Draft

Damage to bamboo shoots by the Eastern Grey Squirrel (*Sciurus carolinensis*)

Chris Stapleton

Summary: The Grey Squirrel, a native of N America, was introduced to the UK in the early 20th Century and has since become common in lowland Britain, wher it has largely eradicated the native red squirrel, and causes extensive economically devastating damage to forest trees. It is rated as one of the world's worst invaders, and in negative impact is second only to the brown rat. In feeding habits it is adaptable and intelligent, learning to binge feed and also to collect and store food when there is a seasonal excess. Bamboo is not part of its natural diet, and the potential of the inner parts of bamboo shoots as a food source has to be learnt. After making this discovery, which seems more likely with highly palatable species, the behaviour pattern is reinforced and spread, unless offending animals are culled. The damage to bamboos in the US is currently minimal, however, quite possibly because of heavy predation, mainly by man but also by carnivorous wildlife. Introduction of the grey squirrel to mainland Europe and the failure of the Italian authorities to control its spread is of grave concern to environmental and natural resource managers throughout Europe, as well as mainland C and E Asia. Bamboo production is particularly threatened. Adaptation of Man's own feeding habits to emulate those in the Southern US, where 2.5 million squirrels are officially hunted and consumed in Mississippi alone, may be the best means of controlling this unwelcome visitor.

Damage in the UK

Damage to new bamboo shoots by the N American Eastern Grey Squirrel is a relatively new problem in the UK. From about 1994 it was realised that production of new shoots was diminishing in the Bamboo Garden at Kew, and a reduction in maximum culm size was also noticed for most species. At first, loss of new shoots was attributed to poor nutrient status, drought, or damage by visitors. Attempts were made to counter any reduction in bamboo vigour by a program of fertilisation and mulching, and sprinkler irrigation was increased in the summer months. However, scattering of remains of shoots at tree bases suggested other causes of the decline, and before long grey squirrels could readily be observed carrying and eating shoots they had removed from nearby clumps. Having been trained as a forester, and having lived and worked in the beechwoods of the Chiltern Hills in Buckinghamshire, I am well used to the pervasive damage that the teeth of these 'tree-rats' can cause, stripping off the bark and eating out the young leaders, leaving stag-headed, diseased monstrosities instead of elegant trees. Switching to bamboo shoots in the early summer is obviously a change in learned behaviour for the local squirrel population, possibly as a result of the increased size of

the expanding bamboo garden at Kew, but it is fully in character for grey squirrels. They are renowned for their adaptability, their ability to learn how to obtain new sources of food, their binge feeding, and their social rather than territorial behaviour. In February and March in the US, they consume buds and shoots of maples, dogwoods, silverbell, buckeye, American hornbeam, oak, and even pine.

Public access and animal rights concerns have made it difficult to implement effective squirrel control measures for many years in Kew's Bamboo Garden, and the situation reached a steadily higher level of depradation of new shoots each year. Clumps that previously produced hundreds of new shoots seemingly as thick as hairs on a pig's back, such as *Fargesia robusta*, may only have a handful of late, thin, whippy shoots to show at the end of the year. Around 75-100% of new shoots have been eaten each year, from mid-February onwards. Newly planted bamboos can be prevented from producing new culms altogether for several years. Because of the natural ability to produce further shoots from rhizomes in these plants, the bamboos do not appear by any means devastated, merely stunted. In most species, a second crop of new shoots grows later in the year. By mid-June the squirrels are progressively diverted away from bamboo shoots, initially by a mid-summer burst of reproductive behaviour, and then by the production of seeds and fruits, especially from oaks and sweet chestnuts at Kew. This allows a higher success rate for later shoots arising from July onwards, but sizes of resultant culms may only be 30-50% of normal size, and a dense thicket of shorter, thinner, whippy shoots will often be the result. This may be so dense that shoots are protected, and some larger, earlier shoots may be more successful the following year, as long as the clumps are not thinned out for aesthetic reasons.

Palatability of different bamboo species would appear to vary substantially, but once the squirrels have learnt to eat bamboo shoots, it is apparent that no bamboo is completely safe. *Phyllostachys dulcis* and *Borinda utilis* would appear to suffer the heaviest levels of attack, while the ground-cover species with thin shoots such as *Sasaella ramosa* are least attractive. Species with denser clumps are inherently more resistant, but new shoots can only arise in the centre of the clump, and these are often shorter than those in new ground on the perimeter.

Damage has been prevented in some clumps by protection measures. The most successful, apparently developed by the gargener of the late David McClintock, has been the formation of a barrier of holly twigs and branches right around the base of the clump. This, however, may have only diverted squirrels to other clumps, but it has at least allowed faster establishment of some new introductions. Consistent control of the squirrels themselves is very difficult to undertake for several reasons. Public opinion is naturally supportive of anything so soft and furry. A large reservoir of habituated squirrels has developed in surrounding areas, and they

may visit at any time. It would seem that such a large number of squirrels are now so used to consumption of bamboo shoots in the Bamboo Garden at Kew, that each year severe damage has become inevitable at some time between February and July.

Kew's grey squirrels were kindly given to the Gardens by the Duke of Bedford in 1907. Other introductions from the US into different parts of Great Britain and Ireland led to rapid establishment in areas with broadleaved trees, and the exclusion of the native red squirrel to remote areas of pure coniferous forest, where the grey squirrel cannot find enough food.

Having now visited different parts of the US, I have been curious to find out how the squirrel situation differs there, where squirrel damage does not seem to have been reported as a problem in bamboos. I have also been interested to follow the situation in continental Europe, where some authorities have at long last appreciated the threat posed by the grey squirrel, albeit far too late to do much about it.

Grey squirrels in the US

No bamboo contacts I have made have personal experience of squirrel damage, and I saw no squirrels in the eastern states that I visited. However, as the Grey Squirrel is native to the US, much information on its habits, control, and even conservation is readily available from natural history websites, and the following information is taken from such sources.

In terms of habitat, broadleaved forest areas with trees bearing large, edible seeds are clearly most popular. These autumnal food items are supplemented during certain seasons by the buds, flowers, and fruits of trees such as dogwood, silverbell, buckeye, and American hornbeam, but as an opportunistic feeder, it will also eat bird eggs, bones, insects, frogs and agricultural crops including maize. They usually feed on just one food at a time, changing the item as additional sources come along. When mast crops fail in one area, the squirrels usually move en masse to other areas where food is more abundant.

Although it is recognized that squirrels can cause damage, no current threat is perceived. However, it is recognised that squirrels were devastating to the crops of early colonists, and it is noted that they are a very serious pest to ecology and forestry in Great Britain and Ireland. It is stated that in the UK the grey squirrel is ranked second in negative impact only to the Norway rat, and it has been nominated by the IUCN as among 100 of the "World's Worst Invaders". However, in the US the squirrel seems to be regarded as unimportant or even benign, acting as a dispersal agents for seeds, and aiding forestry through reforestation. Consideration is even given as to how forests should be managed to help them survive.

So why is it that a cute furry creature turns into a vicious predator and destroyer of forests and bamboo groves as it moves from one ecological setting to another. It would seem that part of the answer is likely to be predation. In North America, the list of natural predators of squirrels is long, including hawks, owls, coyotes, foxes, bobcats, timber rattlesnakes, weasels, raccoons, and wolves. There is also a virus, a pox related to rabbit mixomatosis, although according to the Department of Natural Resources of the State of Michigan, where the disease has been particularly prevalent, it has had little impact on population levels. A further factor may well be the world's most effective predator - man. In the US squirrels are highly prized as game. Eastern grey squirrels provided food for Native Americans, and the tradition continues. In most parts of their range they are decreasing in numbers because of overhunting. They are even protected by state game regulations in some states such as Texas. In the State of Mississippi alone around 2.5 million are officially bagged each year, with an economic impact of 12.5 million dollars each hunting season, from August through to February.

However, maybe the taste for grey squirrel is lacking in other areas, as their distribution is apparently expanding rapidly. In recent years, they have moved quickly east into Southern New Brunswick from Quebec and the US, and will eventually reach Nova Scotia. Apparently it is 'not yet known' what effect this larger squirrel will have on the smaller, resident species of squirrels in these regions, such as the red squirrel and the Northern flying squirrel, but experiences in the British Isles should serve as a warning. Hunting is not really part of the rural tradition in England, despite the images portrayed on Christmas cards. Strict gun controls are also in force in the UK, as they are in Canada, which may be one reason why the impact in Canada is becoming more severe and is likely to increase.

Grey squirrels in Continental Europe

Continental Europe has managed to avoid the curse of the Grey Squirrel, up to now at least. Some of the finest broadleaved forests in the world extend over large areas especially in France and Germany. The risk posed by the grey squirrel, evidenced by the devastation it has caused both to native red squirrels and to broadleaved trees in Great Britain and Ireland, have been sufficient to prevent its introduction in the past.

However, small, contained populations have existed in N Italy, where it was first introduced in 1948. One later introduction was successfully eliminated, but the population in the Piedmont/Po plains has persisted, and grown slowly but steadily. Although this population was relatively confined in an agricultural belt with few trees, where the rate of spread and

population growth could only be very slow, Wauters et al. (1997) estimated that the population had reached a total of ca 2,500 by 1996. They noted that if they continued to increase their range they would eventually get close to the continuous mixed forests of the pre-Alps and to large hazel plantations, in which they could spread much more rapidly. They recommended that control measures to stop the spread of grey squirrels, and eventually to eradicate them, should be implemented immediately.

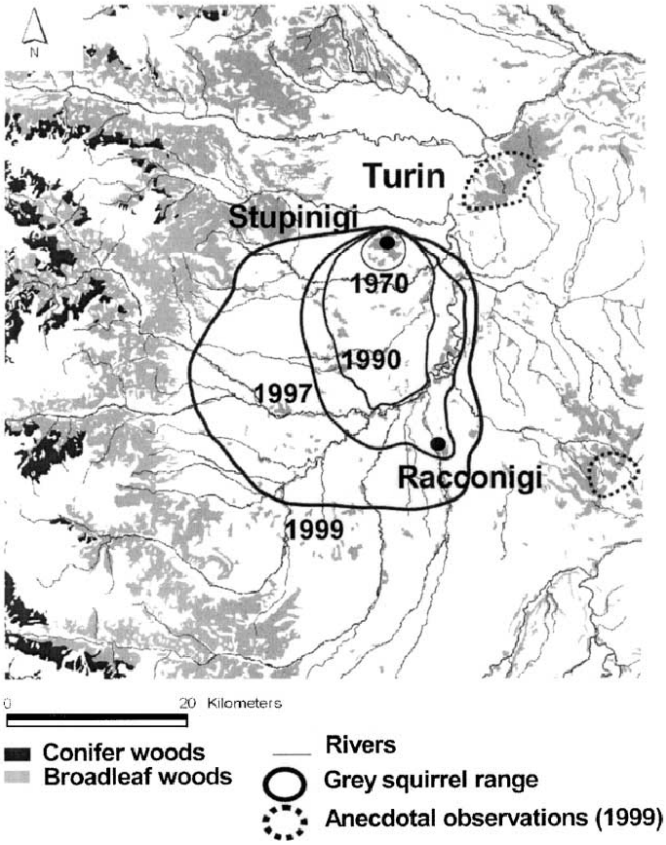

Figure 1. Grey squirrel expansion in the 1970–1999 period. Distribution in 1970, 1990 and 1997 defined from data published in Wauters et al., 1997b (modified). Distribution in 1999 defined on the basis of hair-tube data. (Reproduced from Bertolino & Genovesi, 2002)

Bertolino & Genovesi (2002) published a disturbing follow up paper. They reported how the threat posed to the red squirrel by its American cousin was underlined by the IUCN, the UK Forestry Commission, and WWF, and how Italy's obligations under the Berne Convention and the Convention on Biological Diversity required immediate action to remove this threat. Consequently the Italian National Wildlife Institute initiated a program of trapping and 'euthanasia', but only after the squirrels had extended their range to within 7 km of the contiguous swathe of broadleaf forest and hazelnut plantations of the Piedmont Hills. This area is very similar in terrain and forest to the Piedmont Region

of Georgia, one of the favourite natural habitats of the grey squirrel in N America, no doubt so-named on account of the similarity. It should come as no surprise that this will form an ideal environment in which grey squirrels can multiply and spread. It should also come as no surprise that animal rights activists managed to stop the control program of the Italian authorities for three years, during which time the squirrels reached the hazelnuts and acorns. Expansion rates of only 1.1km ^{2} per year in the plains increased to 250 km^2 per year (Bertolino & Genovesi, 2002). The IUCN now reports that the squirrels are at large in the woodlands of the Alps and Piedmont and that eradication is no longer feasilble. They may already be close to the French border, and now the whole of not just Europe, but also most of Eurasia is threatened by an invasion. For the Italian authorities to blame the animal rights activists is not entirely justified. Their objections could have been predicted, and the question remains – why did the concerned authorities wait until the squirrels could almost smell the hazelnuts and acorns before acting?

The whole of Continental Europe should be aware of the rapid expansion capabilities of the Grey Squirrel. In the US it is known that when mast crops fail in one area, the squirrels usually move en masse to other areas where food is more abundant. This accounts in large measure for long-distance migrations of squirrels that are frequently reported. A major migration of thousands of squirrels took place in October 1968 in Tennessee, Georgia, and North Carolina. This movement was attributed to substantial nut production and a high reproduction rate in 1967, followed by a late frost and little nut production in 1968. Rivers will not be a barrier to migration as grey squirrels can swim up to two miles.

Not only for the UK, but also for the Canadian Maritimes and Continental Europe, if we want red squirrels, broadleaved forestry or impressive bamboo plantations, the future seems stark. One US source advises that a garden can be protected by enclosing it with a 1/4 inch wire mesh. However, “since squirrels climb you will need to have a roof as well as walls”. Maybe we may need to introduce rattlesnakes, bobcats, coyotes and even wolves, not to mention squirrrel pox. In addition we may still need to emulate the good people of Mississippi, who hunt and eat 2.5 million grey squirrels each year. The latest research (Gurnell et al. 2004) now seems to focus no longer on control measures, which may be futile, but instead on the precise mechanisms by which the grey squirrels will effect the inevitable extermination of their native Eurasian cousins in due course.

References

Bertolino & Genovesi (2002). Spread and attempted eradication of the grey squirrel (Sciurus carolinensis) in Italy, and consequences for the red squirrel (Sciurus vulgaris) in Eurasia. *Biological Conservation* 109: 351-358.

Wauters, L. A., Gurnell, J., Currado, I. & Mazzoglio, P. J. (1997). Grey squirrel *Sciurus carolinensis* management in Italy - squirrel distribution in a highly fragmented landscape. *Wildl. Biol.* 3: 117-124.

Gurnell, J., Wauters, L. A., Lurz, P. W. W., & Tosi, G. (2004). Alien species and interspecific competition: effects of introduced eastern grey squirrels on red squirrel population dynamics. *J. Animal Ecol.* 73: 26–35.

Fisher, M. Introduced Species Summary Project: Grey Squirrel (Sciurus carolinensis). Columbia University.

Links

http://www.columbia.edu/itc/cerc/danoff-burg/invasion_bio/inv_spp_summ/Sciurus_carolinensis.htm (March 2 2002 version seen)

http://www.europeansquirrelinitiative.org/introduction.html

http://www.savethegrey.org