent – mostly from Sweden and central Europe (Ritchie 1920, Lowe & Gardiner 1983, Yalden 1999, Hale et al. 2004, Harris et al. 2006). It led to the situation – as confirmed by DNA study (Hale et al. 2004) – that the vast majority of red squirrel population currently living in the UK are descendants of squirrels recently introduced from Scandinavia – often long after the introduction of grey squirrels to the UK (Hale et al. 2004, Harris et al. 2006).



The biggest pox virus outbreak among red squirrels in the UK

Despite such loss in red squirrel population caused by killing them "to protect trees" the population had a chance to regenerate naturally. And then there came the biggest known so far outbreak of pox among

red squirrels in the UK that in short time reached 14 counties and caused massive population decline. **That outbreak could in no way be linked to the presence of grey squirrels because they were present in only 4 out of 14 districts affected by the outbreak** (Middleton 1930, Edwards 1960, Vizoso 1968, Scott et al. 1981, Keymer 1983).

In later years no pox outbreak on such scale was ever again noted in red squirrel population in the UK but considering recent at that time decimation – under the pretences to "fight the tree pests" – they were already seriously threatened although maybe it wasn't realised who in fact was responsible for such a bad shape of red squirrel population in the UK (Middleton 1930).

Improvement of habitat and the beginning of persecution of red squirrels in the UK

Vast forests planted at the end of 18th century in the UK matured in 19th century and that allowed sudden increase in red squirrel population. It was at that time when red squirrels were considered the "main pest destroying trees" and subjected to a widespread "population control" (Ritchie 1920, Shorten 1954, Tittensor 1975, Harris et al. 2006) which meant organising local and later national culls of their population, often for the UK taxpayer money (Duncan 1927).

The scale of persecution of red squirrels in the UK in 20th century

Just one of many active at the time organisations – not counting thousands of private people – boasted that they killed 82 thousands of those "pests" (Ritchie 1920, Tittensor 1975, Harris et al. 2006, Bestwick 2013). Until today scientists have not been able to establish how many hundreds of thousands of red squirrels were killed as the result of not so "ecological" actions. Despite such a huge population decline, until the end of 1970ies – when in the majority of England and Wales area there were no populations numerous enough to be able to sustain themselves – red squirrels were legally "pests" and killed for that.

Mass destruction of habitats

Post-war advances in agriculture and urbanisation resulted in felling almost 50% (and in some areas of England and Wales even 100%) of "ancient forests" in the UK (Tickell et al. 2000) inhabited mostly by red squirrels which was the final blow that the human could cause to red squirrel population, especially serious in England and Wales.

Effect of urbanisation on red squirrel population decline

Detailed scientific studies conducted in the last 20 years (Shuttleworth 2001, Dutton 2004, LaRose et al. 2010, Simpson et al. 2013) let very precisely determine the main statistical causes of "unnatural deaths in red squirrel population in the UK". Below we present graphically the most frequently listed in the above studies reasons of unnatural deaths in red squirrel population in the UK.

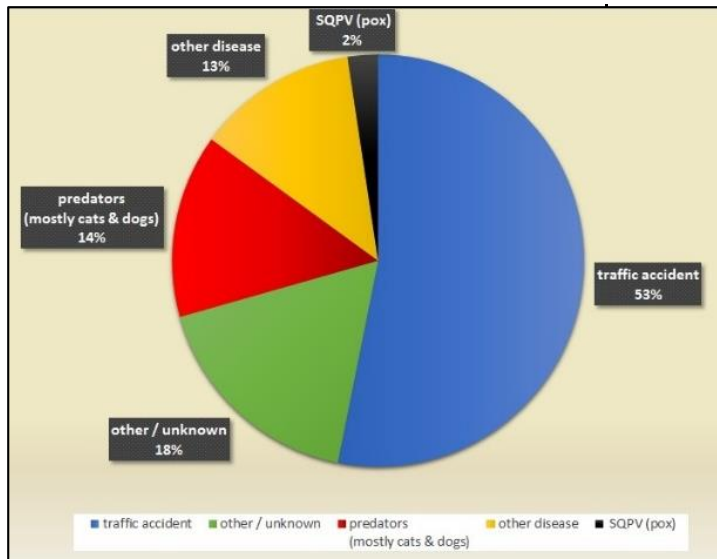


Figure 1. Causes of red squirrels mortality: from the collection of research data from the last 20 years by Shuttleworth 2001, Dutton 2004, LaRose et al. 2010, Simpson et al. 2013.

All above listed papers list road traffic accidents as the main cause of unnatural deaths in red squirrel population in the UK. In "suburban areas and gardens" **unnatural deaths resulting from road accidents reach even 88% of examined cases** (Shuttleworth 2001). Surprisingly high (36%-83,6%) mortality due to this reason is also noted in the areas where "level of urbanisation" definitely is not one of the highest in the UK (Dutton 2004). The most recent data collected from areas of varied level of urbanisation show that road traffic accidents are the reason of over 41% (41.7%) of unnatural deaths of red squirrels in the UK (Simpson et al. 2013).

Statistically the second reason which can account for even 36% of unnatural deaths in red squirrel population in the UK (Dutton 2004) **is attack by another animal** (most frequently unguarded – and/or not equipped in devices audibly signalling their presence – household pets). This cause of unnatural deaths in red squirrel population in the UK mainly occurs habitats near "moderately urbanised" areas (most often near small towns or villages). In the areas least urbanised (nature reserves and surroundings) the problem can affect even 12% (Shuttleworth 2001) of population (in that last case – reserves – very often it is not clear if the death was caused by a household pet or by a wild animal). The most recent data collected from areas of varied level of urbanisation show that pets cause over 9% (9.2%) of unnatural deaths of red squirrels in the UK (Simpson et al. 2013).

Incorrect forestry practices during tree felling

Even though red squirrel has been for 40 years officially "protected species", in places where their protection collides with economic interests in practice they don't have any protection. **In the UK there are vast areas of forests felled** in the areas of common occurrence of red squirrels even **in breeding seasons** which causes **every year deaths of hundreds if not thousands of young red squirrels** completely dependent on their mothers.

During forest clearing operations in the area with red squirrels present **Forestry Commission don't even**

require leaving – at least for a few months – so called "**woodland corridors**" which **give animals a chance to move to another place after habitat loss**. Such forestry practices lead to significant decline of red squirrel population and very often to local extinction (Lurz et al. 1998). These unfavourable forestry practices – in use in the UK for many decades – are common in the UK today not only in profit-focused commercial woodlands.

As scientific research shows, **red squirrels are very vulnerable to habitat fragmentation** (Gurnell & Pepper 1991, Rodriguez & Andren 1999, Huxley 2003, Verbelyen et al. 2003, Flaherty et al. 2012). **They are also definitely less "mobile" than grey squirrels who in adverse conditions can travel even several miles** looking for a suitable habitat – **such practices of tree felling in fact accelerate the spread of grey squirrels into new areas**.

Scientists and environmentalists agree that loss of habitat availability and quality is one of the main reasons of the significant red squirrel population decline in the UK (Verboom & Apeldoorn 1990, Kenward & Holm 1993, Bryce et al. 2002, Huxley 2003, Lurz et al. 2003, Harris et al. 2006, Bryant 2011, Flaherty et al. 2012).

Changes in the preference of planted forests

Even though at present the UK has 3 times less forests than so called "European average" (House of Lords 2009) it's not the quantity but quality of forests that poses the biggest problem in red squirrel conservation in the UK (Lurz et al. 1998, Harris et al. 2006). The most of tree species currently planted in the UK – mainly in commercial forests – are of little or no use for red squirrels conservation (Lurz et al. 1998, Ticknell 2000, Scottish Environment Statistics 2006, Harris et al.

2006) and at the same time support the growth of grey squirrel population (Bryce et al. 2002, Harris et al. 2006). Even though the planted woodland area in the UK keeps growing in the recent decades, **the area of forests favourable for red squirrels relatively shrinks at a quick rate** – plantations of trees favourable for red squirrels are now mature and intensely felled and at the same time replaced with less favourable but more profitable tree species (Lurz et al.1998, Ticknell 2000, Bryce et al. 2002, Scottish Environment Statistics 2006, Harris et al. 2006).

Table 1. The changes in woodland cover in England (1980-1998) (Forestry Commission 2001) and Scotland (1980-1995) (Scottish Environment Statistics, 2006), with the suitability of habitat for squirrels based on definitions by Bryce et al. (2002)*

Species	Percentage forest change (England)	Percentage forest change (Scotland)	Suitability for squirrels
Sitka spruce	+14	+61	Poor for reds/ greys
Norway spruce	-21	+1	Good for reds/ greys
Douglas fir	+3	+1	Good for reds
European larch	-34	-39	Good for reds
Mixed/Japanese larch	-3	+21	Good for reds
Scots pine	-5	+8	Poor for reds/ greys
Broadleaved woodland	+36	+68	Good for greys

*Data collected and presented (Harris et al. 2006) by the research team from the School of Biological Science, University of Bristol.

Effect of habitat quality on red squirrel population

Scientists agree that to sustain red squirrel population in the area, the priority is to provide high quality habitat (Wauters & Gurnell 1999, Wauters et al. 2000, Wauters et al. 2001a, Bryce et al. 2005, Harris et al. 2006). The most robust habitat for red squirrels with regard to annual/seasonal variations in seed availability are definitely coniferous forests ensuring stable reproduction success even with quite strong intraspecific competition (Wauters & Lens 1995). Coniferous tree species most favourable for red squirrels are Douglas fir, larch (Bryce et al. 2002, Harris et al. 2006) and yew (Haigh et al. 2015). Unfortunately currently in commercial plantations "tree species mixtures" of coniferous trees beneficial for red squirrels are rarely planted because for the woodland owners the profits will always be the most important factor (Lurz et al.1998, Bryce et al. 2002). Already years ago environmentalists observed that another significant decline in red squirrels population coincided with the end of hazel coppicing (Bryant 2011). The end of planting hazel in the UK could have had a significant negative effect on red squirrel population because hazelnuts are important part of their diet especially to sustain high population numbers

(Kenward & Holm 1993). The most recent studies also showed that planting yew is extremely beneficial for sustaining a healthy red squirrel population (Haigh et al. 2015).

New threats - Incorrect supplementary feeding of red squirrels can promote local outbreaks of squirrel poxvirus (SQPV)

The risk of the disease transmission via shared feeders was pointed out by scientists already but all possible ways of disease transmission were not known at the time (Huxley 2003, Duff 2012) and that theory so far didn't have a definite support in scientific research.

Recently information from scientific research about places and dates of local squirrel pox (SQPV) outbreaks in 2005 – 2012 in the UK (White & Lurz 2014) was compared with information about the introduction of supplementary feeding of red squirrels in those areas using shared feeders (ICSRS 2015f). It turns out that in most of the places where SQPV was never

noted before the outbreak was preceded by the introduction of intensive supplementary feeding of red squirrels in a given area using shared feeders (ICSRS 2015f).

In one of the biggest areas in the UK where for the last 15 years there has been work done with the goal of "red squirrel conservation", before the start of the program (2000) pox virus didn't occur at all. After 12 years of "conservation work", done among other actions by using shared feeders, that area became a place where pox occurs most frequently in the red squirrel population in the UK causing locally serious losses (ICSRS 2015f). Similar correlation between the introduction of supplementary feeding of red squirrels using shared feeders and the occurrence of pox outbreak was observed in many other areas in the UK and Republic of Ireland (ICSRS 2015f).

Scientific research published in 2012 as one of results determined that red squirrel infected with pox is many times more dangerous to other squirrels than a grey squirrel with the same infection (Warnock et al. 2012, Collins et al. 2014). The threat is caused not only by the fact that pox infected red squirrels have even 2500 times more virus level in the blood but mainly because they are able – unlike grey squirrels – to transmit pox virus via droplet infection (saliva) (Warnock et al. 2012, Collins et al. 2014).

As it's commonly known, "droplet infection" is one of the most frequent way of disease transmission. The risk of transferring a disease via droplet infection is increased significantly when infected individuals – like European red squirrels with pox infection – are in contact with each other in large numbers in a small area – like for example "shared feeding station".

Editors note: We've received many e-mails asking "can grey squirrels be fed using shared feeders"?

Yes, grey squirrels can be fed using shared feeders because as research shows they don't transmit the pox virus via saliva*. The virus can be spread via droplet transmission (saliva) by European red squirrels* and for them "scatter feeding" should be applied – with no shared feeders.

*(Warnock et al. 2012, Collins et al. 2014, ICSRS 2015f)

Summary

Over the course of centuries among red squirrel population in the UK there were declines bordering on extinction. The main reasons of declines noted earlier were destruction of habitats by man and intensive hunting. Intensive hunting and other forms of persecution resulted in the situation where in the last 150 years the dying population had to be supplemented with animals introduced from the continent. DNA studies confirmed that red squirrel population currently living in the UK is a mixture of descendants of animals introduced from Sweden and central Europe in the last 150 years. DNA studies so far did not confirm the existence of red squirrels that could be explicitly called as "native to the UK".

Since the beginning of 20th century there were organised intensive hunts for red squirrels because of the huge damage to trees that they allegedly caused. Scientists find it hard to estimate today how many hundreds of thousands of red squirrels were killed at that time by various organisations and private persons. Red squirrels were legally "pests" in the UK until the end of 1970s when in the most of England and Wales only small populations were left mostly unable to survive a few severe winters or significant annual variations of tree seed crops.

Intensive hunts for red squirrels coincided with the biggest known so far pox outbreak among red squirrels. The outbreak could in no way be linked to grey squirrels because they were present (in small local populations) only in 4 out of 14 districts affected by the disease. It's also worth to note that the outbreak and quick distribution of the disease took place in the area of very intensive hunting for red squirrels. Many studies confirm that killing

squirrels in one area causes faster dispersal and immigration of squirrels from other areas. It could have contributed to such fast distribution of the disease as observed at the time.

Despite such intense persecutions and a huge outbreak that affected red squirrels in the UK there was still a chance for a natural regeneration of their population. Unfortunately at that time for economic reasons the intensive felling of "ancient forests" inhabited mainly by red squirrels was started which caused further declines due to a quick loss of habitats. Red squirrels lost huge areas of habitat to agriculture and urbanisation. Even though since that time there were more forests planted than cut down, the majority of planted woodlands are deemed by scientists unfavourable habitat for red squirrels. For economic reasons there are practically no forests beneficial to the red squirrels planted in the UK. Forests good for red squirrels, after they mature, are felled and replaced with trees better in terms of financial profits. It causes continuous and fast decrease in habitats favourable for red squirrels. Scientific research conducted in the last 25 years confirms that providing suitable habitat is of priority importance for the stability and reproduction success of red squirrel population. Without a change in preferences for planted trees on a national scale there is no chance for the success of red squirrel conservation in the UK. Even if thanks to human help local red squirrel population grows it won't compensate for declines which take place throughout the country. Also current practices of woodland felling without leaving "woodland corridors" cause usually extinction of red squirrel population in many areas. Red squirrels are less mobile than grey squirrels which can travel tens of miles looking for appropriate habitat. The lack of ban on tree felling during breeding season in the areas with red squirrels could result every year in thousands of deaths of young red squirrels still dependent on their mothers.

The most recent research also confirmed that in the areas covered by "conservation works" where supplementary feeding of red squirrels using shared feeders was commonly performed it usually led to a pox outbreak. Outbreaks occurred even in the areas where the disease never occurred before even though red squirrels lived there with grey squirrels for many decades. The risk of the disease transmission via shared feeders was pointed out by scientists already but all possible ways of disease transmission we know about now were not known at the time. Although it needs further research it is very likely that such form of feeding red squirrels contributed

ICSRS

Analysis of scientific research about the reasons of red squirrel population decline in the UK

to a great degree to the spread of pox virus in red squirrel population in the UK.

Apart from continued loss of suitable habitats the decline in red squirrel population is also to great extent the result of urbanisation. For the last 20 years statistically the main cause of unnatural deaths in red squirrel population is road traffic

accident (53%). The second reason listed in the above statistic is death caused by household pets (14%). Like in the case of harmful forest policies there are no significant actions aimed at eliminating these main reasons for unnatural deaths of red squirrels.

References and more about squirrels: www.i-csrs.com/red-squirrels-decline-0

Visit the Facebook page and sign the petition to stop grey squirrel cull:
www.facebook.com/StopSquirrelCull

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